

The role of performance limitations in the acquisition of verb-argument structure: an alternative account*

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ABSTRACT

This study investigates the role of performance limitations in children's early acquisition of verb-argument structure. Valian (1991) claims that intransitive frames are easier for children to produce early in development than transitive frames because they do not require a direct object argument. Children who understand this distinction are expected to produce a lower proportion of transitive verb utterances early in development in comparison with later stages of development and to omit direct objects much more frequently with mixed verbs (where direct objects are optional) than with transitive verbs. To test these claims, data from nine children aged between 1;10.7 and 2;0.25 matched with Valian's subjects on MLU were examined. When analysed in terms of abstract syntactic structures Valian's findings are supported. However, a detailed lexical analysis of the data suggests that the children were not selecting argument structure on the basis of syntactic complexity.

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Instead, a clear predictor of the frames used by the children with specific verbs was the frames used by the children's mothers with those same verbs, regardless of whether they were transitive or intransitive. This suggests that the most important determinant of the children's use of verb frame was the specific patterns of verb use in the input rather than abstract grammatical knowledge constrained by performance limitations. The implications of these findings for performance-based explanations for children's early errors and early patterns of language use are discussed.

INTRODUCTION

Children do not produce adult-like utterances from the very beginning of multi-word speech. For example, children learning English have a tendency to omit subjects where they are grammatically required and initially use fewer inflected forms of verbs and nouns and fewer auxiliaries than their adult models. However, many current theories of language development assume that despite the fact that children's early utterances are clearly not adult-like and lack many components of grammatical speech, children are operating with an abstract knowledge of grammatical categories (Pinker, 1984, 1989; Hyams, 1986; Valian, 1986, 1991; Radford, 1990; Wexler, 1994, 1996). Thus, nativist theories of language development typically rely, to some extent, on the notion of performance limitations to explain the primitive appearance of early child speech whilst claiming that children operate with a complex and abstract grammar.

For example, Pinker (1996 '2nd edn': 160) describes early language production in terms of a 'processing bottleneck' in order to explain the incomplete nature of children's early utterances and invokes similar principles to explain overtensing errors (e.g. *Does it rolls?*). Thus, he proposes a specific performance limitation, namely children's limited memory capacity which governs their ability to realize sentence constituents overtly and apply grammatical rules appropriately. By contrast, Bloom, Miller & Hood (1975) examined a wide range of possible production limitations and concluded that whether all sentence constituents forming a productive schema for the child (e.g. subject-verb-complement) are overtly realized depends on many different performance factors. The difficulty, however, with this latter type of approach is that it becomes relatively easy to find 'evidence' that children operate with some kind of abstract grammatical knowledge since so many factors are assumed to influence whether their underlying knowledge is overtly realized. Another common approach to early errors is to claim that those errors which are not predicted by particular grammatical accounts (e.g. Wexler's (1996) OPTIONAL INFINITIVE HYPOTHESIS; Hyams' (1986) null subject phenomenon) are so infrequent that they cannot possibly represent a

lack of grammatical knowledge (Hyams, 1986; Wexler, 1996) and must therefore be due to (usually unspecified) performance limitations. A problem common to all of these accounts is that they fail to provide a clear definition of 'performance errors' or determine a principled way in which errors can be predicted rather than explained in an *ad hoc* manner (although see Bloom, 1990; Gerken, 1991).

Given the apparently inconsistent application of grammatical knowledge seen in children's early utterances, if performance limitations are to explain the primitive appearance of early speech, researchers whose theories depend upon such limitations must provide specific predictions concerning the nature of limitations and the ways in which they would be expected to affect children's early speech. Only when this level of theoretical detail is provided will performance limitations gain predictive power in terms of a theory of language acquisition. Although it is likely that performance limitations do affect children's early language production, it is the *ad hoc* nature of performance-based explanations of children's errors which renders them empirically untestable. Furthermore, children's errors can be explained in other ways which cannot be distinguished empirically from performance-limited production mechanisms e.g. low-scope lexical learning (Pine, Lieven & Rowland, 1998; Rubino & Pine, 1998) or performance-limited LEARNING whereby long or complex utterances may initially be beyond the capacity of the child's learning mechanism.

Valian (1991) is one of only a small number of researchers who attempt to derive precise predictions regarding the ways children's language might be affected by early production limitations. She assumes that the child, from the start of language development, has a full model of adult grammar and must simply establish the precise lexical items which map onto each adult grammatical category. She explains the pattern of early language use in terms of full competence read through performance limitations which affect the child's ability to produce long and complex utterances early in development. These limitations, she claims, affect both children's ability to acquire verb-argument structure and to produce a wide range of grammatical constituents e.g. auxiliaries, subjects, (see also Bloom, 1990; Gerken, 1991; Valian, Hoeffner & Aubry, 1996 although also see Hyams & Wexler, 1993 for arguments against processing accounts of subject omission).

The focus of the current paper is Valian's account of early argument structure acquisition. She aims to provide an explanation for children's early use of argument structure in terms of the length of utterance that a child, at any one point in development, is able to produce, as utterance length is clearly determined by factors beyond the domain of language such as memory capacity and the child's ability to efficiently encode and convey complex information (Olson, 1973). If, as Valian assumes, children are equipped with an abstract knowledge of grammar, they are expected to avoid

producing utterances which they ‘know’ to be ungrammatical. For example, children who understand that the verb *hit* is transitive should avoid producing this verb without a direct object argument because direct object arguments are obligatory with pure transitive verbs. Similarly, children who understand that the verb *fall* is intransitive should not produce direct object arguments with this verb based on their knowledge that intransitive verbs do not take direct object arguments. Based on the assumption that children operate from the beginnings of language development with an abstract grammar of this nature but are constrained in language production by performance limitations, Valian derives a series of predictions concerning the nature of children’s early use of verb-argument structure.

Valian’s predictions

Use of verb frame. All verb utterances can, broadly-speaking, be divided into three categories: pure transitive, pure intransitive and mixed. Transitive verbs (e.g. *want*) take obligatory direct object arguments, intransitive verbs (e.g. *fall*) are not permitted to take direct object arguments whilst mixed verbs (e.g. *eat*) may take an optional direct object argument but are not required to do so.

Transitive	*I want	I want a drink
Intransitive	I’m sneezing	*I’m sneezing my nose
Mixed	I’m eating	I’m eating an apple

Valian assumes that children are able to distinguish between different verb types at an abstract level and therefore predicts that young children will produce a greater proportion of intransitive verb utterances than children who are more advanced in their language development. This is because intransitive verbs do not require a direct object argument and thus are shorter and demand less processing power than transitive utterances:

‘...one way the beginning speaker can lighten the burden of producing objects for verbs is to produce more verbs that do not require objects.’
(Valian, 1991: 70)

The accompanying claim is that children will avoid producing what they ‘know’ to be ungrammatical utterances, for example, transitive verbs with an omitted direct object argument. Over time, as processing restrictions decrease, children are expected to show a proportional increase in their use of transitive verbs.

Direct object provision. Valian’s second prediction concerns children’s provision of direct object arguments with the three groups of verbs. Thus, children are assumed to ‘know’ that direct objects are obligatory with

transitive verbs and therefore, they are expected to produce a high proportion of direct object arguments with this group of verbs. In contrast, mixed verbs take optional direct object arguments. Valian claims that children are able to identify which verbs are 'mixed' from the use of these verbs in the input. Since producing an utterance without a direct object argument requires less processing capacity than producing a direct object, children are initially expected to produce a lower proportion of direct object arguments with mixed verbs than with pure transitive verbs. However, as performance limitations decrease over time, Valian predicts that children's production of optional direct objects with mixed verbs will increase.

Before examining Valian's evidence, it is necessary to explore exactly what is implied by the claim that children understand in an abstract sense the difference between transitive and intransitive verb frames. Clearly, if children are able to identify direct object arguments in a general and abstract manner, one must assume that children have abstract representations of the transitive and intransitive verb frames, i.e. for English, Subject–Verb–Object and Subject–Verb word order.

However, there are two lines of evidence in the literature which suggest that children's early knowledge of language is not of such a general and abstract nature. Firstly, many naturalistic studies of early language development suggest that rather than generating their early utterances from an abstract knowledge of grammar, children's early knowledge of syntax is tied to individual lexical items with respect to auxiliaries (Kuczaj & Maratsos, 1983; Pine *et al.*, 1998); determiners (Pine & Martindale, 1996; Pine & Lieven, 1997); pronouns (Lieven, Pine & Baldwin, 1997); and verb morphology (Bloom, Lifter & Hafitz, 1980; Clark, 1996). More specifically, there is evidence to suggest that children's knowledge of verb–argument structure develops initially around individual verbs (Tomasello, 1992; Allen, 1998) and individual lexical frames (Braine, 1976; Lieven *et al.*, 1997). Such evidence suggests that children do not have a grammatical category of verb when they initially begin to use verbs, nor do they operate with abstract categories such as Subject or Direct Object. It is thus questionable whether children at the earliest stages of language development operate with abstract representations of the transitive and intransitive verb frames.

The second line of evidence concerning the nature of children's early knowledge of verb–argument structure comes from experimental work. If children have an abstract understanding of verb–argument structure as is suggested by Valian, they should understand the difference between the subject and object of a transitive verb and how to manipulate this knowledge through the use of word order. Typically, however, children taught nonsense verbs reproduce these verbs in the same syntactic frame that the experimenter used, showing no evidence that they are able to generalize knowledge of syntactic frame or even that they understand the role of word order (Olguin

& Tomasello, 1993; Akhtar & Tomasello, 1997; Tomasello, Akhtar, Dodson & Rekau, 1997). Although children tend to produce correct word order with familiar verbs (Bloom, 1970; Brown, 1973; Radford, 1990), their inability to generalize such knowledge to novel verbs suggests that word order may initially be learnt conservatively on a verb-by-verb basis rather than representing a more general Subject–Verb–Object word order pattern.

Thus, it is not clear that children's early verb combinations merit the complex and abstract explanation suggested by many researchers. However, if children are not operating with abstract syntactic knowledge, it is unclear what role performance limitations interacting with an abstract understanding of argument structure can play in early production. For example, if children do not have an abstract representation of the transitive verb frame, they cannot be expected to 'avoid' production of this frame for performance reasons.

Given these difficulties, the aim of this study is to replicate Valian's (1991) analysis of early verb use to establish firstly, whether the data merit the claim that children operate with an abstract understanding of verb–argument structure read through performance limitations and secondly, what other factors could account for the pattern of verb use observed.

Valian's subjects

To test her predictions, Valian examined approximately 90 minutes of natural language from twenty-one English-speaking children who were divided into groups based on their MLU. There were five children in group 1 (MLU $M = 1.77$; age range 1;10 to 2;2) and five children in group 2 (MLU $M = 2.49$; age range 2;3 to 2;8). Although there were two other groups of children, Valian found the most significant developments in terms of her predictions regarding early verb use to occur between groups 1 and 2, and thus only these stages are examined in the following analyses. The number of verb utterances per child ranged from 47 to 274.

Valian's method

To examine the children's use of verb frame, all verb utterances were divided into the three categories of transitive, intransitive and mixed and the proportional use of each group calculated for each MLU group. To examine the children's provision of direct object arguments, all utterances including copulas, the verbs *put* and *get*, and verbs taking sentential complements or adjunct phrases were excluded. Copulas do not take direct object arguments in the same way as other verbs, *put* takes two post-verbal arguments, and *get* is reported by Valian as difficult to categorize. Presumably, utterances containing complex complementation were excluded because one might expect them to be affected differently by performance limitations governing length of utterance.

Valian's results

Valian found that there was a proportional increase in the use of transitive verbs between group 1 and group 2 ($M = 45\%$ in group 1; $M = 59\%$ in group 2) providing evidence in support of her performance limitations account. Secondly, the children in groups 1 and 2 were fairly consistent in their production of direct objects with transitive verbs ($M = 93\%$) and produced few direct objects with intransitive verbs ($M = 4\%$ in group 1; $M = 8\%$ in group 2). In addition, the children's proportional use of direct objects with mixed verbs increased between groups 1 and 2 ($M = 49\%$ in group 1; $M = 66\%$ in group 2) which, she suggests, provides further support for her performance limitations account.

However, although Valian claims that the data support her performance limitations account of early verb-argument structure acquisition, the general nature of the analysis allows alternative explanations of the data. Firstly, she claims that children:

'... typically do not use a verb unless they know how it subcategorizes with respect to objects.' (Valian, 1991: 74)

The support for this claim comes from the fact that the children in her study made very few errors of producing a direct object argument with an intransitive verb or of omitting a direct object argument with a transitive verb. However, there is suggestion in the literature that direct object omission with transitive verbs may be relatively common at the earliest stages of development:

'When we examine the data presented in the published literature, however, we find... numerous examples of transitive verbs used without overt objects.' (Radford, 1990: 213-14 – see Radford, 1990: 213-17 for examples from children aged between 1;8 to 2;0).

Clearly, if children at early stages of development produce obligatory direct objects at a lower rate than that reported by Valian, the argument that children know about transitive verbs in an abstract sense seems problematic. It is possible that their knowledge may be lexically-specific and the rate of direct object provision related to the specific verb in question (Tomasello, 1992).

Secondly, Valian claims that the children 'know' the difference between mixed and transitive verbs:

'... they provide objects much more frequently for pure transitive than mixed verbs, indicating that they recognize the difference between when an object is obligatory and when optional.' (Valian, 1991: 74-5)

However, it is not clear that the children were using the same verb both with and without a direct object and therefore, they may not in fact have these groups separated with respect to the optionality of the direct object. It is possible that they learned some mixed verbs as intransitive verbs and others as transitive verbs. Furthermore, Valian assumes that children use parental input to determine a verb's argument structure but provides no evidence that 'mixed' verbs actually appeared in the input in both the transitive and intransitive frames. Thus, the use of the intransitive frame with mixed verbs in the children's language may simply reflect use of this frame in the input. Moreover, rather than using parental input to establish in an abstract sense whether a verb is transitive, intransitive or mixed, children may simply be learning the pattern of argumentation associated with individual verbs on a verb-by-verb basis without, at least initially, realizing any abstract relationship between different verbs (Tomasello, 1992).

Finally, Valian claims that the increase over time in the production of direct objects with mixed verbs and in the proportional use of transitive verbs reflects a decrease in performance limitations. However, this pattern of learning could be explained by a performance-limited *LEARNING* mechanism rather than a performance-limited *PRODUCTION* mechanism. Transitive verb frames are longer than intransitive frames and therefore may be more difficult for children to acquire if they are initially beyond the scope of their learning mechanism. It is possible that the children were merely learning an increasing number of mixed verbs which they used predominantly in the transitive frame and an increasing number of transitive verbs. This would also have the effect of increasing both the children's proportional use of direct object arguments with mixed verbs and their use of transitive verbs.

If Valian is correct and children's early language use reflects full competence masked by performance limitations, she must predict that:

1. Individual children will show differential use of verb frame with respect to individual mixed verbs. To determine whether a child knows that a particular verb is mixed, s/he must use both the transitive and intransitive verb frames. If, however, production is affected by performance limitations, the child should show greater use of the simpler intransitive frame at early stages of development.
2. Individual children will show an increase in the production of direct object arguments with the verbs that they know to be mixed at the earliest stages of development. Thus, for those verbs which the children produce in both frames from early in development there should be an increase in the proportional use of the transitive frame with individual verbs over time.

If the children simply produce a large number of verbs solely in the (shorter) intransitive frame early in development and acquire transitive verb frames

late in development, it is impossible to distinguish Valian's account from a performance-limited learning account. This is because the early production of intransitive frames could either indicate a complete avoidance of more complex transitive frames for performance reasons, or the child may not have learnt the transitive frames from the input as a result of constraints imposed by his/her learning mechanism.

The alternatives to Valian's account are either a performance-limited learning account or a frequency-dependent learning account based on the input. A performance-limited learning account would predict that:

1. Children will learn a large proportion of their early verbs in the intransitive frame only. Evidence in support of this prediction would be the exclusive use of the intransitive frame with individual mixed verbs. This account makes no predictions with respect to the proportional use of the intransitive and transitive verb frames for verbs where the children have acquired both frames.
2. Over the course of development, children will acquire an increasing number of transitive verb frames. Evidence in support of this prediction would be the exclusive or predominant use of the transitive frame with late-acquired mixed verbs or the acquisition of the transitive frame with verbs previously produced intransitively. This would result in an increase in the proportional use of the transitive frame with mixed verbs and an increase in the proportional use of pure transitive verbs as seen in Valian's data.

In general terms, data which could be taken as evidence in support of Valian's predictions could also be viewed as evidence in support of a performance-limited learning account although early use of the intransitive frame would be interpreted as evidence of performance-limited learning rather than limitations in production. The main difference to note is the prediction made with respect to the children's use of individual mixed verbs that are produced in both frames. Whilst Valian must predict a bias towards use of the intransitive verb frame in order to provide evidence of the effects of performance limitations in production, the learning account simply predicts that transitive frames will be more difficult for the child to acquire and therefore less common in early speech. Once a child has acquired both frames with a particular verb, there are no constraints to determine which frame the child is more likely to produce at a given time in development.

If these predictions are confirmed, they would suggest that children's early use of verb-argument structure is determined by performance-limited learning. It is possible, however, that children's early acquisition of verb argument structure may depend, at least in part, on the frequency of particular lexical items and verb frames in the input. Previous studies suggest that children are indeed sensitive to the distributional properties of the

language they hear and, in particular, to the relative frequencies of individual lexical items in the input (Naigles & Hoff-Ginsberg, 1998). In addition, it has been shown that the number of verb frames used with individual verbs in the input both predicts the order of acquisition of verbs (Naigles & Hoff-Ginsberg, 1998) and is reflected in children's use of verb frame (de Villiers, 1985). However, it is necessary to further investigate the effects of frequency in the input with relation to the current study to distinguish between a frequency-dependent account and a performance-limited learning account. A frequency-dependent account would predict that:

1. Children's use of verb frame with individual verbs will reflect the use of verb frame in the input. Thus, if some mixed verbs are used with an intransitive bias, this will reflect a bias in the input whereas verbs used transitively in the input will be used transitively in children's speech.
2. The verbs children acquire early will be found with higher frequency in the input than the verbs children acquire later in development.

If these predictions are confirmed, they will help to distinguish between a performance-limited learning account and a frequency-based account. A performance-limited learning account predicts that children will not use transitive frames from early in development whereas a frequency-dependent account predicts that children will use verbs in the transitive frame if they appear in this frame in the input. In reality it is likely that there is an interaction between the two variables. Thus, some transitive frames will be learnt early because they appear with high frequency in the input but clearly there are length restrictions on what children are able to learn from the earliest stages of language acquisition, regardless of the frequency of use in the input. A frequency-based account could explain Valian's findings if it turns out that transitive verbs are of lower frequency in the input than intransitive verbs. If this is the case, a frequency account would predict that transitive verbs would be acquired later in development and therefore result in an increase in the proportional use of the transitive verb frame in children's speech.

This study examines Valian's findings on a verb-by-verb basis looking at individual children and comparing the same children at two different stages of development to establish whether her findings can be replicated and, if the findings are replicated, whether alternative explanations provide a better account of the data. In particular:

1. Does analysis at the general level mask a more limited-scope knowledge of argument structure related to individual verbs?
2. Does children's use of verb frame with mixed verbs differ from adult use in ways which suggest that they are operating with full grammatical competence read through performance limitations?

METHOD

Subjects

The children in this study were nine of twelve children, selected to match Valian's subjects on MLU, who took part in a longitudinal study of early language development. The children were from predominantly middle-class families and were recruited through newspaper advertisements and local nurseries. All of the children were from monolingual English-speaking families, were first-borns and were cared for primarily by their mothers. At the beginning of the study the children ranged in age from 1;10.7 to 2;0.25 with MLUs ranging between 1.06 to 1.79 in morphemes ($M = 1.43$, $S.D. = 0.21$).

Procedure

The children were audiotaped in their homes for an hour on each of two separate occasions in every three week period for one year. They engaged in normal everyday interaction with their mothers. The data were orthographically transcribed using the CHILDES system (MacWhinney & Snow, 1990; MacWhinney, 1995). The MLU for each tape was then calculated.

The speech corpora

The children's data were divided into stages based on MLU. At stage 1 MLU ranged from 1.00 to 1.99, at stage 2 MLU ranged from 2.00 to 2.49, and at stage 3 MLU ranged from 2.50 to 2.99. For purposes of comparison with Valian's data, stage 1 data were compared with her group 1 children and stage 3 data were compared with her group 2 children. Data from stage 3 match the more advanced of Valian's group 2 children and thus should provide strong evidence in favour of Valian's hypothesized decrease in performance limitations if such a change occurs. The nine children selected for this analysis represent all those children from the larger study who produced some stage 1 data. Excluded from the children's speech corpora were self-repetitions and imitations, incomplete utterances, partially intelligible utterances and routines (counting, nursery rhymes etc.). The children's corpora were then searched for all single verb utterances excluding copulas and each utterance coded for whether the verb was transitive, intransitive or mixed. Verbs were categorized based on known use in common language and with reference to Levin (1993). Following Valian, the verbs *put* and *get* were then excluded from the corpora as were verbs taking sentential complements. Each remaining utterance was coded for the presence or absence of a direct object argument.

For purposes of comparison with the input, the mothers' data from the tapes comprising the stage 1 and stage 3 data for each child were examined.

All incomplete utterances, partially intelligible utterances and routines were excluded from the mothers' corpora. In order to establish that the maternal input data were consistent over time and therefore not subject to differential influence of the child at different points in development, verb frequency in the input was correlated at the first recording and the last recording (i.e. a 12 month interval). The frequency distribution of forms in the input was extremely skewed and therefore log transformations were used in the analysis (see Huttenlocher, Haight, Bryk, Seltzer & Lyons, 1991). The correlations between log verb frequency at tape 1 and log verb frequency at tape 34 ranged from $r = 0.56$ ($df = 36$, $p < 0.01$, two-tailed) to $r = 0.81$ ($df = 44$, $p < 0.01$, two-tailed) which suggests that the mothers' use of individual verbs was consistent over time. Each mother's data were searched for all exemplars of mixed verbs used by a minimum of five of the children (*catch, clean, climb, colour, cook, draw, drink, drive, eat, fight, help, mend, paint, pay, play, pull, push, reach, read, see, sing, throw, tidy, wash, watch, write*)¹ and each utterance coded for the presence or absence of a direct object argument. The data obtained were then used in the subsequent analyses.

RESULTS

Table 1 presents a comparison between the present study and Valian's study of MLU and the number of verb utterances provided. It can be seen that MLU is comparable across the two studies but that a much larger number of verb utterances were contributed by the children in this study. The results are therefore likely to provide a more reliable indication of children's early verb use than the previous study.

Analysis at the general level

The children's data were examined and the proportional use of transitive, intransitive and mixed verbs at each stage calculated with respect to verb tokens. Figure 1 shows the proportional use of each verb type at each stage. It is clear that the children's use of pure transitive verbs increased between stage 1 and stage 3 whilst their use of pure intransitive verbs decreased in accordance with Valian's findings.

Figure 2 shows the children's proportional use of direct objects with each verb type. As Valian predicts, the children produced a lower proportion of direct object arguments with their mixed verbs than with pure transitive verbs, and there was an increase in the proportional use of direct objects with

[1] The classification scheme used here may not accord with some other verb classification schemes found in the literature where some of these verbs are listed as transitive (e.g. Bloom, 1990). However, all of the verbs listed as 'mixed' verbs in this study are found in the input in both the intransitive and transitive verb frames and are therefore available to the children as mixed verbs.

PERFORMANCE LIMITATIONS

TABLE 1. Comparison of Valian's data with present subjects

	Group 1 / Stage 1		Group 2 / Stage 3	
	MLU	No. of verb utterances	MLU	No. of verb utterances
Valian's study mean (<i>n</i> = 5)	1.77	86	2.49	207
This study mean (<i>n</i> = 9)	1.66	353	2.84	1504
Aran	1.62	253	2.78	1080
Anne	1.84	580	2.90	2799
Becky	1.64	523	2.72	1031
Dominic	1.61	394	3.01	2717
Gail	1.80	230	2.84	2062
Joel	1.63	251	2.74	1445
Liz	1.67	260	2.88	888
Nicole	1.51	513	2.87	618
Ruth	1.58	172	2.78	893

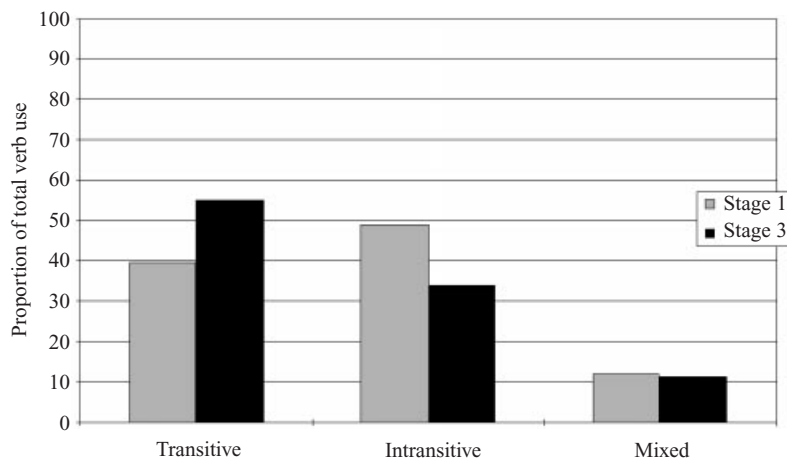


Fig. 1. The proportional use of transitive, intransitive and mixed verbs.

mixed verbs between stage 1 and stage 3. However, at stage 1 these children did not produce direct object arguments with pure transitive verbs with the same consistency as reported in Valian's study. Although the mean level of production was relatively high ($M = 79.0\%$, $S.D. = 11.52$), there was a great deal of variation between individual children (range $56.3-92.2\%$) with only one child producing direct object arguments with transitive verbs over 90% of the time. Since Valian cites the high provision of obligatory direct

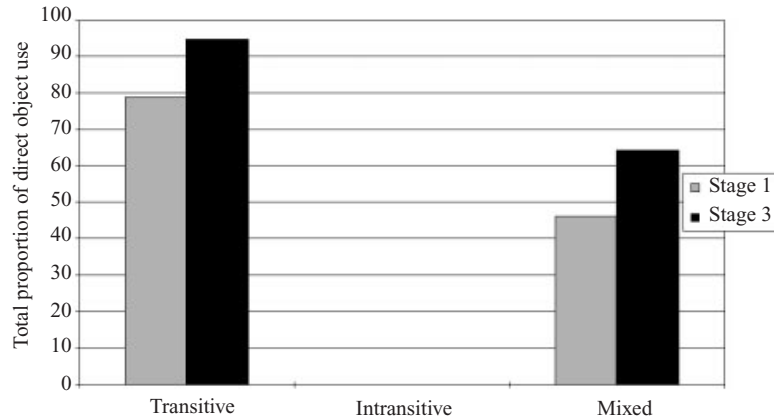


Fig. 2. The proportional use of direct objects with transitive, intransitive and mixed verbs.

TABLE 2. *The number of mixed verbs used in the transitive frame only, the intransitive frame only or both frames at stage 1*

	Transitive only	Intransitive only	Both frames	Total no. of mixed verbs used	Mean no. of tokens per verb	Proportion of mixed verbs used in a single frame only
Aran	0	9	5	14	2.7	64.3
Anne	8	4	8	20	3.9	60.0
Becky	4	6	6	16	3.3	62.5
Dominic	1	2	2	5	3.8	60.0
Gail	1	3	2	6	2.5	66.7
Joel	1	9	4	14	2.2	71.4
Liz	4	5	2	11	3.4	81.8
Nicole	4	13	8	25	3.4	68.0
Ruth	2	1	0	3	1.3	100
Mean						70.5

objects as evidence that children can distinguish between verb types in an abstract sense, this evidence suggests that these children may not be operating at such an abstract level. It is possible that the lower rate of direct object provision found here may reflect performance-limited learning which would predict the increase in direct object provision with pure transitive verbs observed at stage 3.

Thus, at a general level, the data from these children provide support for Valian's findings. There was a general trend among the children to show an increased proportional use of transitive verbs at stage 3 accompanied by a

decrease in the proportional use of intransitive verbs compared to stage 1. In addition, the children showed an increase in the proportional use of optional direct object arguments with their mixed verbs. We now investigate whether the children were 'choosing' to produce a greater proportion of their mixed verbs in the intransitive frame early in development based on processing demands, or whether in fact they used some 'mixed' verbs transitively and others intransitively without having any knowledge that alternative verb frames may be used. If the children were affected by performance limitations in production, they should produce both the transitive and intransitive verb frames with all their verbs but show a preference for the simpler intransitive frame with each verb. If, instead, the children were affected by performance limitations constraining their ability to learn complex sentence frames, they should produce a large number of verbs in only the intransitive frame. In order to address this issue, the children's verbs were examined individually. First, each verb was categorized according to whether it appeared in the transitive frame only, intransitive frame only or in both frames. Second, for each verb which appeared in both frames the proportional use of the transitive verb frame was calculated.

Analysis at the lexical level

Table 2 shows the children's use of mixed verbs at stage 1 on a verb-by-verb basis. It is immediately apparent that the majority of the children's verbs were produced in a single frame only ($M = 70.5\%$, $S.D. = 13.0$). Thus, for the majority of their mixed verbs, the children show no evidence that they know that the verbs are in fact 'mixed' in adult language. Since the children showed little evidence to suggest that they were aware that many of these verbs may be used transitively, there is little evidence that they were selectively producing the intransitive verb frame on the basis of processing restrictions.

Given that for the majority of the children's mixed verbs there is little evidence that the children in any sense had a 'choice' in terms of the verb frame they produced, the verbs the children produced in both frames were examined further (*clean, climb, colour, draw, drive, drink, eat, help, lick, miss, paint, pay, play, push, pull, reach, see, sing, throw, tidy, wash, write*). If the children produced a particular verb in both the transitive and intransitive verb frames, this provides evidence that the children actually had a 'choice' in terms of the verb frame they produced. Thus, if performance limitations were in any sense affecting the children's use of verb frame at stage 1, it is expected that they should show a tendency to produce each of these verbs more frequently in the intransitive frame since this strategy would allow them to reduce processing demands.

For the purposes of the following analyses, verb use was defined in the following manner. An intransitive bias in use was represented by the

proportional transitive use of an individual verb of between 0% and 49%. Adopting this criterion, it was found that a minority of the children's mixed verbs were used with the intransitive bias predicted by Valian's performance limitations account ($M = 34.2\%$, $S.D. = 16.1$). Thus, for 65% of the verbs the children used in both frames there is no evidence of a bias towards use of the intransitive frame. The overall bias towards use of the intransitive frame with mixed verbs in the children's speech must therefore be due mainly to the children's exclusive use of the intransitive frame with verbs that are mixed in the adult grammar. An analysis of direct object provision comparing two-frame (transitive and intransitive) verbs with those produced in a single frame (either transitive or intransitive) reveals that direct object provision with two-frame mixed verbs is higher than with those verbs which appear in a single frame (two-frame $M = 49.3$, $S.D. = 7.5$; single frame $M = 38.2$, $S.D. = 26.0$). Thus, the early bias towards use of the intransitive frame seems to reflect the children's early learning of individual verbs in the intransitive frame rather than the selection of the intransitive frame determined by performance considerations. This is further illustrated by an analysis of verb types which reveals that a mean of 65.6% of all single-frame mixed verbs used were used intransitively at stage 1.

However, it is also necessary to account for both the increase in the proportional use of direct object arguments with mixed verbs observed at stage 3 and for the increase in the proportional use of pure transitive verbs observed at stage 3. Both of these findings are predicted by Valian's performance limitations account.

Increase in the use of direct object arguments with mixed verbs

Initially, the increase in the proportional use of direct object arguments with mixed verbs was considered. If it is the case that children were producing direct object arguments where previously they were omitted for performance reasons, it should be possible to trace this development on a verb-by-verb basis by comparing the use of individual verbs at stage 1 with the children's use of these verbs at stage 3. The alternative is that the increase in the proportional use of direct object arguments reflects the children's late acquisition of verbs which they acquired solely or predominantly in the transitive frame.

To address the first issue, the children's use of two-frame mixed verbs at stage 1 was compared on a verb-by-verb basis with their use of these verbs at stage 3. Overall, an average of only 13.4% (range 0–50.0%) of the children's mixed verbs used at both stages showed any indication of a progression from an intransitive bias in use at stage 1 to a transitive bias in use at stage 3. These proportions, however, represent no more than a single verb for any individual child (e.g. Becky *eat*; Liz *draw*). Thus, only a very

PERFORMANCE LIMITATIONS

TABLE 3. *The number of mixed verbs used in the transitive frame only, the intransitive frame only or both frames at stage 3.*

	Transitive only	Intransitive only	Both frames	Total no. of mixed verbs used	Mean no. of tokens per verb	Proportion of mixed verbs used in a single frame only
Aran	8	5	6	19	5.6	68.4
Anne	11	6	15	32	6.9	53.1
Becky	13	5	7	25	4.1	72.0
Dominic	10	6	11	27	10.4	59.3
Gail	14	8	11	33	5.1	66.7
Joel	11	7	7	25	5.0	72.0
Liz	5	7	6	18	4.7	66.7
Nicole	8	5	6	19	2.9	68.4
Ruth	6	4	5	15	3.6	66.7
Mean						65.9

small number of verbs provide any support for a performance limitations account of development.

To address the second issue, the children's use of individual mixed verbs at stage 3 was documented according to their use of verb frame. Table 3 shows that the majority of the children's mixed verbs were produced in only a single frame ($M = 65.9$, $S.D. = 6.1$). This suggests that again the children were not selecting verb frame on the basis of processing considerations but rather that they were producing many of their mixed verbs in a single frame without showing any awareness that an alternative use is acceptable. However, 61.0% of the mixed verb types the children produced in a single frame at stage 3 were used transitively in comparison with 34.4% at stage 1. This difference was tested using a Wilcoxon signed rank test and was found to be marginally significant ($W = -1.955$, $n = 9$, $p = 0.051$). In addition, direct object provision (calculated on verb tokens) with verbs produced in a single frame increased from 38.2% at stage 1 to 69.5% at stage 3. This difference was also tested using a Wilcoxon signed rank test and found to be significant ($W = -2.310$, $n = 9$, $p < 0.05$). Thus, given that only a small minority of the children's verbs showed a shift in use towards the transitive frame, the increased use of this frame can only be accounted for by the children's acquisition of new verbs produced in the transitive frame.

Comparison with the input

There is no clear evidence from the data that performance limitations are responsible for the increase in direct object provision with mixed verbs and the increase in the proportional use of transitive verbs. When the children's

use of individual verbs is examined, there is no indication of the shift in use of verb frame predicted by Valian. It is not clear, however, whether the pattern of argument structure use observed is the result of a performance-limited learning mechanism which influences children's ability to learn transitive structures early in development, or whether the pattern of development could be explained by the child's sensitivity to the statistical properties of the input.

The input data were examined to determine firstly whether the children's use of verb frame with individual mixed verbs reflects the use of verb frame in the input and secondly, whether the stage of acquisition of particular mixed and transitive verbs might reflect the relative frequency of these verbs in the input.

Increase in the use of the transitive frame with mixed verbs

To investigate the relationship between the use of verb frame with individual mixed verbs in the input and the children's use of verb frame with these particular verbs, each mother's data was searched for the mixed verbs produced by all of the children and the proportional transitive use of each of these verbs was calculated. We then tested whether there were individual differences between the mothers with respect to their use of verb frame with individual mixed verbs by examining the correlations between pairs of mothers for the proportional use of the transitive verb frame with individual verbs. The majority of the correlations (86.1 %) were above 0.70 showing that the proportional use of the transitive verb frame with individual verbs is similar across mothers. Therefore, we examined the effects of the use of verb frame in the input on the children's use of verb frame across the sample as a whole. The average proportional transitive use for each verb was calculated across the mothers and across the children and the two groups compared. The correlation between the average proportional use of the transitive frame with individual verbs in the input and in the children's speech was found to be significant ($r = 0.95$, $df = 5$, $p = 0.001$ two-tailed). Since the number of mixed verbs which were produced by all the children was relatively small ($n = 7$; *draw, eat, help, play, pull, read, see*), we then examined the relationship between the use of verb frame in the input and the children's use of verb frame for a smaller set of dyads, which resulted in a larger group of verbs being available for comparison ($n = 15$; above plus *catch, climb, drink, drive, sing, throw, wash, watch*). To do this, a subset of five mother-child dyads was selected. Examining the verbs produced by at least five of the children ensures that a reasonable number of verb tokens enter into the calculation of average proportional transitive use. The five dyads selected were those who shared the greatest number of verbs. The correlation between the average proportional use of the transitive frame with individual verbs in the input and the children's speech was again found to be significant

($r = 0.88$, $df = 13$, $p < 0.001$ two-tailed). This suggests that the most important determinant of the children's use of verb frame is the use of verb frame in the input, regardless of whether the frame in question is transitive or intransitive.

To address the second issue, namely whether the frequency of particular verbs in the input influences the stage at which children acquire these verbs, the input data from the first four hours of data for each of the mothers were searched for all mixed verbs used at stage 1 by a minimum of five of the children (*draw, drive, eat, play, pull, read, see, write*) and for all mixed verbs occurring in a minimum of five of the children's speech as new verbs at stage 3 (*help, sing, throw, tidy, wash, watch*). Examining the verbs produced by at least five of the children allowed us to compare the frequency of use in the input of a larger number of verbs than would have been possible if the verbs in question had to be produced by all the children at stage 1 or by all the children as new verbs at stage 3. It also ensured that we identified a group of common verbs that were learnt early by a considerable number of children and a group of common verbs that were not learnt until later in development by a considerable number of children. This allowed us to look at the input for differences in the use of these groups of verbs to see if this might explain why one group of verbs was acquired earlier by a considerable number of children than the other group of verbs. As discussed earlier, the mixed verbs the children acquired later were more likely to be used transitively than those acquired early in development. If the late acquisition of these verbs is related to frequency of use in the input rather than to the complexity of the transitive frame this would suggest that performance limitations may not be responsible for the pattern of acquisition observed. To determine whether the mothers differed with respect to the relative frequency of use of individual verbs, pairwise correlations were examined. Since 77.8% of the correlations were above 0.70 showing that the relative frequency of use of different verbs is similar across mothers, we tested the overall effects of verb frequency in the input on the stage of acquisition of different verbs across the children. The average frequency for each verb across the input data was calculated. A Mann-Whitney test showed that the verbs the children acquired at stage 1 were significantly more frequent in the input sample than the verbs that were not acquired until stage 3 ($Z = -2.324$, $p = 0.02$). Thus, the children's acquisition of individual mixed verbs may be more dependent on the frequency of individual verbs in the input than on the complexity of the syntactic frame in which the verbs appear.

Increase in the proportional use of pure transitive verbs

It is also necessary to account for the observed increase in use of the transitive frame at stage 3. The data show that the children produced a greater number of new transitive verbs at stage 3 than new intransitive verbs,

with a mean of 38.9 new transitive verbs (range 19–56) compared to 28.2 intransitive verbs (range 9–44). This difference was tested using a Wilcoxon signed rank test and was found to be significant ($W = -2.494$, $n = 9$, $p < 0.05$). Thus, the late acquisition of a large number of transitive verbs provides the most likely explanation for the observed proportional increase in use of transitive verbs at stage 3. If the transitive verbs produced at stage 1 were more frequent than those acquired at stage 3, this would suggest that it is the frequency of these verbs rather than the complexity of the syntactic structure which determines the observed pattern of acquisition. A procedure similar to that used with mixed verbs was carried out to determine whether the transitive verbs the children acquired at stage 1 (e.g. *do, find, have, like, make, want*) were more frequent in the input than the verbs they did not acquire until stage 3 (e.g. *bring, buy, hold, let, move, need*). Again, pairwise correlations between the mothers revealed that the mothers were similar in the relative frequency with which they produced individual transitive verbs (97.2% of the correlations were above 0.70). A Mann–Whitney test shows that the verbs used by a minimum of five children at stage 1 were significantly more frequent in the input than the verbs not acquired by at least five of the children until stage 3 ($Z = -3.073$, $p < 0.01$). This again suggests that it is the frequency of particular verbs in the input rather than the complexity of the syntactic frame in which they appear which determines the order of acquisition.

DISCUSSION

The present study was aimed at testing a performance limitations account of the pattern of children's early acquisition of argument structure. It examined first, whether Valian's findings with respect to children's early use of verb-argument structure could be replicated and secondly, if the findings were replicated, whether the data merited the attribution of abstract syntactic categories to the child or whether, in contrast, the data could be better explained in terms of low-scope learning related to individual verbs. More generally, the purpose of the present study was to investigate whether there was any evidence that children at the early stages of language development have an abstract understanding of verb-argument structure and are able to use this knowledge to avoid producing ungrammatical utterances and to reduce processing load in their early use of verb-argument structure. In terms of an analysis at the level of adult grammar, Valian's findings were supported. The children increased their provision of optional direct object arguments with 'mixed' verbs at later stages of development and increased their proportional use of pure transitive verbs in comparison with the earliest stages of development. However, analysis at the lexical level failed to provide support for Valian's claims.

Firstly, if children were ‘choosing’ to produce the intransitive frame with mixed verbs for performance reasons, one would expect to find evidence that the children ‘know’ that transitive utterances are acceptable with these verbs. However, the data show that the children produced many of their mixed verbs in only a single frame therefore providing no evidence that they were aware that there was a choice to be made. Moreover, for those verbs where the children produced both the transitive and intransitive verb frame, there is little evidence of a bias in use towards the intransitive frame. Clearly, if the children were using abstract knowledge of verb frame to reduce processing demands, they should show a clear avoidance of the more complex transitive verb frame with those verbs where there is evidence to suggest that the children know both verb frames are acceptable.

Secondly, if the children were affected by performance limitations which increase the likelihood that they will produce the intransitive frame with mixed verbs, one would expect the children to show a greater bias towards production of the intransitive frame, regardless of whether such a bias is observed in adult speech. If differences between the children’s speech and adult speech cannot be observed, it is unclear what role performance limitations play in early verb-argument structure production. However, the data show that a strong predictor of the verb frame the children used with a particular mixed verb was the verb frame used with that particular verb in the input, regardless of whether the frame was transitive or intransitive. Thus, there is no evidence to suggest that the children differ from adult speakers in their use of verb frame in the ways that would be expected if the children were operating under performance constraints of this nature.

Thirdly, if one assumes that there is a relative bias towards the intransitive use of mixed verbs in early speech, one would expect to see a shift towards greater proportional transitive use with individual verbs over the course of development as performance limitations decrease. However, there is little evidence to suggest that such a shift occurs. Only a very small number of verbs showed this pattern whereas the majority of verbs used at both stages in development were used in exactly the same way at both stages. The shift in overall proportional use of the transitive frame with mixed verbs can only be accounted for by the late acquisition of a number of mixed verbs used predominantly or exclusively in the transitive frame. Thus, there is no evidence that Valian’s performance limitations are affecting the children’s actual use of verbs.

The specific predictions laid out earlier which distinguish Valian’s account from a performance-limited learning account of early language development are not supported. Even if there are other, as yet unspecified, ways in which transitive structures can be analysed as more complex, the late acquisition of these structures could reflect either performance-limited production (i.e. full competence read through performance limitations in production), or, alter-

natively, performance-limited learning resulting from the learning mechanism being initially limited in ways that prevent the children from acquiring long, complex structures. However, an alternative explanation is offered for this pattern of verb learning. If children are sensitive to the patterns of verb use in the input including the relative frequencies of particular lexical items, they are expected to acquire those verbs which occur in the input with high frequency earlier than those verbs which occur with lower frequency. The data provide support for this prediction. The verbs the children acquired at stage 1 were significantly more frequent in the input than those verbs which they did not acquire until stage 3. It appears that the late acquisition of a large number of verbs used in the transitive frame may occur as a direct result of their relative frequency in the input. Thus, there is no need to posit a complex performance-related mechanism to account for the pattern of early verb acquisition observed.

One important issue which has not yet been addressed in this paper is the role of discourse factors in determining whether a mixed verb is produced in the intransitive or transitive verb frame. Although a particular verb may be mixed in syntactic terms, whether the direct object argument is actually optional depends on the discourse context of the utterance. For example, acceptable responses to the question 'What are you eating?' would be 'an apple' or 'I'm eating an apple' but not 'I'm eating' because only the direct object argument provides the information requested. In contrast, both 'He's reading' and 'He's reading a book' are acceptable answers to the question 'What's the little boy doing?'. Whether an utterance is intended to convey general or specific information determines the speaker's choice of verb frame.

Whilst these factors undoubtedly influence use of verb frame in the adult language, it is unclear whether discourse factors of this type could account for the pattern of results found in children's early use of mixed verbs. Firstly, if the early use of the intransitive frame reflects a predominance of discourse contexts which require the intransitive frame, it is unclear exactly which contexts this would be. Whilst some contexts require the transitive frame, very few actually disallow the transitive frame and therefore it is unlikely that a lack of discourse contexts which allow production of the transitive frame can account for the early intransitive bias observed. Secondly, in order to explain the late use of the transitive verb frame, a radical change in the types of discourse context present in the mother-child interaction would have to occur. If, as is suggested in this paper, the increase in use of the transitive frame results from the late acquisition of verbs in this frame, it is unclear how the presence of particular discourse contexts would determine the order of acquisition of particular verbs. Thus, whilst it is likely that individual mixed verbs differ with respect to the optionality of the direct object argument in the adult language, this phenomenon cannot, without further elaboration, explain the pattern of results reported in this study.

These findings have important implications for performance-based theories of early language acquisition. The most obvious point to make is that the analyses indicate that Valian's (1991) account of early verb-argument acquisition is an over-interpretation of the data and highlight the need to analyse early language data at the lexical level. Moreover, the present findings suggest that *any* theory of performance limitations, if presented in terms of adult syntactic categories, is essentially analysing the data at the wrong level. If children's early knowledge of verb-argument structure is based around individual lexical items rather than organized at a more general level (e.g. transitive and intransitive structures) it seems unlikely that they will operate under performance constraints formulated in terms of these general categories. Thus, theories of language development which rely on performance-limited production mechanisms to explain patterns of early language use or early errors of omission must provide principled accounts of how such limitations might be expected to operate at the lexical level and should make predictions as to how these performance limitations would affect the specific lexical distribution of forms as opposed to general categories. Without this level of detail, it is possible that the child's early knowledge may consist of isolated lexical structures rather than exemplars of a more general grammatical structure and may reflect lexically specific patterns in the input or the workings of a performance-limited learning mechanism.

Finally, this study highlights both the importance of the input in the child's early acquisition of argument structure and the importance of characterizing the input before making claims with regard to its role in acquisition. The present study suggests that children may learn verbs and their argument structures on the basis of relative frequencies in the input. Thus, broadly speaking, the present findings are consistent with a constructivist distributional learning account of early development. The verb-argument structures used with individual verbs in the input are reflected directly in the low-scope patterns of use found in children's early speech. However, much more work is needed in order to predict more accurately which factors of the input are important in terms of children's early acquisition of verb-argument structure. It seems unlikely that frequency alone can explain the exact pattern of verb-argument structure acquisition although it does appear to play a more important role than has traditionally been recognized. In particular, it is likely that frequency should be considered with respect to both token frequency and type frequency. If children learn language based on distributional regularities and build up their knowledge of argument structure gradually beginning with lexically-specific frames, those structures (e.g. the transitive frame) used most frequently (tokens) and with the greatest number of exemplars (verb types), are more likely to be acquired early because they are frequent and highly generalizable. The child will be

better able to extract commonalities where there is much variation within a frequently used frame than for structures where there is less reinforcement (token frequency) and fewer points of comparison (type frequency).

A related issue concerns the assumptions researchers make regarding the nature of the input, in particular the role played by the input in children's very early learning. For example, Valian assumes that children are able to differentiate, on the basis of the input, between transitive and mixed verbs. However, since she fails to examine the input itself, she has no evidence that the verbs she assumes are produced in both intransitive and transitive frames in the input are actually used in this way. Clearly, the argument that children 'select' verb frame with mixed verbs from the use of these verbs in the input hinges on there being a choice to make. When this assumption is challenged by the fact that mothers too use verbs in limited ways, the theoretical argument concerning the effects of performance limitations on a full competence grammar is severely weakened. The central point is that if one wishes to compare children's use of particular structures with adult use or claim that children operate with an adult grammar, it is essential that adult use is defined in terms of native speakers' actual language use rather than in terms of how language could be used. Although a particular utterance may be possible in the language, one cannot infer that a child will necessarily hear that utterance with any great frequency, if at all. In order to compare a child's use of language with adult use, it is necessary to establish a baseline of use which relates to the forms which the child actually hears and not the forms s/he could possibly hear.

In conclusion, the present study suggests that there is no evidence that children at the very earliest stages of verb-argument structure acquisition are operating under performance limitations at the level of the transitive and intransitive verb frames. When the data are approached from a lexical-learning perspective, the pattern of verb-argument structure acquisition is best explained in terms of limited-scope learning which reflects the most dominant patterns of verb use in the input. If performance based explanations of early language use are to have any predictive power, they must be testable at the level of individual lexical items and not just at the level of abstract categories.

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