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Lexical word formation in children with grammatical SLI: a grammar-specific versus an input-processing deficit?

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Abstract

An ongoing controversy is whether an input-processing deficit or a grammar-specific deficit causes specific language impairment (SLI) in children. Previous studies have focussed on SLI childrens' omission of inflectional morphemes or impaired performance on language tasks, but such data can be accounted for by either theory. To distinguish between these theories we study compound formation in a subgroup of SLI children with 'grammatical (G)-SLI'. An input-processing account (e.g. Leonard, L. (1998). *Children with specific language impairment*. Cambridge, MA: MIT Press), in which perception and production of inflections requires extra processing resources, would predict that G-SLI children will omit the regular plural *-s* in compounds (e.g. *rat-eater*). A grammar-specific deficit account (e.g. Ullman, M. & Gopnik, M. (1994) The production of inflectional morphology in hereditary specific language impairment. *The McGill Working Papers in Linguistics*, *10*, 81–118; van der Lely, H. K. J. & Ullman, M. (1996). The computation and representation of past-tense morphology in normally developing and specifically language impaired children. In A. Stringfellow, D. Cahana-Amitay, E. Hughes & A. Zukowski, *Proceedings of the 20th Annual Boston University Conference on Language Developmen*t (pp. 816–827). Somerville, MA: Cascadilla Press), in which G-SLI children are impaired in regular inflectional morphology, would predict that G-SLI children will produce regular plural *-s* forms inside compounds (e.g. **rats-eater*). We compared the responses of 16 G-SLI subjects (aged 10 years 4 months to 18 years) with those of 36 normally developing control children (24 matched on language ability and 12 matched on age and cognitive ability). All the groups produced irregular plural nouns in compounds (*mice-eater*). The normally developing children and teenagers rarely, if ever, produced regular plural nouns inside compounds (**rats-eater*), whereas the G-SLI

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subjects did so often. This pattern of results conflicts with the predictions of the input-processing deficit account. The findings support the grammar-specific deficit hypothesis. The data provide further evidence that specialized grammatical abilities may be differentially impaired within the language system.

Keywords: Specific language impairment; Children; Lexical word formation

1. Introduction

Specific language impairment (SLI) is a heterogeneous disorder of language acquisition in children who have no other apparent cognitive, social or neurological deficit which can obviously account for their impairment (Menyuk, 1964). It affects around 7% of children (Leonard, 1998). A considerable controversy in developmental psycholinguistics surrounds the cause of this disorder. The controversy revolves around whether an input-processing deficit (Bishop, 1997; Elman, Bates, Johnson, Karmiloff-Smith, Parisi & Plunkett, 1996; Joanisse & Seidenberg, 1998; Karmiloff-Smith, 1998; Leonard, 1998; Tallal et al., 1996) or a grammar-specific deficit (Gopnik, 1990; Rice & Wexler, 1996; van der Lely, Rosen & McClelland, 1998) causes SLI. One reason for the controversy is that the findings from many previous investigations, such as omissions of inflectional morphemes (e.g. third person, singular *-s*, ''*The boy go home*'') and impaired syntactic comprehension (e.g. for reversible passive sentences, ''*The boy is pushed by the girl*''), are accounted for by both theories (Bishop, 1997; Elman et al., 1996; Joanisse & Seidenberg, 1998; Leonard, 1998; Rice & Wexler, 1996; van der Lely et al., 1998). To distinguish between these theories we study compound formation in children with SLI.

An input-processing account (e.g. Leonard, 1998) in which perception and production of inflections requires extra processing resources would predict that children with SLI will omit the regular plural *-s* in compounds (*rat-eater*), as indeed do children developing normally (Gordon, 1985). A grammar-specific deficit account (e.g. Ullman & Gopnik, 1994, 1999; van der Lely & Ullman, 1996), in which regular inflection morphology is impaired, would predict that children with SLI will produce regular plural *-s* inside compounds (**rats-eater*), in contrast to children developing normally.

We investigate a selected subgroup of children with 'grammatical (G)-SLI'. van der Lely and colleagues have claimed that this particular subgroup has a primary, domain-specific deficit in the computational grammatical system that extends to regular morphology (van der Lely, 1994, 1998; van der Lely & Stollwerck, 1997; van der Lely & Ullman, 1996; van der Lely et al., 1998). The apparent impairment in regular morphology and the apparent pure form of SLI found in this subgroup, but not all groups of children with SLI (cf.Vargha-Khadem, Watkins, Fletcher & Pasingham, 1995), makes them particularly well-suited to testing the opposing theories of SLI. The performance of subjects with G-SLI (aged 10 years 4 months to 18 years) is compared to the performance of a younger group of normally developing, language matched control children and age and cognitive ability matched control teenagers. Accounting for the performance of children with impaired language acquisition and children developing normally also provides a challenge for theories of language acquisition and cognitive development.

1.1. The cause of SLI

The input-processing account hypothesizes that impaired input processes and processing capacity causes SLI (Bishop, 1997; Elman et al., 1996; Joanisse & Seidenberg, 1998; Karmiloff-Smith, 1998; Leonard, 1998; Tallal et al., 1996). Tallal and colleagues claim that SLI can be traced to an impaired rate of auditory processing that is not language-specific (Leonard, McGregor & Allen, 1992; Tallal & Piercy, 1978; Tallal et al., 1996; Wright, Lombardino, King, Puranik, Leonard & Merzenich, 1996). Leonard et al. (1992) propose that this auditory perceptual impairment causes problems in the perception of morphemes, such as *-ed*, and *-s* which have 'low perceptual salience'. Therefore, they claim that children with SLI require additional processing resources to perceive and produce such morphemes, which causes further problems in 'building morphological paradigms' (Leonard, 1998). In addition, they claim that these childrens' general processing capacity limitations affect short-term memory, particularly phonological memory, the production of consonant clusters and the speed of processing and retrieving words, such that consonants and final morphemes may be lost in the production process (Bishop, 1997; Elman et al., 1996; Gathercole & Baddeley, 1989; Joanisse & Seidenberg, 1998; Leonard, 1998). Therefore, children with SLI omit the *-s* in *two big dogs*, or *the boy jumps…* There are two reasons for these omissions. First, they do not always perceive the morpheme and so, Leonard (1998) claims, are unable to learn fully the morphological paradigms. Second, producing *-gz* or *-ps* requires greater phonological STM and processing capacity, which is in limited supply in these children compared to normally developing children.

The grammar-specific deficit account claims that impairment with mechanisms and/or representations specific to the grammatical system causes SLI (Clahsen, 1989; Gopnik, 1990; Gopnik & Crago, 1991; Rice & Wexler, 1996; Ullman & Gopnik, 1994, 1999; van der Lely, 1994, 1996a, 1997a, 1998; van der Lely et al., 1998). Therefore, aspects of language that rely on grammatical processes may be impaired whilst those that rely on other processes, such as associative learning and memory, may not be impaired. One explanation consistent with this general view is that children with SLI may omit the *-s* in *two big dogs* or *the boy jumps…* because they fail on occasions to check grammatical features of the noun or verb within the syntactic structure (van der Lely, 1998).

Investigations of grammatical abilities, non-grammatical language abilities and non-linguistic cognitive abilities led van der Lely and colleagues to claim that a primary, grammar-specific deficit is evident in (at least) a subgroup of G-SLI subjects (van der Lely, 1997a, 1998; van der Lely & Dewart, 1986; van der Lely

& Stollwerck, 1996, 1997; van der Lely et al., 1998).[1] Thus, no non-verbal cognitive deficit has been found in these children that could affect their performance in this investigation.

Note, SLI is a heterogeneous disorder with varied linguistic and cognitive characteristics (Aram, Morris & Hall, 1993) and it is unlikely that one theory will account for all forms of the disorder. The sub-group of children with G-SLI investigated in this study is characterized by a persisting grammatical impairment in the comprehension and expression of language. These children do not have severe articulatory-phonological deficits, pragmatic-social impairment or non-verbal cognitive deficits. The abilities and disabilities characterizing children with G-SLI can be distinguished from the characteristics of children with only expressive SLI (Whitehurst, Fishel, Arnold & Lonigan, 1992), semantic-pragmatic SLI (Bishop & Adams, 1989), resolving SLI (Bishop & Edmundson, 1987), or individuals with SLI and co-occurring articulatory and non-verbal deficits (Vargha-Khadem et al., 1995). The validity of G-SLI as a qualitative distinct subgroup is an empirical issue to which this paper may contribute.[2]

1.2. Regular morphology in children with SLI

The morphological representation of regular and irregular inflections in children with SLI is of particular relevance to this study. Previous investigations of plural and past-tense inflectional morphology in children with SLI provide conflicting findings. The findings suggest that some, but not all, children with SLI are impaired in regular morphology. First, significant frequency effects are reported in several studies for regularly inflected plural nouns and past-tense verbs for children with SLI but not for children developing normally (Oetting & Horohov, 1997; Oetting & Rice, 1993; Ullman & Gopnik, 1994, 1999; van der Lely & Ullman, 1996, 1998). An atypical effect of frequency is also evident in German-speaking children with SLI. German-speaking children developing normally over-generalize the regular-default, but relatively infrequent, *-s* plural affix (Bartke, 1998; Clahsen, Rothweiler, Woest & Marcus, 1992). However, some children with SLI over-generalize the most frequent -en plural affix (Bartke, 1998; Clahsen et al., 1992). Second, normally developing children show an advantage for regular over irregular past-tense inflectional marking for real and novel verbs (van der Lely & Ullman, 1996, 1998). In contrast, studies of two different subgroups of individuals with SLI, the 'KE' family and G-SLI subjects, report an absence of this regularity advantage (van der Lely &

[1] The children with G-SLI studied by van der Lely and colleagues are aged 9 years 3 months upwards and have a persisting grammatical deficit in comprehension and expression of language. Approximately only 20% or less of children classified as having a persisting SLI fall into this subgroup (van der Lely & Stollwerck, 1996). As yet we do not know whether other children with SLI who show different linguistic characteristics will also be found to have such a discrete grammatical deficit.

[2] An anonymous reviewer suggested that the G-SLI subgroup might represent a post-hoc slicing of the normal distribution. Although this is certainly a possibility, several considerations militate against this interpretation. These considerations and this issue are discussed in van der Lely (1999) and so will not be repeated here.

Ullman, 1996, 1998; Vargha-Khadem et al., 1995) (however, cf. Ullman & Gopnik, 1994, 1999). The data from the large KE family and G-SLI subjects may be interpreted as consistent with the view that, in contrast to normally developing children, regular and irregular inflections are represented and retrieved from an associative system (Ullman & Gopnik, 1994, 1999; van der Lely & Ullman, 1996, 1998). Thus, these findings suggest that the grammatical computations and/or representations underlying regular inflections are impaired in some children with SLI (Ullman & Gopnik, 1994, 1999; van der Lely & Ullman, 1996, 1998).

However, for some children with SLI the findings suggest normal representation of regular morphology. Following Kim, Marcus, Pinker, Hollander and Coppola (1994), Oetting and Horohov (1997) investigated regular and irregular past-tense formation for irregular verbs and denominalized verbs (*fly–flew/flied*) in young children with SLI. When prompted with an irregular root verb, the children with SLI used irregular past-tense forms (*flew*) 80% of the time (*The plane flew around the room*). In contrast, when prompted with a denominal verb, they used the regular past-tense (*flied*) 46% of the time (*They flied the paper*). Oetting and Horohov (1997) found that production of irregular forms for the children with SLI was similar to age controls (85%) and higher than MLU matched controls (41%). However, the SLI childrens' production of regular past-tense forms was less than both the age controls (77%) and the MLU control children (67%). Oetting and Horohov (1997) concluded that the children with SLI and the children developing normally show a largely similar pattern, distinguishing between irregular and regular past-tense marking for the irregular and denominalized verbs, respectively. However, the differences between the groups for the production of regular past-tense marking suggest that some of the children with SLI may not represent regular inflections normally.

Previous investigations of compound formation in children with SLI from the general SLI population have also reported finding a distinction between the use of regular and irregular plural nouns that is found in normally developing children. Oetting and Rice (1993) used an elicitation task to investigate 21 young English-speaking children with SLI (age 4 years 9 months to 5 years 5 months). Oetting and Rice (1993) found that most of their children with SLI, like normally developing children, omitted the regular *-s* plural in noun compounds (*rat-eater*). However, three (21%) of the 14 children with SLI used the regular plural in compounds (*rats-eater*) 29% of the time. Thus, it is possible that these subjects represent a subgroup of the Oetting and Rice (1993) SLI population.[3]

Clahsen et al. (1992) reported an analysis of the spontaneous speech of noun compounds in 19 German-speaking children with SLI. They found that German children with SLI omitted the most frequent *-en* plural in known noun compounds 43% of the time. Taking the regular default inflection to be the most frequently over-

[3] Oetting (pers. commun., 1998) and Clahsen (pers. commun., 1998) have both confirmed that the children with SLI in their studies were children with SLI selected from the general speech and language pathology caseloads. They were not selected subgroups of the SLI population. Furthermore, Oetting (1992) highlighted a child with SLI (and her twin) who may not have a rule-based system. This child produced 5/6 compounds with regular plural nouns. I thank Janna Oetting for pointing this out to me.

regularized *-en* form, Clahsen et al. (1992) concluded that children with SLI show the same constraints on word formation rules as normally developing children. The data of Clahsen et al. (1992), on the one hand, are persuasive as the children with SLI are omitting the *-en* affix, but not other plural affixes. However, it is surprising that the children with SLI used their 'regular' *-en* plural form in compounds 57% of the time, whereas normally developing children rarely produce compounds with the regular-default plural noun. Following up on Clahsen's analysis of spontaneous speech, Bartke (1998) used an elicitation task based on Gordon (1985). She tested three German-speaking children with SLI and eight children developing normally. One of the subjects in the study by Bartke (1998), Dieter (aged 12 years 6 months), had participated in the Clahsen et al. (1992) study (then aged 7 years 2 months). The study by Bartke (1998) revealed differences between the children with SLI and the normally developing children in forming simple plural nouns and noun compounds. The control group over-generalized the *-s* affix 70% of the time. In noun compounds, they omitted this regular-default *-s* affix on 97% of nouns where the *-s* affix was either an over-generalized plural affix or a correct plural affix (Bartke, 1998). By contrast, the controls omitted irregular plural affixes only 28% of the time (Bartke, 1998). The children with SLI showed an atypical pattern of over-generalization. They over-generalized the plural affix *-s* 30%, *-en* 40% and *-e* 30% of the time. One explanation for this pattern of over-generalization is that this productivity is based on frequency, phonological similarities and cluster strength in an associative lexical memory (cf. Prasada & Pinker, 1993), rather than a rule-based system restricted to one morpho-phonological plural form. For the children with SLI, over-generalized affixes (*-s*, *-en* or *-e*) were rarely used (one of 12 occasions) inside compounds regardless of the form of the plural affix. However, the children with SLI did not necessarily omit their 'regular' plural affixes in compounds when the noun correctly formed plurals with this affix. For example, although Dieter omitted his frequently over-generalized *-en* plural affix in compounds, he generally maintained this affix (on three of four occasions) inside compounds on nouns that correctly formed plurals with the *-en* affix. This apparent contradiction in the data makes it unclear whether the German-speaking children with SLI truly have a normal regular plural system. Taking the most frequently over-generalized plural affix alongside the most frequently omitted plural form to determine the default form, the three children with SLI omitted the 'regular' affix (for two children *-s*, for one *-en*) 69% and the irregular affixes 34% of the time. Thus, the German-speaking SLI children, like English-speaking children, generally show a difference between the omission of the 'regular' and irregular plural affixes inside compounds, but this difference is less pronounced than in normally developing children. Moreover, their overall pattern of regular plural marking is not typical of normally developing children of a similar age (7–12 years) or younger children of 3–5 years (see Bartke, 1998 for further discussion of the German data).[4]

In conclusion, the findings for regular morphology from English- and German-

[4] I thank Susanne Bartke for translating parts of Bartke (1998), for making these data available to me, and for comments on this section.

speaking children with SLI suggest that differences exist within the SLI population. Subgroups of children with SLI may be impaired in syntactic but not morphological computations but others may be impaired in both syntactic and morphological computations. With respect to the conflicting hypotheses of the cause of SLI the data showing omissions of regular inflections in compounds for the children with SLI, regardless of whether this is normal or not, can be accounted for by either hypothesis. Therefore, in this study we only investigate the G-SLI subgroup whose impairment is hypothesized to include regular inflection, as the predictions for noun compound formation for this subgroup directly test the two accounts of SLI.

1.3. Lexical word formation

Kiparsky (1982, 1985)proposed a 'level-ordering' framework for lexical rules of word formation. Building on the work of Allen (1978) and Siegel (1977), Kiparsky (1982)claimed that phonological and semantic properties determine three levels of word formation rules. He proposed that Level 1 contains rules of primary affixation (e.g. + *ian*, + *ous*), irregular morphology (*foot–feet*, *swim–swam*), and pluralia tantum nouns (*clothes*, *scissors*). Host deforming processes such as stress shifting or vowel reduction or phonological alternates characterize the phonological properties at this level. Semantically, at this level, meanings are idiosyncratic and non-compositional. Level 2 contains rules of secondary affixes of derivational morphology (e.g. *-er*, *-ism*, *-ness*) and is the level of compounding. The application of rules at Level 2 is characterized by the properties of being phonologically non-deforming and semantically more predictable. At Level 3, grammatical processes of regular inflections are applied (*-s*, *-ed*). Maintenance of the phonological properties of the word stem and affix characterize Level 3. Level 3 rules are fully predictable and productive. The three levels operate successively such that rules at a later level (e.g. Level 3, rules of regular inflection) may not be applied prior to those at a previous level (e.g. Level 2, rules of compounding). Therefore, Kiparsky's level-ordering hypothesis predicts that singular or plural irregular forms and singular regular forms will occur inside compounds (*mouse-eater*, *mice-eater*, *rat-eater*) but plural regular forms will not (**rats-eater*).

Although the semantic properties of words have a role in word formation, they do not distinguish the acceptability of *mice-infested* from the unacceptability of **rats-infested* (Gordon, 1985). In contrast, morpho-phonological properties of plural nouns appear to be inextricably tied to the constraints on word formation proposed by the level-ordering hypothesis. The formation of irregular plural nouns is based on morpho-phonological properties (Kiparsky, 1985) that may associatively link stored forms (Pinker, 1991). Moreover, irregular plural nouns are typically considered to be stored whole rather than morphologically decomposed into a singular stem plus plural affix, although this would be possible for some irregular forms (e.g. *ox-en*). In contrast, regular plural nouns can be morphologically decomposed and may be computed by a grammatical rule that adds a plural affix to a noun stem (Pinker, 1991). This morpho-phonological representation of regular plural nouns appears to be tied to the grammatical constraint prohibiting its use inside compounds. Importantly for our purposes, specifically grammatical processes, determined by the morpho-phonological properties, constrain word formation so that regular plural nouns do not occur inside compounds.

Gordon (1985) investigated the ability of 33 young children to produce singular and plural forms of nouns and novel agentive noun compounds (*rat-eater*). His study showed that young children of 3–5 years of age clearly adhered to the level-ordering rules proposed by Kiparsky (1985). As soon as the children used irregular plurals, they also used them inside compounds (e.g. *mice-eater*) (Gordon, 1985). In addition, once pluralia tantum nouns were not reduced in a singular context (**scissor*) and were understood to be irregular forms, they too were used inside compounds (*scissors-eater*). In contrast, the children rarely (less than 4%) produced regular plural nouns inside compounds (e.g. **rats-eater*). Gordon (1985) argued that these findings strongly suggest that this phenomenon is independent of the input received. Moreover, he claims that level-ordering is innately available to language learners as a set of (universal) grammatical constraints.

1.4. Predictions

The input-processing deficit predicts that children with G-SLI will omit the regular plural morpheme from noun compounds, as indeed normally developing children do. The prediction holds however processing resources are measured. If processing resources are measured in terms of perceptual saliency, then perceiving and producing non-salient *-s* and *-z*, particularly within words, requires more capacity from an already limited supply and such morphemes will be omitted (Leonard, 1998). If processing resources are measured in terms of phonological complexity (Joanisse & Seidenberg, 1998), then producing consonant clusters (*-ks*, *-ts*, *-dz*, *-vz*) ‘costs’ more than producing single consonants, so *-ks*, *-ts*, *-dz* etc. will be reduced to *-k*, *-t*, *-d*. Alternatively, if phonological short term memory (STM) or ‘working memory’ is used to measure processing resources (Gathercole & Baddeley, 1989; Joanisse & Seidenberg, 1998), and additional capacity is required to store and produce the additional phonemes, then the final phonemes are likely to be lost. Thus, in all cases the input-processing deficit account predicts that children with SLI will omit the regular plural affix. In addition, the input-processing account claims that whilst children with SLI are impaired in information processing, the mechanisms and representations serving language, in particular regular inflection, are similar to those of normally developing children (Elman et al., 1996; Joanisse & Seidenberg, 1998). Therefore, this hypothesis predicts that the performance of children with SLI and normally developing children will be similar.

Within the grammar-specific deficit framework, van der Lely and Ullman (1996) have claimed that the impairment of children with G-SLI extends to the grammatical computation underlying the formation of regular morphological inflection. Thus, G-SLI children may store regular plural forms of nouns, like irregular plurals, in memory or derive all plural nouns associatively, rather than computing the regular plural form using a morphological rule (van der Lely & Ullman, 1996). Therefore, this version of the grammar-specific deficit predicts that for children with G-SLI, Level 1 will contain both regular and irregular plural nouns. Thus, both singular and plural forms should be accessible to Level 2 where compounding occurs. In summary, the grammar-specific account predicts that both singular and plural regular nouns, like irregular nouns, may occur in compounds (i.e. *rat-eater*, **rats-eater*, *mouse-eater*, *mice-eater*).[5]

The prediction based on the grammar-specific deficit view is a strong one as it claims that G-SLI subjects will show an ‘incorrect’ use of the regular-plural *-s* in compounds, whereas SLI subjects typically omit inflectional morphemes in contexts where they should occur. Furthermore, this account predicts that G-SLI subjects will show a qualitatively different pattern of responses to normally developing children and teenagers.

To ascertain whether children with G-SLI are ‘normal’ in noun compounding we first need to show that they virtually never use regular plural nouns in compounds. Secondly, we need to show a significant difference between their regular and irregular use of plurals in compounds (due to level-ordering constraints) as is found in normally developing children (Gordon, 1985). Third, we need to show that their use of regular and irregular plural nouns in compounds does not differ from normally developing children matched on language abilities or age and non-verbal cognitive abilities.

2. Method

The experiment was based on the study by Gordon (1985) of normally developing 3–5 year olds. We examined three types of nouns, i.e. (1) regular plural, (2) irregular plural and (3) pluralia tantum. Following Gordon (1985) we elicited singular and plural forms for the nouns followed by noun-agentive compounds (*rat-eater*).

2.1. Subjects

Four subject groups participated in the experiment: a group of G-SLI subjects; two groups of younger children who provided control groups for different tests of language abilities (LA controls); and a group of teenagers who provided a control group for age and non-verbal cognitive abilities (CA controls).

2.2. Grammatical specifically language impaired subjects

Sixteen children and teenagers aged between 10 years 4 months and 18 years

[5] Another logical possibility is that the hypothesized grammar-specific deficit also impairs the grammatical constraints themselves of level ordering. However, as we hypothesize that G-SLI subjects are impaired in regular inflection formation, and the framework underlying the grammar-specific account proposes that level ordering is dependent in part on the morpho-phonological properties of regular words, this possibility cannot be tested independently in this study. It is debatable whether grammatical constraints underlying level ordering can be ‘normal’ if a person’s lexicon does not have the morpho-phonological characteristics that distinguish between regularly and irregularly inflected words. However, for the purposes of this study a clear distinction between impaired grammatical constraints of level ordering and impaired regular inflection is not critical to testing the two different accounts of SLI.

participated in the study. Seven of the subjects had participated in previous studies over the past 5 years. All the G-SLI subjects, including the nine new subjects, met the criteria for G-SLI (van der Lely, 1996a; van der Lely & Stollwerck 1996, 1997). That is, all the subjects showed persisting problems in grammatical comprehension and expression of language as revealed by standardized tests as well as non-standardized procedures that were designed to assess specific grammatical abilities which characterize G-SLI. For example, the non-standardized tests assessed tense and agreement marking in expressive language, assignment of theta roles in reversible active and passive sentences (van der Lely, 1996b), and the assignment of reference to pronouns and anaphors (van der Lely, 1997b). The subjects' non-verbal IQ fell above 85 (range 86–119) as measured on the overall performance test of the British Ability Scales (BAS) (Elliott, Murray & Pearson, 1978). The block design sub-test from the BAS was used to match the SLI subjects' cognitive abilities to a control group of teenagers. The SLI subjects' mean IQ score on this sub-test was 105.5. Further details of the selection procedure for children with G-SLI are well documented so will not be repeated here (see van der Lely, 1996b; van der Lely & Stollwerck, 1996, 1997). Many of the linguistic characteristics of G-SLI subjects are similar to those found for other groups of children with SLI (e.g. Bishop, 1994, 1997). An important difference between this sub-group and some non-selected sub-groups of children with SLI is that they do not have co-occurring non-verbal deficits, or any obvious phonological deficits or dyspraxia (Bishop et al., 2000; Vargha-Khadem et al., 1995). Table 1 provides a summary of the subject details and their scores for three language tests and the block design test. It can be seen from Table 1 that on the grammatical closure sub-test from the Illinois Test of Psycholinguistic Abilities (GC-ITPA) (Kirk, McCarthy & Kirk, 1968) – a test of expressive morphology – the SLI subjects had a mean equivalent age of 7 years. On the Test of Reception of Grammar (TROG)[6] (Bishop, 1983) – a test of sentence understanding – the childrens' mean equivalent age was 7 years 8 months. Their scores on the British Picture Vocabulary Scale (BPVS) (Dunn, Dunn, Whetton & Pintilie, 1982) – a test of single word comprehension – produced a mean equivalent age of 8 years 6 months.

2.3. Language ability control groups

Two groups of 12 children developing normally provided language ability (LA) control groups. The children were randomly selected from a state school in central London. Three standardized tests were administered. Only children who fell within the normal range of abilities as assessed by these tests were included in the study. The younger LA1 control group had a mean age of 6 years 1 month (range 5 years 2 months to 6 years 8 months) and provided a morphological matched control group. Their raw scores did not differ from the G-SLI subjects' scores on the GC-ITPA

[6] Scores on the GC-ITPA and TROG tests should be taken as a general guide to the SLI subject's grammatical knowledge as these tests assess a range of abilities, not only those that are problematic for G-SLI subjects. The tests are always supplemented with non-standardized assessments that target specific morpho-syntactic knowledge, which we see as crucial to the linguistic characteristics of G-SLI.

Table 1
Subject details: chronological ages and raw scores on the standardized tests used for evaluating and matching language or non-verbal cognitive abilities[a]

	Subjects (mean (SD))			
	SLI subjects ($N = 16$)	LA1 controls ($N = 12$)	LA2 controls ($N = 12$)	CA controls ($N = 12$)
Chronological age (years/months)	13:11 (29.6)	6:1 (5.7)	7:2 (4.3)	16:0 (17.5)
Range	10:4–18:0	5:2–6:8	6:9–7:10	14:0–17:4
GC-ITPA				
Raw score	22.31 (3.86)	23.91 (5.35)	25.75 (2.83)	
Z-score	–[b]	−0.05 (0.20)	−0.18 (0.58)	
Equivalent age	7:3 (1.06)	7:7 (1.4)	8:2 (0.99)	
TROG				
Raw score	14.75 (1.84)	14.17 (1.75)	14.66 (2.43)	18.67 (1.07)
Z-score	−1.63 (0.81)	0.36 (0.6)	0.24 (1.16)	0.23 (0.94)
Equivalent age	7:7 (1:8)	7:3 (1:6)	7:6 (2:0)	–[b]
BPVS				
Raw score	80.94 (17.57)	64.08 (14.36)	68.83 (8.36)	128.36 (10.50)
Z-score	−1.92 (0.62)	0.69 (1.06)	0.44 (0.70)	0.23 (0.63)
Equivalent age	8:6 (2:1)	6:9 (1:6)	7:4 (0:9)	16:4 (2.2)
Block design BAS				
Z-score	0.36 (1.01)			0.34 (0.84)
IQ	105.5			104.75

[a] GC-ITPA, grammatical closure sub-test from the Illinois Test of Psycholinguistic Abilities; TROG, Test of Reception of Grammar; BPVS, British Picture Vocabulary Scale.
[b] Score not available for ages of subjects.

($t(26) = -0.88$, $P < 0.389$) or the TROG ($t(26) = 0.85$, $P = 0.405$). However, the LA1 controls' vocabulary raw scores on the BPVS were significantly lower than the G-SLI subjects' scores ($t(26) = 2.79$, $P < 0.010$).

The older LA2 controls had a mean age of 7 years 2 months (range 6 years 9 months to 7 years 10 months) and provided a sentence comprehension matched control group. Analysis revealed that the LA2 controls did not differ from the G-SLI subjects on the TROG ($t(26) = 0.100$, $P = 0.92$). However, their morphological scores on the GC-ITPA were significantly higher than the G-SLI subjects ($t(26) = 2.41$, $P = 0.024$). In contrast, the LA2 controls' scores on the vocabulary test were significantly lower than the G-SLI subjects ($t(26) = -2.72$, $P < 0.012$). Table 1 provides a summary of the subject details for the LA control groups.

2.4. Cognitive ability and age control group

Twelve teenagers aged between 14 years and 17 years 4 months (mean 16 years) participated in the study (see Table 1). The block design sub-test (BAS) was administered to provide an estimate of the childrens' non-verbal cognitive abilities. Based on this test, the group had a mean estimated IQ of 104. The cognitive ability (CA) controls' and the G-SLI childrens' scores on the block design did not differ ($t(26) = 1.000$, $P > 0.05$). The CA controls' vocabulary and sentence understanding as measured by the BPVS and the TROG, respectively, fell within normal limits. The CA controls' scores on the language tests were significantly higher than the G-SLI childrens' scores (BPVS: $t(26) = 8.401$, $P < 0.001$; TROG: $t(26) = 4.874$, $P < 0.001$).

2.5. Design and materials

The design, materials and procedure for eliciting singular, plural and compound nouns followed the study by Gordon (1985) as closely as possible. Nine referents for mass nouns were used as target items to elicit plurals and compounds in the training phase. The stimuli were either real or toy examples of the items. The training items contained the following items: rice, (baby sweet)corn, paper, wood, plastic, fruit, cereal, money. The experimental phase contained 18 referents for pluralizable count nouns. These items had either regular plural morphology (*beads*, *rats*, *hands*, *babies*, *ducks*, *shirts*, *toys*, *shoes*, *knives*[7]), irregular morphology (*teeth*, *mice*, *feet*, *men*, *geese*) or were pluralia tantum nouns (i.e. a noun which is only used in the plural form) (*clothes*, *trousers*[8], (*sun*)*glasses*, *scissors*). Each regular noun was semanti-

[7] An anonymous reviewer suggested that we should classify *knife–knives* as an irregular noun, as the plural form has regressive voicing. Senghas, Kim and Pinker (1993) investigated the acceptability of plural forms with regressive voicing inside compounds in adults. The acceptability ratings of the regressively voiced plural nouns in compounds were not significantly different from common regular nouns but were significantly less acceptable then irregular plural nouns in compounds. On the basis of these data we maintain our classification of *knives* as a regular plural noun.

[8] We substituted the American English '*pants*' used in Gordon's study for the British English '*trousers*'.

cally matched to either one of the five irregular nouns, or to one of the four pluralia tantum nouns. A ‘Cookie Monster’ puppet was used in the sessions.

2.6. Procedure

Subjects were tested either at home or in a quiet room at school by an experimenter who was familiar to the subjects. The wording was slightly modified for the older subjects to make it appropriate for their age. The subject was introduced to the Cookie Monster puppet. ‘‘*Do you know who this is?/Can you tell me the name of this puppet?…Its the Cookie Monster*’’. Most of our 5–7-year-old British children knew this American puppet, however, our older SLI subjects and CA controls expressed less recollection of this character and so were told his name. ‘‘*…and do you know what he likes to eat?…*’’ ‘‘*…he likes to eat all sorts of things*’’. ‘‘*Today we shall look at several things the Cookie Monster may like to eat. The Cookie Monster is having a party on Saturday…he’s going to be 10. So today we are going to make a list of all the things you think he’d like to eat*’’.

The first training object (rice) was then brought out and the child was asked to name it. He/she was then asked, ‘‘*What would you call someone who eats rice?*’’ If the required form was not elicited at first (e.g. two responses were *Chinese* and *A vegetarian*), then the desired compound form was given, and the child was told to follow this pattern. The child was then asked ‘‘*Do you think the Cookie Monster would like to eat X?*’’ ‘‘*Shall we include it on the list for his party?*’’ We found that the children quickly understood the requirements of the task, with elicitation of the desired compound form being achieved by the second training mass noun. However, all nine mass nouns in the training phase were presented.

For the experimental items, singular, plural and compound forms were elicited. The child was shown a single object and asked to name it. This was followed by four of the objects, accompanied by the experimenter saying ‘‘*Here is a bunch of…?*’’ Following Gordon (1985), the plural form used by the child was then used (even if incorrect) to elicit the compound, e.g. **What do you call someone who eats mices?*

A Sony digital audiotape (DAT) recorder with an ECT microphone was used to record the childrens’ responses. This enabled an independent evaluation of the childrens’ responses and a back up to manual scoring. A test-scoring booklet was used for each child with the basic presentation format for each item (the nine training items followed by the 18 test items) in a set random order.

2.7. Coding of responses

All the subjects completed all the test items without difficulty. If subjects spontaneously changed their initial response, as if to correct himself/herself, then the second response was scored. All of the subjects used a plural noun or a singular noun in the compounds. There were not any ‘no responses’ or ‘other responses’, such as a semantically related noun being used in the compound.

The subjects’ responses for the singular and plural noun contexts and the form of the noun used in the compound were transcribed from the DAT recordings. These were checked against the written responses made at the time of testing. For the few cases which did not concur, another person listened to the recording and a mutually agreed decision was made as to the form of the noun used.

3. Results and discussion

3.1. Regular and irregular plural nouns

None of the subjects used the plural form of the nouns in the singular context. The first analysis considered the correct plural forms for the five irregular nouns (*mice*, *men*, *teeth*, *feet*, *geese*) and the five semantically matched regular nouns (*rats*, *babies*, *beads*, *hands*, *ducks*). The four groups' mean correct plural responses can be found in Table 2. For the regular plural nouns, the LA control groups produced over 95% correct responses and the SLI and CA control subjects produced 100% correct responses. The CA controls also produced 100% correct responses for the irregular plural nouns. However, the children with G-SLI and the LA controls produced fewer correct irregular plural responses (see Table 2). Analysis revealed that the G-SLI subjects produced significantly fewer correct irregular plural nouns than the CA control children (one sample *t*-test, $t(11) = 4.88$, $P < 0.010$). Further analyses were carried out on the G-SLI and LA control groups' correct responses.

A 3 (group: G-SLI subjects, LA1, LA2 controls) × 2 (noun type: regular, irregular) ANOVA revealed a significant effect of noun type ($F(1, 37) = 32.08$, $P < 0.0001$) which reflected the better production of regular than irregular plural nouns. There was no main effect of group ($F(2, 37) = 1.46$, $P > 0.25$). The interaction was not significant, although the analysis suggested that there could be some differences between the groups ($F(2, 37) = 2.59$, $P < 0.089$) (see Table 2). Therefore, we followed up this analysis by investigating the numbers of correct irregular forms and the numbers of over-regularizations (*mouses*, *mices*) produced by the groups. Two one-way ANOVAs by group revealed no significant differences between the groups for either the number of correct irregular plural forms ($F(1, 37) = 2.03$, $P = 0.146$) or for the numbers of over-regularizations ($F(1, 37) = 1.65$, $P = 0.206$).

In summary, the G-SLI subjects' production of regular plural nouns did not differ from that of the LA controls or the CA controls. In addition, the G-SLI subjects' and LA controls' production of irregular plural nouns and over-regularization of irregular nouns did not differ significantly. The production of irregular plural nouns for the subjects with G-SLI was significantly below the CA controls. The most likely reason for this is the significantly lower vocabulary scores of the subjects with G-SLI than the CA controls. The findings for the G-SLI subjects for plural marking on regular and irregular nouns support previous investigations (Bishop, 1994; Clahsen et al., 1992; Oetting & Rice, 1993). They indicate that the production of plural forms themselves is not an area of particular difficulty for G-SLI subjects in relation to their overall language abilities. However, this does not necessarily imply that the underlying morphological representation of regular plural nouns for G-SLI subjects is similar to normally developing children.

Table 2
Simple regular and irregular plural forms and plural forms used in compounds for the five regular plural nouns and five irregular plural nouns

	Subjects			
	SLI subjects Mean (SD) [%]	LA1 controls Mean (SD) [%]	LA2 controls Mean (SD) [%]	CA controls Mean (SD) [%]
Plural forms				
Regular nouns [*rats*]	5.0 (0) [100]	4.83 (0.39) [96.7]	4.92 (0.29) [98.4]	5.00 (0.0) [100]
Irregular nouns [*mice*]	2.75 (1.65) [55]	3.92 (1.73) [78]	3.67 (1.50) [73]	5.00 (0.0) [100]
Over-regularizations [*mouses/ mices*]	1.75 (1.53) [35]	0.75 (1.22) [15]	1.25 (1.55) [25]	0 [0]
Plural nouns inside compounds				
Regular nouns [*rats-eater*]	1.75 (1.77) [35]	0.33 (1.15) [6.6]	0.083 (0.29) [1.6]	0.0 (0) [0]
Irregular nouns [*mice-eater*]	2.37 (1.71) [47.5]	3.08 (1.44) [61.6]	2.75 (1.21) [55.0]	1.42 (1.24) [28.3]
% Over-regularized[a] (*mouses/ mices-eater*)	10.7 (3/28)	0 (0/9)	0 (0/15)	0 (0/0)

[a] The percentages were derived from only the over-generalized nouns used in the plural context. Actual numbers in parentheses.

3.2. Regular and irregular noun compounds

We first analyzed the numbers of regular and irregular plural nouns produced in compounds (**rats-eater*, *mice-eater*). It can be seen from Table 2 that all the groups produced some irregular plural nouns in compounds. The G-SLI subjects also produced a substantial number of regular plural nouns in compounds, whereas the LA control groups produced hardly any, and the CA controls produced none. Thus, it is clear that the children with G-SLI are producing more regular plurals inside compounds than the CA controls.[9] However, for the production of irregular plurals inside compounds analysis revealed no significant difference between the G-SLI subject and CA control groups ($t(26) = 1.64$, $P > 0.11$).

The G-SLI subjects' and LA control group's use of plural nouns inside compounds was compared using a 3 (group: G-SLI, LA1, LA2) × 2 (noun type: regular, irregular) ANOVA. This revealed a significant interaction ($F(2, 37) = 7.66$, $P = 0.002$). This interaction was further investigated using planned comparisons. The G-SLI subjects were found to produce significantly more regular plurals in compounds (**rats-eater*) than the LA1 and LA2 controls ($F(1, 37) = 13.49$, $P < 0.001$). The performance of the LA1 and LA2 control groups did not differ ($F(1, 37) = 0.22$). In contrast, the G-SLI subjects' use of irregular plurals in compounds (*mice-eater*) did not differ from the LA1 and LA2 control groups ($F(1, 37) = 1.26$, $P = 0.269$). The LA1 controls' use of irregular plurals did not differ from that of the LA2 controls ($F(1, 37) = 0.30$). However, the older CA controls used significantly fewer irregular plural nouns inside compounds than the LA controls ($t(34) = 3.28$, $P < 0.002$).

To assess whether the G-SLI subjects and the control groups showed a qualitative difference between their use of plural regular and irregular nouns in compounds (**rats-eater* versus *mice-eater*), we carried out *t*-tests for each group. The results revealed that the G-SLI subjects' frequency of regular and irregular plural nouns in compounds did not differ significantly ($t(15) = 1.43$, $P = 0.173$). However, the LA1 controls and the LA2 controls showed a significantly greater frequency of irregular plural nouns (*mice-eater*) than regular plural nouns (*rats-eater*) in compounds (LA1: $t(11) = 5.11$, $P < 0.0001$; LA2: $t(11) = 7.50$, $P < 0.0001$). In addition, a one-sample *t*-test revealed that the CA controls' production of irregular plurals inside compounds was significantly above zero ($t(11) = 3.026$, $P < 0.01$). Thus, all the control groups produced significantly more irregular plurals than regular plurals inside compounds but the subjects with G-SLI did not. These results indicate qualitative differences between the use of regular and irregular plural nouns in compounds for the LA and CA control children but not the G-SLI subjects.

If level-ordering constraints are operating normally then we may expect that the numbers of plural forms used in compounds for irregular nouns would not differ from chance, in contrast to regular nouns. This is because for irregular nouns both the singular noun form and the plural noun form would be available for compounding, whereas for regular nouns only the singular form should be available. For the

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[9] The lack of variance for some scores here and later for the CA controls prohibited statistical analysis of these data.

irregular nouns, one-sample *t*-tests (two-tailed) for each group confirmed that their use of plural nouns in compounds did not differ from chance (G-SLI: $t(15) = 0.292$, $P > 0.5$; LA1: $t(11) = 1.399$, $P > 0.1$; LA2: $t(11) = 0.581$, $P > 0.5$). However, the CA controls' use of irregular plurals in compounds was significantly less than chance ($t(11) = 3.026$, $P < 0.05$). Thus, it appears that normally developing teenagers have a preference for using fewer irregular plural nouns inside compound than the younger children. However, these teenagers still used significantly more irregular plural nouns than regular plural nouns inside compounds.

For the regular nouns, like the irregular nouns, the G-SLI childrens' use of plurals in compounds did not differ from chance (G-SLI: $t(15) = 1.694$, $P > 0.1$). In contrast, the LA control groups used significantly fewer regular plural nouns in compounds than the expected level if either singular or plural forms were optionally allowed in compounds (LA1: $t(11) = 6.499$, $P < 0.001$; LA2: $t(11) = 29.01$, $P < 0.0001$).

We next considered the over-regularized forms for the irregular nouns (e.g. *mouses/mices*) which were used by the subjects. The G-SLI subject group over-regularized 28 items and the LA control groups over-regularized 24 items. Thus, based on the level-ordering hypothesis of Kiparsky (1982), if these items are being treated as regular forms, then the plural form, such as *mouses-eater* or *mices-eater*, should not occur in compounds. As a group the G-SLI subjects produced 3/28 over-regularizations in compounds, whereas the LA controls did not produce any (0/24). However, the difference between the G-SLI subjects and the LA control subjects was not significant ($\chi^2 = 1.99$, $P = 0.158$). This may be partially attributed to the small numbers involved.

Finally, to assess if age differences were affecting our results, we carried out a correlation between the subjects' frequency of use of regular plurals inside compounds and their age. The results revealed no relationship between these factors for either the G-SLI subjects ($r(14) = 0.045$, $P > 0.87$) or the LA controls ($r(22) = -0.008$, $P > 0.969$). These results and the CA controls' total omission of any regular plural nouns inside compounds clearly go against age factors explaining the G-SLI subjects' frequent use of regular plurals inside compounds.

In summary, the results from the normally developing children and teenagers aged between 5 years 4 months and 17 years 4 months replicate and extend the findings of Gordon (1985) for younger 3–5 year olds. The children show a qualitative difference between their use of regular plural and irregular plural nouns in compounds. Our normally developing children and teenagers, like Gordon's younger children, used very few, if any, regular plural nouns in compounds but used irregular plurals in compounds.

The results for the G-SLI subjects are striking for several reasons. First, the G-SLI subjects showed a qualitatively different pattern of use of regular and irregular plural nouns in compounds in comparison to the normally developing children. The children with G-SLI produced significantly more regular plural nouns in compounds in comparison to the LA and CA controls. However, the G-SLI subjects' frequency of irregular plural nouns in compounds did not differ from that of the LA controls or the CA controls. Second, in contrast to the LA and CA controls, the G-SLI subjects' relative frequency of use of regular and irregular plural nouns in compounds did not differ from each other. Third, for the G-SLI subjects, the frequency of regular and irregular plural nouns in compounds did not differ from chance. In contrast, the LA and CA controls' frequency of regular plural nouns in compounds was significantly below a chance level. Fourth, in this study the grammatical error of the subjects with G-SLI involved the incorrect use of a morpheme, rather than the omission of a morpheme that has been found in many previous investigations of SLI.

3.3. Singular and plural forms for pluralia tantum and regular nouns

This set of analyses focuses on the four pluralia tantum nouns and the four semantically matched regular nouns. Gordon (1985) predicted that pluralia tantum nouns should be optionally allowed in compounds in their plural form while the semantically matched regular nouns should not. However, he found that a few 3–5-year-old children reduced some pluralia tantum nouns to singular forms in singular contexts and then reduced these forms in compounds (*scissor-eater*, (*sun*)*glass-eater*). Thus, it appeared that the children were regularizing these nouns. We considered this possibility in our study.

The first analysis considered the childrens' correct regular plural responses and the 'regularized' plural responses to the pluralia tantum nouns. A 'regularized pluralia tantum' noun was determined by the use of a reduced form in the singular context (e.g. *scissor*) followed by an unreduced form in the plural context (*scissors*). It can be seen from Table 3 that all of the groups produced a few regularized pluralia tantum nouns. For the matched set of true regular nouns (*knives*) production of plurals was at or close to ceiling for each group (see Table 3). Analysis revealed that there was no significant difference between the numbers of regularized pluralia tantum nouns (*scissor–scissors*) used by the children with G-SLI and the CA controls ($t(26) = 0.78$). Further analysis was carried out on the G-SLI subjects' and LA control childrens' production of simple plural forms. A 3 (group: G-SLI, LA1, LA2) × 2 (noun type: regular plural nouns, regularized pluralia tantum nouns) ANOVA revealed no significant group effect ($F(2, 37) = 0.25$, $P = 0.770$) and no significant interaction ($F(2, 37) = 0.28$, $P = 0.761$). Thus, the G-SLI subjects and the LA control children produced a similar number of regular plural forms and regularized plural forms for the pluralia tantum nouns (8–12.5%) (see Table 3). The few regularized pluralia tantum nouns made by our G-SLI subjects were limited to *scissor–scissors* (five instances), (*sun*)*glass*–(*sun*)*glasses* (one instance) and *trouser–trousers* (one instance). *Clothes* was not reduced by any child in the study to '*clothe*' in the singular context.

The results, revealing a similar production of plural forms for all the groups, indicate that any differences in their use of plural forms in compounds cannot be attributed to any obvious differences in their ability to produce these plural forms per se.

3.4. Pluralia tantum and regular nouns: plural forms in compounds

Table 3 shows the mean percentage of plural nouns used in compounds. For the

Table 3
Simple plural forms and plural forms used in compounds for the four regular nouns and four pluralia tantum nouns

	Subjects			
	SLI subjects Mean (SD) [%]	LA1 controls Mean (SD) [%]	LA2 controls Mean (SD) [%]	CA controls Mean (SD) [%]
Plural forms				
Regular nouns [*knife–knives*]	3.98 (0.25) [99.5]	4.00 (0.00) [100]	4.00 (0.00) [100]	4.0 (0.0) [100]
'Regular' pluralia tantum [*scissor–scissors*]	0.44 (0.73) [10.9]	0.33 (0.49) [8.3]	0.50 (0.52) [12.5]	0.25 (0.45) [6.3]
'Irregular' pluralia tantum [*scissors–scissors*]	3.56 (0.73) [89.1]	3.67 (0.49) [91.75]	3.5 (0.52) [87.75]	3.75 (0.45) [93.75]
Percentages of plural forms inside compounds	Mean (SD) [%]	Mean (SD) [%]	Mean (SD) [%]	Mean (SD) [%]
Regular nouns (*knives-eater*)	51.56 (38.15)	10.41 (19.82)	8.33 (16.28)	0.0 (0.0)
'Irregular' pluralia tantum[a] (*scissors-eater*)	89.06 (20.34)	54.83 (31.09)	52.08 (26.93)	40.33 (31.21)
'Regular' pluralia tantum[b] (*scissors-eater*)	57.1 (4/7)	0.0 (0/4)	16.6 (1/6)	0.0 (0/4)

[a] The percentages were derived from only the pluralia tantum nouns that were treated as true irregular nouns and were not reduced in the singular context.
[b] The percentages were derived from only the plural tantum nouns that were treated as regular pluralia tantum nouns. Actual numbers in parentheses.

main analysis of pluralia tantum nouns, the frequency was derived from only those nouns that were not reduced in the singular context (here after 'irregular pluralia tantum' nouns). Once again the control groups used few, if any, regular plural nouns inside compounds. In contrast, the G-SLI subjects produced regular plural nouns inside compounds over 50% of the time (see Table 3). Analysis of the G-SLI subjects' and CA controls' use of non-reduced forms of the irregular pluralia tantum nouns inside compounds (*scissors-eater*) revealed a significant difference ($t(26) = 5.00$, $P < 0.001$). Interestingly, four of the CA controls reduced all of the irregular pluralia tantum nouns inside compounds. However, the remaining eight CA controls used between 50 and 75% non-reduced forms inside compounds. Thus, although the CA controls reduce very few pluralia tantum nouns in singular contexts, they appeared to identify the final *-s* as a potential regular plural in nouns such as *trouser-s*, *scissor-s*, (*sun*)*glass-es*, and *clothe-s*.

We next compared the G-SLI subjects' and LA controls' use of plural forms in compounds using a 3 (group: G-SLI, LA1, LA2) × 2 (noun type, regular plural (*knives-eater*), irregular pluralia tantum (*scissors-eater*)) ANOVA. A significant main effect of group ($F(2, 37) = 15.22$, $P < 0.0001$) and noun type ($F(1, 37) = 68.86$, $P < 0.0001$) was found, but there was no interaction. Planned comparisons revealed, once again, that the G-SLI produced significantly more regular plurals in compounds than the LA1 and LA2 control groups ($F(1, 37) = 21.74$, $P < 0.0001$). The LA1 and LA2 controls' use of regular plural nouns in compounds did not differ ($F(1, 37) = 0.030$).

For the irregular pluralia tantum nouns (i.e. the nouns which were not reduced in the singular contexts) the children with G-SLI rarely reduced these items in compounds and produced non-reduced forms such as '*scissors-eater*' almost 90% of the time (see Table 3). In contrast, the LA controls, like the majority of the CA controls, produced almost equal numbers of non-reduced forms (*scissors-eater*) and reduced forms (*scissor-eater*) in compounds. Planned comparisons confirmed that the difference between the G-SLI subjects' and the LA1 and LA2 controls' use of the pluralia tantum forms was significant ($F(1, 37) = 18.14$, $P < 0.0001$). The LA1 and LA2 controls' use of the pluralia tantum forms in compounds did not differ significantly ($F(1, 37) = 0.070$). In addition, there was no significant difference in the LA controls' and the CA controls' use of the irregular pluralia tantum forms inside compounds ($t(34) = 1.26$). Thus, the normally developing individuals from 5 years to adulthood may reduce irregular pluralia tantum nouns in compounds, whereas the children with G-SLI rarely do so.

Finally, we considered the 'regularized' pluralia tantum nouns; that is, the items the children reduced in the singular context. If these pluralia tantum nouns were represented as regular nouns for the children then we could expect them to reduce these forms in compounds according to the level-ordering hypothesis (Kiparsky, 1982). The groups' pattern of 'regular' plurals used in compounds for these regular pluralia tantum nouns was similar to the pattern found for true regular nouns (see Table 3). The CA controls did not use any non-reduced regular pluralia tantum forms inside compounds (0/4). The LA1 and LA2 control groups rarely used these regularized pluralia tantum forms in compounds (1/10). In contrast, the G-

SLI subjects used non-reduced regularized pluralia tantum nouns in compounds (*scissors-eater) (4/7) as well as reduced forms (scissor-eater) (3/7). The difference between the G-SLI subjects and the LA controls was significant ($\chi^2(1) = 4.41$, $P < 0.036$).

The results for the pluralia tantum nouns and the semantically matched regular nouns reveal a consistent and qualitatively different pattern of use of plural forms in compounds for the G-SLI subjects in comparison to the normally developing younger children and teenagers. The G-SLI subjects use regular plural nouns in compounds for true regular nouns and regularized pluralia tantum nouns. In contrast, the LA and CA controls rarely, if ever, use the regular plural nouns in compounds for either the true regular or the regularized pluralia tantum nouns. However, for the irregular pluralia tantum nouns, the LA and CA controls use non-reduced forms as well as reduced forms in compounds. The few reduced irregular pluralia tantum forms in compounds produced by the subjects with G-SLI is consistent with the view that they are less likely to spontaneously segment a potential plural affix from a potential stem at the morpho-phonological level. This process may require an abstract grammatical representation of a noun stem and the plural affix, which is problematic for G-SLI subjects.

3.5. Individual subject analysis

The data for the G-SLI subjects were scrutinized to see if all the children conformed to the pattern reported above. The nine regular nouns used overall in the experiment were considered, plus any over-regularized nouns. The G-SLI subjects' use of the regular plural in compounds showed a fairly even distribution and varied from zero to nine. Three of the 16 G-SLI subjects (C.P., A.Z. and M.P.) produced only one regular plural in compounds. However, C.P. also produced one over-regularized noun inside a compound. Two subjects (S.M. and C.G.) did not produce any regular plural nouns in compounds. C.P. and C.G. also did not produce any irregular plural noun in compounds, and A.Z. produced just one. Thus, it appears that these G-SLI subjects simply use singular forms in compounds regardless of the regular–irregular distinction. However, one G-SLI subject (S.M.), who used no regular plural nouns in compounds, used 3/3 irregular plural noun forms that were known to him in compounds and M.P. (aged 18 years) used one regular plural noun and 4/4 irregular plural nouns in compounds. The findings from the CA controls indicate that the use of even one regular plural noun inside a compound is atypical of normally developing teenagers. S.M. and M.P. may represent the normal variation found in experiments. However, it is not possible to conclude that S.M. and M.P. are qualitatively different from normally developing children and teenagers. In view of this finding, we re-examined all of our data, going back in the case of M.P. some 12 years, to see if we could find any other linguistic differences between these subjects and the rest of the group. One aspect of their linguistic characteristics distinguished them. Both of the subjects made tense errors, but they were restricted to past-tense errors. Neither of these children made any errors on the third person singular present-tense agreement elicitation task.[10] This task involved a minimum of eight contexts where agreement was required. Thus, interestingly, M.P. and S.M. produced third person singular *-s* in appropriate syntactic contexts, but generally omitted this same sounding morpheme inside regular noun compounds. Further investigations are required to substantiate this finding and provide further insight into their linguistic characteristics. We will continue to scrutinize the data from these subjects in our future experiments to see if any further linguistic differences come to light.

4. General discussion

The results from this investigation into noun compounding in subjects with G-SLI and normally developing young children and teenagers are remarkably distinct. Generally, the G-SLI subjects used some regular plural nouns and regularized pluralia tantum nouns in forming compounds. In contrast, the controls rarely used regular plural nouns or regularized pluralia tantum nouns that were not reduced in compounds. All of the groups used some irregular plural nouns in forming compounds. These results for our normally developing children aged 5–17 years support and extend the findings of Gordon (1985) for 3–5-year-old children. The data indicate that grammatical constraints restrict the use of regular plurals inside compounds for normally developing children and teenagers, but not for subjects with G-SLI.

For the irregular plural nouns there were similarities between the G-SLI subjects' performance and the normally developing younger (LA) childrens' performance in the production of correct simple plural forms, in the frequency of over-generalizations and in the use of the irregular plural forms in compounds. In addition, the frequency of irregular plurals in compounds for the G-SLI subjects and the teenage CA controls was similar. However, the G-SLI subjects produced significantly fewer correct simple irregular plurals than the CA controls. They also produced significantly fewer reduced irregular pluralia tantum nouns in compounds than both the CA and LA control groups. Although the CA controls produced significantly fewer irregular plurals inside compounds than the LA controls, the groups did not differ in their use of irregular pluralia tantum nouns in compounds. In addition, each control group maintained a significant difference between their use of regular and irregular plural nouns in compounds, whereas the subjects with G-SLI did not.

We will now consider how well the input-processing deficit hypothesis and the grammar-specific deficit hypothesis can account for these data. Finally, we will compare the findings from this study with previous investigations of children with SLI.

[10] Note that M.P. and S.M. produce the other grammatical-syntactic errors which characterize the group. For example, they omit past-tense marking on verbs in past-tense contexts, make 'reversal errors' when interpreting full passive sentences, show errors when assigning co-reference to anaphors and pronouns in sentences, and have problems forming WH questions.

4.1. The input-processing deficit account

The contrasting findings for G-SLI subjects and control groups in the use of regular plural nouns in compounds pose considerable problems for the input-processing account. Specifically, the findings go directly against the predictions of the input-processing account. According to Joanisse and Seidenberg (1998), Leonard (1998) and others, producing consonant clusters such as *-ts*, *-dz*, or *-ks*, particularly with non-salient inflectional *-s*, requires extra processing capacity. Based on the findings for the use of irregular plural nouns in compounds we may have expected the G-SLI subjects' production of regular plural nouns to be between the frequency of regular plural nouns used by the LA and CA control groups. However, this was not so.

Another possibility is that differences in age or processing resources are causing differences in the groups' approach to the general cognitive and pragmatic demands of the task. Gordon (1985) suggested that older children might use more regular plurals inside compounds because of a meta-linguistic strategy. The teenage controls avoided using any regular plural nouns inside compounds. This indicates that older normally developing children do not resort to any meta-linguistic strategy that overrides the grammatical constraints restricting the use of regular plurals in compounds. In addition, we found no evidence that age was significantly affecting the use of regular plurals in compounds. An increase in the use of regular plurals in compounds was not significantly correlated with age for any group. Furthermore, there was no evidence that vocabulary development was significantly affecting the results for the different groups. The G-SLI subjects' vocabulary development was more advanced than the LA controls, although significantly below the CA controls. Therefore, if vocabulary development was influencing the childrens' performance we would have expected the G-SLI subjects' frequency of regular plural use to fall between the frequency of the LA and CA control groups. The mean scores for regular plural nouns in compounds, if anything, decrease with more advanced vocabulary development and age for the normally developing participants in this study and in the study by Gordon (1985). Finally, the similarity between the G-SLI subjects and the CA controls in the use of irregular plurals in compounds militates against the subject with G-SLI having a different approach to the task that could account for their use of regular plurals in compounds.

The input-processing deficit account also proposes that, due to processing capacity limitations affecting the perception of the phonological forms of words, SLI children learn new words less quickly and need more exposures to a word before it is learnt (Leonard, 1998). Thus, the input-processing account might predict that failure in the storage or access of words (due to less accurate phonological representations) could cause the impaired production of irregular plurals that was found for the G-SLI subjects in comparison with the CA controls. However, other investigations of the same groups of children who participated in this study do not support this view. Jones and van der Lely (1998), using an on-line lexical decision task to investigate nouns and regular and irregular verbs, found that G-SLI subjects responded as fast as the CA control group and significantly faster than the LA control group. Thus, this finding clearly goes against the processing limitation view that G-SLI subjects are slower than normally developing children in identifying and accessing the phonological form of words. Consequently, it seems unlikely that the impairment in the production of irregular plural nouns or the pattern of compound formation found for the subjects with G-SLI was due to processing limitations, impairing perception of the phonological representation of words per se.

However, the G-SLI subjects' over-regularizations may be accounted for by the high frequency of the regular plural *-s* in the English language. Connectionist-associative simulations of English regular and irregular morphology have revealed that such systems are relatively good at over-generalizing inflectional forms based on frequency, phonological similarity and cluster strength (Plunkett & Marchman, 1991, 1993). The few (10%) reduced pluralia tantum nouns produced by the G-SLI subjects could also be accounted for by an associative system by running the system 'backwards' from a plural to a potential singular form. However, other factors may have contributed to the G-SLI subjects' and control groups' production of '*sunglass*' and '*trouser*'. Both *glass* and *trouser* may be stored lexical forms for the children as these words occur in the language as a semantically related word (*The small glass*) or as a known compound (*trouser-leg*). Whilst the input-processing account can explain how the subjects with G-SLI are able to over-regularize irregular plural nouns it does not explain why they are still over-regularizing irregular nouns in their teens. This point will be discussed later.

In conclusion, the input-processing deficit account may account for some of the findings for the irregular plural nouns, such as the over-regularizations for the G-SLI subjects and the control subjects. However, the contrasting findings for the subjects with G-SLI and the normally developing children and teenagers for compound formation using regular nouns and regularized pluralia tantum nouns go directly against the input-processing deficit account and the theoretical framework underlying this account.

4.2. The grammar-specific deficit account

The grammar-specific deficit explanation for the G-SLI subjects' over-regularizations and reduction of some pluralia tantum nouns is consistent with the input-processing deficit account. Productivity within the associative memory system, although relatively limited, can account for these forms (e.g. Xu & Pinker, 1995). The poor ability of subjects with G-SLI to over-generalize regular inflections to novel words (van der Lely & Ullman, 1996, 1998) is also consistent with the resistance of associative models to over-generalize to novel inputs, particularly if they do not sound like known forms (Prasada & Pinker, 1993). Thus, both the grammar-specific and the input-processing deficit accounts can explain these findings. However, in contrast to the input-processing account, the grammar-specific deficit account provides a parsimonious explanation for why G-SLI subjects produce regular plurals in compounds, whilst normally developing children do not. The grammar-specific deficit account predicted that for G-SLI subjects regularly inflected forms, like irregular forms, are lexically stored at Level 1 and, therefore, regular plural forms would be available for compounding at Level 2. Thus, these data are totally consistent with the predictions of the grammar-specific account. The account is strengthened by the contrasting findings from the G-SLI subjects and the normally developing children and teenagers. These data provide further evidence that there are qualitative differences between the representation of regular and irregular plural nouns. Furthermore, this distinction is required for grammatical constraints to restrict the use of regular plurals but not irregular plurals inside compounds. In summary, the findings from this study provide further support for G-SLI subjects' impairment of regularly inflected words, for the duel mechanism view of regular and irregular morphology, and for the influence of grammatical constraints within the lexicon in normally developing children.

The grammar-specific deficit hypothesis may also explain why irregular plural forms are impaired in subjects with G-SLI for their chronological age and indeed why their vocabulary development generally is impaired, although more mildly than their grammatical abilities. Bloom and Markson (1998) propose that there are (at least) two mechanisms of word learning. One mechanism involves the use of perceptual and social cues and is most relevant for learning concrete nouns and verbs. The other involves the use of structural-grammatical cues and is relevant for learning more abstract nouns and verbs (Bloom & Markson, 1998). Our children with G-SLI were found to be normal with respect to logical reasoning and social-pragmatic inference (van der Lely et al., 1998), the abilities likely to underlie the first mechanism. However, children with SLI are impaired in using grammatical cues to learn novel verbs (van der Lely, 1994), and are particularly impaired in learning the semantic scope of quantifiers (*every*, *all*) (Drozd & van der Lely, 2000) and abstract words and relational terms (Leonard, 1998). That is, G-SLI subjects show an impairment with exactly the words and aspects of meaning for which grammatical cues are particularly relevant for learning. The syntactic context provides additional cues to identify irregular plural forms, such as number agreement between the determiner and noun or between the noun and verb (*These mice are…. This mouse is…*). It is also possible that grammatical number features help to structure lexical links between morphological variants of the same lexical form. Thus, these grammatical cues may facilitate linking irregular plural forms of nouns to their singular forms, thereby reducing over-regularizations. Note these grammatical links between words can be distinguished from any semantic links developing between morphological variants of the same word or semantically related words. A deficit in using grammatical cues to learn words may also partly explain why a particular subject with G-SLI, like many children with SLI, produces different morphological variants for the same target plural noun or past-tense verb in similar syntactic contexts (e.g. *mice*, *mouses*, *mices*; *fell*, *falled*, *felled*, *fall*). These errors indicate that the children with G-SLI have stored the lexical forms of irregular plural and past-tense forms but that the blocking mechanism preventing a regular inflection being affixed to a stem (Marcus, Pinker, Ullman, Hollander, Rosen & Xu, 1992) is not functioning appropriately. In conclusion, we propose that the childrens' mild vocabulary impairment results from their grammatical deficit, which impairs their use of grammatical cues to learn new words and possibly develop grammatical links between morphological variants of the same word.

The apparent broad spectrum of G-SLI within the grammatical system and secondary deficits in the lexicon opens up the question of whether the G-SLI subjects' deficit also extends to the grammatical constraints themselves underlying level ordering. The overall profile of G-SLI, including the use of correct alongside incorrect (over-regularized) irregular plural forms, suggests that their impairment extends to grammatical processes in the lexicon. If this is so, then grammatical constraints within the lexicon are also likely to be impaired. However, as already mentioned, this experiment cannot clearly distinguish between impaired regular inflectional formation versus impaired regular inflection formation and impaired grammatical constraints, so we will not discuss this issue further.

In conclusion, the predictions of the grammar-specific deficit account are confirmed in this experiment. The grammar-specific deficit account along with the underlying framework for this account provides a parsimonious and comprehensive explanation of the contrasting pattern of performance found for the G-SLI subjects and normally developing children and teenagers.

4.3. Fractionation of deficits within the grammatical system

The findings from this study provide further evidence that the majority of G-SLI subjects are impaired in regular morphological formation in comparison to normally developing children and teenagers. Thus, for this SLI population, the underlying deficit is impinging on grammatical computations underlying regular morphology as well as syntax (van der Lely, 1998; van der Lely & Ullman, 1996).

The findings for the majority of the G-SLI subjects contrast with the findings for two subjects in this study (M.P. and S.M.), and most of the subjects in the study of noun compounding by Oetting and Rice (1993). Their findings indicated that the majority of their subjects were normal with respect to regular morphology. However, three of their 14 children with SLI used the regular plural nouns in compounds at least 28% of the time (Oetting & Rice, 1993, p. 1245). Thus, these three subjects in the study by Oetting and Rice (1993) may be like the majority of our G-SLI subjects, whereas M.P. and S.M. from this study may be more like the majority of Oetting and Rice's subjects.

The data from the German-speaking children with SLI (Bartke, 1998; Clahsen et al., 1992) show some similarities with the data from this study. Clahsen et al. (1992) report that for the 8/19 subjects who omitted some of the default *-en* plurals in compounds, 57% of their responses contained the *-en* plural in compounds in spontaneous speech. Bartke (1998), using an elicitation task similar to the one conducted in this study, reported a frequency of over 30% regular plural forms (sometimes *-s*, sometimes *-en*) inside compounds. The detailed analysis of the German-speaking children with SLI suggested that they were not homogeneous (Bartke, 1998; Clahsen et al., 1992). Some children did not identify the regular-default plural *-s*; instead they regularized the *-en* affix and then produced this affix in compounds some of the time (e.g. 'Deiter' reported in Clahsen et al. (1992) and Bartke (1998)). Other SLI children in their groups appeared to have normal regular morphology and correctly identified the *-s* affix as the regular affix and omitted this affix in compounds (e.g. 'Connie' reported in Bartke (1998)).

In sum, the contrasting general findings between and within studies point to the heterogeneity of the SLI population and the fractionation of deficits within the grammatical system. There appear to be some SLI children with a primary grammatical disorder affecting regular morphology and syntax, such as the majority of our G-SLI subjects. However, for other children with SLI, regular morphology may be spared and the primary deficit appears to be only in syntax, such as the majority of subjects studied by Oetting and Rice (1993). These patterns of impairment can be contrasted with those reported for children studied by Leonard and colleagues (Leonard, 1998). Leonard et al. (1992) report morphological deficits but not syntactic deficits in their cohort of children. It is evident that the possibility of fractionation of deficits within the grammatical system needs to be considered in future investigations to substantiate this difference between subgroups of the SLI population.

4.4. Conclusion

The findings from this study distinguish between the grammar-specific deficit and the input-processing deficit accounts of the cause of SLI in children. The hypothesized grammar-specific deficit was found to affect grammatical constraints on lexical word formation in a predictable way. In contrast to normally developing children and teenagers, G-SLI subjects were found to produce regular plural nouns and regularized pluralia tantum nouns inside compounds. All of the groups produced irregular plural nouns and irregular pluralia tantum nouns inside compounds. The input-processing deficit hypothesis cannot account for G-SLI childrens' use of an affix in a context normally developing children rarely, if ever, use it in. Moreover, the findings directly conflict with the predictions of the input-processing account of SLI and hence the theoretical framework underlying this account (Elman et al., 1996; Joanisse & Seidenberg, 1998; Karmiloff-Smith, 1998; Leonard, 1998; Tallal et al., 1996). In contrast, the findings are consistent with an underlying grammar-specific deficit causing G-SLI. The theoretical framework that posits different specialized cognitive mechanisms underlie different domains of language (Chomsky, 1988, 1995; Pinker, 1994) provides a parsimonious account of the findings for the normally developing children and the G-SLI subjects.

This investigation has revealed that for this subgroup of G-SLI subjects, their deficit affects mechanisms and/or representations underlying regularly inflected words as well as syntactic structure (van der Lely, 1994, 1996a, 1998; van der Lely & Stollwerck, 1997). The data support the view that SLI subjects may not form a 'grammatical rule' for plurals which requires an abstract representation of the stem and plural affix (Ullman & Gopnik, 1994; van der Lely & Ullman, 1996). However, this primary grammatical impairment might cause secondary deficits to arise in the lexicon in the implementation of grammatical constraints and processes and also may impair lexical development (van der Lely, 1999). Further investigation of this suggestion is warranted.

This study has highlighted the heterogeneous nature of SLI. Thus, while a grammar-specific deficit accounts for the performance of the G-SLI subgroup, caution is expressed in the generalizability of the findings to other SLI groups. Moreover, we do not discount the possibility that an input-processing deficit might account for some forms of SLI, albeit that it does not account for the findings for G-SLI. The data from G-SLI subjects do not generally provide evidence for fractionation of the grammatical system. However, two of the subjects from this study and data from previous investigations of children with SLI (Bartke, 1998; Clahsen et al., 1992; Oetting & Rice, 1993) suggest normal regular morphological abilities but impaired syntax in some children with SLI. Whether or not these patterns of abilities and disabilities reflect the severity of impairment and the relative difficulty of morphological versus syntactic computations or true fractionation of the developmental grammatical system requires further investigations of other SLI subgroups or developmental disorders. Such investigations into different subgroups of children with SLI may provide further insight into the relative autonomy and inter-relations between morphology, syntax and phonology and the effects of selected deficits on normal language development.

Finally, the data from this study provide another small piece of evidence that supports the view that within the language system specialized, grammatical abilities may be differentially impaired in a predictable way.

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