Empirical Evidence for the Modularity of Language from Grammatical SLI Children

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1. Introduction

The controversial issue of the modularity of mind is at the centre of many theoretical debates. The focus of one line of this debate is whether language provides evidence for or against "modularity" (Fodor, 1983) and which aspects of language, if any, are modular. In this paper evidence is presented from three sets of investigations into a sub-group of 12 Grammatical specifically language impaired (SLI) children. The investigation provides insight into the underlying nature of Grammatical SLI, thereby contributing to the modularity debate.

Fodor (1983) argues that the language faculty is an input system on a par with the senses, such as vision or smell. However, not all aspects of language fit the criteria of a module. In particular, the criterion of "informational encapsulation" (Fodor, 1983), which states that information is impervious to encyclopedic knowledge, is not consistent with some aspects of language. For example, syntax, inflectional morphology, and phonology may be seen as part of the modular language system, whereas pragmatic inference and conceptual-lexical knowledge may be seen as part of the (non-modular) central system language functions (Chomsky, 1981; Sperber & Wilson, 1987; Smith & Tsimpli, 1995).

Grammatical SLI children have a persisting language impairment. The subjects in this study were aged from 9;3 to 12;10. Some of the most notable linguistic characteristics of Grammatical SLI children are: omission of tense marking; omission of agreement marking; and incorrect assignment of theta roles, particularly in full passive sentences. Many of these characteristics have also been found in other groups of younger SLI children (Clahsen, 1989; Gopnik and Crago, 1991; Leonard, McGregor and Allen, 1992; Bishop, 1994; Rice, Wexler & Cleave, 1995).

Clahsen (1989, 1991) first identified an underlying impairment with structurally dependent relationships in agreement, based on data from German speaking SLI children. Subject verb agreement illustrates this deficit whereby the features of agreement (AGR) are realised on the verb. However, van der Lely (1994) proposed that the different observations from SLI children cited above are basically similar in that they **all** involve some form of dependent structural relationship between syntactic constituents. For example, correct tense marking in sentences requires a syntactic relationship between the verb and Inf (or TNS) (Chomsky, 1986). More complex syntactic relationships between the verb and Comp (complement) may be required to integrate Tense into the overall syntactic frame (Enc, 1987). A different type of structure-dependent relationship is required for theta role assignment. The thematic role of a noun phrase is dependent on a combination of the verb's lexical properties and the noun's syntactic relationship to the verb (i.e., whether it is the subject NP or

object NP). Thus, I propose that this group of deficits found in Grammatical SLI children can be accounted by a "Representational Deficit for Dependent Relationships" (RDDR).

Two major issues are raised by the RDDR. One is to define the linguistic characteristics of the RDDR more narrowly. The second, which is the focus of this paper, is to define the extent of the domain of the deficit. That is, is the underlying impairment 1) a domain specific and modular deficit affecting only grammatical representations (syntax, morphology, phonology) (the "narrow RDDR" hypothesis); 2) a domain specific (non-modular) language deficit affecting general linguistic representations (the "broad RDDR" hypothesis); or 3) a domain neutral deficit affecting linguistic and non-linguistic representations (the domain neutral RDDR hypothesis). This paper reports the findings from three sets of investigations which have tested these competing proposals. Importantly, each of the tasks requires forming a representation which requires forming a dependent structural relationship. To test the narrow RDDR hypothesis, syntactic dependent relationships were investigated. Specifically, these were the syntactic constraints determining anaphoric and pronominal reference as characterised by Binding Theory (Chomsky, 1981, 1986). The broad RDDR hypothesis was tested by exploring pragmatic dependent relationships which are required for the appropriate use of pronominal reference in narratives. The domain neutral RDDR hypothesis was tested by means of a computer generated visual transitive inference task. The details for each task will be given below.

2. Subjects

The performance of 12 Grammatical SLI children (aged 9;3 - 12; 10) was compared with three groups of 12 language ability (LA) control children on each of the three sets of investigations. The LA1 controls (5;5 - 6;4) were matched to the SLI children on a test of sentence understanding (TROG, Bishop, 1983) and on a test of expressive morphological ability. The LA2 controls (6;5 - 7;4) and LA3 controls (7;5 - 8;9) were matched on tests of single word expression and comprehension. (See van der Lely (in press) and van der Lely & Stollwerck (in press) for details of the subject selection and matching procedure and further subject details.) 12 chronological age (CA) control children were also tested on the visual non-linguistic task. The CA controls were matched on chronological age and non-verbal mental abilities based on sub-tests of the British Ability Scales (Elliott, Murray & Pearson, 1978).

3. The investigation of Binding Theory

These data have previously been reported (van der Lely & Stollwerck, 1983). Therefore, only a summary of the data will be provided so that the wider theoretical implications can be drawn.

The interpretation of anaphors, such as reflexives, and pronouns is determined in part by knowledge of the syntactic structural properties of the language. These syntactic constraints governing referential dependency have been characterized by Binding Principles A and B (Chomsky, 1986). Principle A states that an anaphor must be bound in its governing category, where bound means c-commanded by and coindexed with an antecedent (see 1).

1.   Mowglie$_i$ says [Baloo Bear$_j$ is tickling himself$_{*i/j}$]

Principle B states that a pronoun must be free in its governing category (free = not bound) as shown in 2 below.

2.   Mowglie$_i$ says [Baloo Bear$_j$ is tickling him$_{i/*j}$]

The questions that were addressed in this first study were i) do SLI children assign reference to reflexives and pronouns according to Binding Principles A & B? ii) Can SLI children assign reference to reflexives and pronouns when the assignment is not crucially dependent on knowledge of Binding Principles? That is, when it may be pragmatically inferred on the basis of conceptual-lexical knowledge. iii) Does SLI children's performance differ from that of the younger groups of LA matched control children?

3.1 Method

The study was based on Chien & Wexler's (1990) study. Two experiments using a sentence picture pair *yes/no* judgement procedure were carried out. Half of the sentence-picture pairs "matched" and for the other half there was a "mismatch". Half of the sentences had a name antecedent, (name-pronoun and name-reflexive conditions) and half had a quantified noun antecedent (quantifier-pronoun and Quantifier-reflexive conditions). In Experiment 1, lexical and/or semantic knowledge could be used to rule out coreference. In Experiment 2, two additional "mismatch" conditions were included (name-reflexive syntax and Quantifier-reflexive syntax conditions). For these sentence-picture pairs, syntactic knowledge was crucially required to rule out inappropriate coreference. For example, the "name-reflexive syntax" mismatch picture, for the sentence in (1) above, showed Mowglie tickling himself. Thus, the reflexive action is correctly depicted, but the antecedent is not the locally bound antecedent. In addition to the experimental test sentences there were five sets of control test sentences. The control conditions assessed the children's ability to assign reference to reflexives and pronouns when semantic-conceptual lexical cues (e.g. semantic gender (sex)) could be used to rule in or rule out coreference.

3.2 Results

The results of Experiments 1 & 2 concurred. In this summary I shall largely focus on the results from Experiment 2. The mean scores for the four groups for the experimental test sentences in Experiment 2 can be found in Table 1. All the groups performed well on the control conditions. For example, for the semantic gender control conditions the three LA control groups and the SLI children produced more than 83% correct responses on the match and mismatch conditions. Thus, any failure in the experimental conditions can not be attributed to some general problem with the test paradigm.

Match conditions. The experimental conditions in Experiment 2 were analysed using a 4 x 4 (Group x Sentence type) ANOVA. This revealed significant effects

for Sentence type (F[3,132] = 8.20, p < .001) and a significant interaction (F[9,132] = 2.35, p = .017). The main effect of Group was not significant. Further analysis revealed that the interaction could be attributed to a significantly worse level of performance on the quantifier-pronoun and quantifier-reflexive conditions by the SLI children than the LA1 controls and the LA2 and LA3 control groups. This finding may be taken to indicate a weakness in SLI children's interpretation of the quantifier NPs. However, caution is expressed in attributing too much to these results as the SLI children produced more than 83% correct responses on the experimental match conditions.

SENTENCE TYPE	SUBJECTS			
	SLI Mean	LA1 controls Mean	LA2 controls Mean	LA3 controls Mean
Name-pronoun Match	5.67	5.83	5.92	5.92
Mismatch	3.83	5.58	5.50	5.75
Quantifier-pronoun Match	5.83	6.00	6.00	6.00
Mismatch	5.33	5.83	5.75	5.67
Name-reflexive Match	5.75	5.75	5.50	5.83
Mismatch	4.83	5.75	5.58	6.00
Quantifier-reflexive Match	5.00	5.00	5.67	6.00
Mismatch	2.75	4.33	4.58	5.59
Name-reflexive syntax Mismatch	3.00	4.67	5.17	5.75
Quantifier-reflexive syntax Mismatch	3.75	4.92	5.42	5.08

Note: Maximum score = 6.

Table 1. Experiment 2: Mean scores for the experimental sentence conditions for the SLI children and the LA control groups.

Mismatch conditions. A 4 x 6 ANOVA (Group x Sentence type) revealed significant main effects of Group (F[3,44] = 13.16, p < .001) and Sentence type F[5,220] = 13.08, p < .001), and a significant interaction (F[15,220] = 2.14, p = .004). The SLI children performed significantly below all three LA control groups on the majority of sentence conditions (see Table 1). Furthermore, the SLI children's performance did not differ from chance on the name-pronoun, quantifier-reflexive, name-reflexive syntax, and the quantifier-reflexive syntax conditions. However, they performed significantly above chance on the name-reflexive and quantifier-pronoun conditions (see van der Lely & Stollwerck,

1993, for full details). In contrast, even the youngest LA controls group performed significantly above chance for all sentence conditions and generally correctly rejected inappropriate antecedents for reflexives and pronouns.

The results from the two experiments revealed that, in contrast to the LA controls, the SLI children incorrectly accepted a non-local antecedent for reflexives if the antecedent was carrying out a reflexive action and would accept a local antecedent for pronouns. Thus, the SLI children will violate the syntactic constraints characterised by Principles A & B. The quantified antecedent significantly improved performance on the pronoun conditions, but decreased performance for the reflexive conditions. A similar trend was found for the LA control children. It appears that the SLI children and on occasions young normally developing children have difficulties in constructing the bound variable reading for a quantifier, as suggested by Grimshaw & Rosen, 1990. This may facilitate their performance with pronouns but impair their performance with reflexives.

The pattern of responses from these experiments indicates that both the SLI children and the LA controls are sensitive to the semantic-conceptual lexical properties associated with reflexives and pronouns, such as semantic gender (sex) and reflexive marking of the predicate. The children's knowledge of theta roles assignment, i.e. the agent is assigned to the NP preceding the main verb, also needs to be taken into consideration to account for the data. The children use their knowledge of semantic-lexical properties and theta role assignment to help make judgements about an appropriate reference for anaphors and pronouns. In the absence of the additional lexical support, to rule in or rule out coreference, normally developing children generally are still able to determine coreference appropriately based on their syntactic knowledge. This was clearly not the case for the SLI children who performed at chance when syntactic information was required to rule out inappropriate coreference. Thus, Grammatical SLI children do not appear to have the syntactic knowledge of Binding Principles. These data provide initial support the narrow RDDR hypothesis.

4. The investigation of pronominal reference in narratives

The second study investigated Grammatical SLI children's use of pronominal reference when it is dependent on structural pragmatic knowledge in a narrative. In a narrative the linguistic form of a referent will be determined by an interaction between the overall global and local narrative structure, and the linguistic function of the referent. An adult or mature speaker will typically use an indefinite article plus noun to initially introduce a referent; a definite article plus noun to re-introduce (or switch) a protagonist; and a pronoun to maintain reference to a protagonist (Bamburg, 1987). Other factors such as the speaker's knowledge of the world and their understanding of the listener's need to know (i.e., the speaker's pragmatic knowledge) also influence the referential device used. At young ages a different pattern of pronominal use than that described above may be evident. Karmiloff-Smith's (1985) study of children's narratives has revealed that at 3-4 years children may reserve the pronoun for subject-focus position for the main protagonist for both maintaining reference and re-

introduction functions (The thematic-subject constraint). At 5-6 years pronouns and NPs may be used equally for the re-introduction function (Bamburg, 1987).

The questions posed in this study were *i*) do SLI children use a range of referential devices in a narrative? *ii*) Do SLI children and the LA controls show a similar pattern of use of referential expressions for introducing; re-introducing; and maintaining reference?

4.1 Method

The picture book known as *Frog where are you?* was used to elicit the narratives. The child chose one of five envelopes. Unknown to the child, each contained the frog story. The child looked at the book by himself and then came back to tell the story to the experimenter. The experimenter, who could not see the pictures, was to guess which of the five stories the child had chosen. The narratives were audio recorded on a DAT tape recorder and later transcribed. A coding scheme was devised to track the referential expressions in sequence to establish their linguistic function (i.e. introduction, re-introduction and maintenance function). The analysis focused on the main protagonist, a boy, and the secondary protagonist, a dog.

4.2 Results

An initial analysis was undertaken to establish whether the SLI children and the LA controls were producing a similar overall length of narrative and if their overall total number of references to the boy and the dog were comparable. This revealed that the four groups differed neither in the overall word length of their narratives nor in the total number of references made to the two main protagonists.

The linguistic forms used to initially introduce the boy and the dog were analyzed separately. None of the children used a pronoun for initial introduction of the boy or the dog. The majority of the SLI children (83% (10/12)) and the majority of the three LA control groups (67% to 85%) used an indefinite article plus noun to initially introduce the boy. A similar, though less marked, pattern was found for the introduction of the dog. 58% of the SLI children and between 67% and 85% of the LA control groups used an indefinite article plus noun for introducing the dog. There were no significant differences between the groups' performances. The large number of children using the indefinite article plus noun rather than the definite article plus noun in this study may be taken to reflect the procedure used. As far as the children were aware, the experimenter did not know which book was selected and he could not see the book during the narrative.

To re-introduce the boy the LA control groups showed a slight preference for nominals rather than pronominals (55%-57% vs 42% - 45% respectively). This pattern was more marked for the SLI children who used approximately 77% nominals to re-introduce the boy. The SLI children's performance differed significantly from that of the LA control groups. Interestingly, this difference in performance may be taken to reflect the SLI children's more mature linguistic abilities in this task. To re-introduce the dog both the SLI children and LA controls used over 90% nominals rather than pronominals. No significant

differences were found between the groups. Bamberg (1987) also found that adult speakers primarily used nominals for re-introducing the boy and the dog. Thus, these findings for the SLI children in this study concur with the pattern found for mature speakers. However, the performance of the younger 5;6 to 8;10 year old LA control groups is typical of young children of this age whereby the pronoun may be used for re-introductory purposes for the main protagonist (Bamberg, 1987).

For the maintenance function a different pattern was found. All the children showed a preference for using pronominals for maintaining reference. The SLI children used 74% pronominals and the LA control groups used between 85% to 93% pronominals when maintaining reference to the boy. Analysis revealed that the SLI children used significantly fewer pronominals than the LA1 and LA2 controls, but their performance did not differ from the older LA3 controls. The preference for using pronominals for maintaining reference was also evident, though slightly less marked, for references to the dog. The SLI children used pronouns 68% of the time and the LA control groups used pronouns between 53% and 86% of the time to maintain reference. There were no significant differences between the four groups.

To summarise: The Grammatical SLI children primarily used an indefinite article plus noun to introduce the two main protagonists, a definite article plus noun to re-introduce the protagonists, and a pronoun to maintain reference to the two protagonists. This pattern of linguistic forms used by the SLI children for reference to the boy and the dog in the narrative indicates that they are highly sensitive to the linguistic function of the referential device, the pragmatic constraints of the linguistic structure of the narrative, as well as the pragmatic needs of the listener. Where differences occurred between the SLI children and the younger LA control groups, they reflected the SLI children's more mature linguistic abilities in this area. The findings from this investigation do not support the "broad RDDR" hypothesis.

5. Testing the domain neutral RDDR hypothesis

To test the domain neutral RDDR hypothesis, parallels between language and cognitive processes must be drawn. One way this can be done is by looking at the complexity of structural mapping. Halford (1987) has defined three levels of structural mapping. The first of these is *Element mapping*, whereby an individual element in one structure is mapped onto a single element. This may be seen as analogous to naming an object. The second level of mapping described by Halford is *Relational mapping*. This involves a binary relationship between a pair of elements in a set being mapped onto a corresponding binary relationship in another set. Semantic bootstrapping where the agent-theme pair is mapped onto the subject and object may be taken to be an example of relational mapping. The third and most complex form of mapping is *System mapping*. Here the mapping is from a systematic relation of one representational structure to another. Transitive inference is an example of system mapping. For example, if 1 is bigger than 2, and 2 is bigger than 3, it can be inferred that 1 must be bigger than 3. Crucially at least two binary relations must be compared. In language, subject verb agreement which involves both the structural syntactic system and

the lexical features of the noun phrase may be taken as a form of system mapping.

Thus, in domain neutral terms the RDDR may be reformulated as a systems mapping deficit. To test the domain neutral RDDR a computer generated visual transitive inference task was used.

5.1 Visual transitive inference: Method

The task required each child to judge the relative size of five differently coloured bars which I shall label A (large) to E (small). The bars were presented pair wise. An experimental phase followed two teaching phases. In the teaching phase only adjacent bars were presented. In the experimental phase all possible parings occurred. The crucial combination was the BD combination since, firstly, this combination was a novel combination, and secondly, the B and D bar were both bigger and smaller in other combinations. Thus, a simple element mapping strategy, labelling a bar the bigger or smaller, could not be used.

In the teaching phase the prompt bigger or smaller appeared on the screen and was read by the experimenter. The first pair of bars appeared on the screen with the tops of the bars hidden by a box. Depending on the prompt, the child had to press a key below the bigger or smaller bar. Immediately after the child responded the true size of the bars was revealed. The position of the bars (left/right) and the prompts bigger/smaller were randomized using the MEL programme. The children were told to respond correctly and as quickly as possible. Following eight successive correct responses the second pair of bars were presented. In the second teaching phase, presentation of the adjacent pairs of bars was randomized. Therefore bars BC could be presented first, followed by DE, followed by AB etc.. In the experimental phase each of the 10 possible pairs were presented four times in a set random order. The bars appeared on the screen with their sizes hidden by the box. No feedback was given during the experimental phase. Correct responses and reaction times were recorded on the computer for later analysis.

5.2 Results

Correct responses. All the groups correctly identified the relative sizes of the majority of the pairs of bars correctly (see Table 2). A 3 (Group, SLI, LA controls, CA controls) x 10 (pair type) ANOVA revealed a significant effect of pair type but no significant effect of Group or interaction. No significant differences were found between the SLI children's number of correct responses and that of the LA controls or the CA controls.

	Subjects		
	SLI children Mean	LA controls Mean	CA controls Mean
Overall:			
% Correct responses	85.2	85.5	87.9
Reaction times	1625	1783	2585
BD only:			
% Correct responses	87.5	79.9	89.6
Reaction times	1995	2202	2806

Table 2. Correct responses and reaction times for the SLI children, LA and CA controls.

The significant effect of pair type reflected the decrease in correct responses for the central combinations (i.e., those involving combinations with B, C, and D bars). This was particularly evident for the CD combination, and each group's performance did not differ from chance. This was surprising as this combination had previously occurred in the teaching phase. Therefore, it may be taken to reflect the order in which this pair was taught. However, it was the novel BD combination which was of particular interest in this study. As can be seen from Table 2 the SLI children's correct responses did not differ from either the LA control groups or the CA control group. The SLI children produced almost 90% correct responses for this BD pair. Thus, the SLI children were as accurate as the normally developing children. However, non-modular processing hypotheses put forward to account for SLI have proposed that it is the speed of processing which underlies SLI. Therefore, we could expect that the SLI children would be slower at this task.

Reaction times. The overall mean reaction times and the reaction times for the BD pair for the four groups can be found in Table 2. A 3 (Group: SLI children, LA controls, CA controls) x 10 (pair type) ANOVA revealed a significant effect of Group and Type, but no significant interaction. Surprisingly, further analysis revealed that SLI children had significantly **faster** reaction times than the LA control groups and the CA control groups. Again, the central pairs of bars were found to be more difficult, as indicated by the slower reaction times, than the combinations which included the outside A and E bars. Further analysis of the BD combination revealed that the SLI children were as fast if not faster than the LA control groups and the CA controls. Thus, the domain neutral RDDR hypothesis as tested by this study is not supported.

6 Conclusion

I have proposed that Grammatical SLI children's linguistic impairment can be accounted for by a general deficit with structural relationships between constituents, i.e. the RDDR hypothesis. This paper provided a first test of the extent of the domain of the underlying deficit based on a hypothesis which attempts to account for the linguistic deficits in Grammatical SLI children. Three

possible variants of the RDDR hypothesis were tested to see if *i*) the deficit extends to only modular language abilities, *ii*) the deficit extends to non-modular language abilities, or *iii*) if it is a domain neutral deficit and extends to non-linguistic as well as linguistic processing. To test these competing hypotheses the SLI children's knowledge of Binding principles; their use of pronominal reference in a narrative; and their ability to make visual transitive inference were explored.

The performance of a group of 12 Grammatical SLI children and three groups of LA control children were compared on the three sets of experiments. In addition the SLI children's performance was compared to 12 CA and mental age matched controls on the visual inference task.

The findings from the investigation of Binding Principles revealed that the SLI children could not rule out co-reference for reflexives and pronouns when knowledge of Binding Principles were required. In contrast, the younger LA control children generally showed an appropriate ability to use this syntactic knowledge to assign reference to reflexives and pronouns. These data indicate that the SLI children do not have the modular linguistic knowledge characterized by Binding Principles.

On the narrative task, the Grammatical SLI children showed a similar if not more mature pattern of use of pronominal reference to the LA control groups. Thus, the SLI children's use of pronominal reference was appropriate when this was determined by the pragmatic functional role of the referent and structural-pragmatic knowledge of narratives.

The visual transitive inference task revealed that the SLI children were as accurate and as fast as, if not faster than, the LA controls and the CA control children, in their judgements which required visual transitive inference.

This series of studies has revealed a differential functioning for the same surface form (pronouns). It has demonstrated qualitatively different abilities in different domains of language (syntax vs pragmatics) and has provided evidence of differential impairment in the language system. Furthermore, no impairment was found in a non-linguistic task designed to assess similar processes which could underlie SLI children's linguistic impairment. Therefore, it is concluded that the RDDR hypothesis does not extend to pragmatic abilities or domain neutral cognitive abilities as tested by these studies. Furthermore, the evidence supports the modular, domain specific nature of the Representational Deficit with Dependent Relationships which I have proposed underlies Grammatical SLI children.

The data from these studies provide exciting empirical evidence from a group of developing children of an isolated deficit within the language module. Further specification of the linguistic characteristics of Grammatical SLI in children may provide additional insight into language acquisition and the modularity of aspects of language.

Endnotes

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