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1.0. Introduction.

The fundamental problem of language acquisition remains unsolved: how do children master the intricacies of their native tongue ? [1] To answer this question we must (a) restrict the hypothesis-space available to a child, and (b) specify how a child generates hypotheses within that space. Linguistic theory approaches the first task by placing restrictions on the total range of possible hypotheses; it defines universal grammar. What no adult language permits is, by hypothesis, excluded from the range of hypotheses that a child may consider. Nevertheless the range of hypotheses permitted by universal grammar is infinite. It is the special province of language acquisition research to show how a child can select the single appropriate grammar for his community.

In brief, we shall argue that a child over-restricts his hypothesis-space in the initial phases of language acquisition. Therefore, connections that exist in the adult grammar are not seen by children. In other words, the hypothesis-generator (or language-acquisition device) systematically excludes certain rules which in fact function in adult languages. For instance a child might understand the semantics of a verb class and might understand a syntactic structure, but fail to see that the grammar of a particular language has a necessary link between those verbs and that syntactic structure (see Goodluck and Roeper, this volume). Our focus here falls upon stress phonology. We shall show that children may understand a morphological rule of stress and a phonological rule of stress but fail to realize that one conditions the other.

The rules of English stress assignment are unusually complex. In fact there is a great deal of current debate over how best to represent them. All of the theories recognize one fact: phonological, morphological, and syntactic information may be relevant to stress assignment. That is, information from three diverse domains in grammar must be combined in order to make correct projections of stress for English words. In order to stress the word object correctly we must know if it is a noun or a verb ([ˈɔbjɛct]$_N$ or [ɔbˈjɛct]$_V$). In order to stress reprove correctly, we must know if there is a morphological boundary between re and prove (i.e. re # prove or prove again, as opposed to denounce). And in order to stress usurp correctly one must know that the second syllable has a strong cluster.

These facts have a direct consequence for an hypothesis-generator. In principle, there is an exponential increase in the hypothesis-space for each domain that is relevant to stress rules. If stress were exclusively phonological, the range of hypotheses would be much smaller. However the child must multiply the set of possible phonological hypotheses by the set of possible morphological ones by the set of possible syntactic ones. There may well be some limits on the interface between grammatical levels that are established by universal grammar; it is not yet fully clear what they will be. It may well be, for instance, that only categorical information (N, V, A) will be relevant to stress and not phrasal information (NP, VP, AP). Nevertheless the fundamental fact remains: a system which refers to several grammatical levels causes an increase in the range of grammars that an hypothesis-generator must search through.

It does not, however, follow that an acquisition device must consider

all hypotheses at once.[2] It has been proposed in the past that hypotheses are completely ordered. For instance, it is claimed that in syntax hypotheses about word-order precede hypotheses about inflections. This proposal may be too strong. We propose to limit initial hypotheses by constraint:

1) Initial hypotheses are homogeneous.

This means that a child first explores hypotheses within one domain of grammar before he explores hypotheses that entail information from two domains in one rule. This proposal presupposes the existence of formally separable domains in grammar. We have not mentioned semantics, but clearly semantics may also be involved in certain rules. For instance, the rules which define separable prefixes in German[3] appear to involve both phonological and semantic information.

It is not completely clear how our proposal connects with universal grammar. It may have no impact whatsoever on the statement of universal constraints on grammar. However, insofar as earlier hypotheses may affect the range of possible later hypotheses, the order in which hypotheses are generated may affect the total range of hypotheses expressible in universal grammar (see Chomsky (1975), p. 121). We shall say no more about this question but rather turn to our evidence and arguments for the proposed constraint.

2.0. English Stress.

A typical rule of English stress is the Alternating Stress Rule (as developed in The Sound Pattern of English (SPE) by N. Chomsky and M. Halle):

$$2)\quad V \rightarrow 1\ \text{str} \;/\; \_\_\ C_0\ (=)\ C_0VC_0\ \underset{[1\ \text{stress}]}{V}\ C_0\ ]_{NAV}\ (NAV = \text{noun, adj., verb})$$

This rule provides stress for words like cóncentràte, éxtirpàte, cónvolùte. It says, roughly, that a vowel (V) will take primary stress (1 str) when it precedes one or more consonants (C_0), an optional morphological boundary (=) where parentheses mark options, a medial syllable (CVC) and a final syllable where a vowel has already received stress. We shall not explain the notation further but rather confine ourselves to the observation that the rule involves reference to grammatical category, phonology and morphological boundaries. In principle each feature in the notation is changeable and could be different for a different language; therefore, in principle, each element of the notation could be the subject of a child's hypothesis (see Chomsky (1967)). Thus a child might need many hypotheses to confirm the numerous individual features of a single rule.

It is extremely unlikely that a child must consider every possible hypothesis. Presumably knowledge of universal constraints enables the child to preclude some hypotheses and concentrate upon others. It is also unlikely that a child can fix immediately all the parameters of a complex rule at once. Therefore we can expect that children will exhibit stages in the acquisition of stress rules. Now the question becomes what those stages are, or, put differently, what is a first order approximation to a complex rule which a child exposed to the subtly variable data of English

would develop ? We shall suggest that the principle of homogeneous rules dictates a simple and direct first approximation.

In our analysis we shall refer to a recent revision of SPE theory by Liberman and Prince (1977). Their analysis both simplifies the rules of SPE, without loss of generalization, and as we shall demonstrate, relates naturally to the grammars which we have independently developed for children. It is worth emphasis, however, that both these theories (or any other theory) pose the same question for the language acquisition device: how does the child develop a unified stress system when factors that determine stress come from different domains of grammar ?

In the Liberman and Prince theory there are two important rules which assign stress to English words. They are, first, the iterative English Stress Rule.

$$V \rightarrow 1 \text{ str} \;/\; \_\_\; C_0(V(C))_\alpha \begin{pmatrix} V \\ [-\text{ ing}]_\delta \end{pmatrix} C_0)_\beta \begin{pmatrix} V \\ [+\text{ str}] \end{pmatrix} X)_\gamma \;\#$$

Conditions: $\nu\gamma \supset \delta$; $\nu\alpha$, $\nu\beta$

Under certain morphological and lexical conditions this rule can reapply, giving stress to several different vowels in a single word. It guarantees that initial syllables receive stress. These rules must be supplemented by rules which have the effect of de-stressing certain syllables in order to prevent "clashes," that is, a sequence of too many stressed syllables. Thus English maintains a generally iambic pattern:

Destressing Rule.

$$\begin{bmatrix} V \\ +\text{ long}_\alpha \\ +\text{ stress} \end{bmatrix} \rightarrow \begin{bmatrix} -\text{ stress} \\ -\text{ long} \end{bmatrix} \;/\; +\,[X\ V]_\beta\ C_0 \_\_ (C)\ [C_0 = C_0]_\gamma\ V$$

Condition: $\alpha \supset (\beta \vee \gamma)$

The destressing rule is in an important sense defined in terms of the output of the stressing rule. These two rules must be supplemented by the lexical category prominence rule which, among other things, represents separately the fact that nouns and verbs receive different stress and that various special features of the lexicon (idiosyncracies of various word classes) effect stress. We shall return to these rules when we apply them to our results.

2.1. The "Full-Entry" Theory of the Lexicon.

Stress rules apply to words just as syntactic rules apply to sentences. There is an important difference, however. We remember particular words in some kind of mental lexicon, while sentences are forgotten almost as soon as we say them. Recent proposals by Halle (1973) and Aronoff (1976) suggest that people do not newly generate stress patterns for each word but rather remember the stress pattern for each word just as they remember the meaning of each word. The rules then describe classes in a mental lexicon and provide a means with which to assign stress patterns to new

words. They are then once-only rules; as soon as a word is created and assigned meaning, phonology, and stress pattern, it is entered into the mental lexicon.

This view of the lexicon is compatible with an acquisition model in which children learn many individual words before they begin to make generalizations about them. It follows that children might provide complex words, if known, with correct pronunciation although they lack the rules which form the patterns their words exhibit. This view fits simple observation; children make surprisingly few errors in stress assignment in spontaneous speech. However those errors are in the direction predictable from their developing rules. Some children will say phótogràphy and keep stress on the original word (photograph).[4] Other forms like póosham (for shampoo) and stáchemus (for mustache) are reversals that are consistent with the generalization that nouns take initial stress (examples due to J. Gourley).

In the experiment we report below we found further evidence consistent with this view of the lexicon. In general, when we used real words, children seemed to know them and pronounce them correctly (with some interesting exceptions, see below). We assume that they had in fact learned each word as a separate lexical item.

3.0. Acquisition Rules.

We return to the question: how does a child project the correct rules to organize his memory for words and enable him to stress new words ? Infinite possibilities are imaginable. The child could generate a rule entirely in terms of syllables, or consonants, or the beginnings of words, or in terms of morphological boundaries, or semantics, or context. Many of these possibilities will be ruled out by universal grammar.

There is moreover the quite real possibility that the child will deal with new words on the basis of a non-rule-governed system. For instance, when one child was asked to say cabran he said carbon; for adment we received admit. This phenomenon is well-known in reading. We consider this method to be analogical and non-rule-governed because it is based upon seeing similarities between specific individual words, rather than being based on a rule which operates abstractly without respect to particular phonological segments.[5] Thus a rule, but not an "analogy," can apply to both regort and bidimp. If, however, a child refers to his lexicon and sees report, he may let it influence his pronunciation of regort. Adults also report that they are conscious of similar real words when they pronounce nonsense words. We attribute therefore some of the minor variability in our results to analogy.

3.1. Homogeneous Rules.

How does one proceed to determine what a child's first hypothesis about stress might be ? There is no apriori position from which to investigate the potential infinite range of hypotheses. We shall derive a commonsense proposal that follows from the hypothetical principle which we mentioned above: homogeneous rules.

We propose then that a child begins with separate hypotheses for each domain of grammar. Each hypothesis can be applied directly; each is simple to state. Each, presumably, is elaborated as far as possible within a

domain before rules are hypothesized which collapse information from two domains:

4)	A.	Syntactic:	1. Nouns take initial stress 2. Verbs take final stress
	B.	Morphological:	Words that can be analyzed into prefix and stem take final stress
	C.	Phonological: (Spelling)	Stress falls on vowels followed by two consonants ("strong syllables")

These hypotheses apply beyond two-syllable words as stated. We have limited our current experiment to two-syllable words; we shall expand the model in the future. These generalizations should, however, be construed only with reference to two-syllable words. We shall illustrate the predictions made by the rules with nonsense words. (A) predicts that a child will know that the verb to abtéct has final stress, while the noun an ábtect has initial stress. (B) predicts that presort will take final stress because of the prefix. (C) predicts that pentel will take initial stress, because it has two medial consonants.

3.2. Conflict.

One might ask why these rules cannot serve as adult rules. The answer is that these rules are so broad that they often fail to make a unique decision for a given word. Adult grammars require a fairly high degree of resolution so that most words receive one and only one stress assignment. The rules in (4) often conflict with each other. Suppose we have a verb that has a strong cluster in initial position (to pentel). One rule predicts final stress (the Category rule) and the other produces initial stress (the Spelling rule). The substance of our experiment deals with children's responses to such conflict situations.

In our experiment we gave children nonsense words in which the set of rules will generate conflicts. This is not an unusual situation. It is presumably the existence of numerous conflict words in English which forces children to develop a more elaborate system for stress assignment. In particular, they must then consider relations of ordering, disjunction, markedness, and metrical structure in the organization of rules.

4.0. Preliminary Experiments.

We shall describe two preliminary experiments in summary fashion. Then we turn to a detailed discussion of our most recent experiment. In our first experiment we held all factors constant except the fact that a given word was a noun or a verb. We used recognizable prefixes throughout and we made both syllables either strong or weak. Ten sentences were given to a group of 24 4th. graders from the University of Chicago Lab school. Here are sample sentences:

5) a. we know that we can drogréss / we are leaders in drógress
   b. the óbriss is good / will he obríss the chance

The children were asked to read the sentences. The results were very clear:

from a total of 215 responses, 93% of the nouns received initial stress, and 91% of the verbs received final stress (as indicated in (5)).[6] Similar findings emerged from an experiment in German.[7]

That experiment established the claim that category alone was sufficient to trigger differential stress assignment among fairly young children. Nonetheless the children are fairly old with respect to most of language acquisition; in general stress acquisition may be somewhat delayed due to the fact that the required Latinate vocabulary does not enter the vocabulary of children until they are beyond six and seven.[8]

In the next experiment we presented a group of twenty 3rd. and 4th. graders with a series of nonsense nouns with strong second syllables and real nouns. This set up a potential conflict between the Category rule (noun), which assigns stress to the initial syllable, and the Spelling rule, which assigns stress to the second syllable. On the whole the real words were stressed correctly no matter what their structure was (see (7a)). It is possible that some words were not recognized by the children as real words (6); where incorrect answers appeared they were consistent with the stress rules:

6)

Noun	1st. Syll.	2nd. Syll.
massage	8	2
canteen	8	2
dessert	4	6
corral	9	1

The nonsense words (7b) all received first syllable stress except where there was a strong second syllable and a plausible analogy:

7)

a.

Real	1st. Syll.	2nd. Syll.
report	0	10
garage	0	10
cement	2	8
amount	0	10

b.

Nonsense		
bippel	9	0
vorrage	10	0
sammige	10	0
regort	6	4
bement	8	0

The real word cement had primarily second syllable stress while the nonsense word bement had first syllable stress. Regort may have been affected by analogy. In sum the real words generally receive correct stress even where a conflict exists between the Category rule and the Spelling rule; the nonsense words appear to follow the noun rule. All exceptions are compatible with the spelling rule. Note that the mixed responses come where there is a conflict. It is as if the children recognized that they were faced with a choice between two rules and had to choose one or the other. We shall find more evidence of mixed responses in the evidence below.

5.0. Third Experiment.

We turn now to our third and most extensive experiment. Our goal was to develop tasks in which all three factors were systematically contrasted: Category, Spelling, and Morphology (hereinafter Analyzability). We designed a story in which 32 nonsense words each occurred twice. The story enabled us to give categorical definition to each word and keep the children's interest: the signalled nouns and to signalled verbs. We gave the story to five groups of people to read out loud: 3rd., 4th., 5th., and 6th. graders and adults. There were ten subjects in each group. Each response was judged by two people. The set of responses was tabulated on the following Data Matrix:

VERBS

	NONSE	STEM	PREFIX	PREF & STEM
VCCVC (S-W)	cabran	terpel	subris	subfer
VCVC (neutral)	pratis	stamit	desab	premit
VCVCC (W-S)	tesalt	masist	prebant	presort
VCCVCC (neutral)	arbist	sabment	subrimp	absert

NOUNS

	NONSE	STEM	PREFIX	PREF & STEM
VCCVC (S-W)	pental	balfer	adnal	adfit
VCVC (neutral)	pobet	sibel	osel	depel
VCVCC (S-W)	basant	gasist	degart	resert
VCCVCC (neutral)	sampelt	padnect	adbist	adment

["S" = Strong : "W" = Weak .]

We considered de-, sub-, pre- and ad- to be well-defined prefixes although it is possible that some children did not identify them as prefixes. We used -pel, -sist, -ment, -fer, -nect as stems. We expected that the overall statistical preferences would outweigh the occasional lacunae in the knowledge of various children.

5.1. Performance Strategies.

A rule system describes a basically deterministic model. If rules are applicable to a word's structure, then the rule must apply and it will produce a fixed array of outcomes. A number of formal constraints, however, permit percentage results. For instance, the notion of optional rules. The existence of optional rules means that a child (or an adult) sometimes will and sometimes will not produce a given form. Hence the form will appear in some percentage of the cases. For instance in syntax the rule of subject-verb inversion is an optional transformation which will occur just if the speaker wants to ask a question (and a few other rhetorical conditions).

Thus the rule is not intrinsically probabilistic but probabilistic insofar as factors extraneous to grammar determine whether it shall or shall not apply. Those performance factors may include aspects of context or of the larger biology of the organism (memory, breath requirements, etc.).

The question arises as to whether percentage results allow us to choose among possible formal constraints. We shall argue that they do. In particular we argue that a system of homogeneous rules, which produce conflicts, will resolve the conflict in terms proportionate to the number of rules which potentially apply. The more rules which dictate second syllable stress, the higher the proportion of second syllable stress. This is then a cumulative model of rule application. Halle (1973) has argued on independent grounds for stress rules which are cumulative.

5.2. Markedness.

The first feature of our results which we shall discuss is one that treats the entire set of responses as a group. We found that over 90% of the nouns received initial stress and that, in addition, over 50% of the verbs received initial stress. (Statistical analysis indicates a significance difference at better than the .05 level.) However this raises the question of how to account for those numerous verbs where there is initial stress and no factor (Category, Spelling, or Analyzability) which puts the stress on the initial syllable. One possibility is that there is an unmarked strategy which obligatorily places the stress on the initial syllable of every two-syllable word. On independent grounds, Halle has proposed the same rule, called the "initial" stress rule (incorporated into ESR in Liberman and Prince):

8) $V \rightarrow 1\ \text{str} \ / \ \#\ C \_\_\ X$

Further evidence for this unmarked rule is the fact that there were a number of children who gave exclusively first syllable stress on all words.

How then do we analyze those instances where stress falls on the second syllable ? If all first syllables have stress, then second syllable stress can arise just when there is more than one rule which can place stress on the second syllable. Since some of the responses did not give second stress where all factors were present, we propose that none of the rules (except the unmarked rule) is obligatory. They all have the status of being optional. Here are the previously mentioned homogeneous rules:

9)	Category:	1.	V → 1 str	/	Syl ___	(Verb rule)
		2.	V → 1 str	/	___ Syl	(Noun rule)
	Analyzable:	3.	V → 1 str	/	+ ___	("+" = boundary)
	Spelling:	4.	V → 1 str	/	___ CCVC#	(1st. syllable stress)
		5.	V → 1 str	/	VC ___ CC#	(2nd. syllable stress)

Rules (1) and (2) show the impact of category. Rule (3) functions in terms of a boundary. Rules (4) and (5) place stress on the first syllable, if strong, or the second syllable, if strong.

First we shall show that each factor has a separate effect. The presence of a category effect is obvious because of the difference between 90% initial stress for nouns and 50% for verbs. The effect of analyzability (prefix, stem, or prefix & stem) is revealed in Figure 1. The surprising fact revealed by this graph is that stems have little or no effect; they are equal to nonsense words in their capacity to trigger second syllable stress. In concert with that observation is the fact that prefix & stem is roughly equivalent to prefix alone. This generalization does not hold for adults where prefix & stem is equivalent to nonsense words. We shall recurrently find that the adult grammar does not submit to analysis in terms of cumulative homogeneous rules. The factored out effect of prefix alone and stem alone are revealed in Figure 2. We conclude that analyzability contributes to stress placement.

We turn now to the Spelling effect. We find that a structure of the form weak-strong (VCVCC) is decidedly favored to receive second-syllable stress over strong-weak (VCCVC). See Figure 3. The neutral cases (W-W and S-S) fall between the other two for both the nouns and the verbs. This holds, once again, for the children but not the adults. The adults show no difference in the neutral spellings and the strong-weak. They show, with verbs, exclusively a preference for weak-strong in second syllable stress. If we analyze the data entirely in terms of second syllables -- strong or weak -- we find the following clear spelling effects. See Figure 4. Statistical analysis shows that both first and second syllable strong syllables are significant at the .05 level. The primary factor is nonetheless the strong second syllable. This is not surprising since the strong first syllable duplicates the effect of the unmarked rule. Nevertheless we shall show that there is value in having a rule that specifies stress on the strong first syllable.

5.3. The Additive Model.

We turn now to the question of how these rules work in concert. Our hypothesis states that each is a discrete rule, for which we have given evidence above, and that the rules have cumulative effects. We shall consider first an analysis in which each factor has the weight of +1: Spelling, Category, and Analyzability. We shall assume that only the final syllable matters in the Spelling rule. See Figure 5.

FIGURE 1

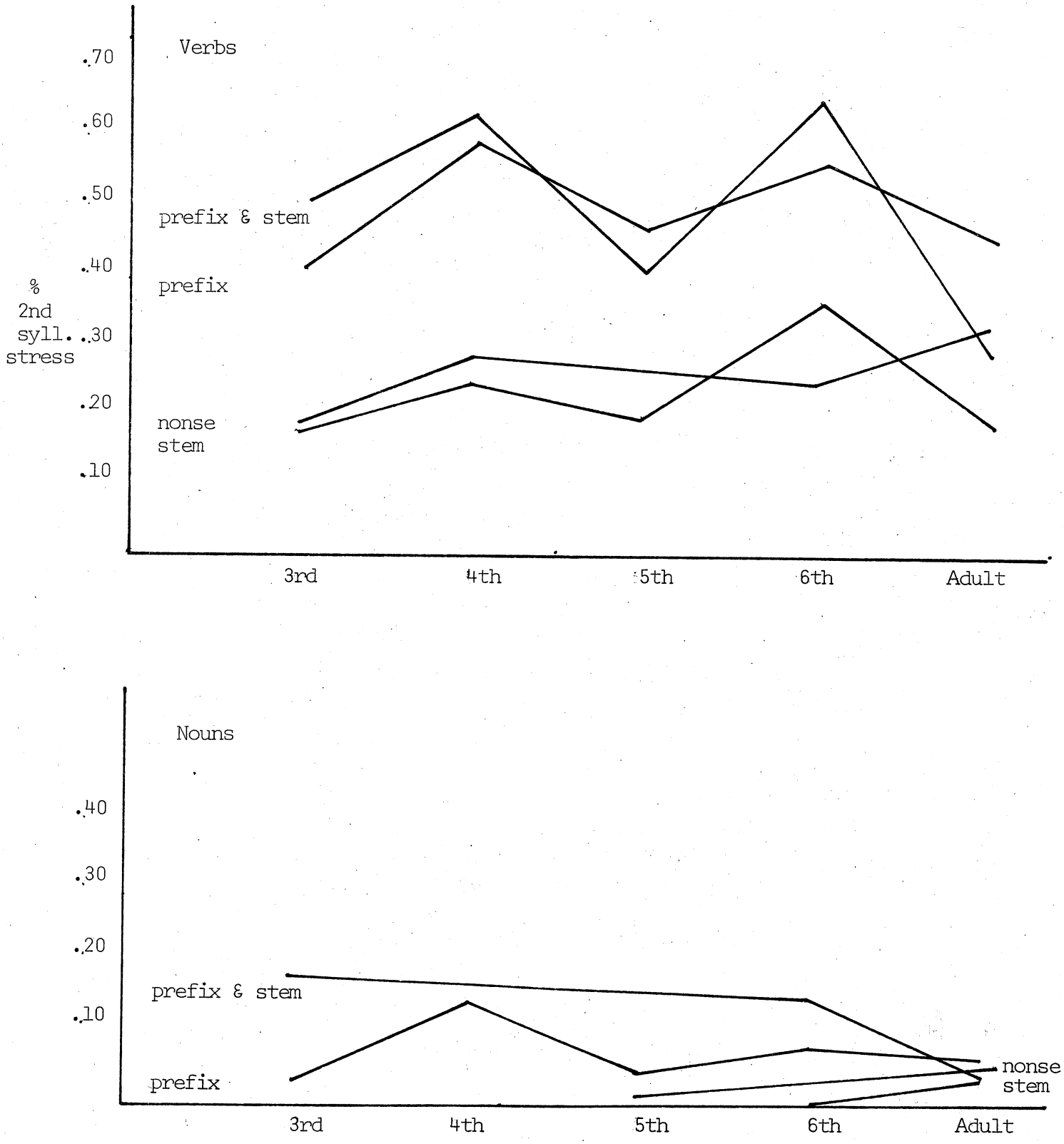
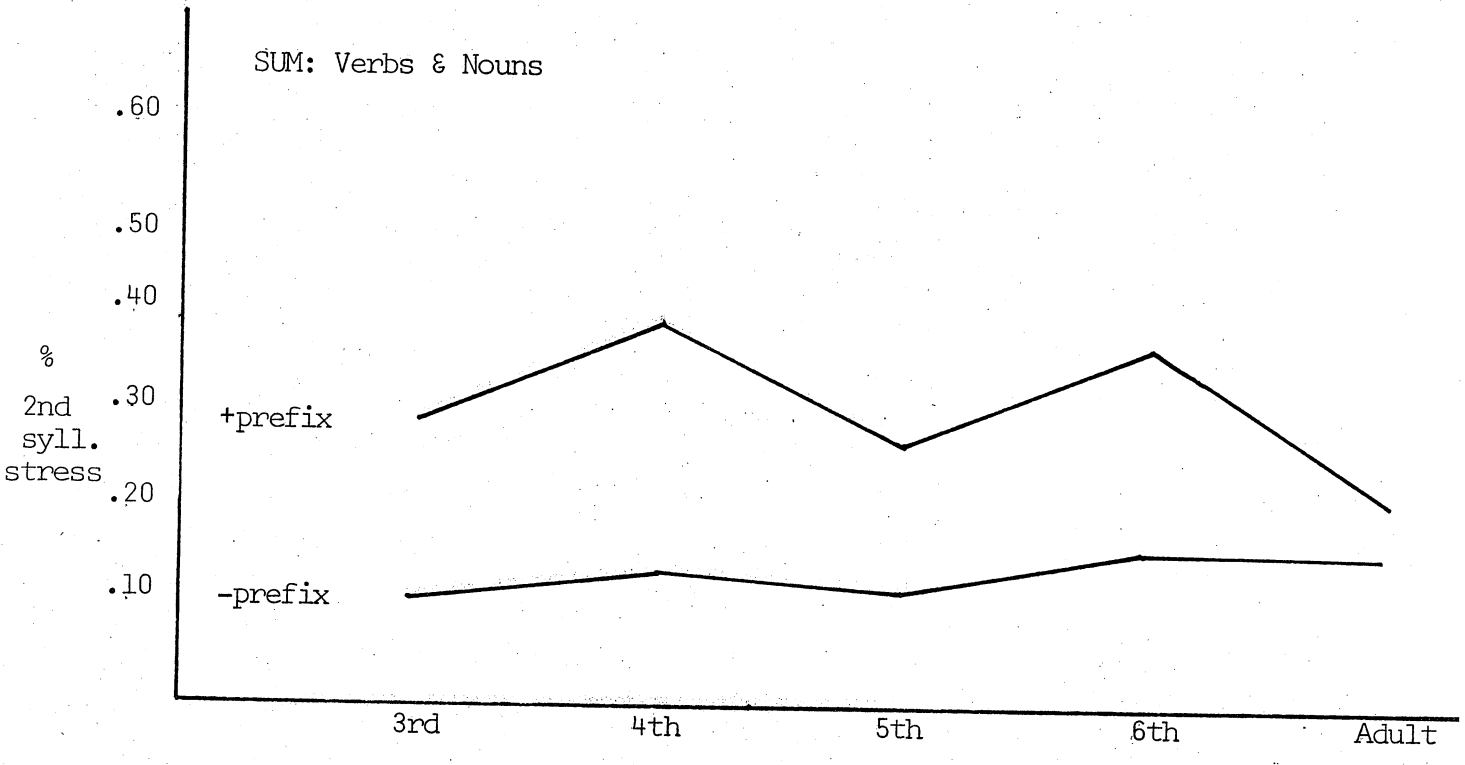

Verbs
.70
.60
.50
.40
.30
.20
.10
% 2nd syll. stress
prefix & stem
prefix
nonse stem
3rd
4th
5th
6th
Adult
Nouns
.40
.30
.20
.10
prefix & stem
prefix
nonse stem
3rd
4th
5th
6th
Adult

FIGURE 2


SUM: Verbs & Nouns
.60
.50
.40
.30
.20
.10
%
2nd
syll.
stress
+prefix
-prefix
3rd
4th
5th
6th
Adult

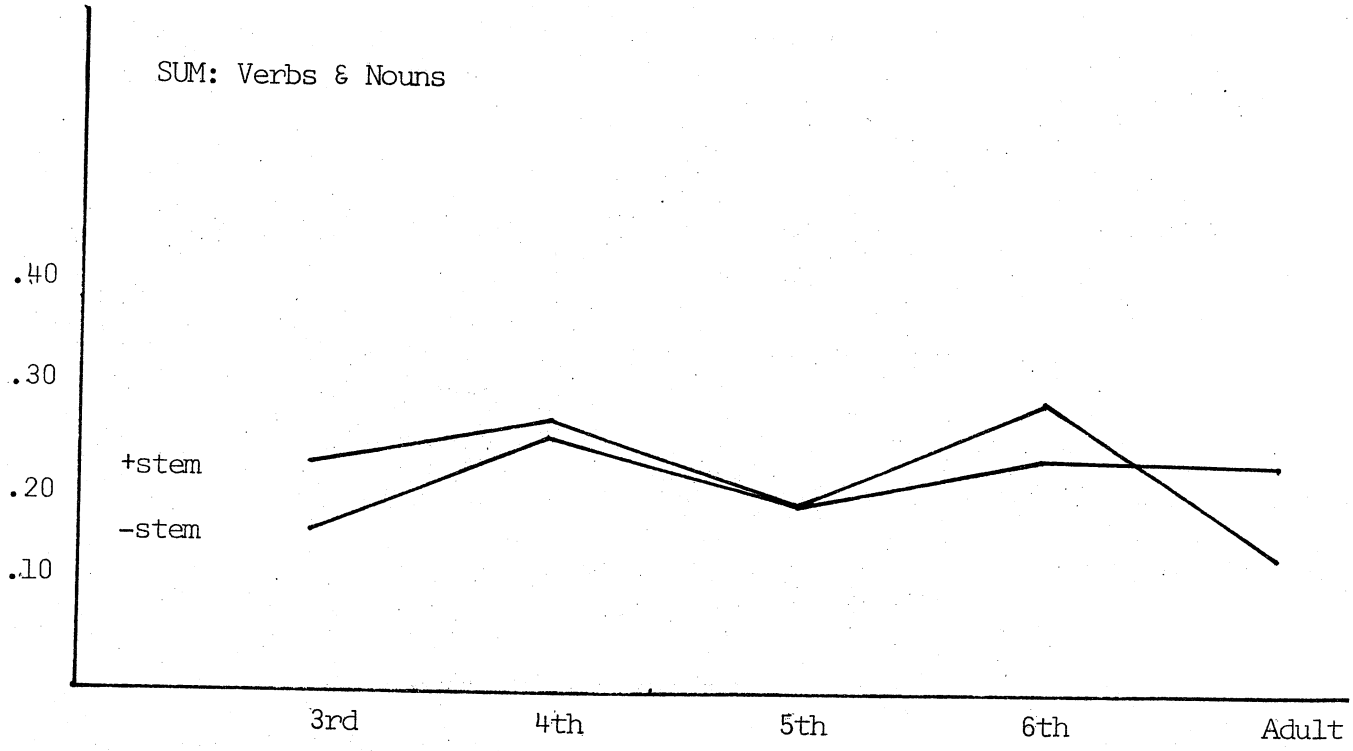

SUM: Verbs & Nouns
.40
.30
.20
.10
+stem
-stem
3rd
4th
5th
6th
Adult

FIGURE 3

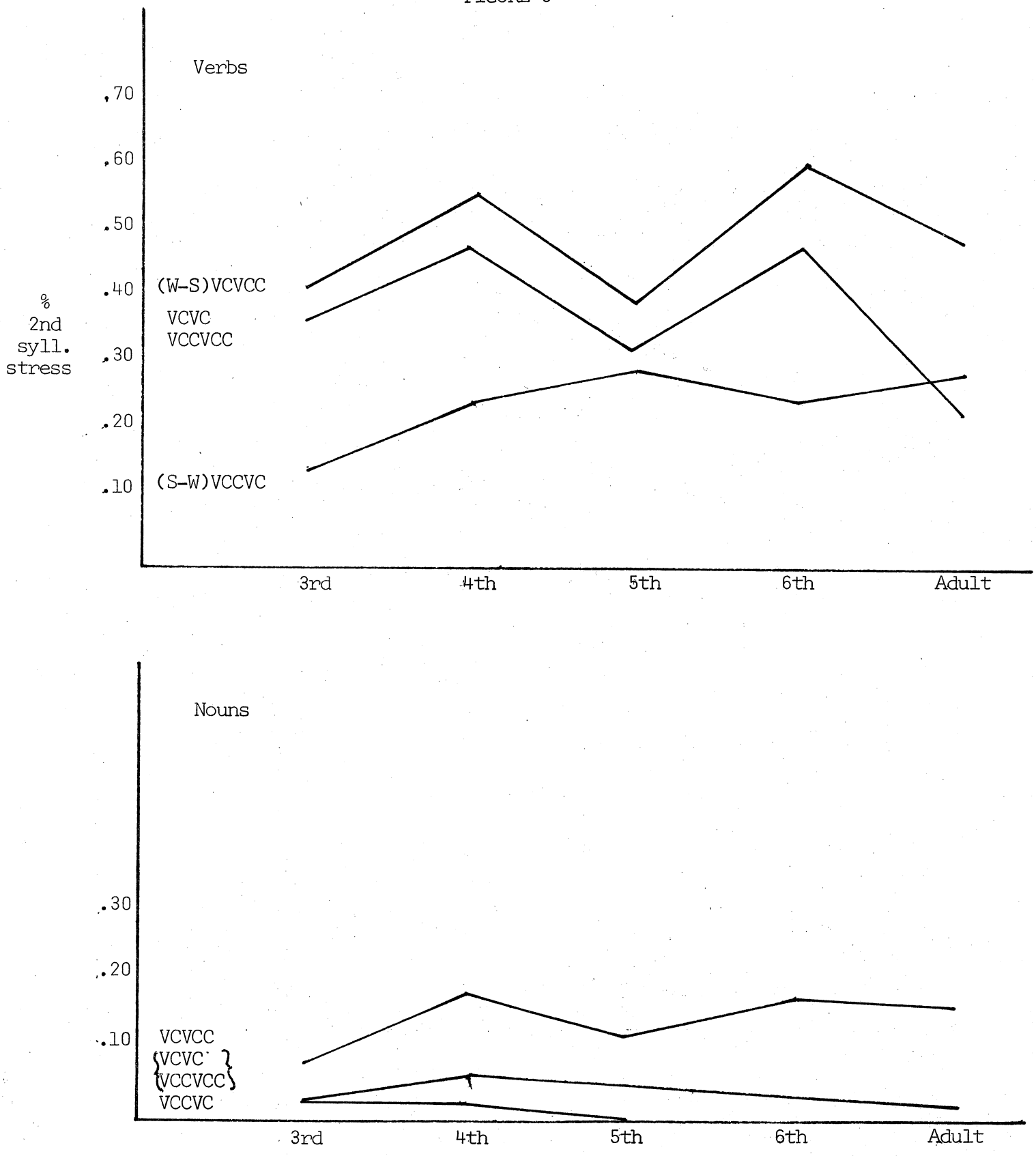

Verbs
.70
.60
.50
.40
.30
.20
.10
% 2nd syll. stress
(W-S)VCVCC
VCVC
VCCVCC
(S-W)VCCVC
3rd
4th
5th
6th
Adult
Nouns
.30
.20
.10
VCVCC
{VCVC
{VCCVCC
VCCVC
3rd
4th
5th
6th
Adult

FIGURE 4

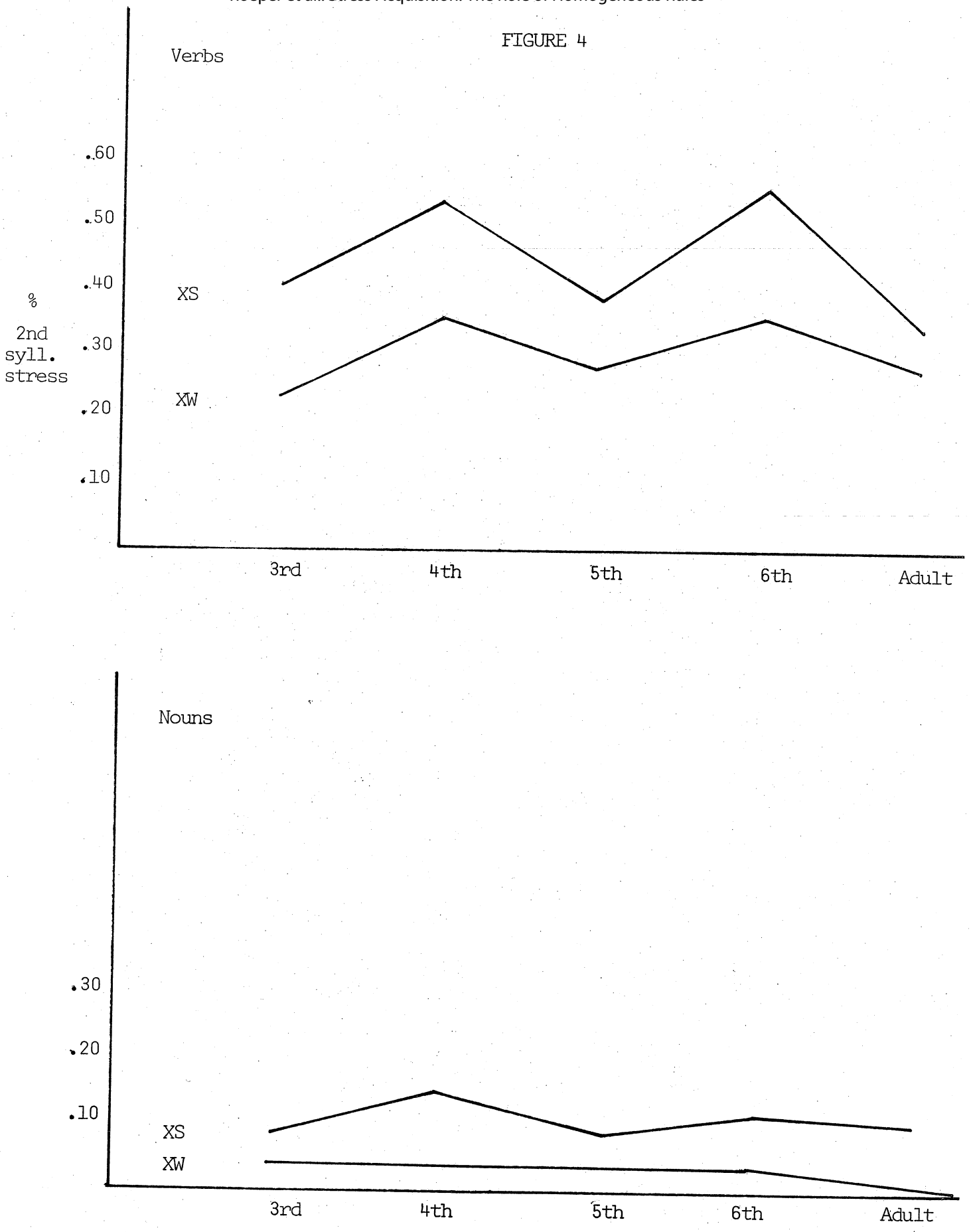

Verbs
.60
.50
.40
.30
.20
.10
%
2nd
syll.
stress
XS
XW
3rd
4th
5th
6th
Adult
Nouns
.30
.20
.10
XS
XW
3rd
4th
5th
6th
Adult

Figure 5.

1st. Syllable Stress.

	3rd	4th	5th	6th		Adult
+3	41%	29%	49%	34%		65%
+2	78%	67%	73%	60%		73%
+1	94%	90%	91%	92%		90%
0						

For the children, the results show a clear and constant increase in 1st. syllable stress for each increment of +1. There is an average difference of 31% between two and three factors and 22% between one and two factors. The adults show a small difference between two and three factors, 8%, and a more sizeable difference between one and two factors, 17%. These results fit a rule system in which one rule functions independently and the other two have been collapsed into a single rule. We shall return to the adult data below and associate these effects with specific rules.

We shall consider now a more complex weighting system in which both first and second syllable spelling effects are considered:

10)

Verb	= +1	Noun	= -1
Weak-Strong	= +1	Strong-Weak	= -1
Prefix	= +1	Nonsense	= -1

Weak-weak and Strong-strong = 0

This system reveals the following progression in our data:

11)

	-3	-2	-1	0	+1	+2	+3
Child	0%	0	6	10	30	50	68
Adult	0%	0	14	2	39	32	47

Again we find an even progression (of 20%) among the children with the addition of each factor above zero. Once again there is a jump for the adults between zero and one, and then a fairly constant percentage thereafter.

5.3.1. Data Grouping.

We have chosen to analyze the children as a group rather than by each grade. This is a consequence of the fact that we found surprisingly little shift between third and sixth grade and that we found a dip among fifth graders. This does not mean that we believe that there are no developmental shifts. The primary developmental differences may occur before third grade[9] and after sixth grade when the bulk of the Latinate vocabulary is learned. We think, however, that our failure to find developmental trends between

grades lies in the fact that grades (and age) are not the appropriate criteria. Children show substantial differences in their linguistic maturity and in their ability to read. Some other linguistic criterion might be preferable as a guide to earlier and later phases of acquisition.

6.0. Theoretical Discussion.

We shall now clarify the theoretical model which we advocate as an explanation for the results presented so far. We assume that the children follow a rule-governed system in which the presence of optional rules allows for proportionate results.

First the unmarked rule applies to every word. Therefore every word has initial stress on the first syllable. Then each of the rules in (9) is examined for its applicability. If it is applicable, then it may be applied. We chose to assume that there is an overall 50% probability that a given rule applies when it is optional. There are doubtless other factors that affect this probability in individual rules and in individual children. We take these other factors as the source of minor deviations.

In the cumulative model there will be second syllable stress when there are more than two rules which favor second syllable stress; they then overrule the one unmarked rule which gives first syllable stress. When there is one first syllable rule and one second syllable rule that applies then we expect the child to make an arbitrary choice: 50% will fall on each syllable.[10]

We shall now do a kind of "performance derivation" for two similar words: degart and resert. These are both nouns; they have an identifiable prefix, hence they are analyzeable; and they have a strong second syllable. They thus have two features which cause first syllable stress (the unmarked rule and the noun rule) and two which cause second syllable stress. We shall consider all the alternatives that each of the optional choices allows:

12)	degart	1st. Syll.	2nd. Syll.	
a.	Unm = +1	100%		
b.	Unm + N = +2	100%		
c.	Unm - Sp = 0	50%	50%	
d.	Unm - A = 0	50%	50%	
e.	Unm + N - A = +1	100%		
f.	Unm + N - Sp = +1	100%		
g.	Unm - Sp - A = -1		100%	
h.	Unm + N - Sp - A = 0	50%	50%	
		550%	250%	250/800 = 32%

[Unm = unmarked; Sp = spelling; A = analyzeability; N = noun rule.]

Under this analysis every combination of possible optional rules is chosen once. (For other words only two or three rules are possible.) The notion that most rules are optional during certain phases of language acquisition has independent support in other studies.[11] The results here suggest that degart and resert should receive second syllable stress 32% of the time. In Figure 6 we show how all the different nouns and verbs fared under this analysis. There were only two counterexamples to the

analysis and they appear in boxes:

Figure 6.

% 2nd. Syllable Stress.

Verbs	Predicted	Actual		Predicted	Actual
cabran terpel	6%	21%	subris subfer	31%	26%
stamit pratis	12%	15%	desab premit	50%	63%
tesalt masist	31%	30%	prebant presort	69%	68%
abrist sabment	12%	36%	subrimp absert	50%	54%
Nouns	**Predicted**	**Actual**		**Predicted**	**Actual**
pental balfer	0%	0%	adnal adfit	6%	2%
pobet sibel	0%	0%	osel depel	6%	11%
basant gasist	6%	0%	degart resert	32%	32%
sampelt padnect	0%	1%	adbist adment	6%	5%

We conclude that our model has made correct predictions in both an overall analysis and an anlysis in terms of individual words.

6.1. Mispronunciation and Stress.

We found, not surprisingly, that children mispronounced a fair number of words. This one might consider to be random breakdown in a performance system that had not reached full development. We found, however, that there was a high degree of regularity in the children's errors and that an overwhelming number of these errors favored the stress patterns predicted by our rules. There were the following kinds of transformations:

13) $VC_1C_2VCC \rightarrow VC_1C_2C_3VC$ or $VC_1C_2VC_3C_4 \rightarrow VC_1C_2VC_3$

The effect is to transform a Strong-strong sequence into a Strong-weak

sequence with stress on the first syllable:

14)	sampelt	→ sámplet	33 instances
	masist	→ más(s)it	19 instances
	gasist	→ gás(s)it	25 instances

There were a total of 85 instances of metathesis that favored stress. There were 58 instances of deletion that favored stress. Four instances were contrary to stress and one case was neutral. There were a few others that were wildly inaccurate mispronunciations and as we mentioned before, there were instances where real words were substituted for the nonsense words. There were also occasional instances of children adding a completely new segment to a word. Here is a selection of the errors:

15)	1st. Syll.		2nd. Syll.	
	pratis	→ pártis		
	sabment	→ sábmet	desab	→ desérp
	stamit	→ stámpit		
	presort	→ préstor	absert	→ abérst
	osel	→ óslo		
	degart	→ dérgat	adment	→ amént
	padnect	→ pádnet		
	basant	→ bánset		
	desab	→ déstab		

We find for instance that desab is shifted to déstab for first syllable stress and to desérp for second syllable stress. In each case the metathesis works to favor stress. One of the few counterexamples is a case like balfer →bláfer where the strong medial cluster is dissolved. These "errors" reveal how linguistic rules work in concert to eliminate conflict where possible. This is just what one would expect if we assume that conflict is psychologically real.

6.2. Tensing.

We did not control for tensing in order to simplify the set of variables with which we dealt. It was clear that a number of children tensed words anyway. Therefore we undertook an analysis of tensing to determine if tensed vowels attracted stress or interacted with other factors. We eliminated /ae/ from the study because it is ambiguous between being an underlyingly lax or tense vowel. This left us with fourteen words to examine.

Of the fourteen, five showed very few or no cases of vowel tensing, leaving nine cases of interest. In all nine cases, it was always the vowel of the first syllable and never the second syllable that was tensed. See Figure 7. In the first column are the total number of cases where the vowel was tensed and the stress fell on the first syllable. In the second column are the cases where the vowel was tensed, but the stress nevertheless fell on the second syllable. If tensing has an effect, there should be a difference between the two columns. There is clearly a good deal of variation in whether or not words underwent tensing. It seems

FIGURE 7

Word	1st stress/1st tense	2nd stress/1st tense	Total	%2nd syll stress w/tensing	%2nd syll stress w/o tensing
premit	7	14	21	.66	.54
presort	8	21	29	.72	.72
tesalt	8	2	10	.20	.39
pobet	31	0	31	.00	.00
sibel	12	0	12	.00	.00
osel	19	1	20	.05	.00
depel	17	4	21	.19	.22
degart	12	4	16	.25	.15
resert	13	12	25	.48	.33

quite plain, however, that tensing does not have the effect of shifting stress, although the stress rules of SPE formulate tense vowels in such a way that they attract stress. (1) It is clear from our data that words with a preponderance of first syllable stress (osel, pobet, sibel) do not shift tensing to the second syllable. (2) Next we must ask if tensing attracts stress. We turn therefore to those cases where we find tensed first syllable vowels together with a stressed second syllable. We computed the ratio of second syllable stress to first syllable stress among those cases where tensing occurs and to cases where tensing does not occur. These figures show (columns 4 and 5, Fig. 7) that tensing has no consistent effect on the placement of stress. In some cases the percentage is the same with and without tensing; in other cases it increases and in still others there is a decrease. If stress were attracted by a tense vowel we would anticipate that the latter figure was considerably higher than the former in all cases. This only seems to happen in the case of tesalt.

Our study was not designed to determine how tensing operations work. It is an interesting subject to which future work should be devoted.

7.0. Adult Data.

First it is important to mention special factors that affect the adult data. Baker and Smith (1975) found that adults often regard nonsense words as somehow "foreign." This could invoke special rules that are used to deal with subsets of foreign words in English. Second many adults reported that they found themselves consciously searching for real-word analogies. It is not clear how these factors may have affected the adult responses.

Our results show clearly that both children and adults have a Category rule: there is a noun/verb distinction in the stress rules of adult language. The point requires emphasis because there have been proposals that the noun/verb distinction might be illusory (Halle, 1973). In particular, under the full-entry theory one could mark each word for the stress rule it undergoes without reference to syntactic category. However this argument does not apply when one uses nonsense words. If the noun/verb distinction were unreal, then we would expect to see no consistent pattern of difference in adult responses to nonsense words. The distinction is captured, however, in the Lexical Category Prominence Rule advocated by Liberman and Prince. Our evidence provides further support for that distinction within their system.

We have argued that it is a property of the acquisition device to seek homogeneous rules. We should expect then that adults reveal non-homogeneity in their application of rules. We believe that there is evidence for that view. We shall look at the effects of Analyzeability and Spelling. (See Figures 8 and 9.)

We shall concentrate upon the verbs but the argument holds for the nouns as well. If we look (Figure 8) at the adult matrix for verbs we find that they give 63%, 65% and 66% second syllable stress when either Spelling or Analyzeability or both are a factor. For the children we find that there is a sharp increase from 67% and 55% to 38% when both factors are present. In the latter case there is a cumulative effect; in the former, adult, case we find no evidence for cumulative rules whatsoever. The effects are very clear across all the grades (see Fig. 9). These results are precisely what one would predict for adults if the Analyzeability rule

FIGURE 8

Children grades 3-6: % 1st Syllable Stress

VERBS

-prefix	+prefix	Ave.
121/147 .82	81/146 .55	.69
91/135 .67	55/145 .38	.52
.75	.47	.61

NOUNS

-prefix	+prefix	Ave.
156/156 1.00	144/155 .93	.96
111/112 .99	122/148 .82	.90
1.00	.88	.93

Adults

-prefix	+prefix	Ave.
39/39 .82	25/40 .63	.72
25/38 .66	24/37 .65	.65
.74	.64	.69

-prefix	+prefix	Ave.
40/40 1.00	38/39 .97	.99
30/33 .91	36/40 .90	.90
.96	.94	.95

entail their having additive effects. In SPE, rules which apply 1 str can not increase 1 stress. However Halle (1973) has recently proposed on independent grounds that stress assignment should function additively and that a special rule of destressing would take effect in terms of the number of 1 stresses a syllable receives. In Liberman and Prince the interaction with metrical structure is more complex. In general our putative child grammar is not at odds with universal grammar.

How does our model suggest an improvement in the learnability of grammars ? We suggested earlier that the hypothesis of homogeneous rules limits the set of possible hypotheses at the first phase of stress acquisition. It is worth note that the adult rules which replace the homogeneous rules may not involve a radical reanalysis of those rules. The operation is primarily one of collapsing the existing rules into a set of inter-defined rules. Or, as in our analysis, there is a shift of a rule from a stress rule to a destress rule. It is conceivable that the child loses hypothesis-power during the latter phases of acquisition, namely the power to project the initial stress rules. What remains is the power to re-order and collapse rules, etc. This view would preclude a radical reanalysis of stress rules at the later stages of acquisition. It is possible that an acquisition device ought to keep all powers at all phases: a new phonological feature might entail a reanalysis that involved every aspect of a hypothesis-generator. However the opposite possibility would improve learnability. If some hypothesis-powers decayed as other powers matured, then at each phase of acquisition, the child would have a different range of potential hypotheses, but at each phase the range would be significantly smaller. There would, in fact, be an exponential decrease in possible grammars if the hypothesis-power changed but did not increase. Far more data is needed before we can decide upon either of these possibilities.

A good deal of current work in language acquisition has shown that it is important to verify claims through several methodologies.[13] This work is meant to fit into a larger study of how children acquire multi-syllable stress systems. All of our hypotheses must remain tentative until further work is done.

Footnotes.

1. We would especially like to thank Charles Clifton for a great deal of helpful advice and good discussion on many aspects of this paper. We would also like to thank the members of the Summer Acquisition Research Group at Amherst, Alan Prince, and Barbara Skladanek of the University of Chicago, who carried out the initial experimental work. This work was supported by a grant from the University of Chicago and N.I.H. Grant HD09647-02S1 to S. J. Keyser and T. Roeper.

2. This is the issue of the "instantaneous" model. This model assumes the power of Universal grammar applies at once to a sufficient body of data to produce English. The claim is obviously false, but the assumption that Universal grammar is honored throughout language acquisition may not be.

3. See Roeper (1974) for discussion of the acquisition of prefixes in German.

4. See Roeper (op. cit.) for discussion of children's tendency to stress roots and not affixes.

5. See Baker and Smith (1975).

6. Baker and Smith (op. cit.) also found these results.

7. See Roeper (op. cit.). We found that the first syllable was stressed in Missbrauch and the second syllable was stressed in the verb missbrauchen. Occasionally the noun was given second syllable stress but it was never the case that the verb received first syllable stress.

8. See Myerson (1975).

9. See Myerson (op. cit.) for evidence that children do control some of the Latinate shifts by this age.

10. There could, of course, be variation among individuals and among individual rules that would cause deviations from 50%. We expected these deviations to disappear across the data. In fact, the estimate of 50% appears to have been surprisingly accurate insofar as the predicted and actual stress preferences were very close. We do not, of course, know which of the rule combinations a child has chosen when he stresses a given word. Therefore, it is impossible to see directly whether 50% is accurate as the breakdown of stress preferences where an equal number of rules applied to both first and second syllable stress.

In general, there could be a wide range of factors which cause certain optional rules to interact and thus be more likely or less likely combinations. As long as their interaction is not a formal aspect of the grammar, we would expect these differences to average out. This is just what our results suggest.

11. Brown (1974) and Miller (1973).

12. Jessica Wirth has suggested to us that the restriction may be stronger than a limitation to homogeneous rules in the initial phase. It could be that there are no collapsed rules (therefore, no parentheses) in use by the children. This seems plausible to us and a possible subject of further investigation.

13. See, for example, Maratsos (1974), Myerson (1975).