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EVIDENCE FOR AND IMPLICATIONS OF A DOMAIN-SPECIFIC GRAMMATICAL DEFICIT

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In 1967, Lenneberg, in his seminary and thought-provoking book "The biological foundations of language", reported that language impairments run in families in simple Mendelian fashion, and that such evidence provides striking proof of Chomsky's (1965) theory that language has a genetic basis. However, Lenneberg did not document whether such language impairments were part of some more general cognitive impairment, part of the language system as a whole, or specific to aspects of language, such as grammar. It is highly controversial whether developmental domain-specific grammatical deficits exist, in just those aspects of language that are core to the human language faculty (e.g., agreement, recursion) that non-humans do not achieve. This is because such data would directly challenge the view that cognitive systems underlying grammar are not restricted to grammatical acquisition and processing (Bates, 1993; Bates and Goodman, 1997; Elman *et al*., 1996; Karmiloff-Smith, 1998; Thomas and Karmiloff-Smith, 2003; Tomasello, 2000). Moreover, Bates and colleagues claim that, if necessary, general cognitive mechanisms can be used for grammatical acquisition and processing. Evidence for domain-specificity has implications for how the brain is organised and the ongoing role of genes and experience in determining the developmental course of specialised cognitive systems. Thus, Lenneberg's inspiring book and the issues it raised are still central to a current major controversy in cognitive science that surrounds how the brain works and how specialised human capacities develop.

In this chapter, I present evidence from Grammatical-Specific Language Impairment (G-SLI) for a domain-specific deficit, which, I claim, indicates the existence of pre-determined specialised neuronal circuitry underlying the domain-specific cognitive system. First, I provide an outline of the general issues and distinguish related but separate questions central to the domain-specific debate and G-SLI. Following this, I provide details of the non-verbal cognitive and non-grammatical language abilities of G-SLI children, who are a subgroup of children with SLI. In the second section of the chapter, I review the data from grammatical (morpho-syntactic) investigations of G-SLI children and provide a hypothesis ---the Representational Deficit for Dependent Relations (RDDR)-- to account for G-SLI syntax. The predictions of the RDDR hypothesis are tested in English and then cross-linguistically. Finally, I report current investigations of the phonological structure of G-SLI children. I claim that our investigations reveal a grammar-specific deficit affecting syntax, morphology and phonology. The autonomous but cumulative contribution of each affected grammatical system is exposed in regular and irregular morphology.

RELATIONS BETWEEN GENES, COGNITIVE SYSTEMS, DEVELOPMENT & GRAMMATICAL DEFICITS

The assumptions or working hypotheses about the nature and development of specialised cognitive systems have a significant influence on investigations in cognitive science. In this section, I set out the argument, and distinguish questions where the study of specific language impairment (SLI) can (and cannot) contribute to the current debate. Further, I contend that we should seek to explain data that exist ---such as those from SLI and in particular G-SLI--- which challenge some researchers' (e.g., Elman *et al*., (1996); Karmiloff-Smith, (1998); Thomas & Karmiloff-Smith, (2003)) assumptions about the lack of specificity in the role of genes in pre-determining the development of specialised cognitive systems.

Proponents on one side of the debate argue that domain-general or "domain-relevant" cognitive systems underlie specialised cognitive systems (Elman *et al.*, 1996; McClelland and Patterson, 2002b; Thomas and Karmiloff-Smith, 2003; Tomasello, 2000). Moreover, domain-relevant systems become specialised from the developmental process itself and crucially depend on developmental conditions (Karmiloff-Smith, 1998; Thomas and Karmiloff-Smith, 2003). Because, according to Karmiloff-Smith and colleagues, a) genetic factors do not determine *a priori* the specificity of mechanisms, b) no mechanism is unique to any one system, and c) mutual compensation can occur between mechanisms, then no mechanism is innately specialised and atypical development cannot produce selective deficits while the rest of the system develops normally. Thereby, developmental disorders cannot provide evidence for domain-specificity (Thomas and Karmiloff-Smith, 2003; Karmiloff-Smith, 1998). Such a conclusion clearly depends on their assumptions concerning the development of specialised cognitive systems. As genes are differentially expressed in different areas of the brain, it would be surprising if one area could fully substitute or compensate for another (Pallas, 2001).

Alternatively, some researchers such as Chomsky (1986), Fodor (1983), Pinker (1994; 2002) and Marcus (2001) claim that predetermined specialised cognitive mechanisms underlie different domains of cognition. However, clearly, the adult specialised system will reflect the developmental interaction between environmental influences and genetically determined underlying specialised circuitry. This hypothesis predicts that primary impairments of specialised systems should exist. Thus, this controversy concerns basic questions about the development, structure and function of the brain. Evidence for a developmentally domain-specific deficit can move this debate forward.

Specific language impairment (SLI) can elucidate the development of one particular, and uniquely human, specialised cognitive system ---language, or more precisely, grammar---and provides a test case for the existence of a domain-specific deficit. SLI affects about 7% of the population. It is a heterogeneous disorder, in which language acquisition is impaired, in an otherwise apparently normally developing child (Leonard, 1998). Not surprisingly, the specificity of this deficit has been the focus of considerable discussion (Elman *et al*., 1996; van der Lely *et al., 1998*; Tomblin and Pandich, 1999). However, before I can advance the debate with the data from one subgroup of SLI children --- those with "Grammatical(G)-SLI" (1996; 1998) ---, several related but logically distinct questions need to be distinguished concerning relations between genes, domain-specificity, SLI, the heterogeneity and sub-groups of SLI, as well as domain-specific disorders. Further, I consider secondary effects of a disorder on other cognitive functions, and the relevance (or not) of "residual normality" (Thomas and Karmiloff-Smith, 2003) for the existence of domain-specific deficits.

Recent research, identifying variable genetic defects associated with SLI, suggests that SLI occurs in qualitatively different forms (Lai *et al*., 2001; SLI Consortium, 2002). Moreover, this work has propelled SLI to centre stage because of its potential for understanding relations between genes and specialised higher cognitive abilities (Pinker, 2001). Based on the recent genetic investigations (Fisher *et al*., 1998; Lai *et al*., 2001; SLI Consortium, 2002), there is little doubt that a single gene (FOXP2) can cause at least one form of SLI, ---that exhibited by the KE family (Lai *et al*., 2001). Moreover, regions on chromosome 16 and 19 have been linked to impaired performance on nonword repetition tasks, implicating phonological deficit, and the expressive scores on the CELF-R (a test of receptive and expressive language) respectively.

Although a single gene can disrupt the language system, this is not, of course, to claim that there is "a gene for grammar," as the popular press reported in the 1990's! Despite the FOXP2 discovery linked to one form of SLI, like many behavioural traits, SLI is thought to be genetically complex, with several loci contributing to the overall risk of the disorder (SLI Consortium, 2002). The genetic contribution to SLI is not disputed (Bishop *et al*., 1995; Fisher *et al.*, 1998), but the specificity of the disorder is (Elman *et al*., 1996), and we are a long way off from understanding the developmental pathways from genes to cognitive functions. Moreover, we must distinguish questions relating to the regional and temporal expression pattern of a gene, from those relating to genes predetermining specialised neuronal circuitry that could underlie domain-specific cognitive systems, and, indeed, from questions relating to the existence of domain-specific systems and

deficits. The expression pattern of genes underlying different forms of SLI, whether they are highly specific, or affect several locations but might only be "relevant" to specialised circuitry underlying a specialised cognitive system, or whether SLI, on occasions, can be associated with genes that are expressed in multiple locations, does not militate against a domain-specific cognitive system. In contrast, finding discrete cognitive deficits, thought to be caused by genetic factors, provides some of the strongest evidence, for our current state of knowledge, for predetermined domain-specific cognitive systems. This chapter aims to provide this evidence.

The heterogeneity of linguistic characteristics of children with SLI is well known (Bishop, 1997; Leonard, 1998). Children with SLI display varying degrees of deficits within grammar (syntax, morphology and phonology[1]), semantic and, or pragmatic deficits as well as lexical deficits. Further, there are reports of varying degrees of non-verbal cognitive deficits occurring alongside language impairment (Leonard, 1998). However, as yet, research has not consistently shown any direct (or indirect) relations between language and non-verbal deficits, indicating a co-morbidity of impairment (Rutter *et al*., 1990), rather than a deficit with a common underlying mechanism or system. Moreover, developmental evidence suggests that even within grammar (syntax, morphology, phonology), deficits do not necessarily co-occur. For example, morpho-syntactic deficits do not consistently co-occur with phonological deficits as studies in children with dyslexia illustrate (Ramus, 2001; 2003; Snowling, 2000). It is unclear whether some of the heterogeneity of SLI phenotypes results from a single genotype, in the context of variable (pre or post natal) environmental influences, or whether such variation reflects heterogeneous genotypes. It is highly likely that many genes could disrupt particular developmental pathways in various ways. However, neither SLI heterogeneity, nor the existence of co-occurring grammatical deficits alongside mild to moderate cognitive deficits militate against predetermined domain-specific mechanisms/circuitry underlying domain-specific cognitive systems. Thus, the cause of the variation in the SLI phenotype and its relation to the genotype and environmental influences is important but distinct from the issue of predetermined domain-specific circuitry and domain-specific systems.

Further, we must differentiate a primary deficit causing secondary deficits in a different domain vs. a primary deficit and "residual normality" (Thomas and Karmiloff-Smith, 2003) and the implications of these for the existence of domain-specific mechanisms. Thomas and Karmiloff-Smith (2003) imply that if "residual normality" of other cognitive functions is not found alongside a domain-specific deficit then this militates against such a deficit and by implication domain-specific mechanisms. However, the logic of Thomas and Karmiloff-Smith's (Thomas and Karmiloff-Smith, 2003) argument for "residual normality" only holds if one thinks, as Thomas and Karmiloff-Smith appear to, that the nature and form of a "mechanism" itself is a direct reflection of its experience through development, and that no mechanisms are specific from the beginning. That is, specialised mechanisms are not predetermined but "constructed" through development and moreover, genetic deficits are not specific to any one mechanism (Karmiloff-Smith, 1998; Thomas and Karmiloff-Smith, 2003). Clearly, there is danger of circularity in this

[1] Semantics could also be included in this list as part of the grammatical computational system (Chomsky, 1993). However, this sense of semantics at LF (Logical Form) should be distinguished from lexical-conceptual knowledge.

argument and confusion between several distinct issues with respect to genetic factors (discussed above) and primary vs. secondary deficits that need to be separated from issues of domain-specificity. To illustrate my point: secondary deficits of grammatical impairment can occur in vocabulary/lexical knowledge as a consequence of grammatical deficit. Word learning is reliant on many systems, some of which are thought to be language-specific (such as the use of syntactic cues) but many are not specific to grammar or even to language (Bloom, 2000). Grammatical-syntactic cues play an important role in word learning, particularly with abstract nouns and verbs (Bloom, 2000). Thus, grammatical deficit is predicted to affect word learning when grammatical cues are required. A resulting lexical deficit should be differentiated from a general learning deficit for words, for instance, in using pragmatic, inferential cues to identify the referent of a word, or in associative mapping between phonological word forms to meaning, or identifying, storing or retrieving words. Thus, normal vs. impaired functioning of mechanisms underlying lexical mapping, storing and retrieval must be established and distinguished from lexical deficits arising from grammatical impairment in order to evaluate whether a domain-specific deficit exists.

The possible effect of a primary language deficit on non-verbal cognitive functioning has received relatively little attention, although some researchers attribute decreasing non-verbal IQ scores with age in some children with SLI to such secondary effects (Bishop, 1997; Tomblin *et al*., 1992). Once again, such potential secondary effects must be distinguished from primary deficits both within language and in non-verbal cognitive functioning. There appears to be no *a priori* reason why the absence of "residual normality" which reflects secondary deficits would be evidence against predetermined domain-specific mechanisms.

A related issue concerns identifying specialised mechanisms (or circuitry) which are crucial to a system (e.g., the grammatical system) vs. "domain-relevant" (Karmiloff-Smith, 1998) and general mechanisms that might contribute to a system. One possibility is that domain-specific systems are only sub-served by domain-specific circuitry. However, this is not the only possibility. Whereas a domain-specific mechanism is necessarily required for a domain-specific system, domain-relevant and domain-general mechanisms could contribute to some aspect of normal functioning of that system. Within a modular framework, the function of the former, specialised mechanism could not be compensated for by other mechanisms, whereas the function of domain-relevant or general mechanisms could be sub-served by other mechanisms or processes.

In sum, potential complex patterns of genetic inheritance, heterogeneous SLI phenotypes evincing variable and/or multiple deficits across the language system, variable non-verbal abilities, secondary effects in non-grammatical language abilities (lexical development) do not logically militate against the existence of predetermined domain-specific cognitive systems as claimed by some cognitive scientists. Clearly, evidence for a developmental domain-specific deficit, if it can be shown, provides the strongest argument for predetermined domain-specific circuitry/mechanisms. I evaluate below the evidence from G-SLI children for a discrete developmental grammatical deficit and seek to establish if any primary or secondary language or cognitive deficits are evinced along side this deficit, which would count against a domain-specific

deficit. Such data most strongly speak to whether or not we have evidence for a domain-specific mechanism that can be selectively impaired. These data do not provide direct evidence for a genetic impairment that could cause such a deficit, but provide tentative indications with respect to the innate underpinnings of specialised cognitive systems.

GRAMMATICAL-SLI

The subgroup of SLI children characterised by G-SLI (van der Lely and Stollwerck, 1996) provide a unique testing ground for the domain-specific/domain-general debate. Van der Lely *et al*. (1998) claim that these children suffer from a relatively pure developmental deficit in the grammatical aspects of language (syntax, morphology, and phonology) that are core to the human language faculty. G-SLI children are characterised by their persistent grammatical impairment as shown when grammatical knowledge is needed for comprehension, expression and judgement of sentences. Between 12 and 16 children with G-SLI participated in our studies who were aged between 9 to 20 years, with the majority falling between 10-15 years of age. G-SLI affects around 10-20% of children who are already diagnosed as SLI, are over 9;0 years, and whose non-verbal IQ scores fall above 85 on standardised tests of intelligence (van der Lely and Stollwerck, 1996; Bishop *et al*., 2000). A preliminary investigation of familiar aggregation of language and/or reading problems in first degree relatives of G-SLI probands revealed that 70% of the subjects had one parent with a positive history and 43% of their siblings had a positive familiar history (van der Lely and Stollwerck, 1996). These preliminary data are consistent with an autosomal dominant inheritance.

Non-verbal Cognitive Abilities

The first set of investigations tested whether any non-verbal or auditory perceptual deficits, thought by some to cause SLI (Elman *et al*., 1996; Bishop, 1997; Merzenich. *et al*., 1996; Tallal, 2000) could be found. On full standardised IQ performance tests and sub-tests, each G-SLI subject falls within normal limits (British Ability Scales (BAS) (Elliott *et al*., 1978) mean performance IQ 99.08, 11sd; Block-Design BAS sub-test Mean IQ 109, range 86-119). Further on Raven's progressive matrices (Raven *et al*., 1978), a non-verbal test in which some SLI children perform poorly (Bishop, 1997), they also show a normal range of abilities (Mean IQ 93(12sd).

In addition to the standardised non-verbal tests, we designed a test of complex structural mapping (Halford, 1987) with processing demands comparable to the grammatical tasks in which G-SLI children fail. The grammatical rules that are problematic for G-SLI children require complex structural mapping; for example, producing the inflection *-s* on a verb (*Mary likes Jill, cf. I like Jill)*, requires knowing something about the position of *Mary* in the sentence (i.e., it is in a subject relationship to the verb) and knowing about syntactic properties of this subject noun phrase, (i.e., it is the third person singular). Visual transitive inference tasks also require a systematic relationship of

one structure to another (Halford, 1987). Our task required the child to judge the relative sizes of five differently coloured bars of increasing size (bars A to E). The BD bar combination, novel in the test phase, required a transitive inference to be made, as both bars were bigger and smaller in relation to other bars. The G-SLI subjects' overall accuracy (85.2% correct, 34/40), and for the crucial BD combination (87.5%) did not differ from their age peers (overall 87%; BD 89%) or language peers (overall 85%; BD 79%). Furthermore, their reaction times (overall 1625ms; BD 1995ms) revealed that they were faster than their age peers (overall 2585ms; BD 2806ms) and general language peers (overall 1783ms; BD 2202ms) (van der Lely, 1996a). Thus, on this test of processing complexity and speed of response, the G-SLI subjects performed similarly to normally developing children.

Researchers supporting the domain-general perspective, in line with their assumptions that experience determines the development of specialisation, claim that a more general deficit in processing speed causes SLI by degrading the speech input (Bates, 1993; Elman *et al*., 1996; Karmiloff-Smith, 1998; Tallal *et al*., 1996). In support of this claim are reports that children with SLI are impaired in: 1) discriminating rapidly (but not slowly) presented non-speech sounds (high vs. low tones; and 2) discriminating speech sounds distinguished by rapid acoustic transitions ((*/ba/-/da/)* (Tallal and Piercy, 1973; 1974). Further, Tallal, Merzenich and colleagues (Tallal *et al*., 1996; Merzenich. *et al*., 1996) found significant improvements in speech discrimination and language comprehension following intensive training in a computer-controlled rehabilitation program emphasising the auditory processing of rapidly changing elements in speech and non-speech sounds. Some researchers take this remedial effect as strong support of the domain-general view of the development of specialised linguistic abilities (Karmiloff-Smith, 1998; Karmiloff and Karmiloff-Smith, 2001). To explore this possibility, we investigated auditory abilities --- carefully distinguishing speech from non-speech sounds --- in G-SLI children and age and language matched control groups, thereby evaluating affects of language and age on performance. Listeners were tested on their ability to discriminate rapid formant transitions in speech (ba/da) and non-speech contexts (an isolated F2 formant from the ba/da condition) and short tones differing in fundamental frequency, presented with varying inter-stimulus intervals (ISI). Overall performance with speech and non-speech sounds differentiated the G-SLI children from the control groups, whereas speed of processing did not (van der Lely *et al*., 2003). On the non-speech F2 condition almost 70% (9/13) of the G-SLI subjects performed within normal limits for their age with 49% gaining z-residual scores above +1SD; however only 31% (4/13) did this well for the speech sounds. For the overall Tone condition, 49% (6/13) of the G-SLI subjects performed within the normal range in comparison to age and IQ matched controls. Moreover, the same children (49%) performed within the normal limits on the rapidly presented tones, which had ISI of 0 or 10ms. Thus, the majority of G-SLI children showed normal auditory processing of non-speech sounds, and no relations were found between auditory performance and language abilities (van der Lely *et al*., 2003). Further, 6 children without SLI were impaired in their auditory processing (van der Lely *et al*., 2003). Similar findings are reported for non-selected groups[2] of SLI children (Bishop *et al*., 1999). The findings revealed no evidence that domain-general deficits in processing rapid acoustic information causes the language impairment

[2] By "non-selected", I refer to groups of SLI children whose language deficit is not necessarily restricted to grammar, i.e., they do not necessarily have a domain-specific deficit.

in the majority of this G-SLI subgroup and militate against a unitary cause of SLI. The hypothesis that SLI *per se* is caused by a perceptual deficit is no longer tenable.

Non-grammatical Language Abilities

There are variable reports of non-grammatical language deficits in children with grammatical deficit (Bishop, 1997). Co-occurring pragmatic deficits causing, for example, problems with pragmatic inference are reported for children with SLI (Bishop *et al*., 2000; Bishop and Adams, 1989; Norbury and Bishop, 2002). In order to investigate this possibility we first explored the G-SLI children's pragmatic-social knowledge of pronouns with a picture storybook. Specifically, we investigated pragmatic knowledge that involves anticipating the knowledge and needs of the listener (intuitive psychology) rather than knowing the grammatical rules of English (grammar system) (Pinker, 1994). For example, it is inappropriate to initially introduce somebody with a pronoun, as in *Once upon a time he had a frog.* From around 7 to 8 years, children know that a person should be initially introduced and re-introduced using a name or noun phrase (*John/The boy*), and that pronouns should only be used to maintain reference (Karmiloff-Smith, 1985). Our younger control children of less than 7;4 years incorrectly used a pronoun (*he*) to re-introduce as well as maintain reference to the boy in the story. On the occasions when the G-SLI subjects used pronouns (*he, they, it*) they correctly restricted their use to maintaining reference (van der Lely, 1997). Therefore, when appropriate, they alternated the use of pronouns with noun phrases (e.g., *he* with *the boy*). This kind of performance could be expected of any socially competent person who can take into account the listener's knowledge. Thus, the G-SLI children showed a mature pragmatic-social knowledge of pronouns (van der Lely, 1997).

The second non-grammatical language investigation tested if G-SLI subjects could make a logical inference which required either: i) an implicated assumption, ii) an implicated conclusion, iii) Modus ponens (if P then Q, P therefore Q), iv) Modus tollendo ponens (either P or Q, not P therefore Q). Fifty mini-dialogues were staged and recorded by three speakers. The third speaker provided a probe question which required a yes/no answer; e.g., Sam: *Have you ever flown in a helicopter?* Mary: *I've never flown.* Probe: *Do you think Mary has been in a helicopter?* The G-SLI subjects' performance (mean 88% correct) was normal compared to the expected performance for their age (age controls: 94% correct) or general language test scores (language controls: 85% correct (van der Lely, unpublished data). In addition, G-SLI children's ability to detect utterances that violated pragmatic conversational maxims (avoid redundancy, be informative, truthful, relevant and polite) was normal. Each of the children in the G-SLI group and a control group scored at least 17/25 correct which was significantly above chance (G-SLI mean correct 85%; Controls, mean correct 86%), and the G-SLI children did not differ significantly from the normal controls in any violation type (Surian *et al*., 1996). In contrast, in a group of children with autism, most children performed at chance on this task (Surian *et al*., 1996).

Another related pragmatic ability is Theory of Mind (ToM) (Baron-Cohen *et al*., 1985). Although some researchers argue for the relative autonomy of meta-representational capacity that underlies

false beliefs and language abilities or mental verbal age (Baron-Cohen *et al*., 1985; Leslie and Frith, 1988), others claim that a certain level of linguistic abilities is a necessary, but not sufficient, prerequisite for false belief understanding (DeVilliers and DeVilliers, 1998; Tager-Flusberg, 1993). To ascertain if G-SLI children's language deficit was causing or associated with impairment in ToM, we tested whether our children could make first and second order belief attribution ((Baron-Cohen *et al*., 1985), which requires the child to take another person's perspective in order to understand what somebody else could be thinking. The classic "Sally-Ann" paradigm was employed to assess the attribution of first order false belief (Baron-Cohen *et al*., 1985; Wimmer and Perner, 1983). In this test of ToM an object is displaced unbeknown to one of the characters who comes to hold a false belief as to its whereabouts**.** The "Ice-cream van task" enabled us to assess second order false belief attribution (Perner and Wimmer, 1985). Almost all the G-SLI children (11/12, 91%) evinced first order belief attribution and 9/12 (75%) second order belief attribution. Thus, the majority of the G-SLI children show normal performance on these ToM tasks.

To summarise, on a range of tests of non-grammatical language abilities, the G-SLI subjects show good pragmatic-social knowledge, are able to make conversational inferences and use logical reasoning and the majority show appropriate ToM abilities.

In contrast to these normal cognitive and non-grammatical language abilities reported above, the G-SLI subjects are impaired in their vocabulary knowledge for their age, albeit not as severely as in their grammatical knowledge. Tomblin & Pandich (1999) take this as evidence against a domain-specific deficit in G-SLI. However, I have argued above that this deficit appears to be secondary to their grammatical deficit. Here I present further data to support this claim. First, I looked at G-SLI subjects' ability to use syntactic cues to infer a potential meaning to a novel verb and assign appropriate thematic roles to the noun phrases as in (1).

(1) *The lorry is voosed by the car*

The G-SLI children showed a significant impairment in comparison to language matched control children (van der Lely, 1994), indicated that they were having problems using syntactic cues to learn words. More recently, in a series of experiments, Karen Froud and I investigated G-SLI subjects' ability to use syntactic knowledge of the count/mass distinction (*a bik, some bik)* to identify the meaning of novel nouns when presented with novel objects, substances or "neutral material" (e.g., beans, pasta). Normally developing children matched on age or different language abilities (vocabulary, grammar) used the syntactic cues to determine whether the noun was a count or mass noun, thereby pluralizing the novel nouns when introduced with count noun syntax. In contrast, the G-SLI children did not distinguish between nouns on the basis of the syntax. They pluralized all nouns regardless of the materials they were associated with or whether they were introduced with a count or mass noun syntax (Froud and van der Lely, 2003a; 2003b). Further, the G-SLI subjects were not able to learn novel collective nouns based on syntactic cues, although they showed lexical-semantic understanding of known collective terms such as *family,* and *army* (Froud and van der Lely, 2003b). In contrast to this severely impaired use of syntactic

cues for word learning, a lexical-contrast experiment revealed that G-SLI children could use pragmatic-inferential cues to learn words (Froud and van der Lely, 2003b). Their use of semantic cues for word-learning is also normal. Following a demonstration of the meaning of novel verbs, the G-SLI children could map thematic roles of nouns onto appropriate syntactic positions in their expressive language (van der Lely, 1994).

In other ways too, the lexicon of G-SLI subjects appears normal. In an on-line auditory lexical decision, priming task, their speed of lexical access was significantly faster than that of language controls, and generally they did not differ from age controls (Jones and van der Lely, 1998). Moreover, related primes affected the groups in a similar way, indicating that the lexicon of G-SLI subjects is normally organised. Semantically related nouns (*pony-horse*) and morphologically related lexical verbs (*jumped-jump*) facilitated lexical access, whereas phonologically related nouns (*petrol-pet*) had little facilitative effect. Thus, although G-SLI children's vocabulary knowledge is impaired for their age, our investigations indicate that it is only when grammar is required that they are impaired in lexical tasks. They evince a normal use of both semantic and pragmatic cues to learn words and their lexical access speed and organisation is similar to that of age and language matched control children. Thus, although such lexical impairment violates Thomas and Karmiloff-Smith's (2003) notion of residual normality there does not seem to be any reason why this provides evidence against a domain-specific deficit.

Grammatical Abilities

Equally important to profiling non-verbal and non-grammatical abilities, when seeking to identify domain-specific deficits, are fine-grained linguistic analyses of morpho-syntax and phonology to differentiate linguistic phenotypes of SLI subgroups. Contrasting profiles might (one day) be linked to particular genetic profiles, with an understanding of environmental factors that contribute to the developmental pathways that result in normal and atypical development. Our investigations into G-SLI children aim to provide a further step towards identifying which aspects of the grammatical system are autonomous from other cognitive and language functions. I will present linguistic evidence from the G-SLI subgroup showing a broad but discrete and predictable grammatical deficit in the structural computational language system affecting grammatical complexity. Within syntax this deficit, affecting hierarchical dependent relations, is characterised by a deficit in syntactic movement, which is optionally applied (The RDDR hypothesis). This hypothesis can account for the broad range of deficits found in SLI, as well as the strengths in their syntactic system in English and cross-linguistically. I will present findings from investigations testing the predictions of the RDDR hypothesis with respect to impaired and normal performance. Finally, in this section, I discuss recent findings from phonological investigations that reveal that the deficit extends to prosodic (hierarchical) complexity, characterised by the degree of "markedness" of syllabic and metrical structure.

Morpho-syntax. Our previous psycholinguistic investigations show that G-SLI children inconsistently manipulate aspects of syntax that are thought to be core to the human language

faculty (Smith, 1999). First, a picture elicitation task (Verb Agreement and Tense Test (VATT) (van der Lely, 2000), reveals that G-SLI subjects are impaired in tense and agreement marking, and use infinitive forms in finite contexts around 20 to 80% of the time (see (2)).

(2) a. *Every day Woody slam the door*
b. *Yesterday Woody slam the door*

These data for G-SLI subjects are consistent with many studies of children with SLI (Rice and Wexler, 1996; Clahsen *et al*., 1997). As with all their grammatical errors, these errors are found regardless of processing factors. For instance, tense marking errors, where the infinitival form is used in a finite context, are found in spontaneous speech, story-telling and elicitation tasks, as well as grammaticality judgements (Gollner, 1995; van der Lely, 1997; van der Lely and Ullman, 1996; 2001). Moreover, G-SLI children show optionality in their use of tense marking. Thus, the same lexical item is used both correctly and incorrectly in similar syntactic contexts (e.g., "*My dad goes home"; "My mum go to work"*) (van der Lely, 1997). A similar optionality for tense marking is reported for young children (Wexler, 1998) and other groups of children with SLI (Rice *et al*., 1995).

However, G-SLI is not restricted to inflectional morphology. One of the most reliable findings for 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 and Dewart, 1986; van der Lely and Harris, 1990; van der Lely, 1994; 1996). 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; Precious and Conti-Ramsden, 1988; Norbury *et al*., 2001; Stavrakaki, 2001; 2002). G-SLI subjects' 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*) (van der Lely and Stollwerck, 1997). Thus, although G-SLI children can use pronouns appropriately when pragmatic-social knowledge is required, when syntactic knowledge is required, that is normally acquired by 5 years of age, they are impaired. In addition, G-SLI children have problems with embedded phrases and clauses (*The frog with the blanket…*) (van der Lely and Hennessey, 1999). This deficit is revealed in elicitation and comprehension tasks (van der Lely and Hennessey, 1999), as well as story telling, where they produced few if any spontaneous embedded or subordinate clauses (van der Lely, 1997). These data reveal that the syntactic deficit in G-SLI is much broader than inflectional morphology, or deficits with non-salient forms (Joanisse and Seidenberg, 1998; Leonard, 1998). Increasingly, research is revealing that similar broad (but constrained) grammatical deficits are found in non-selected subgroups of children with SLI as was well as in subjects with G-SLI. For instance, similar deficits with general dependent structural relations affecting verb structure, noun phrases, clitics, as well as clauses and embedded structures are slowly emerging in the literature for other groups of children with SLI cross-linguistically

(Bishop *et al.*, 2000; Hamann *et al*., 1998; Jakubowicz *et al*., 1998; Ingham *et al*., 1998; Norbury *et al.*, 2001; Stavrakaki, 2001; 2002). For example Hamann *et al.* (1998), investigating German speaking SLI children from three different labs, found that they left the infinitival form of the verb in the verb final position rather than move it to the correct finite V2 position, approximately 50% of the time. Further, in their Swiss-German data (a "scrambling language"), although the object NP was realised correctly in IP, further movement to CP was problematic (Hamann *et al.*, 1998).

Finally, G-SLI subjects, like many children with SLI, show both correct and incorrect performance for the same syntactic structure across this broad range of syntactic structures (not just tense marking). 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 fact that correct and incorrect performance is found for the same lexical item in similar syntactic contexts suggests that grammatical rules, by definition obligatory, might be optional in G-SLI grammar· the Representational Deficit for Dependent Relations (RDDR) hypothesis provides a detailed account of the deficit within the syntactic system

The Representational Deficit for Dependent Relations (RDDR) Account of G-SLI

The Representational Deficit for Dependent Relations (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. As noted above, the RDDR account identifies the underlying deficit in the computational syntactic system (van der Lely, 1994; 1998; van der Lely and Stollwerck, 1997). The RDDR hypothesis assumes that certain aspects of grammar have an autonomous psychological and neural basis. The RDDR largely adopts the Minimalist program (Chomsky, 1998; 1999) to provide a precise linguistic 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 characterised 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 non-interpretable feature (e.g., tense, gender) for the purposes of feature checking. Specifically, Move takes place when neither Merge nor Agree are options for non-interpretable feature deletion; i.e., it is the "last resort chosen when nothing else is possible" (Chomsky, 1998:14). Although Chomsky (1995; 1998; 1999) defines this syntactic dependency operation as "Movement", the terminology to describe this operation may change (is changing!) with developing linguistic theories (cf. Lightfoot's, (2002), "feature-copying"). Indeed, completely different theoretical frameworks would handle all of the operations and constructs invoked here entirely differently; our adoption of Minimalism is intended to show the consequences for that theory, and the assumptions it makes, of the experimental data presented here. Any theory, we claim, will need to be able to account for the particular facts from

G-SLI considered here (cf. Joanisse and Seidenberg (1998)). However, it is this basic operation of syntactic dependency in conjunction with the grammatical operations/processes "Move" that is central to the RDDR account of G-SLI and, indeed, central to developing complex structures in the syntax. Bearing this in mind, we will continue to define the RDDR within Chomsky's (1998; 1999) framework.

The optionality --- rather than the absence --- of Movement that characterises G-SLI grammar, indicates that the operation or rule "Move F" (a Feature) is available to them. Therefore, the underlying deficit is not in the operation Move itself, but the implementation of the operation (van der Lely, 1998)—i.e., Move *per se* is not missing. R. Manzini (personal communication, 1998) suggested that the locus of the deficit is with the Economy principles (Chomsky, 1998). Van der Lely (van der Lely, 1998) explored this proposal and concluded that of the various principles or properties of Economy (e.g., Minimal Link Condition, Last Resort), 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 sub-label of K". Last Resort may be thought of as comprising two principles (R. Manzini, personal communication, 1998). The first principle, Economy 1, ensures that the operation Move only operates, if at all, if it satisfies a feature-checking relation when Merge and Agree cannot satisfy this operation. Thus, Economy 1 ensures that Move F occurs only if there are features to be checked but does not ensure the obligatory nature of Move for un-checked features. Further, without Economy 1, the operation Move F would be totally missing, which is not attested in G-SLI. The second principle, Economy 2, forces Movement, and thereby obligatory checking of un-checked features, if the target has not had its features checked. Thus, the Economy 2 principle of Last Resort ensures that Movement operations are obligatory (van der Lely, 1998). Van der Lely (1998) contends that the Economy 2 ("the Must-Move") principle of Last Resort is missing in G-SLI grammar and that this accounts for the optionality of Movement. From a computational, mechanistic viewpoint, this could be interpreted as an impaired (specialised) algorithm, underlying Movement representations or operations in G-SLI, such that Movement can occur, but, in contrast to normal grammar, is not "automatic" and compulsory--- that is, a steady state has not been achieved. Thus, the split of Last Resort into Economy 1 and 2 is necessary to account for the optionality of Move in G-SLI, and the acceptance in Grammaticality judgement tasks of sentences where Movement has not taken place (Davies, 2001; 2002; Jones and van der Lely, 1998).

Problems with Head-to-Head Movement (e.g., V to I) can account for G-SLI subjects' deficit with tense and agreement marking[3]. 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). Note that we adopt Manzini and Roussou's (2000) and Hornstein's (1999) proposals of A-Movement and control which departs from standard transformational theory of A-Movement and enables a parsimonious explanation of our data (see van der Lely (1998)). For instance, the RDDR characterisation of G-SLI correctly predicts that

[3] Cf. Wexler (Wexler, 1998) for an alternative view with respect to a deficit in DP Movement which is more akin to the RDDR hypothesis and, specifically, earlier versions of this proposal, discussed in van der Lely and Stollwerck (1997).

problems with root sentences may occasionally surface if non-grammatical strategies cannot facilitate performance (see van der Lely (1994); van der Lely & Harris (1990)). Thus, I contend that the RDDR can account for the range of deficits found in G-SLI subjects, whereas other accounts of the linguistic deficits in children with SLI, such as the Extended Optional Infinitive account (Rice and Wexler, 1996; Wexler *et al*., 1998), or the Agreement deficit account (Clahsen *et al.*, 1997), can only account for their tense and agreement errors. Note that it falls outside the scope of this chapter to further discuss alternative accounts of these data (see, van der Lely (1998) for discussion of this issue).

Testing the Predictions of the RDDR Hypothesis

1) Predicted deficits. The RDDR hypothesis predicts that G-SLI subjects would have problems with Wh-Movement, and Q-feature Movement. Although errors with question formation had been noted in the literature, (Eyer and Leonard, 1995; Hamann *et al.*, 1998; Menyuk, 1964), we were not aware of any systematic exploration of the production of Wh-subject and Wh-object questions in SLI children, despite the importance such investigations have played in recent years in the theoretical linguistic and language acquisition literature (e.g., de Villiers 1995, 1996; Manzini (1992); Rizzi (Rizzi, 1991); Roeper and DeVilliers (1991; 1994); Stromswold (1990); Thornton (1990; 1995)). Thus, Jackie Battell and I investigated Wh-Movement of questions in G-SLI children to test the predictions of the RDDR hypothesis and in doing so fill a gap in the SLI literature characterising the linguistic deficits of children with SLI (van der Lely and Battell, 2003).

We focused our investigation on simple, matrix subject and object questions and restricted our enquiry to Movement operations. The syntactic differences between subject and object questions have been the topic of much debate (Manzini, 1992; Rizzi, 1990; 1991; Roeper and DeVilliers, 1994; Stromswold, 1990, 1995). For consistency, we adopted Rizzi's (Rizzi, 1991) analysis for subject and object questions. It is generally agreed that formation of object Wh-questions involves two forms of Movement. First, A-bar Movement of the Wh-operator to the specifier (Spec) position of the complementiser phrase (CP), leaving a trace behind in the internal verb argument position, which is bound by the Wh-operator, shown in (3a) below (Rizzi, 1991) (hereafter "Wh-operator Movement"). This precludes, in normal adult grammar, the empty internal verb argument position being filled by a determiner phrase (DP), as shown in (3b). Second, object questions necessitate Movement of "*do"* bearing the Q-feature into the head of CP, that is I to C Movement, ---known as *do-support* (see 3a) and determines appropriate tense and Q feature marking in object questions (hereafter T/Q-feature Movement)

(3) a. $[_{CP}\text{Who}_i\ [_{C'}\ \text{did}_j\ [_{IP}\ \text{Simon}[_{I'}\ e_j\ [_{VP}\ [_{V'}\text{see}[_{NP}t_i?]]]]]]]$
b. *$[_{CP}\text{Who}_i\ [_{C'}\ \text{did}_j\ [_{IP}\ \text{Simon}[_{I'}\ e_j\ [_{VP}\ [_{V'}\text{see}[_{NP}\text{Karen}_i?]]]]]]]$

In contrast, subject questions do not incur *do-support*, and therefore no I to C Movement. Thus, in subject questions, tense is typically marked on the matrix verb following (the less costly) overt

V to I Movement. Following Rizzi (Rizzi, 1991) the Wh-word moves from an original position within the inflectional phrase (IP) to the CP, as shown in (4a). Note that in production of subject questions, if Wh-Movement has not taken place the correct word order will surface (4b). Therefore, we attended to errors such as "gap-filling" for evidence of failed wh-operator Movement.

(4) a. $[_{CP}\text{Who}_i\ [_{C'}\ [_{IP}\ t_i [_{I'}\ [_{VP}\ [_{V'}$ saw Liz ?]]]]]]
b. $[_{CP i}\ [_{C'}\ [_{IP}$ Who$[_{I'}\ [_{VP}\ [_{V'}$ saw Liz ?]]]]]]

Predictions for Wh-questions. The characterisation of subject and object questions above leads to clear predictions with respect to the RDDR hypothesis for G-SLI grammar. First, if Movement-feature checking is optional for G-SLI grammar, as claimed by the RDDR account, then G-SLI subjects would, on the one hand, be impaired in both Wh-operator Movement, and T/Q-feature Movement, and on the other hand evince accurate Wh-operator and Q-feature Movement on occasions. Second, because "no Movement" of the Wh-word in subject questions results in the correct word order, and further the Q-feature is satisfied by the less costly, covert V to T Movement that is needed independently of question formations, the RDDR/optional Movement account predicts that G-SLI subjects should evince fewer errors with subject questions than object questions. Further, if syntactic Movement is indeed an area at the core of G-SLI subjects' grammatical deficit, as the RDDR proposes, then we predicted that their performance would be impaired in comparison to younger children developing normally who are matched on other aspects of language abilities. Alternatively, if G-SLI subjects are acquiring language in the same way to normally developing children, contra to the RDDR's proposal, albeit extremely delayed, then we would expect them to show a similar level and pattern of performance on subject and object questions as younger children matched on language abilities.

We studied 15 G-SLI subjects (aged 11:5 to 18:2 years) and 24 younger children (aged 5:3 to 9:1 years) language ability controls (LA controls), matched on sentence understanding, or vocabulary and elicited 36 questions balanced for subject and object questions and Wh-words *(Who, Which, What*). The results confirmed our predictions. The G-SLI subjects were significantly impaired in producing wh-questions in relation to the control children. Further, they showed particular difficulties with object questions, producing less than 35% correct grammatical object questions. The majority of G-SLI subjects (80%) evinced both Wh-operator and T/Q-feature Movement errors whereas only one control child (4%) did so (van der Lely and Battell, 2003). Yet on occasions, all the G-SLI subjects used appropriate Movement operations to satisfy the wh-criterion, thus producing both correct subject and object questions. An example of either tense/Q-feature errors (e.g., omissions of "do" support, tense marking or double tense marking), or Wh-movement errors (e.g., "gap-filling", the referential phrase left in base position) or both types of movement errors made by the G-SLI children are shown in (5), (6) and (7) respectively (van der Lely and Battell, 2003). Only the G-SLI subjects, but not the younger control children, made Wh-phrase errors (see (6) and (7b)). These errors illustrate a lack of movement of the Wh-phrase (*coat, jewellery, door)*, technically referred to as "pied-piping" (Chomsky, 1995).

(5) **–T/Q , +WH**

a.* *What cat Mrs White stroked?* b. * *What did they drank?*

c.* *Who carry her bag?* d. * *Which telephone did rang?*

(6) **+T/Q, -Wh**

a.* *Which one did he wear the coat?* b.* *What did Mrs Peacock like jewellery?*

(7) ***–T/Q –WH***

a.* *Who Mrs Peacock saw somebody?* b.* *Which Rev. Green open a door?*

c.* *What did colonel Mustard had something in his pocket?*

d.* *Which door did it creaked?* e.* *What something in Mrs Brown's desk?*

In summary, the findings of severely impaired Wh-question formation, alongside some correct formation of questions supported the RDDR account whereby Movement is optional. Van der Lely & Battell (2003) proposed that in the face of no Movement, the wh-word and, on occasions *do,* are Merged *in situ* in the CP, and function as an interrogative adjunct.

2) Predicting G-SLI subjects' strengths: Negation. In contrast to predicted deficits, the RDDR hypothesis also predicts normal performance in some areas of syntax—that is, in computations that do not involve movement (dependent relations). Lee Davies (2001) hypothesised that if the RDDR hypothesis was indeed characterising the core deficit of G-SLI children's syntactic impairment, then negation should not be problematic. This is because negative particles (*not, n't*) are inserted, or Merged, directly from the lexicon in the position where they surface (Pollock, 1989). Note, the contracted negative particle is "non-salient", and therefore other theories (Leonard *et al*., 1992) might predict that they would be problematic and/or more impaired than the non-contracted negative particle. Thus, although errors are predicted for I to C movement (do-support), required in the production of negative sentences, errors in the form of omission of the negative particle are not predicted. Using a picture-sentence judgement task, in which the children had to explain their answers, Davies (2001; 2002) elicited 288 negative sentences (see 8). In all 288 sentences, the G-SLI subjects never omitted the negative particle, correctly producing both full and contracted negative particles in the sentences. (Davies, 2001; 2002). However, they produced the expected I to C errors as illustrated in (9).

(8) a. *They're not running.* b. *They aren't on the skateboard.*

c. *He's not on the skateboard* d. *He isn't skipping.*

(9) a. * *They not wearing hats.* b. * *He not on the skateboard.*

The investigations of negative particles in G-SLI children illustrates that, although the RDDR characterisation of G-SLI is broad, it is, non-the-less, a discrete characterisation which correctly predicts both impaired and normal performance.

Cross-linguistic evidence for the RDDR. The generalisation of a hypothesis is crucial. Cross-linguistic data provide an excellent avenue to explore and test predictions of any linguistic hypothesis. There are two cross-linguistic tests of the RDDR hypothesis (that I know about); one in Greek (Stavrakaki, 2001) and one in Hebrew (Friedmann and Novogrodsky, 2002), both investigating subjects with G-SLI.

Question formation in Greek, like English, exhibits Wh-operator movement (see 10). However, the Wh-pronoun is case-marked, but otherwise shows similar movement operations to English. Further there is no "do support" in Greek, but the verb is considered to move up to the head position of C (V to I to C movement) to check Q-features (Philippaki-Warburton, 1992). Note as with English question formation, movement takes place in subject questions, but whether or not movement has occurred the word order is SVO (10a), in contrast to object questions, where the word order is OVS (10b). Thus, Stavrakaki predicted that, as in English, object questions would cause more difficulties than subject questions for the Greek G-SLI children.

(10) a. Subject questions: *Pios* *sinantise* *to Jani?*
[Who$_{ti}$-nom meet $_{ki}$-3spast t_i k_i the John-acc?]
(Who met John?)

b. Object questions: *Pion* *sinantise* *o Janis?*
[Who $_{ti}$ -acc meet $_{ki}$ -3s-past the John-nom k_i t_i]
(Who did John meet?)

Stavrakaki (2002) elicited 24 subject and object questions from 8 G-SLI subjects (age 8:1 range 6-10 years) and 16 younger language matched control children (age 4:4 range 3:6 to 5:6 years). As predicted, the G-SLI subjects were significantly impaired at producing questions. Whereas, the younger control children produced 95% subject questions and 87% object questions correctly, the G-SLI children did so only 57% and 11% respectively. Moreover, the Greek-speaking children evinced similar "gap-filling" errors as the English G-SLI subjects as well as producing yes-no questions for object questions, which have a special intonation but do not require movement (see 11 a, and b respectively).

(11) a. Gap filling errors
O andras *pion* *chtipise ton pithiko*?
The-man-nom-**who-acc**-hit-3s-past-**the-monkey-acc?**
[Target form: Pion chtipise o andras?]

Who-acc hit the man-nom?

b. Yes-no questions instead of object wh-questions

O elefantas klotsise?

The-elephant-nom-kick-3s-past?

[Target form: Pion klotsise o elefantas?]

Who-acc kick-3s-past the elephant-nom?

Thus, not only are the G-SLI children significantly impaired in Greek question formation but they are predictably worse at object questions than subject questions (Stavrakaki, 2002).

Hebrew exhibits similar Wh-movement operations to Greek Wh-questions as shown in (12).

(12) Hebrew: a. Subject questions

Eize yeled menashek et ha-saba?

Which child $_{ti}$ t_i kisses Acc grandpa?

b. Object question:

Et eize yeled ha-saba menashek?

Acc which child $_{ti}$ grandpa kisses t_i?

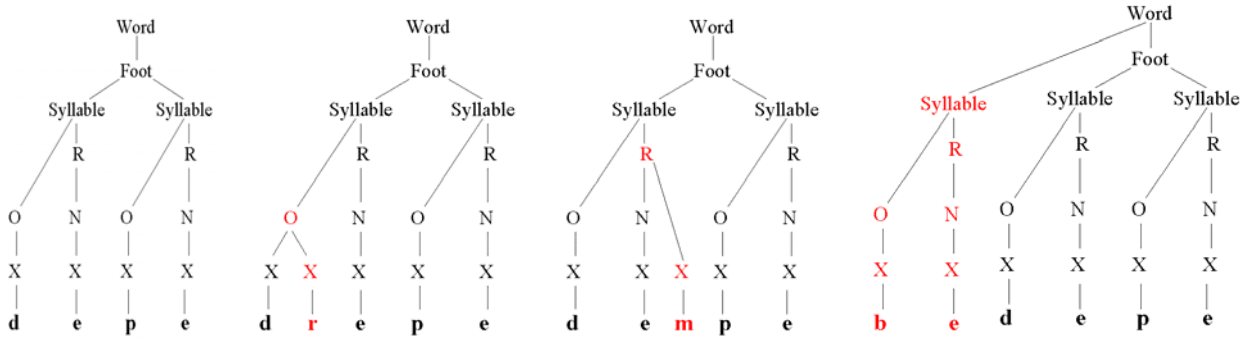
Using a picture choice task, Friedmann and Novogrodsky (2002) investigated comprehension of Wh-referential questions (see 12) in eight 8;0 – 12;4 year old (mean age 10;9) Hebrew speaking G-SLI children and compared their performance with that of language matched 6-7 year-old children. For subject questions, both groups evinced good performance; the language controls performed at ceiling (99% correct) with the G-SLI subjects achieving 92% correct. In contrast, for object questions whereas the language controls still maintained their high level of performance (80% correct), the G-SLI children's performance did not differ from chance (62% correct). Thus, Hebrew-speaking G-SLI children are also significantly impaired in question formation with particular difficulties with object questions that require non-local dependency relations.

In sum: these cross-linguistic investigations of G-SLI in English, Greek and Hebrew reveal a similar pattern showing a discrete, predictable, syntactic deficit and provide further support for the RDDR hypothesis characterising the syntactic deficit in these children.

Phonological representations and G-SLI children. Recent investigations reveal that the majority of (but not all) children in this group of G-SLI subjects are also impaired in phonological knowledge. The Test of Phonological Structure (TOPhS) (Harris and van der Lely, 1999), which uses a nonword repetition procedure, enabled us to explore children's phonological abilities. Taking the basic phonological structure of a word as shown in (13a) (Harris, 1994), this test

varies the prosodic structural complexity of novel words with respect to five parameters. Three parameters affect syllabic structure (onset, rhyme, word-end) and two, metrical structure (left adjunction, right adjunction). A parameter can be either "marked" or "unmarked". The marked version is considered more complex, being acquired later and not attested in all languages. Examples of marked onset (13b), rhyme (13c), and left adjunction (13d) are illustrated below. The combination of marked parameters was systematically varied to produce a set of non-words containing between none and 4 marked parameters.

(13) a. b. c. d.



As a group, the G-SLI children were significantly impaired, producing almost 40% errors for the non-words, whereas the younger language controls produced less than 10% (Gallon, 2002). Furthermore, the G-SLI subjects showed an incremental increase in errors with increasing number of marked parameters (Gallon, 2002). Interestingly, production of prosodically complex structures was not unavailable to the G-SLI children, but was simply more prone to errors. Thus, "optionality" appears to be a general characteristic of G-SLI children's grammar, extending to phonological representations as well as syntactic ones. Note that increasing the number of syllables (as with marked metrical structures vis a vis right and left adjunction) did not increase errors more than increases within the syllabic structure such as marking the onset (Gallon, 2002). Thus, Gathercole and Baddeley's (1990) claim, that a deficit in short-term phonological memory, determined by number of syllables or word length causes SLI, does not account for these data for G-SLI children that are associated with prosodic hierarchical complexity. An explanation, consistent with the data, is that G-SLI children rely on a linear structural representation rather than a hierarchically organised one (Marshall *et al*., 2002).

In sum, these preliminary phonological investigations reveal that increasing the prosodic complexity affects the ability of G-SLI subjects to repeat non-words, and indicates that their underlying phonological representations are not normal. The relation of G-SLI children's escalating difficulty with increasing hierarchical structural complexity alongside production of correct and incorrect forms with identical structures in phonology, as well as syntax, warrant further exploration, as does the potential interaction between deficits in the morpho-phonological and syntactic interfaces. Further, current investigations using the TOPhS are revealing that in a non-selected group of SLI children only half the group evince phonological deficits, whereas the

other half are normal compared with grammar and vocabulary matched controls, albeit that the two sub-groups do not differ in their grammatical impairment, (Ebbels, in preparation).

Autonomy, Interaction or Cause: Evidence from Regular and Irregular Morphology

Steven Pinker (1999) suggested that regular and irregular morphology might be to cognitive science what the fruit fly is to genetics or molecular biology. Perhaps regular and irregular morphology could also be the "fruit fly" of SLI—in particular illuminating the autonomy and cumulative contribution of deficits in different levels of language—that is syntax, morphology and phonology. Alternatively, could the morphological deficit found in SLI children merely be a reflection of syntactic impairment or vice versa? Furthermore, what, if any, is the effect of phonological impairment on regular and irregular morphology? Joanisse and Seidenberg (1998) and McClelland and Patterson (2002a) have challenged our claim that a domain-specific grammatical deficit underlies G-SLI (van der Lely *et al.*, 1998). They argue that G-SLI children's past tense deficit (as well as differences between regular and irregular morphology) can be explained by an information processing deficit, that particularly effects unstressed material (2002a; 2002b). Further, Joanisse and Seidenberg (1998) claim that such impairment impacts on phonology from which the morphological and syntactic deficits derive. Recent findings from G-SLI children militate against this interpretation. Our data from regular and irregular forms indicate that syntactic, morphological and phonological deficits cannot be reduced to one aspect/level or system of language, (and nor can regular and irregular inflection be reduced to one system), but deficits in each system independently and collectively contribute to the overall deficit exhibited in regular and irregular morphology.

First, with respect to syntactic past tense marking in sentences, the G-SLI children's very low level of past tense marking across regular and irregular morphological forms in sentences cannot be attributed solely to morphological problems with the regular morphological rule. Instead, it indicates a syntactic impairment that goes above and beyond regular and irregular morphological marking. We found, using an elicitation task, e.g., *Every day I look at Susan. Yesterday I ….* , that the G-SLI children produced only around 20% correct responses. Between 60 to 75% of these errors were unmarked infinitival stem forms (van der Lely and Ullman, 2001). However, production of past tense marking in a story-telling task revealed that the G-SLI children made fewer infinitival errors (between 25% to 30%). G-SLI children also accept approximately 90% regular and irregular non-finite (stem) forms in past tense contexts (van der Lely and Ullman, 1996).

Further, with respect to morphology, in contrast to normally developing children who exhibited a regularity advantage, the G-SLI children evinced no difference between their performance on regular and irregular forms (van der Lely and Ullman, 1996; 2001). The finding that the G-SLI children showed a consistent frequency effect for both regular and irregular verbs, whereas the controls only did so for irregular verbs, led us to conclude that the G-SLI children were preferentially storing regular forms alongside irregular forms in the lexicon, rather than

decomposing such forms into a stem + ed morpheme (van der Lely and Ullman, 2001). Thus, these data indicate that the G-SLI children are impaired in both syntactic tense marking and morphological rule based processes underlying the use of past tense marking on verbs.

Nonetheless, it could be argued that these data on regular and irregular past tense do not discount a primary syntactic impairment (cf Rice & Wexler's (1996) hypothesis), or a general processing impairment (McClelland and Patterson, 2002a). However, the independence of G-SLI children's morphological deficit is shown by their use of compounds. If G-SLI children are storing regular morphological forms as van der Lely and Ullman (2001) claimed, then they should use both regular and irregular forms inside compounds (e.g., *rats-eater, mice-eater).* In contrast, normally developing children should only use irregular forms, as regular rule formation occurs after the process of compounding. Therefore only stored lexical forms can enter into the compounding process. Note the production of a regular morpheme by G-SLI children where it is not normally found, strongly militates against an input-processing account of SLI (van der Lely and Christian, 2000). The results supported our predictions: G-SLI children produced regular plural forms inside compounds, whereas the control children hardly ever did so (van der Lely and Christian, 2000). Thus, the findings reveal a morphological deficit that cannot be explained by impaired syntactic representations alone or a processing deficit. But what about phonology? Can G-SLI children's phonological deficit explain these findings?

Chloe Marshall investigated the differential effect of phonology and morphology by re-analysing the elicitation past tense data from van der Lely and Ullman (2001) to see whether a phonological deficit causes the morphological one. Holding phonological complexity constant, ten regular verbs whose inflected form ends with a cluster comprising a stem-final consonant and the past tense suffix were selected from the set. Five of the verbs have "legal" phonology (e.g., *scowled, flapped, crossed),* in that the sequence of word end clusters occur naturally in mono-morphemic words and 5 have illegal clusters, which never occur in mono-morphemic words (e.g., *tugged, slammed, rushed*) Further, the legal and illegal regular word sets do not differ in frequency. Thus, these legal regular verbs could possibly be lexically stored as a monomorphemic form, whereas the illegal regular verbs could not ---at least not as a monomorphemic word that conforms to English phonology[4]. We propose, therefore, that the only way to form these illegal past tense forms within the rules of English phonology is to use a grammatical, morphological rule (Pinker, 1999). Note all irregular word have "legal phonology" consistent with monomorphemic words, enabling lexical storage conforming to phonological rules. In contrast, single system accounts of the past tense would not make the legal-illegal distinction. We hypothesised that if G-SLI children are indeed impaired on regular morphology and are preferentially storing regular and irregular forms, independent of phonological complexity and frequency effects, then these illegal regular forms would cause them particular difficulties. The results confirmed this prediction. The G-SLI children were significantly worse at producing the illegal than legal regular forms. In contrast, vocabulary control children (7-9 years) showed better

[4] Storage of such "illegal" words as a monomorphemic form is clearly not impossible, as we can store foreign words that do not conform to English phonological rules. However, it is unclear whether storage of such forms utilizes the same areas in the brain, or the same grammatical system (see, Dupoux *et al*. (1999; 2001)).

performance on illegal than legal forms, whereas two younger groups of grammar control (5-7 years) children showed no difference between such forms (Marshall & van der Lely, submitted). We interpret that the difference found in the G-SLI children between legal and illegal verbs indicates that they implicitly "know" a lot about linear phonology with respect to possible and impossible phonotactic sequences of monomorphemic words. Such "knowledge" could derive from direct experience from the phonological input ---rather than an abstract representation--- and therefore would be subject to frequency effects. However, the data indicate that they have problems learning the (abstract) grammatical computational rule in morphology, which would allow them to add the past tense morpheme to the stem form, or indeed, store such a form as a dimorphemic form.

Finally, when only legal regular forms are considered, increasing phonological complexity decreases correct past tense performance in 9-16 year old G-SLI subjects, but such an effect is only weakly shown in young normally developing children and is ameliorated with age (5-9 years) (Marshall, in prep). Thus, G-SLI children's phonological impairment affecting phonologically complex words, non-surprisingly, affects their production of inflected words, as well as non-inflected lexical forms.

In sum, G-SLI children's performance on regular and irregular past tense and plural morphology illustrates that their impairment cannot be accounted for by a deficit in any one aspect of grammar, vis a vis syntax, morphology, or phonology, nor in some general processing impairment. In contrast, I claim that it provides evidence for the autonomy and cumulative contribution of different levels of language --- that is syntax, morphology and phonology --- to impaired and normal language.

CONCLUSION

I have provided evidence for a discrete developmental grammatical language deficit. G-SLI children show no evidence of the auditory or cognitive deficits hypothesised to be responsible for SLI. Further, G-SLI children evince normal pragmatic and non-grammatical language abilities, but show predictable deficits in word-learning and vocabulary knowledge when grammatical knowledge is required. Their language shows a pervasive deficit in the computational grammatical system that is core to human languages. Specifically, their deficit affects hierarchical structural relations causing problems in building complex linguistic representations in syntax, morphology and phonology. The RDDR hypothesis more narrowly defines the syntactic impairment within Chomsky's Minimalist framework and claims that the basic operation involving dependent relations characterised by Move is "optional" in G-SLI grammar, whereas it is obligatory in adult grammar. The RDDR hypothesis is supported by cross-linguistic tests investigating Wh-questions in English, Greek and Hebrew, and a test investigating negative particles in English. The autonomy and cumulative contribution of impairments at different levels of grammar (syntax, morphology, and phonology) alongside normal lexical-storage are illustrated in the production of regular and irregular past tense verbs and plural nouns. I claim that the data

from G-SLI provide evidence for a domain-specific grammatical deficit. Regardless of the nature of altered molecular mechanisms and developmental neuronal pathways that underlie G-SLI, which have yet to be identified and worked out, the evidence from G-SLI argue for the existence of a genetically determined specialised sub-system in the brain required for grammar that cannot be fully sub-served by more general mechanisms.

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