LANGUAGE AND COGNITIVE DEVELOPMENT IN A GRAMMATICAL SLI BOY: MODULARITY AND INNATENESS

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Abstract—This paper aims to provide insight into the contentious issue of the hypothesised innate basis to domain specific, modular aspects of language [Fodor, F. J., The Modularity of Mind, MIT Press, Cambridge, MA, 1983; Chomsky, N., Lectures on government and binding. Foris, Dordrecht, 1981]. In order to do this a distinction is made between modular language abilities, non-modular language abilities (i.e. language abilities outside the language module in question) and non-linguistic cognitive tasks. Based on this distinction, a series of investigations were carried out into the abilities of a 10 year old boy (AZ) with Grammatical specific language impairment. The investigations of modular language abilities focused on inflectional morphology (agreement, and regular and irregular past tense marking) and syntax (knowledge and use of phrase structure, thematic role assignment and Binding Principles). The investigations of non-modular language abilities included tests of pragmatic inference and verbal analogical reasoning. Non-linguistic assessments included standardised tests and a test of visual transitive inference. A clear dissociation was revealed between AZ’s severely impaired modular language abilities and good non-modular and non-linguistic abilities. AZ’s performance on the tests was compared with 36 younger language control children (aged 5:4–8:9) and 12 age matched control children. Z-scores computed for AZ’s performance in comparison with the normal children, based on standardised language measures (vocabulary, morphology) and his chronological age, revealed a significant impairment in morpho-syntactic abilities and normal or above average abilities on the non-modular language tasks and non-linguistic cognitive tasks. I propose that the discreteness of AZ’s language impairment indicates that an underlying modular language impairment is the most parsimonious explanation for his deficit. A deficit with syntactic structural representations characterised by the Representational Deficit for Dependent Relationships [van der Lely, H. K. J. and Stollwerck, L., Binding theory and specifically language impaired children. Cognition, 1997.] can account for his morphological and syntactic impairments. The data provide empirical evidence to support the innate bases to domain specific and modular aspects of language. © 1997 Elsevier Science Ltd

INTRODUCTION

The possibility of a genetic-innate basis to modular and domain specific aspects of human language has been a hotly debated topic in the last decade. On the one hand, this new surge of interest has been fuelled by the development in the use of computational frameworks for modelling language learning. Implementations of these frameworks using connectionist networks claim that all aspects of language can be learnt within a single undifferentiated mechanism [1–4]. This includes some aspects of language which may be thought to be part of the innate endowment of language and to require specialised mechanisms [5, 6]. For example, Plunkett and Marchman [2, 3] propose that both regular and irregular past tense formation may be learnt within the same system with little or no built-in (innate) structure to facilitate learning the ‘-ed’ rule.

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On the other hand, the advances in genetic research have enabled the identification of specific genes or location of genes for various disorders. Some of these disorders manifest with relatively isolated impairments or relative sparing of language or language related abilities, e.g. dyslexia [7], and Williams syndrome [8]. In addition, investigations of subjects with developmental dissociations in cognitive and language abilities have provided insight into the innate-modularity issue. For example, investigations into subjects who display good or relatively good language abilities despite impaired non-linguistic cognitive abilities provide support for the modularity of language [9, 10]. These subjects include DH, a young woman with "chatterbox syndrome" who had an arrested hydrocephalus and a subject known as 'Christopher' who has knowledge of some 19 languages [10, 12]. However, although people like DH [11] and Christopher [10], and also children with Williams syndrome have a severely reduced mental capacity, their non-linguistic abilities are often above those of a five year old. This is a level of cognitive maturity when a normally developing child will have mastered the majority of the phonological, syntactic and morphological rules of language. Thus, using such evidence to argue for modular language abilities is weakened.

Potentially, studies of children with a specific language impairment do not suffer from this problem. The reverse dissociation between language and cognitive abilities is found in specifically language impaired (SLI) children, i.e. severely impaired language abilities alongside normal cognitive abilities. The provocative articles on the 'KE' family (a family of 30 members of whom half are language impaired) [13–16] have provided a valuable focus for the debate for both supporters and opponents of the hypothesised innate domain specific basis to aspects of the language capacity (cf. [9, 16–19]). With respect to the KE family, critics of a modular innate basis to language do not dispute the genetic inheritance of the disorder but the domain specificity of the impairment [17, 18]. Data from Vargha-Khadem et al. [20] have led researchers to suggest that cognitive deficits reported for some of the KE family members indicate that their 'syndrome' is not restricted to language [18].

Elman et al. [18] also claim that detailed studies of other children with specific language impairment show that the disorder is not restricted to language nor to grammar within language. To support their claim, Elman et al. [18] cite deficits in processing rapid temporal auditory sequences [21, 22], symbolic play [23], aspects of spatial imagery [24], specific aspects of non-verbal attention [26], and a range of neurological soft signs (e.g. [27]). However, many of the studies, in which cognitive deficits have been found in groups of language impaired subjects, provide scant information of the linguistic characteristics of the language deficit of the children. Without a characterisation of the nature of the linguistic impairment, we have no way of knowing what or how a linguistic deficit may relate to the cited cognitive deficit. For example, do the linguistic characteristics of children who have been found to have a deficit in symbolic play differ from those with deficits of non-verbal attention? Furthermore, surprisingly, many reports (e.g. [22]) are based on global definitions of SLI, although SLI is now well recognised as a heterogeneous disorder [28]. At present we do not know if and how the different forms of SLI are related. It is logically possible that some forms of SLI may be modular and some not. It is also possible that SLI could co-occur with any other impairment/disorder and the afflicted individuals may span the range of general intelligence found in children without SLI (see [29]). However, whilst SLI and other cognitive deficits or other characteristics (perhaps, red hair?) may be inherited together there may be no direct developmental relationship between them.

It is evident that if we are to use the data from subjects with SLI to further the debate into the genetic, innate basis to modular, domain-specific aspects of language, then we need to
supplement the rich data provided by the KE family with data from other carefully identified sub-groups of children with SLI who do not obviously suffer from any other disorder. Furthermore, a detailed linguistic characterisation is required which includes information about specific aspects of grammatical development, e.g. agreement marking, tense marking, and knowledge of syntactic structural relationships. Impairments in one or more of these areas of language are frequently reported and are central to the characterisation of SLI children [16, 30–38] and, furthermore, these characteristics must be accounted for in any theory of the underlying nature and cause of SLI.

In addition, before we can provide data for or against the innate basis to aspects of language, we need to define what is meant by ‘innate’ and what aspects of language are, and what are not, considered to be part of the modular, innate endowment of language. This will enable appropriate consideration of non-modular language abilities and non-linguistic cognitive abilities alongside specifically modular language abilities. Finally, comparison must be made between the SLI subjects’ performance on all the measures with the appropriate control groups of children to ensure that the observed performance cannot be explained by normal variation in the population.

If evidence were found for a child’s linguistic deficit being primarily limited to modular aspects of language this would provide a strong case for the domain-specific innateness of the human language faculty. In addition it may challenge the view that the processing mechanisms and/or representations underlying aspects of the grammar, and grammatical and non-linguistic cognitive development are commonly shared. Alternatively, if primary deficits were found in either non-modular aspects of language and/or non-linguistic cognitive functioning alongside the modular language deficits then no support will be given to the innate domain-specific, modular view of aspects of language. Such a finding would be more consistent with a behaviour which results from the interaction between ‘multiple levels’, such as those proposed by theories based on connectionist networks [4, 18, 39]. If this was the case, the observed language impairment in SLI subjects could be viewed as one manifestation of a malfunctioning mechanism that subserved language and some other cognitive functions. Importantly, it would indicate that the genetic effect was not restricted to grammar.

Surprisingly, there are few (if any) studies, apart from the KE family, which have investigated SLI children providing detailed investigations of both linguistic and non-linguistic cognitive abilities of the same subjects, which would allow the modularity issue to be properly addressed. This paper provides a first step towards redressing this omission in the literature by reporting details of one of the subjects (AZ) from a carefully defined sub-group of twelve ‘Grammatical SLI’ subjects who have participated in a series of investigations [30, 40–45].

**Innateness and language modularity**

The word ‘innate’ refers to what is genetically determined. However, the content of what is innate is by no means straightforward. Moreover, whilst we may hypothesise (or speculate) as to how our genetic endowment may function to shape development, we can only observe the outcome (behaviour) of this inheritance. Elman et al. [18] boldly tackle the innateness of language issue and provide useful insights. They suggest that for an outcome to be innate means that development is constrained at one or more ‘level’. Elman et al. stress that, typically, behaviour reflects constraints which operate at “multiple interacting levels” (Elman et al. [18], p. 23). Whilst observable behaviour may reflect multiple interacting levels as proposed by Elman et al., it should be noted that this does not preclude the possibility of a deficit at one or more of the levels (or all of the levels) which itself is domain-specific and modular. Elman et al.
propose three forms of innateness which correspond to the three levels at which constraints may operate: representations, architectural and timing. Representational constraints reflect innate knowledge about basic principles, such as those described by Universal Grammar (UG) [10, 19, 46, 47]. This innate knowledge may provide constraints on the representations (e.g. the possible forms of the syntactic structure) that may be formed with the language input that a child is exposed to. Pinker [19] suggests that innate language knowledge is based upon specific wiring of the microcircuitry in the brain which is dedicated to solving a particular family of computational problems.

Elman et al. suggest that architectural constraints may be manifest in ways which include “computational mechanisms” and “learning algorithms”. These architectural constraints may interact with the representational constraints and constrain the form of the representations that further develop as the result of language input. Finally, variations in ‘timing’ may also be genetically determined and affect learning capacity [18, 48, 49]. It is outside the scope of this paper to distinguish between the various levels of innate constraints as proposed by Elman et al. [18]. However, this paper may provide evidence for or against the domain specificity and modularity of the innate endowment for aspects of language.

From Elman et al.'s views of innateness [18], it can be seen that a domain-specific deficit would be consistent with representational nativism and/or dedicated architecture or timing. Indeed, Elman et al. state that a “highly domain-specific grammatical impairment would (if it were true) constitute strong evidence for a genetic effect restricted to grammar” (Elman et al. [18], p.372). However, largely based on the evidence from the KE family (see above) Elman et al. claim that there is mounting evidence against domain-specific representational nativism. Furthermore, connectionist models of development assume distributed representations, which are usually distributed across processing units of considerable flexibility. Thus, Elman et al. [18] claim that “there is a prima facie case against the notion that domains like language must be carried out by dedicated innate domain-specific neural systems” (Elman et al. [18], p. 41). This paper investigates whether there is evidence for a domain-specific grammatical deficit in an SLI boy.

However, this paper does not merely seek to identify a domain-specific deficit (i.e. a deficit in the language domain) as this alone is an insufficient condition for modularity. It is the modular aspects of language which Fodor [50] hypothesises may show a discrete impairment due to innate, genetically determined characteristics of modules (see below). This leads to considering which aspects of language are part of a language module.

There appear to be many misconceptions in the literature about what may constitute the innate modular language system. These may be either too broad and implicate all language, e.g. expression/comprehension [39], or too narrow, e.g. “The gene for the past tense” stories (which hopefully now, if at all, only surface in the popular press!). Before systematically investigating whether any child/children exist with an isolated modular language deficit, we need to clarify which aspects of language are considered to be modular.

The theoretical perspective of modularity on which this paper is based is Fodor’s modularity hypothesis [50]. Fodor [50] argues for a distinction between a central system responsible for rational thought and the fixation of beliefs and a number of modular input systems, one for each of the senses which feed the central system. The language faculty is viewed as an input system on a par with the senses such as vision [50]. Various criteria are required for a system to be counted as a module, which apart from domain specificity, crucially include information encapsulation. In addition, the criteria include specific neural architecture which subserve the modules which may be subject to idiosyncratic pathological breakdown (Fodor [50]). It is this
neural specificity of the architecture of the modules that is claimed to be genetically determined (innate) [19, 50–52].

It is evident that not all aspects of language fit the definition of a module. For example, processing distinctions, such as expression vs comprehension are not relevant to distinguishing modular aspects of language. Sperber and Wilson [53] have provided an outline of crucial distinctions between modular, syntactic and non-modular, pragmatic representations and processes. This distinction follows the code vs inferential processes which may characterise syntactic and pragmatic processes [53]. The code processes exploit the shared knowledge between speakers of a code that associates representations in a given domain alongside mapping rules in another domain or system. Furthermore, there are innate constraints on the representations relating to what can or cannot be coded [46]; in other words there is structural dependency. Thus, only certain forms of syntactic representations are possible in any language, for example, no language encodes tense as a particular linear position in an utterance, such as inflecting the fourth words with a tense marker, although logically this would be a possibility. Similar constraints on representations arguably exist in inflectional morphology [54] and phonology [55].

In contrast to these representations, Sperber and Wilson [53] point out that inferential processes do not exploit a shared knowledge of a coding system but rely on general reasoning abilities and heuristics. In addition, there are no built-in constraints on what information may be used in the inferential process. Potentially any information can be exploited as a cue to the speaker's intended meaning [53]. Thus, by its very nature, pragmatic inference involves an interaction of different knowledge sources. Therefore, it cannot be construed as a modular process.

Thus, a broad distinction can be made which distinguishes modular grammatical vs non-modular aspects of language 3; syntax, inflectional morphology and phonology can be viewed as part of the language module whereas pragmatic inference and the storage of lexical representations may be viewed as outside this particular language module and may be part of the non-modular central system [10, 19, 46, 53, 56]. As a starting point this paper will be based on this broad distinction of language modularity.

**Grammatical SLI children**

In a series of studies, in previous work with colleagues, a small carefully defined sub-group of 12 'Grammatical SLI' children have been identified and investigated [30, 35, 36, 40–44]. This sub-group is characterised by a similar linguistic profile. The Grammatical SLI children have a persistent SLI with a significant impairment in the grammatical comprehension and expression of language. Their grammatical abilities appear to be impaired over and above any general (secondary) language impairment they may have in, for example, lexical development. Concurring severe articulatory/phonological deficits, articulatory dyspraxia or a phonological disorder of the severity to cause frequent omissions of final consonants or unintelligible speech are not a characteristic of this group of children. I am not claiming that Grammatical SLI children do not have any phonological impairment but if it exists it is subtle and, as yet, it has not been investigated in these children. (See [30, 36, 43] for further details of this sub-group's overall linguistic characteristics.)

In addition to the linguistic investigations of these Grammatical SLI, a preliminary study revealed that the group has a significantly higher incidence of a positive familial history of language impairment than a larger group of control children matched on chronological age [43]. The pattern of impairment in their first degree family members is consistent with an autosomal dominant genetic inheritance of Grammatical SLI [43].
Against this background of the investigations of the group of Grammatical SLI children, this paper provides an initial, more detailed, characterisation of the linguistic and non-linguistic performance of one of the Grammatical SLI subjects, AZ (SLI 4). AZ was selected primarily because his linguistic profile typifies that of the group of Grammatical SLI children. However, AZ was one of the five Grammatical SLI children whose standardised visual performance score on the British Ability Scale [57] was equivalent to an IQ above 105.

Control groups

In order to assess whether AZ’s performance could be explained by a more general delay in language or whether his abilities fall within the normal range of variability on the experimental tasks (albeit perhaps at the upper and lower extremes on some abilities) his performance was compared with a large group of normally developing children: 36 matched on language abilities, and 12 matched on chronological age. These children covered a wide range of chronological ages as well as linguistic abilities. Standardised tests of morpho-syntactic abilities and expressive and receptive single word vocabulary administered to the normally developing children enabled AZ’s performance to be evaluated in comparison to an expected performance based on his chronological age, or on the different language abilities as measured by the standardised tests.

THE INVESTIGATIONS OF AZ

AZ: background history

AZ is the first son of the family and lives with his father, step-mother and half-brother who is eight years younger than him. The investigations reported in this paper cover a two-year period from when AZ was 10 years and 3 months which was when I first met him.

AZ has a history of extreme language delay. At the age of 5 years his expressive language consisted of only three words, Mummy, Daddy and Gangan (Grannie). However, he showed that he wanted to communicate and would use intonated jargon plus gestures and/or showing somebody what he wanted. His comprehension of language was reported to be minimal at this age. For example, AZ was unable to understand a simple instruction such as Put the cup on the table. From the age of 7 years he has attended a school which specialises in the education of children with speech and language impairments. At this school he received daily specialized help and has made great progress. At age 10:3, AZ presented as a bright, friendly and cooperative boy who willingly communicated with me and participated in various tasks as requested.

There is a reported family history of language impairment, although this has not yet been systematically investigated. AZ’s father is the son of Polish parents, but was born in England. Polish was the dominant language at home. Although AZ’s father had plenty of exposure to English, he apparently had difficulties in learning it. However, English is his primary language which he feels most fluent in and has always been the language used at home since AZ was born. AZ’s father, who has a degree in mining and electrical engineering, reports that he still has difficulties in finding words and in expressing himself. AZ’s paternal uncle also reported that he had and still has some language difficulties.

AZ’s younger half brother (BZ) is reported to be well above average ability. At age 6:0, BZ does not have any reported language problems.

This paper provides an initial summary of AZ’s abilities on: (1) the standardised tests which were used for selection and matching purposes; (2) the experimental tasks which were designed to tap modular aspects of language, focusing mainly on morphology and syntax; (3) experimental
tests and procedures used to assess non-modular aspects of language, focusing on pragmatic knowledge and pragmatic inference abilities; and finally (4) non-linguistic cognitive abilities.

1. Performance on standardised language tests

AZ, like the other children in the sub-group of Grammatical SLI children studied by van der Lely and colleagues (e.g. [30, 36, 43]) was assessed on six standardised language tests which tapped a range of morphological, syntactic and vocabulary abilities, and incurred both comprehension and expression of language. The tests were: the British Picture Vocabulary Scale (BPVS) [58], a test of comprehension of single words; the Test of Reception of Grammar (TROG) [59], a multi-choice test of understanding a range of grammatical structures in sentences; the Naming Vocabulary sub-test from the British Ability Scales (NV-BAS) [57], which tests the ability to name pictured objects; the Grammatical Closure sub-test from the Illinois Test of Psycholinguistic Abilities (GC-ITPA) [60], which tests production of morphology; the Action Picture Test (APT) [61] and the Bus story (revised version, [62]) which provides measures of grammatical structure and semantic content of expressive language. The expressive responses from the ATP and the Bus story were audio recorded using a Sony DAT recorder and an Electret condenser microphone (ECM-959). Detailed transcriptions were made from these recordings which enabled assessment of AZ’s articulatory ability and intelligibility. The tests provide a standardised measure of language abilities in relation to AZ’s chronological age. A summary of AZ’s performance on the tests at the beginning of the investigation can be found in Table 1 or Appendix A. The four tests shown in Table 1 were used to match three groups of 12 younger children developing normally. AZ’s morpho-syntactic abilities as measured by his performance on the TROG and GC-ITPA were most closely matched to the youngest children in the LA1 control group, while his vocabulary abilities as measured on the BPVS and NV-BAS were most closely matched to the children in the LA2 and LA3 control groups respectively. These LA control children enabled AZ’s

<table>
<thead>
<tr>
<th>Subjects</th>
<th>AZ (N=12)</th>
<th>LA1 controls (N=12)</th>
<th>LA2 controls (N=12)</th>
<th>LA3 controls (N=12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw Score (Z-s)</td>
<td>10:3</td>
<td>5:9 (0:4)</td>
<td>6:11 (0:4)</td>
<td>7:11 (0:5)</td>
</tr>
<tr>
<td>Equivalent age</td>
<td>5:10</td>
<td>5:08–8:06</td>
<td>6:05–&gt; 10:4</td>
<td>8:02–&gt; 10:04</td>
</tr>
<tr>
<td>TROG</td>
<td>12 (-1:9)</td>
<td>12.58 (2:35)</td>
<td>16.00 (1:75)</td>
<td>17.33 (1:23)</td>
</tr>
<tr>
<td>Equivalent age</td>
<td>5:09</td>
<td>5:00–9:00</td>
<td>6:00–11:00</td>
<td>9:00–&gt;11:00</td>
</tr>
<tr>
<td>BPVS</td>
<td>72 (-1:3)</td>
<td>56.25 (8:91)</td>
<td>71.67 (9:71)</td>
<td>80.00 (9:62)</td>
</tr>
<tr>
<td>Equivalent age</td>
<td>7:09</td>
<td>5:11–7:05</td>
<td>5:10–9:05</td>
<td>7:00–11:00</td>
</tr>
<tr>
<td>NV-BAS</td>
<td>19*</td>
<td>15.67 (1:61)</td>
<td>17.17 (1:27)</td>
<td>17.50 (0:90)</td>
</tr>
<tr>
<td>Range</td>
<td>14–18</td>
<td>15–19</td>
<td>16–19</td>
<td>16–19</td>
</tr>
<tr>
<td>Equivalent age</td>
<td>&gt; 7:11</td>
<td>4:03–&gt; 7:11</td>
<td>5:03–&gt; 7:11</td>
<td>6:05–&gt; 7:11</td>
</tr>
</tbody>
</table>

Note: GC-ITPA=Grammatical Closure sub-test, Illinois Test of Psycholinguistic Abilities. TROG=Test of Reception of Grammar. BPVS=British Picture Vocabulary Scale. NV-BAS =Naming Vocabulary, British Ability Scales.
performance to be evaluated on the basis of his different language abilities. Thus, we can have an estimate of whether AZ’s performance on the Experimental tasks to be reported below, is within the range of abilities found in younger children developing normally.

2. Investigations of modular language abilities

2.1. Phonology. Analysis of spontaneous speech, taken from conversations and a narrative of the book Frog, Where Are You?, did not reveal any obvious phonological or prosodic impairment. Thus, superficially, it appears that AZ’s language impairment does not extend to phonology. However, prior to more thorough investigations of AZ’s phonological abilities, it is prudent to restrict claims about his phonological abilities as indicating that his phonological representational system is sufficient for him to produce known words accurately.

2.2. Inflectional morphology. Analysis of AZ’s expressive language showed that he can use all inflectional forms, such as, third person agreement -s, plural -s, regular past tense -ed, and the progressive aspect marker -ing. However, like many children with SLI reported in the literature [31, 34, 38] he does not always use these forms correctly or consistently, e.g. Two mens. Two feet. This is what they ated (10:3 GC-ITPA); The boy climb up . . . and holds onto branches (From AZ’s narrative of the book Frog, Where Are You?); My Mum goes out. My Dad go to work (AZ: 11:2). Goellner’s analysis of AZ’s spontaneous speech [63] and responses to an elicitation task revealed a consistent level of third-person agreement errors on lexical verbs over the investigation period. At age 10:3 AZ produced 70% errors, at 11:2 80% errors and at 12:2 80% errors [63]. AZ also produced 50% agreement errors on auxiliary verbs, using the singular third person auxiliary in a plural third person context (e.g. They was having a race. The bees was after the dog (AZ: 11:2). Thus, he makes an error in number agreement. However, the auxiliary errors may be accounted for by the local dialect where such forms may be used. This view is supported by the fact that AZ does not use the singular, third person present tense auxiliary (is) in a plural context (e.g. They is having a race) which is not present in the local dialect. Moreover, it should be noted that AZ does not use the third person singular s in contexts where it should not occur, e.g. in first person singular contexts. Thus, his agreement errors are restricted to the third person singular contexts.

Goellner’s analysis of AZ’s regular and irregular past tense marking at the beginning of the assessment period [63] revealed substantially more errors with regular than with irregular verbs. At ages 10:3 and 11:2 AZ made 60% and 56% errors on regular verbs but only 21% and 12% on irregular verbs [63]. Errors with regular and irregular verbs were, primarily, use of the stem form in a past tense context, although in the elicitation morphology test (GC-ITPA) occasional overregularisation occurred for irregular verbs (hanged; stolen). The pattern of regular and irregular past tense errors found for AZ appears to be qualitatively different from younger normally developing children. Analysis of the youngest LA1 control group’s regular and irregular past tense marking in spontaneous speech revealed virtually no errors for regular verbs (0.91%) whereas some errors were made for the irregular verbs (8.13%) [40]. By the time AZ was 12:3 this difference between the proportion of regular and irregular past tense errors was no longer evident (20% regular errors; 35% irregular errors) [63]. It appears that AZ had correctly learned the ‘ed’ rule during this period of the investigation. AZ’s explicit awareness that the ‘ed’ was used to form a ‘past-time’ form of a verb suggests that his learning of the regular past tense formation was the result of explicit language remediation. Note however, that the proportion of past tense errors is still considerably more than found for the normal children [40]. If AZ’s impairment with tense marking was confined to inflectional morphology,
problems with regular verbs but not irregular verbs would be expected as irregulars are retrieved whole, directly from the lexicon. Thus, AZ’s continuing level of past tense marking errors for irregular as well as regular verbs indicates that his problems with tense marking extends to the syntactic marking of tense. That is, it appears as if AZ does not ‘know’ that a verb in a matrix clause (roughly the main clause) must be obligatorily marked for tense.

AZ’s production of past tense morphology was further investigated using an elicitation-production task and a morphological judgement task. AZ was presented with a total of 60 verbs in the production task, and 64 verbs in the judgement task. The verbs, which were selected from a set developed by Ullman [64], belonged to four classes: 16 irregular verbs (give–gave), which take only an irregular past; 16 regular verbs (look–looked), which take only a regular past and whose stems are phonologically dissimilar to the stems of all irregular verbs; 16 ‘novel irregular’ verbs whose stems are phonologically similar to the stems of real irregular verbs and which can take irregular or regular pasts (e.g. crive–crove/crived, frink–frank/frank/frinked); 12 ‘novel regular’ verbs in the production task, and 16 in the judgement task, whose stems are phonologically dissimilar to the stems of all irregulars (e.g. prass–prassed). Half the real irregulars and half the real regulars had high past tense frequencies (e.g. gave, looked) and half in each class had low past tense frequencies (e.g. dug, stalked). Further details of the verbs’ selection criteria can be found in Ullman [64]. The verbs were randomised for presentation purposes. Each verb was presented in the context of two sentences, which were spoken by the experimenter. In the first sentence (see (1)a) the child heard the real or novel verb. The child had to repeat the sentence. This was followed by the test sentence, (1) b, i.e. the past tense context sentence.

(1) a. Every day I vurm around London

   b. Just like every day, yesterday I ________ around London.

The subject had to repeat the sentence from yesterday using an appropriate form of the real or novel verb presented in the first sentence. The task was also administered to the 36 LA control children (see [44] for further details of this study).

Although AZ correctly repeated the verbs in the first sentence and understood that he was to provide a past tense form of the verb (i.e. say the verb as if it had happened yesterday) he had great difficulties in providing an appropriate past tense form for the real or novel verbs. For the majority of the 60 verbs (70%), AZ merely produced the unmarked form of the verb. For the regular verbs AZ produced two regular past tense forms (marred, stirred). In addition AZ produced the present tense forms for two irregular verbs (thinks, splits) and a noun which was semantically related to the target verb (grind-corn). None of the LA controls marked any verb with the present inflection instead of the past tense inflection. It is interesting to note that the only verbs for which AZ used the regular past tense inflection were verbs where the addition of the inflection produced a phonological sequence that occurs as part of the stem in other words, e.g. marred/card, stirred/word. AZ did not inflect other regular verbs in the set (e.g. rush, rob) where the addition of the -ed inflection produced a phonological sequence which only occurs with the inflection and not in the root or stem form of words. AZ’s pattern of regular past tense marking is consistent with him treating regular verbs as if they are irregular verbs. That is, the regular past tense form of the verb is either stored and retrieved as a whole word from the lexicon or is produced by analogy based on phonological similarity with other words stored in the lexicon.

For the regular novel verbs AZ only produced unmarked verb forms. For the irregular novel verbs he produced one regular form which formed a real word (sheel–sheel (shield), two
plausible irregularisations with minor phonological errors (i.e. simplification of the initial consonant cluster), and substituted two irregular novel verbs with a phonologically related real verb (steeze–steal, brop–drop). Thus, AZ does not show the regularity advantage for the morphological marking for real or novel verbs that is found in normally developing children [44].

In relation to the single vs dual mechanism debate which surrounds past tense morphology [2, 3, 5, 6], the standardised morphological and single word vocabulary scores are the most appropriate measures of language on which to judge AZ’s performance. Therefore, two regression analyses based on the performance of the 36 LA control children’s GC-ITPA and BPVS scores were undertaken to provide a Z-score for AZ and establish whether his poor performance on the morphological production experiment could have been expected based on his morphological or vocabulary ability. In addition, in order to have an estimate of AZ’s performance in relation to his chronological age, a regression analysis was also carried out based on the LA controls’ ages. Caution is generally expressed in the interpretation of these analyses because of the relatively small number of subjects and particularly with the analysis based on age as the oldest LA controls were around 1.6 years younger than AZ. Table 2 provides a summary of AZ’s Z-scores based on the performance of the 36 LA controls. When evaluating the significance of these results it should be recalled that AZ’s performance on the BPVS and the GC-ITPA was already -1.3 S.D. and -5.5 S.D., respectively, therefore, his performance is being compared with children considerably younger than him. Despite this fact, AZ’s total number of correct responses for the real words was still more than 2 S.D. and 1 S.D. below the expected scores based on his standardised vocabulary score and standardised morphological score, respectively (see Table 2) and more than -4 S.D. based on his chronological age. Table 2 also provides the results of AZ’s performance on regular and irregular past tense marking for real verbs and novel verbs. It is evident that, in relation to the standardised language measures and his chronological age, AZ shows a greater relative impairment in regular over irregular marking. This may be attributed to the regularity advantage shown by the normal children for real regular verbs [44]. In contrast to the normal children, AZ shows a similar (and very low) level of past tense marking for both regular and irregular verbs. Where no substantial differences are found between AZ’s performance and his expected performance based on the LA control’s performance, this is due to a poor performance by the younger LA controls. For example, for real irregular verbs few irregular responses were produced by the LA1 controls or AZ. Thus, AZ’s Z-scores fell within the normal range.

The follow-up morphological judgement task revealed that AZ’s problem was not merely a production-processing problem. In this task subjects were presented with 192 sentence pairs. AZ and the LA controls were asked to judge whether the verb form presented in the past tense context sentence (the second sentence in each sentence pair) was ‘good’ or ‘bad’. Each verb was presented in three different sentence pairs. In one of the presentations the verb was marked with a regular inflection (looked, gived, prassed, crived), in another with an irregular inflection (leck, gave, pruss, crove), and in the third it was unmarked (look, give, prass, crove). Thus, for

| Table 2. Z-scores for AZ’s performance on the elicitation-past tense morphology assessment |
|-----------------------------------------------|----------------|----------------|----------------|
| Real verbs: total correct | -4.07 | -2.61 | -1.34 |
| Regular verbs correct | -4.08 | -2.52 | -1.54 |
| Irregular verbs correct | -2.92 | -1.92 | -0.72 |
| Novel verbs: regular response | -4.36 | -2.16 | -0.69 |
| Novel verbs: irregular response | -0.659 | 0.84 | 0.36 |
the real and novel regular verbs (look, prass), plausible irregular past tense forms were constructed. The verb forms were randomised for presentation (see [44] for further details).

AZ correctly accepted the majority of regularly inflected verbs in the past tense context, i.e. 75% regular verbs (looked); 81% novel regular verbs (plammed); and 88% novel irregular verbs (crived). Surprisingly, AZ also accepted 50% of the regular inflections for the irregular verbs (gived). It appears from these data that for AZ, -ed is an acceptable suffix on most verbs. In contrast, AZ generally only accepted irregular forms for real irregular verbs (56%). AZ did not accept any irregular forms for the regular verbs and accepted less than 22% of irregular forms for the novel verbs. Thus, it is not the case that AZ accepted all verb forms. For five of the irregular verbs, AZ correctly accepted the correct irregular past tense form and the overregularised form (e.g. kepeed/kept, thinned/thought, swung/swung). This suggests that a ‘blocking mechanism’, whereby the affixation of the regular -ed is blocked by knowledge of an irregular past tense form [65], is not functioning adequately in AZ’s system. It is interesting that AZ also accepted the majority (90%) of unmarked verb forms in past tense contexts. These data reflect the errors AZ makes in production and suggests that unmarked and overregularised forms are acceptable to him in past tense contexts and are not merely the result of some production processing problem.

2.3. Syntax

2.3.1. Syntactic structure

One of the most notable features of AZ’s syntax is the simplicity of the structures that he uses. The majority of his utterances consist of only two or occasionally three phrasal constituents. Appendix B provides a transcription of AZ’s expressive language taken from his narrative of the picture book Frog, Where Are You? which was recorded when AZ was 11:2. It can be seen from this sample that AZ’s utterances virtually do not contain any complex NPs, such as The small dog, or complex DPs (determiner phrases), such as All of the Frogs, complex PPs (prepositional phrases), such as on the rock behind the tree, or complex VPs, relative clauses or small clauses. Tensed subordinate structures are also absent from his expressive language. Where embedded or subordinate structures are used, they are infinitival ones (e.g. That’s why the bus driver was trying to fix it. . . Bus story 11:2). Thus, AZ does not exhibit temporal recursion (temporal embedding). That is, he does not embed one tense under another, such as in the subordinate clause John said he went to the park. Therefore, he shows an inconsistent use of temporal marking across utterances as shown in Appendix B. However, Appendix B illustrates that on occasions AZ can correctly inflect verbs and nouns (stops, opened, slipped, falling, bees, branches). However, he may also omit all these inflectional markers along with obligatory prepositions and the infinitival marker to.

In summary, AZ’s utterances may be characterised by the structure NP + V (+infl) + XP where all the phrases contain one or two elements and where syntactic recursion (e.g. embedding an NP inside an NP) does not occur. Syntactic structures of a similar complexity to those used by AZ are typically found in children of less than 4 years of age. Embedded structures usually occur in normally developing 4 year old children’s language.

2.3.2. Argument structure

AZ frequently omits obligatory sub-categorised arguments of verbs and preposition in his expressive language: for example, The dog was poking (his head) in(-to the jar) (see Appendix B for further examples). An investigation was undertaken into AZ’s ability to assign thematic roles (e.g. Agent Patient) of transitive verbs (e.g. hit, cut, eat, paint, mend, push) when presented in active sentences (The fish eats the man), full passive sentences (The fish is eaten by
the man), short progressive passives (The fish is being eaten) and short ambiguous sentences (The fish is eaten) for which either a transitive, verbal passive or a stative, adjectival passive interpretation was possible (for full details, see [36]). The task required the subject to point to one of four pictures which best depicted the sentence. Note, the verbs were selected for their familiarity to children and their early age of acquisition.

Although AZ showed that he differentiated between the sentences he only achieved 78% correct responses for sentences which required a transitive active, or transitive verbal passive interpretation. AZ made the greatest number of errors with the short progressive passive sentences, achieving only 42% correct responses. AZ interpreted 58% of these sentences as a syntactically simpler stative adjectival passive, which involves only one theta role and no syntactic movement (see [36]). For the ambiguous passive sentences AZ, like other Grammatical SLI children [36], generally (83%) of the time) chose the stative, adjectival interpretation. This preference for choosing the syntactically simpler adjectival passive interpretation for the ambiguous passives contrasts with the normally developing children who showed approximately equal numbers of stative adjectival and transitive verbal passive interpretations [36]. Although AZ’s overall correct score (83%)⁸ is clearly above chance it is still considerably below the expected performance in relation to his vocabulary and morphological development. In comparison to the 36 LA controls, AZ’s Z-scores based on the standardised language measures were -1.76 (BPVS), to -1.19 (GC-IrTA)⁷ (see Table 3). Based on AZ’s chronological age his performance was close to Z=-.3. Further investigations are warranted to assess AZ’s ability to assign theta roles with verbs which are acquired later and verbs with more complex argument structure, such as dative or locative verbs.

The characteristics of AZ’s expressive language, showing a lack of syntactic recursion and his receptive language in which assigning even two thematic roles in a sentence is impaired, is consistent with the characterisation provided by van der Lely and Stollwerck [30]. Van der Lely [35] and van der Lely and Stollwerck [30] have characterised Grammatical SLI children’s syntactic deficit as a Representational Deficit for Dependent Relationships (RDDR), whereby simple dependencies are built up but complex dependencies between syntactic constituents are not built. As with young children at an early stage of acquisition [66], elementary (local) dependencies such as [Asp, V] or [D, N] but non-elementary (long distance) dependencies such as [T, Asp, V] or [D, Asp, N] may be problematic. AZ may generate a more simplified structure

<table>
<thead>
<tr>
<th></th>
<th>Age related Z-score</th>
<th>BPVS related Z-score</th>
<th>GC-IrTA related Z-score</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAPS* Argument structure</td>
<td>-2.96</td>
<td>-1.76</td>
<td>-1.19</td>
</tr>
<tr>
<td>Binding Principles test</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experiment 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total correct</td>
<td>-3.02</td>
<td>-2.42</td>
<td>-1.86</td>
</tr>
<tr>
<td>Name–pronoun Match</td>
<td>-4.66</td>
<td>-5.31</td>
<td>-5.79</td>
</tr>
<tr>
<td>Name–pronoun Mismatch</td>
<td>-0.06</td>
<td>-0.09</td>
<td>-0.12</td>
</tr>
<tr>
<td>Binding Principles test</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experiment 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total correct</td>
<td>-2.17</td>
<td>-2.32</td>
<td>-2.10</td>
</tr>
<tr>
<td>Name–pronoun Match</td>
<td>-6.13</td>
<td>-5.85</td>
<td>-5.89</td>
</tr>
<tr>
<td>Name–pronoun Mismatch</td>
<td>-2.55</td>
<td>-2.32</td>
<td>-2.10</td>
</tr>
<tr>
<td>Name–reflexive syntax</td>
<td>-3.03</td>
<td>-1.20</td>
<td>-0.34</td>
</tr>
</tbody>
</table>

* TAPS=Test of Active and Passive Sentences (van der Lely, 1992).
whenever such a structure is ‘sufficient’ (albeit not adult like) to account for all the constituents in an utterance. For example, he may generate two adjacent, coordinated structures for a subordinate utterance, as shown in (2).

I am not claiming that AZ will not show any evidence of movement in his surface syntactic structures, for example in the formation of questions. However, the syntactic representation underlying the utterance may not be adult like. One possibility is that the question word and moved auxiliary form an adjunct which is conjoined to the rest of the phrase structure, rather being in a complex hierarchical dependency relationship with the following phrase. That is, simple structures may be serially conjoined as shown in (3).

In order to test the predictions made by the RDDR, AZ’s knowledge of the syntactic structural constraints, i.e. Binding Principles A & B [46] which determine the assignment of reference to pronouns (him, her) and anaphors such as reflexives (himself, herself) in sentences was assessed (see [30]).

2.3.3. The investigation of Binding Principles

The example in (4) below illustrates the syntactic constraints characterised by Binding Principles A and B.

(4) Mowgli, says Baloo Bear, is tickling him, herself

According to Binding Principle A, himself must refer to Baloo Bear (the local antecedent)
whereas according to Binding Principle B, *him* must not refer to Baloo Bear but can refer to the non-local antecedent, Mowgli [46].

A sentence–picture judgement procedure was used in which there was either a match or ‘mismatch’ between the sentence and the picture. In the mismatch conditions either the sex of the referent and the pronoun/reflexive did not match, or the wrong character was depicted as the referent. For the reflexive mismatch condition, for example, Baloo Bear was shown to be tickling Mowgli (see (4) above). Two experiments were carried out. In the first experiment, which was based on Chien and Wexler’s study [67], the sentence frame in (5) was used.

(5) This is Mowgli, this is Baloo Bear. Is Mowgli tickling him/himself?

The second experiment used the subordinate sentence frame illustrated in (4) above. A crucial factor in the experiments was that for many, but not all of the sentence conditions, logical reasoning and lexical-semantic knowledge were sufficient to deduce the correct answer. For example, with only the knowledge that *self* or *himself* reflexively marks the predicate, a picture showing a non-reflexive action could be rejected. However, in a ‘Name–pronoun’ (match and mismatch) condition in Experiments 1 and 2 and in a ‘Name–reflexive syntax’ (mismatch) condition in Experiment 2, correct responses crucially required the syntactic knowledge characterised by Binding Principles. For example in the Name–reflexive syntax condition, a non-local antecedent (Mowgli in (4) above) was depicted carrying out a reflexive action. Thus, the picture correctly depicted a reflexive action but the non-local antecedent is ruled out by syntactic constraints, characterised by Binding Principle A (see [30] for further details).

**Results.** AZ showed a good use of lexical semantic knowledge such as semantic gender (male vs female), number and reflexive marking of the predicate, and scored at or close to ceiling when these cues could be used to guide his judgements. However, he showed a significant impairment in his ability to accept correct and reject incorrect referents for pronouns, and to reject incorrect referents for reflexives if the non-local antecedent was carrying out a reflexive action (see, Name–reflexive syntax condition, Experiment 2, van der Lely and Stollwerck [30]). AZ’s performance on these conditions did not differ from chance. Whilst young children under 4:0 years may also perform at chance when having to reject the incorrect local referent for pronouns [67] it is very rare for them to reject the correct antecedent. AZ’s performance on the Name–pronoun condition is not attributable to any lack of understanding of the task. As mentioned above, he performed at or close to ceiling when semantic-lexical knowledge was sufficient to determine reference for pronouns or reflexives, i.e. AZ scored 46 out of a possible 48 on sentences where syntactic knowledge was not crucial to determine the reference for pronouns and reflexives. Table 3, providing details of the Z-scores computed for AZ’s performance in Experiments 1 and 2, illustrates his extreme impairment in this task. AZ’s overall total score, across the 108 sentences in Experiment 1 and the 84 sentences in Experiment 2, is significantly below his expected score even when compared with his very poor morphological abilities. It can be seen from Table 3 that there is relatively little decrease in AZ’s Z-scores when the comparison is made in relation to his chronological age. This is because the oldest LA control children (aged 7:5–8:9) were performing close to ceiling. It is evident that AZ’s impairment is not merely due to his problems in forming and interpreting subordinate sentences as he shows a similar pattern of performance across Experiments 1 and 2. Where AZ’s Z-scores do not fall below the expected range of abilities (see Table 3), this is attributable to the youngest control children also being at chance on these conditions. The
normal children’s errors in accepting local antecedents for pronouns in Experiment 1 may be attributed to the lack of an internal sentential antecedent as suggested by Koster [68]. This interpretation is confirmed by Experiment 2 which provided an alternative non-local sentential antecedent which significantly improved the normal children’s performance. In contrast, AZ continued to accept local antecedents for pronouns and his performance remained at chance. AZ’s apparent lack of knowledge of Principle B, which characterises the syntactic constraints determining pronominal reference, is strongly supported by his chance level of performance for the Name–pronoun match condition. Thus, AZ rejects correct antecedent referents for pronouns. The unusualness of this is reflected in his Z-scores for the Noun–pronoun (match) condition which range from -5.357 based on his morphology score to -6.1345 based on his chronological age. The probability of this occurring in the normal control population by chance is less than one in a million. Furthermore, it should be noted that AZ is not alone in the Grammatical SLI population in making errors on the Name–pronoun match condition [30].

In conclusion, these experiments which were specifically designed to test AZ’s knowledge of syntactic dependent structural relationships, on the crucial test items AZ showed that he lacked the syntactic knowledge which is characterised by Binding Theory [46]. In addition, his performance was significantly impaired when compared with children half his age who were at a similar level of morphological development as measured on a standardised test.

To summarise: in spontaneous speech, elicitation and experimental language tests assessing a range of inflectional morphological and syntactic abilities, AZ shows a lack of mastery or knowledge of structures that are normally acquired by the age of 4–5 years of age or younger. These areas of language in which AZ fails are considered to be part of the innate language module [10, 19, 50].

3. Non-modular language abilities

This section on non-modular language abilities will be limited to aspects of pragmatics, such as pragmatic awareness, pragmatic inference, and verbal reasoning. These investigations were undertaken to see if AZ’s modular language impairment is a function of some other impairment which subsumes non-modular aspects of language. As with the previous experimental tasks, the tasks were also administered to 36 normal language ability control children. As more than one year had passed since AZ and the LA controls had originally been assessed they were reassessed on the standardised tests used for matching purpose (see Table 4)⁸. Some of the original LA controls were no longer available so suitable substitutes were found to complete the group.

One possible outcome of this set of investigations is that it may reveal that AZ’s performance on all language tasks is impaired in relation to his chronological age, although his performance on modular language task may be proportionally more impaired. In which case, AZ may show a significant impairment in relation to his chronological age on all tasks but an impairment on only the modular language tasks in relation to his language matched peers. Such a finding would conflict with a strong position with respect to the domain-specific, modularity claim for the acquisition aspect of language. In order to control and explore this possibility a further group of 12 chronological age and non-verbal ability controls (CA controls) were selected who provided an age matched control group. The block design sub-test from the BAS [57] and the TROG [59] provided standardised measurements to estimate non-verbal and language abilities of the CA controls. Table 4 provides a summary of the details of the CA control and LA control groups which participated in these investigations.
Table 4. Subject detail: phase 2. Chronological ages and raw scores from the standardised tests used for matching purposes

<table>
<thead>
<tr>
<th>Subjects</th>
<th>AZ</th>
<th>LA1 controls (N=12)</th>
<th>LA2 controls (N=12)</th>
<th>LA3 controls (N=12)</th>
<th>CA controls (N=12)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Raw score (Z-s)</td>
<td>Mean (S.D.)</td>
<td>Mean (S.D.)</td>
<td>Mean (S.D.)</td>
<td>Mean (S.D.)</td>
</tr>
<tr>
<td>Chronological age</td>
<td>12:03</td>
<td>7.7 (0:3)</td>
<td>8.5 (0:3)</td>
<td>9.6 (0:4)</td>
<td>13:1 (1:1)</td>
</tr>
<tr>
<td>Range</td>
<td>7:3–7:11</td>
<td>8:0–8:11</td>
<td>9:0–10:0</td>
<td>11:4–14:9</td>
<td></td>
</tr>
<tr>
<td>GC-ITPA</td>
<td>24*</td>
<td>28.5 (2.24)</td>
<td>29.1 (2.64)</td>
<td>30.3 (2.49)</td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>25–32</td>
<td>24–32</td>
<td>25–33</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equivalent age</td>
<td>7:11</td>
<td>8:2–10:4</td>
<td>7:11–10:04</td>
<td>8:02–10:04</td>
<td></td>
</tr>
<tr>
<td>TROG</td>
<td>16 (-1:2)</td>
<td>14.9 (1.00)</td>
<td>17.0 (1.41)</td>
<td>17.6 (1.24)</td>
<td>18.00 (1.53)</td>
</tr>
<tr>
<td>Range</td>
<td>13–16</td>
<td>15–19</td>
<td>16–19</td>
<td>15–20</td>
<td></td>
</tr>
<tr>
<td>Equivalent age</td>
<td>9:0</td>
<td>6:0–9:0</td>
<td>8:0–11:0</td>
<td>9:0–11:0</td>
<td>8:0–&gt;11:0</td>
</tr>
<tr>
<td>BPVS</td>
<td>77 (-1.7)</td>
<td>72.8 (6.69)</td>
<td>81.2 (7.60)</td>
<td>92.8 (10.39)</td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>63–84</td>
<td>79–93</td>
<td>81–101</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equivalent age</td>
<td>8:4</td>
<td>6:09–9:02</td>
<td>8:01–10:03</td>
<td>8:04–11:02</td>
<td></td>
</tr>
<tr>
<td>TWF</td>
<td>56 (&gt;2)</td>
<td>66.2 (4.47)</td>
<td>73.3 (4.14)</td>
<td>78.3 (3.77)</td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>58–69</td>
<td>67–79</td>
<td>74–86</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Block</td>
<td>16 (2.33)</td>
<td>6.25 (2.18)</td>
<td>10.35 (1.89)</td>
<td>11.25 (2.34)</td>
<td>12.58 (2.79)</td>
</tr>
</tbody>
</table>


3.1. Pragmatic awareness test. The first assessment of AZ’s pragmatic abilities involved the detection of utterances that violated conversational maxims [69] or in Sperber and Wilson’s terms [53], utterances that failed to achieve ‘‘Relevance’’. Five conversational maxims were investigated, i.e. avoid redundancy, be informative, truthful, relevant and polite (see [45] for full details of this study). Twenty-five short conversational exchanges were staged and tape recorded by three speakers. In each episode one of the speakers asked a question and the other two (one male and one female) gave a short answer (e.g. see (6) below). One of the answers violated a conversational maxim.

(6) Second Maxim of Quantity (Avoid Redundant information)
Speaker 1, Lucy: What did you have for breakfast?
Speaker 2, Tom: I had cornflakes, then a boiled egg on toast.
Speaker 3, Jane: *A hard boiled egg, cooked in hot water in a saucepan.

The subject was asked to point to either a male or female doll who said the silly utterance.

AZ correctly identified all (100%) of the utterances which violated the conversational maxims or relevance. A small group of eight younger normally-developing children (age 6:7) who were matched on language abilities as assessed by the Test of reception of Grammar (TROG) [59] also participated in this task. The normal control children had a mean correct score of 86% (10 S.D.) [45]. Thus, AZ is scoring approximately 1.4 S.D. above his language (TROG) matched peers.

3.2. Pragmatic inference. Based on Smith and Tsimpi’s [10] test of conversational inferences, a further task was administered to investigate AZ’s ability to make conversational
inferences. This task was also administered to the 36 LA control children and 12 CA control subjects.

The subjects were presented with 50 mini dialogues, staged and recorded by three speakers. Each mini dialogue involved a two-utterance spoken dialogue which was followed by a probe question. A yes/no answer was required from the subject. To answer the question, a logical inference had to be made which required either: (i) an implicated assumption; (ii) an implicated conclusion; (iii) modus ponens (if P then Q, P therefore Q); or (iv) Modus tollendo ponens (either P or Q, not P therefore Q). A further set of control dialogues was administered in which no inference was required. An example of one of the dialogues can be found in (7) below and Appendix C provides an example of each of the different types of logical inference tested.

(7) Implicated Assumption.
  Sam: Mary, have you ever flown in a helicopter?
  Mary: I've never flown.
  Probe: Do you think Mary has been in a helicopter?

The dialogues were balanced for yes/no correct responses and were randomised for presentation.

AZ achieved 86% correct responses, indicating that he could generally make the required inference to complete the task. Both AZ and the younger LA control children showed some difficulties with the dialogues involving Modus tollendo ponens. AZ scored 7 out of 10 correct (his lowest score on any condition). The syntactic structure of these dialogues was more complex and involved understanding 'either–or' relations:

  e.g. Mary: Either the burglar couldn't break the lock or he got scared of the alarm.
  Sam: Burglars don't get scared.
  Probe: Do you think the Burglar could break the lock?

Thus, the younger children and AZ’s poorer performance on this set of sentences may at least partly, be explained by the syntactic complexity of the dialogues and the general level of language abilities of the children. Support is provided for this interpretation by the Z-scores, computed for AZ’s overall correct performance in relation to his chronological age and language abilities (see Table 5). AZ’s Z-scores indicated that in relation to his vocabulary and morphological abilities, his performance on this pragmatic task is slightly above the expected level. In contrast, in relation to his chronological age his performance is slightly below the expected level. However, his performance still falls within the normal limits for his chronological age.

3.3. Verbal analogy test. This task investigated AZ’s ability to use verbal logical reasoning. The procedure consisted of a sentence completion task which was based on the classical A:B::C:D analogy (i.e. A is to B as C is to D). The analogies were based on five different criteria: habitat, opposites, hyponymy, function and grammar (see (8) below).

(8) Grammar: Rush is to rushing as bite is to ________

<table>
<thead>
<tr>
<th>Table 5. Z-scores for AZ for the tests of pragmatic inference and verbal analogy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age related Z-score</td>
</tr>
<tr>
<td>---------------------</td>
</tr>
<tr>
<td>Pragmatic inference</td>
</tr>
<tr>
<td>Verbal analogy</td>
</tr>
</tbody>
</table>
Five test sentences were constructed for each type of analogy. An example of one sentence for each of the analogies can be found in Appendix D. The task was administered to AZ, the 36 LA and 12 CA control children.

AZ produced 80% correct responses. His worst performance (60% correct) was for the analogies involving hyponymy, in which he made two errors. It is interesting to note that AZ was able to correctly complete the grammatical analogies involving, for example tense marking (cry is to cried, as jump is to ____), even though he may omit such morphemes in his speech. Moreover, in the morphological past tense elicitation task (reported above) AZ was virtually unable to mark verbs (real or novel) using the same inflection when the cue for doing so was syntactic tense agreement.

AZ’s Z-scores for his overall correct responses (see Table 5) revealed that he was performing above average at around the 65th percentile in relation to his language abilities. He was performing almost at exactly the expected level in relation to his chronological age (48th percentile).

To summarise: on all the tasks involving pragmatic abilities and verbal reasoning AZ performed within normal limits not only in relation to his language abilities but also in relation to his chronological age. Thus, the data indicate that AZ’s language impairment does not affect non-modal, pragmatic aspects of language representation or processing as assessed by these investigations.

4. Non-verbal cognitive abilities

On standardised non-verbal tasks AZ scores in the top 10% or above in relation to his chronological age. For example, he obtained an IQ of 119 (Z = +1.26) based on the British Ability Scales (BAS) visual performance tests. On the Block design, a sub-test of the BAS which was administered to AZ and all the CA control children (to provide an estimate of their non-verbal IQ) he scored in the top 1% for his age (Z = 2.33, equivalent IQ = 135).

Investigations were also carried out into AZ’s ‘Theory of Mind’ (TOM) [71], i.e. his ability to take another person’s perspective which is different from his own. The standard ‘Sally-Anne’ false belief story (first order belief attribution [72]) was administered. In this task, objects change location unseen by the central character (see [71]). The task tests the subject’s ability to manipulate two levels of representations. The ‘Ice cream van task’ [72, 73] was used to investigate second order belief attribution. In this task a further level of representation is required in order to attribute the false belief to one of three characters. First order belief attribution is normally acquired by 4–5 years of age, and second order belief attribution by around 6 years of age [73]. The linguistic demands of the tasks were simplified by presenting shorter but more sentences, avoiding complex subordinate or embedded sentences which may have caused AZ to fail the task.

AZ did not show any difficulties with attributing the appropriate first or second order false beliefs to the characters in the stories. Thus, AZ does not appear to have a ‘theory of mind’ problem which has been found in Autistic [71] and deaf children [74].

Despite AZ’s evident high abilities in non-verbal cognitive tasks it is possible that if he was tested on tasks which tap similar underlying processes or have similar processing demands as the linguistic tasks in which he was failing we would find subtle deficits in his performance. Therefore, to investigate this possibility, two tests were administered which aimed to tap similar processes or have comparable processing demands to the language tasks in which AZ was failing. To do this, 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 [75] 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 in another structure. This may be seen as analogous to naming an object. The second level of mapping described in 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 A is bigger than B, and B is bigger than C, it can be inferred that A must be bigger than C. Crucially, at least two binary relations must be compared. In language, subject–verb agreement (e.g. He jumps) which involves both the structural syntactic system (e.g. Subject NP, V) and the lexical features of the noun phrase (e.g. third-person singular) may be taken as a form of system mapping.

Thus, the linguistic deficit in Grammatical SLI children such as AZ may be reformulated as a systems mapping deficit. It should be noted that language processing is not specific to one particular modality (e.g. the auditory system). Syntax, morphology and phonology is as rich in the visual language system, such as American sign language, as it is in the auditory system (for example, see van der Hulst [76] for acquisition evidence of the phonology of handshapes). Therefore, if AZ’s linguistic impairment is due to a malfunction of mechanism(s) and/or representations which are particularly suited to language and ‘language-like tasks’, tasks which require similar processing or representational requirements may be impaired, regardless of the modality of presentation. To test if AZ had a deficit in system mapping, two tasks which required visual transitive inference were used: the Raven’s Progressive Matrices [77] and a computer generated visual transitive inference task which was specifically designed for this assessment.

4.2. Raven’s progressive matrices. This task is a standardised test in which the subject is shown a picture containing a set of geometric patterns. One section or item from the set is missing. The subject has to choose from a set of 6–8 possible sections or items the correct one to complete the pattern. At the more advanced levels the subject has to work out ‘rules’ from a vertical and horizontal 3 × 3 array of items to infer which is the correct missing item. The task was administered to AZ and all 48 control children.

Results. Based on the standardised scores provided by the test, AZ was performing at a level 1.56 S.D. (equivalent IQ = 123) above the expected level for his age which puts him in the top 6% of abilities on this test. Z-scores were also computer based on this study’s 48 control children (see Table 6). On the basis of AZ’s chronological age, his Z-score of 1.55 compares very favourably with the standardised scores provided by the test. This indicates that the control subjects in this study may be taken to be representative of the population generally. When AZ’s performance on the Raven’s matrices is evaluated in relation to his and the control children’s language scores he is clearly performing at a much higher level than his language peers (Z=4.81, BPVS; Z= 5.62, GC-ITPA) (see Table 6). Clearly, AZ’s performance on this test has not revealed any cognitive impairments.

4.2. Visual transitive inference: method. This task was based on Bryant and Trabasso’s study [78] of transitive inference. The task required each child to judge the relative size of five differently coloured bars which I shall label A (large) to E (small) presented on a portable
computer screen. 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 pairings occurred. The crucial combination was the BD combination since, firstly, this combination was a novel combination, and secondly, the B and D bars were both bigger and smaller in other combinations. Thus, a simple element mapping strategy, such as labelling a bar the bigger or smaller, could not be used.

**Procedure**

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 randomised 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 was presented. In the second teaching phase, presentation of the adjacent pairs of bars was randomised. Therefore bars BC could be presented first, followed by DE, followed by AB etc. In the experimental phase each of the 10 possible pairs (i.e. previously learnt adjacent and novel non-adjacent pairs) was 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.

**Results**

AZ correctly identified the relative sizes of the majority of the pairs of bars (37/40, 92.5% correct). It can be seen from Table 6, showing the Z-scores for this task, that AZ’s accuracy was above both his LA ability and CA peers. Moreover, he produced 100% correct for the novel BD combination. However, processing hypotheses put forward to account for SLI have proposed that it is the speed of processing which underlies their impairment [79]. Therefore, we might have expected that AZ would be slower at this task.

It is evident from AZ’s Z-scores based on his overall reaction times (Table 6) that he is performing within a normal range based on the performance of the 48 control children. In relation to AZ’s chronological age he performed above average, but in relation to his language abilities below average. The results for the BD combination indicate that AZ was responding at the expected level in relation to his chronological age (Z = 0.16), but faster than the expected response in relation to his language scores (e.g. Z = 1.20, BPVS) (see Table 6). It is interesting that the older CA control children’s overall reaction times were slower than the younger children’s [41]. However, for the BD combination which required transitive inference the older children were faster than the younger children. Thus, it appears that when a simple mapping
process may be used, such as labelling bar A the biggest, the younger children are as fast or faster than the older children. In contrast, when a more complex mapping process is required (transitive inference) the older children have the advantage over the younger LA control children. Moreover, AZ was not found to be impaired in the more complex mapping process in comparison with these older CA control children.

4.3. Summary. The results of the investigations into AZ’s non-linguistic cognitive abilities have not revealed any deficits. This was so whether AZ’s abilities were tested by standardised performance scales (BAS) or tasks selected or designed to tap processing abilities which may underlie the linguistic tasks in which he is failing. Indeed, on many of these tasks AZ scored well above the expected level based on his chronological age as well as that expected for his language abilities.

Figure 1(a–c) illustrates AZ’s comparative performance across the various tests and tasks in relation to his chronological age [Fig. 1(a)], his single word vocabulary comprehension (BPVS) [Fig. 1(b)] and his general morphological abilities (GC-ITPA) [Fig. 1(c)]. Once again, caution is expressed in the interpretation of the age related scores for the modular language tasks as these Z-scores were based on only the 36 younger children (aged 5:4–8:9). It is clear from Fig. 1 that, regardless of the reference point for evaluating AZ’s performance, he displays severely impaired modular, morpho-syntactic language abilities, normal performance or well above average performance on tasks which fall outside the hypothesised language module, i.e. pragmatic language abilities and non-linguistic tasks.

DISCUSSION

One of the main aims of this study was to provide detailed empirical evidence of linguistic and non-linguistic abilities to enable evaluation of the hypothesised innate, domain-specific, and modularity of aspects of language. The study has attempted to meet this aim by providing an initial summary of the findings from the investigations of a Grammatical SLI boy, AZ. AZ was one of the subjects from a carefully selected homogenous group of 12 Grammatical SLI children. Clearly, this study is not an exhaustive characterisation of AZ, but it does cover a range of modular morpho-syntactic language abilities, language abilities outside this module and non-linguistic abilities which are needed to evaluate the modularity of language hypothesis.

The overall findings from this study indicate a dissociation between AZ’s modular language abilities, which were severely impaired, and his non-modular language abilities and non-linguistic abilities in which he showed normal or above average performance. However, if the hypothesis that AZ’s underlying deficit is restricted to a modular domain specific language impairment is to be pursued, then some aspects of AZ’s linguistic abilities require further discussion in the light of possible alternative explanations.

Processing capacity and auditory processing

A characteristic of AZ’s language, which is also typical of SLI children generally, is the apparent ‘optionality’ in his grammar. For example, AZ produces and judges sentences as grammatical with either the presence or absence of tense marking. On the surface, this may be seen as some form of auditory processing or a processing capacity impairment as has been suggested by Bishop [80]. However, there are several factors which are inconsistent with a processing explanation. First, AZ shows a similar and consistent impairment with aspects of linguistic knowledge, regardless of the task and the different processing demands of the tasks.
(a) AZ’s age related $z$-score.

(b) AZ’s vocabulary related $z$-score.

Fig 1 (a,b)—legend opposite.
(c) AZ’s general morphology related z-score.

Fig. 1. Summary of Z-scores computed for AZ in relation to: (a) his chronological age; (b) his standardised vocabulary scores (BPVS); (c) his standardised morphology score (GC-ITPA). Codes: L = Standardised language tests; M = morphological elicitation test of regular and irregular past tense; S = Syntactic tests; P = Pragmatic tests; C = standardised and experimental tests of non-linguistic cognitive abilities. L1 BPVS standardised score; L2 TROG standardised score; L3 GC-ITPA standardised score; M1 Real verbs, Total correct; M2 Regular verbs correct; M3 Irregular verbs correct; M4 Novel verbs: regular responses; M5 Novel verbs: irregular responses; S1 Test of active and passive sentences (TAPS): Total correct; S2 Syntactic Test of Pronominal and anaphoric reference (STOP); Experiment 1: Total correct; S3 (STOP); Experiment 1: Name-pronoun Match condition; S4 (STOP); Experiment 1: Name-pronoun Mismatch condition; S5 (STOP); Experiment 2: Total correct; S6 (STOP); Experiment 2: Name-pronoun Match condition; S7 (STOP); Experiment 2: Name-pronoun Mismatch condition; S8 (STOP); Experiment 2: Name-reflexive Syntax (Mismatch) condition; P1 Pragmatic inference test. Total correct; P2 Verbal analogy test. Total correct; C1 British Ability Scale (BAS): Non-verbal performance; C2 Block design sub-test from the BAS. Ability score; C3 Raven’s Progressive Matrices. Z-score; C4 Transitive Inference Test (TINT): Total correct; C5 TINT: Correct responses to BD pair; C6 TINT: Mean response time across conditions; C7 TINT: Mean response time for the BD pair.

For example, he shows a significant deficit in tense marking in (i) spontaneous speech, (ii) narratives, (iii) elicitation tasks, and (iv) a judgement task. Interestingly, in the investigation of the syntactic knowledge characterised by Binding Principles, AZ showed a similar pattern of performance when assessed in simple sentences (Experiment 1) and when subordinate sentences were used (Experiment 2) although the processing demands were increased in Experiment 2. Both experiments revealed that he could assign referents to pronouns and reflexives when semantic cues were available to guide him but he performed at chance when syntactic knowledge was crucially required to determine the referents.

There appears to be little support for the hypothesis that a specific auditory perceptual processing deficit as put forward by Leonard and colleagues [34, 81] can account for AZ’s linguistic performance. Contrary to the predictions of the Auditory perceptual deficit hypothesis [34], AZ’s linguistic impairment is not restricted to morphemes with low perceptual saliency as
illustrated by his deficits in argument structure and knowledge of syntactic dependent relationships such as those characterised by Binding Principles. In addition, there is no evidence at a surface auditory level that AZ does not perceive or process morphemes such as the third person agreement -s or the regular -ed marker. If this were the case, it would be unlikely that AZ would use such morphemes correctly when he did use them.

However, at first glance, AZ’s pattern of performance on the investigations of inflectional morphology may be thought to be inconsistent with a modular language deficit and to indicate a processing capacity limitation. For example, first, AZ shows some productivity of the regular past tense marker -ed, albeit very limited, such as occasional overgeneralisations. Secondly, based on data from ‘lesioning’ a network, Marchman [4] has suggested that SLI children’s greater impairment with regular past tense marking can be accounted for by a general reduction in processing capacity. At the beginning of the testing period AZ’s impairment was greater with regular than irregular verbs. However, two years later, based on an analysis of his spontaneous speech [63], his regular past tense marking showed a marked improvement and proportionally he made a similar number of regular and irregular past tense errors. Furthermore, AZ is impaired in irregular as well as regular past tense formation which does not require processing potentially non-salient morphemes.

Within both the single and dual mechanism models of the past tense [1–3, 5, 6], irregular forms are learnt in and retrieved from associative memory. For the single mechanism model, regular forms are also learnt in the same associative memory. In contrast, according to the dual mechanism view which assumes a modular component in the language system, regular past tense forms are computed by the application of a grammatical -ed suffixation rule to a verb stem [5]. Therefore, if AZ’s impairment is limited to modular grammatical language representations and/or mechanisms, his deficit should preclude a functional rule and regular past tense forms might be learned in the associative system alongside irregular forms. Thus, it could be expected that AZ should not show generalisation of: (i) the -ed suffixation rule to irregular and novel forms; and (ii) an impairment in irregular past tense formation, both of which are found. However, AZ’s past tense inflectional marking may be accounted for by his reliance on a single associative memory system whereas the normal children have both mechanisms available [44]. Within the associative memory system a certain level of ‘productivity’ has been found in both English [82] and Italian [83]. However, this productivity relies on phonological similarity and frequency of the verb forms. Thus, if AZ computed all past tense forms associatively we may expect some productivity of regular and irregular forms, based on the phonological and frequency characteristics of the verbs. Moreover, we may expect that productivity of the regular -ed would be greater than productivity of irregular forms because of the regular high type frequency and the broad range of ‘phonological space’ that regular forms cover. It is difficult to make any strong claims with respect to AZ’s productivity as evidence of productive forms are relatively rare. However, his few overregularisations in spontaneous speech and elicited contexts indicate that when he does use regular -ed productively (e.g. hanged) it is only with verbs which are phonologically similar to other regular past tense verbs (cf. banged) or to the phonological forms of other words not marked for the past tense (e.g. sheel–sheeld, cf. shield). It should be noted that the normal control children in this study, in contrast to AZ and the overall group of Grammatical SLI children, showed a strong regularity advantage in their production of regular over irregular real verbs and a preference for using regular past tense marking for novel verbs in past tense contexts, which was not related to phonological characteristics or frequency of the verbs [44].

It is interesting to compare AZ’s performance with Marchman’s [4] normal and lesioned
connectionist networks trained to learn the regular and irregular past tense mapping. Both AZ
and the simulations using lesioned networks show impaired performance with regular and
irregular verbs with a greater impairment with regular verbs, particularly in the earlier stages of
learning. However, Marchman’s [4] “normal” network does not resemble the pattern of perfor-
mance found for normally developing children [40, 44]. Normally developing children were
found to be better at producing regular than irregular verbs whereas Marchman’s simulation
shows that irregular forms were learnt quicker than regular forms. Thus, Marchman’s single
mechanism model [4] shows some interesting similarities to AZ and the other Grammatical SLI
children’s performance but not to normally developing children’s performance.

It can also be noted that AZ’s impaired pattern of regular and irregular past tense marking is
similar to the findings reported for the KE family [20]. That is, the subjects show an impairment
in both regular and irregular past tense marking and overgeneralise the regular ‘rule’ to some
irregular forms.

AZ’s impairment with irregular past tense marking can be accounted for by the interaction
of his syntactic and morphological impairment. His impairments in syntactic tense marking is
consistent with other features of his syntactic deficit, such as problems with forming embedded
phrases, clauses or subordinate structures, problems in assigning thematic roles, and assigning
referents to pronouns and reflexives which are syntactically determined.

Non-linguistic cognitive functioning

It is difficult to imagine what type of more general cognitive impairment, or even ‘specific
impairment’ which suberves language and certain aspects of non-linguistic cognition, could
account for the data reported in this study, which show a clear dissociation between modular
language and non-modular language9 and non-linguistic performance on a broad range of tasks.
If AZ suffered from a more general speed of processing deficit, as hypothesised by Tallal et al.
[79], it would be predicted that this should primarily affect his phonological and inflectional
morphological development as well as performance on non-linguistic tasks. However, as the
data above show there is no evidence that his impairment reflects such a deficit within linguistic
and non-linguistic cognitive functioning.

It is also of note that no general impairment in cognitive functioning is evident for AZ. Thus,
the implication made by Elman et al. [18] that SLI in children is part of a more diffuse
impairment in cognitive functioning is not generalisable to all SLI children. The findings from
this study for AZ may be contrasted with the family with SLI studied by Gopnik and colleagues
[15] and Vargha-Khadem et al. [20] for whom performance IQs for the language impaired
family members are reported to be on average 18–19 IQ points below the non-affected members.
However, some, though clearly not all, of the affected members of the KE family, like AZ,
performed above average on IQ tasks. Unfortunately, Vargha-Khadem et al. [20] do not provide
details as to whether the subjects with high or low IQ differ in their language profiles.

Another possible explanation which may be raised to account for AZ’s performance is that
his language is merely severely delayed, whereas his more general cognitive abilities are not. If
this was so, he should have shown a similar pattern of language development to younger
children developing normally. Figure 1(a–c) illustrates that this is not so. In some areas of
language, e.g. in making pragmatic inferences, which were defined a priori as falling outside
the modular language capacity, AZ performs within the normal range of abilities for his
chronological age. In addition, when his performance is compared with language matched
children who are half his age, he displays islands of impairments and a lack of linguistic
knowledge which is normally acquired by children of 4 or so years of age. This results in
qualitative differences in AZ's and the normal children's overall language performance.

Inevitably, questions will always be posed to the effect: 'What if investigations had been undertaken into other non-modular cognitive abilities from those reported in this study?' The potential for further investigations is great, but without the theoretical motivation of the cognitive ability under investigation being able to account for AZ's pattern of linguistic and non-linguistic performance they are unmotivated.

The underlying nature of SLI

A parsimonious explanation for the optionality of inflectional marking and syntactic structures, and the range of deficits found in the data for AZ, is that he is unable to build complex syntactic dependent relationships between constituents—the Representational Deficit for Dependent Relationships (RDDR) hypothesis—as proposed by van der Lely and Stollwerck [30]. An example of one possible manifestation of this hypothesised deficit is that the Wh questions would form an adjunct to the following complement (see (3) above and discussion there about). Therefore, the correct syntactic relationship between the question and the following complement would not be made. It can be noted that the input provides evidence of matrix infinitivals in adult language (e.g. Oh, to be in London!) and in questions, sequences such as John go occur (e.g. Where did John go?). Note, neither tense or agreement is marked on the lexical verb (go) in the Wh context. Thus, on this input evidence and in the absence of building complex dependencies between constituents [84] the contexts in which infinitivals (unmarked verb forms) occur would not be restricted.

The RDDR hypothesis implies that one manifestation of AZ's innate modular impairment is that he, like other Grammatical SLI children, lacks aspects of syntactic 'knowledge', i.e. the ability to form complex dependencies in structural representations. I propose that the RDDR hypothesis can account for AZ's production and acceptance of infinitivals in past tense context sentences, and his omission of agreement features on verbs. The ability to form a complex dependent structural representation is needed if the structural constraints determining coreference are to be applied to the appropriate lexical items (i.e. pronouns and anaphors) and to facilitate interpretation of sentences when semantic or pragmatic cues are insufficient for full interpretation. Thus, the RDDR proposal may also account for AZ's problems with assigning thematic roles in sentences and with assigning coreference to pronouns and anaphors.

One manifestation of AZ's deficit may be that during acquisition, in contrast to normal children, he does not 'look for' complex dependent relationships between syntactic positions within the speech stream, such as non-adjacent subject-verb agreement relationships or more abstract hypothesised relationships between functional categories such as Comp (Complementizer) and the verb or pronoun [46] which are needed to embed tense and pronouns in complex structures (see Enc [85] and Partee [86]). AZ's language does not indicate that he lacks the presentations of the functional categories themselves, or elementary local dependent relationships, but it does indicate that he is unable to represent complex syntactic relationships between elements as characterised by the RDDR hypothesis [30]. However, this deficit would not prohibit AZ from building complex representations based on semantic relationships between words. Thus, with time, the semantic properties of morphemes may develop. For example, AZ appears to explicitly 'know' that -ed is a marker for 'past time', but I would question whether he implicitly 'knows' that it is an affix marking syntactic tense, even though children of around 3½ appear to have this implicit knowledge, and thus, obligatorily mark tense in matrix sentences.

It should be noted that I am not claiming that this syntactic impairment will be the only
manifestation of AZ’s modular language impairment. The extent and generalisability of this hypothesis to other aspects of language within this module, such as phonology, is certainly feasible but has yet to be explored.

Innateness, in the light of AZ

In this final section I will address some of the issues which are particularly relevant to the findings from this study which have been raised by Elman et al. [18]. In particular, I will focus on the implications that Elman et al. draw from the findings from SLI subjects for the innateness of language.

First, Elman et al. [18] do not dispute the genetic inheritance of SLI, but they question the domain specificity of the disorder. It would appear that the data from AZ directly challenge this position. The evidence above indicates that the root of AZ’s disorder affects ‘Grammar’ (syntax, inflectional morphology and potentially phonology), of which aspects of syntax and inflectional morphology have been investigated. Furthermore, his language impairment appears to be independent from his general learning and cognitive abilities. Thus, contrary to the implications that Elman et al. draw, largely from data from the KE family [20], learning difficulties and impaired cognitive abilities are not a general feature of SLI.

Whilst studies of normal language acquisition may provide a valuable source of evidence for developmental stages, innate domain-specific and modular abilities and abilities outside a particular module may appear to be inextricably inter-correlated in the normally developing child. However, as the data from AZ indicate this may not be so in children with SLI. The discreteness of AZ’s impairment indicates that his impairment is a highly domain-specific grammatical deficit. This finding is consistent with representational nativism and/or dedicated architecture or timing constraints. Distinguishing between whether AZ’s language deficit results from impaired constraints at one or more of the levels or with the interaction between these levels as proposed by Elman et al. [18] (i.e. representational, architectural or timing levels) falls outside the scope of this paper. However, the data indicate that the genetic effect impairing AZ’s cognitive modular language abilities is restricted to within the domain of grammar.

However, whilst I wish to claim that AZ’s underlying impairment is a modular, domain-specific impairment, some of the secondary effects of the disorder may not necessarily be either domain specific or modular. For example, the development of the lexicon may be seen as the result of an interactive process to which both the ‘products’ of modular and non-modular processes may contribute. Language learning processes may be intrinsically tied to grammatical knowledge; for example, ‘reverse linking’ [87] (more commonly referred to as syntactic bootstrapping, Gleitman [88]) in which the child may use structural syntactic knowledge of the overall sentence (e.g. Subject, Object) to infer the thematic roles (e.g. Agent, Theme) of the arguments of predicates. Reverse linking may be used by children to facilitate and/or refine the semantic representation of lexical items [88, 89]. Thus, not surprisingly, as SLI children have problems with representing structural syntactic knowledge, they have been found to be significantly impaired in reverse linking [35]. Furthermore, SLI children, including AZ, do indeed have delayed development of vocabulary–lexical knowledge as illustrated by the standardised tests used in this study. It is likely that the hypothesised modular language deficit underlying SLI will differentially affect certain aspects of lexical development, such as knowledge of the syntactic sub-categorisation features, or the semantic specification of later acquired abstract words. Further investigations are needed to explore the lexical representations of SLI children.
Finally, when evaluating the data from AZ, it should be kept in mind that AZ has been subject to an intensive remediation programme over many years for his language difficulties. Therefore, it cannot be assumed that the appearance of a surface form long after the normal acquisition time frame, such as his use of the regular past tense inflection, was acquired or learnt via the same ‘mechanisms’ as in the normally developing child. Further investigations are currently being undertaken to try to provide further insight into this issue.

**Conclusion**

This study has provided evidence of a boy with a significant morpho-grammatical deficit in the absence of pragmatic or non-linguistic cognitive impairment. Whilst this study has focused on morphological and syntactic modular language abilities, I do not discount the possibility that AZ’s deficit may extend to phonological representations. Such a deficit is not obviously apparent but may be revealed with thorough investigation of AZ’s phonological abilities.

The findings from this study may be contrasted with those from subjects who suffer from general cognitive impairments but display good grammatical and morphological knowledge, such as subjects with Williams syndrome [8], Christopher [10] and DH [11]. Double dissociations between modular language abilities (as defined in this paper) and cognitive abilities are evident between AZ and, for example, Williams syndrome children. For example, AZ’s high level of performance in non-linguistic tasks, his virtual inability to use the regular past tense marker productively, and his apparent lack of the syntactic knowledge characterised by Binding theory, may be contrasted with Williams syndrome children, who display considerable impairments in cognitive functioning [8] but a good use of regular past tense marking on real and novel verbs and have good syntactic knowledge of Binding Principles (Malmaz and Clahsen, personal communication; Pinker [9]). In the light of these findings, the dissociation between AZ’s modular linguistic abilities and his language and cognitive abilities which fall outside this module provides strong empirical evidence to support the hypothesised innate basis to modular and domain-specific aspects of human language. Continuing investigations are being undertaken to explore the extent of AZ’s linguistic deficit within the modular language domain to help define further the innate language endowment.

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**NOTES**

1 However, see Studdert-Kennedy & Mody (1995) for a critical review of this hypothesis. They provide arguments for why the finding of difficulties in sequencing rapidly presented material such as /ba, da/ can be explained by a specifically linguistic deficit in phonological feature discrimination.

2 See Smith & Tsimpli (1995) for an interesting investigation with respect to trying to teach subjects a grammatical rule of tense in a novel language based on word position.

3 For the purposes of this paper, I shall refer to all aspects of language which fall outside the ‘grammar module’ (i.e. aspects of syntax, inflectional morphology, and phonology) as ‘non-modular aspects of language’. However, note, it may be that there are innate modules in other areas of language or non-linguistic abilities, but these are not considered in this paper.

4 Note, whilst these standardized tests primarily assess morpho-syntactic abilities they also tap other areas of linguistic
knowledge. Therefore, failure on these tests cannot necessarily be taken as evidence for failure of modular morphosyntactic abilities as defined in this paper.

A "Z-score" takes information about the population mean and standard deviation (SD) and uses this information to produce a single numerical value that specifies the location of any raw score within any distribution. The sign (+/-) tells you whether the score is above or below the mean and the number tells you the distance between the subject's score and the mean in terms of standard deviations. If it is a normal distribution, 68% of the population fall within +/-1 SD, 90% within +/-1.64 SD, 95.44% within +/-2 SD, and 99.74% between +/-3 SD. The further a subject's Z-score differs from the population mean (the bigger the Z-score) the greater the likelihood he does not come from the normal population.

This percentage includes both the adjective and verbal passive responses to the ambiguous sentences.

Regression analysis was also carried out to compute a Z-score based on the TROG. The Z-scores from this experiment and further experiments to be reported fell close to the BPVS or between the BPVS and GC-ITPA Z-scores. For the sake of brevity, therefore, they are not reported.

The NV-BAS test was substituted by the Adolescent Test of Word Finding (German, 1990) as AZ and the older LA controls had performed close to ceiling on the NV-BAS.

See footnote 3.

REFERENCES


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APPENDIX A

AZ’s performance on additional standardised language and non-verbal tests

<table>
<thead>
<tr>
<th>Chronological age</th>
<th>Language tests</th>
<th>Action Picture Test</th>
<th>BAS:IQ.</th>
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<tr>
<td></td>
<td></td>
<td>Info. (age)</td>
<td>Action Picture Test</td>
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<tr>
<td>A</td>
<td>10:03</td>
<td>42 (5:03)</td>
<td>13 (7:10)</td>
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</tbody>
</table>

Note: Action Picture Test/Bus Story: Info=information score; sub-clause=number of subordinate clauses; (age) =Equivalent age score. BAS=British Ability Scales.

APPENDIX B

Transcription of AZ’s narrative of the picture book Frog, Where Are You?

[The boy had a frog . . . and put it in the jar . . . but not a lid over it.]
[The dog was poking in [. . . where was it?]
[And the boy was happy.]
[The mother came up (inaudible) “Your bedtime now. . . . Your bedtime!” . . .]
[But he was in mumble night [. . . and the frog climb out]] [. . . and the next morning the boy was . . . sad]
[. . . because the frog was gone.]
[The boy was looking in it everywhere. . . looking inside the boots] [. . . and the dog . . . has lost the _ he got his head _ the jug _ he got a jar _ jug _ I mean a glass on his head.]
[And the boy was shouting: “Frog, frog!” . . .]
[And then the dog . . . slipped from the edge. . . and hit on the ground . . . outside] [. . . and the glass opened]
[. . . and . . . and the boy was very mad.]
The boy still called “Frog, frog!” [. . . and then he was shouting down a hole] [. . . and the dog was looking at these . . . bees] [going to a honey . . . cone.]
[And he got hurt by the little snail or mole.]
[And the dog still was walking about with this bee . . . thing (+) and the dog has broke the cone] [. . . and the boy was loo _ was on the tree and looking through a hole] [and a owl poke up . . . “Woo!” . . . and again the bees was after the dog] [. . . and the boy has run away . . . bit deep in the forest] [. . . and the owl was gone.]
[But the boy climb up the rock . . . and holds onto branches] [. . . but it wasn’t branches] [. . . it was a moose. A moose was running to the edge and stops.]
[And the boy was falling down including the dog.]
Down and down . . . splash!]
[Oh they got wet.]
[And the boy heared what the ribit sound and the boy said “Sh!” to the dog] [. . . and they poke over the log and they saw a male frog and a . . . his fre _ frog.]
[And the little frog came] [. . . well . . . the boy took one frog] [. . . and that’s what happened.]

APPENDIX C

Pragmatic inference test: examples of inference types

<table>
<thead>
<tr>
<th>Inference type</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implicated conclusion</td>
<td>Mary said: Can you tell me the time, Sam?</td>
</tr>
<tr>
<td></td>
<td>Sam said: I haven’t got my watch on.</td>
</tr>
<tr>
<td></td>
<td>Probe: Do you think Sam could tell Mary the time?</td>
</tr>
<tr>
<td>Implicated assumption</td>
<td>Sam asked: Mary, have you ever been in a helicopter?</td>
</tr>
<tr>
<td></td>
<td>Mary said: I have never flown.</td>
</tr>
<tr>
<td></td>
<td>Probe: Do you think Mary has been in a helicopter?</td>
</tr>
</tbody>
</table>
Modus ponens: if P then Q; P therefore Q

Mary said: *If the clock is right, the teacher is late.*
Sam said: *The clock is right.*
Probe: *Do you think the teacher is late?*

Modus tollendo ponens: either P or Q, not P therefore Q.

Sam said: *It is either raining or snowing outside.*
Mary said: *It isn’t raining.*
Probe: *Do you think it's snowing outside?*

Control
Sam said: *Would you like to have some wine?*
Mary said: *No thank you, I am driving.*
Probe: *Do you think Mary accepted the wine?*

**APPENDIX D**

*Verbal analogy test: examples of experimental sentences*

<table>
<thead>
<tr>
<th>Analogy condition</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Habitat</td>
<td>Doctor is to hospital as teacher is to?</td>
</tr>
<tr>
<td>Opposites</td>
<td>Easy is to difficult as rich is to?</td>
</tr>
<tr>
<td>Hyponymy</td>
<td>Kipper is to fish as cheddar is to?</td>
</tr>
<tr>
<td>Function</td>
<td>Pen is to writing and scissors are to?</td>
</tr>
<tr>
<td>Grammar</td>
<td>Book is to books as cup is to?</td>
</tr>
</tbody>
</table>