LEARNING OF A MINIATURE LINGUISTIC SYSTEM:  
EFFECTS OF EXTERNAL REFERENTS AND ORDER OF WORD CLASSES

A miniature linguistic system consisting of four word classes and five rules governing word-class combination possibilities was correlated to a reference system consisting of visual figures, relations between figures, and changes in figures. Two factors were varied in order to establish their effects on learning: (1) the order of the three major word-classes and (2) the presence of the visual reference system. The results indicated that word-class order did affect the language learning process and so did the use of the reference system. Evidence indicated that subjects may have employed different strategies depending on whether or not they were given the visual reference system. Although most subjects learned something, only a few (all given the visual reference system) were able to learn certain language rules and there were some indications that these subjects may have used the reference system to mediate their learning.
LEARNING OF A MINIATURE LINGUISTIC SYSTEM
LEARNING OF A MINIATURE LINGUISTIC SYSTEM:
EFFECTS OF EXTERNAL REFERENTS AND ORDER OF WORD CLASSES

by

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A thesis submitted to the Faculty of Graduate
Studies and Research in partial fulfillment of
the requirements for the degree of Master of Arts

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June, 1969

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ACKNOWLEDGMENTS

The writer is greatly indebted to Dr. A.S. Bregman for critical reading of the manuscript and technical advice and assistance and to Mr. S. Parkovnick for helping to run some of the subjects.

This research was supported by the National Research Council of Canada (Grant No. 67-48). The work took place while the writer held a National Research Council Science Scholarship.
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A number of psychologists have attempted to experimentally reproduce some of the processes of language learning by studying the acquisition of artificial languages which form miniature linguistic systems (MLSs). Although generally these laboratory studies use adult Ss, the S's task in the MLS situation is similar to that of the child learning his first language; he is presented with only a limited subset of all grammatically correct utterances from the language and he must somehow discover the set of rules which characterize the language.

Two major MLS situations have been used by experimenters. The first type originated with Esper (1925) and has been extended by Horowitz (1959) and Foss (1968a, 1968b). Essentially the experiment consists of a set of nonsense figures which vary along certain discriminable dimensions (such as shape and color) and a set of nonsense syllables which are assigned to various aspects of the figures. The syllables are formed into two classes, A and B; those syllables in class A are systematically paired with each variation on one dimension of the figure (i.e., one syllable for each color) and those syllables in class B are systematically paired with each variation on the other dimension of the figure (i.e., one syllable for each shape). Thus the name of a given nonsense figure always consists of two syllables, ordered so that the syllable from one class always precedes the syllable from the other class. The MLS is presented to the S in the form of learning the names for each individual figure and the S is tested to see whether he has discovered
the structural features of the language by exposing him to new shape-color combinations which he has not previously seen and asking him to give the correct two-syllable name.

Esper (1925) found that when Ss were presented with 14 items of a MLS containing 16 figures (combinations of 4 shapes and 4 colors), they were able to correctly respond to the novel stimuli (the two missing figures), often without recognizing that the items had not been seen before. Foss (1968a) also reported that once Ss had learned a subset of items from a systematic MLS, they were able to respond correctly to other items in the MLS that were not originally learned. Foss's Ss not only learned the specific variable to which each syllable referred, but also learned that syllables referring to variables on a particular dimension preceded syllables referring to variables on the other dimension. Thus Ss were able to learn the syntactic rules of the MLS and not just the individual word-figure associations which were presented.

In the second type of MLS situation, word-units are not correlated to stimulus dimensions of figures. Instead Ss are exposed only to strings of words or letters (sentences) which are characterized by some regularities of construction. It is the S's task to discover what these regularities are. Various tests can be used to discover if the S has learned the rules of sentence construction; recognition, recall, and sentence-completion are the most common.

An early experiment of this type by Braine (1963) used children as Ss. The sentences to be learned consisted of two-word strings, the first word belonging to a class A, and the second word to a class P, arranged so that the word classes always followed the order AP in the sentences and never PA. Each class contained
three nonsense words. In the initial learning trials, four of the six words were presented, each in its correct position. When the sentence positions of the four training words had been learned, either a new A or a new P word was presented, with the new A-word being placed in the same position on a board that previous A-words had been placed and the new P-word being placed in the same position that previous P-words had been placed. The alternatives given to be used to complete the sentences always consisted of words used in the initial learning phase, one from each class. Braine reported that most of his Ss were able to create new, grammatically correct sentences, i.e., they chose a P word if the new word was given in the "A" position. In a further experiment, two-word phrases were used instead of individual words, with the same results. Braine concluded that words or phrases tend to become associated with the sentence positions in which they occur, and thus to generalize to new contexts. "What is learned" in language acquisition, Braine proposes, are the positions of words and expressions in sentences.

Smith (1965) has also investigated MLSs consisting essentially of simple two-element sequences. He constructed letter pairs from two classes of letters, A and B, with A-letters appearing first in all sequences, B-letters appearing second. The letter-pairs were sufficiently numerous so that only a small proportion could be learned by rote. Smith found that in a free recall test, Ss reported pairs which had not been presented but which were grammatically consistent with the MLS. Presumably the Ss had learned that rule that certain letters appeared first and certain letters appeared last.

In a later experiment, Smith (1966) utilized four classes of letters, so that a sentence consisted of either MN or PQ structure.
Smith reported that the Ss produced more intrusions of the types MQ and PN than could be expected by chance. He suggested that these results supported Braine's theory of position learning which predicts that Ss will learn which letters come first and which second. Smith's Ss did not learn that N-letters followed M-letters, and Q-letters followed P-letters.

Braine (1965), however, reported that Ss given sentences AXB and PXQ not only learned that A and P went first, X went second, and B and Q went last, but also that B was contingent on A and Q on P.

Reber (1967) has studied the acquisition of a MLS using more complex sentence strings generated by a finite state Markovian process. His Ss were required to learn 28 "sentences", presented in sets of 4 sentences each. Each sentence was shown for 5 seconds and after the set of four had been presented, the S was asked to reproduce them. When the S was able to successfully reproduce all the sentences of one set, he was given the next set, until all 7 sets had been learned in this way. The experimental Ss showed a consistent decline in number of errors to criterion across the 7 sets, while the control group, given randomly constructed sequences, did not. Ss were able to efficiently apply the information they had learned to a transfer recognition task; however they were unable to verbalize any sentence rules and Reber reported that he was unable to uncover any explicit strategies that individual Ss used. Thus Reber suggested that rather than learning to respond to specific coding systems, the Ss implicitly learned to respond to the general grammatical structure of the language.

All of the above mentioned studies indicate that Ss can
learn the grammatical structure of the "sentences" in these artificial languages. However, in most of these experiments the grammar has contained word classes defined only in terms of sentence position. Also the second type of MLS is semantically empty. But natural languages are not semantically empty, and many natural languages, including English, utilize word classes that are defined by their selection restrictions in terms of other words as well as by their position in a sentence. A "selection restriction" means that the occurrence of one word-type in a sentence depends on the presence of another word-type. Braine (1963) writes that his position-learning theory is not relevant to the learning of contrasts between word orders and must be confined to the learning of restrictions on word order. As the theory stands, he writes, it would predict that absurd recombinations would occur by generalization. Thus Braine adds that as well as learning the locations of units, Ss form paired associates whose foci are typically members of the closed morpheme classes such as prepositions, articles, etc. and which provide the sentence with a frame.

However open-class morphemes also show selection restrictions in the sense that words of one class are contingent upon the occurrence of words of another class, i.e., the occurrence of an object is contingent upon whether the verb is transitive or intransitive. Thus it would be interesting to discover how Ss learn such selection restrictions.

If a language contains classes defined by selection restrictions as well as by sentence positions, the question arises as to whether there is an interaction between these two variables which affects the learning process. Also it cannot be forgotten that words are
tied to semantic referents in real languages, and the learning of word orders could also be affected by the meaning of the words. Esper (1925) reported that the color-shape order was learned more quickly than shape-color order, in accordance with what he felt was English structure, and that the shape morphemes were learned faster than the color morphemes. However Horowitz and Jackson (1959), in a more controlled experiment, found no significant differences in either the learning of the orders or the learning of the morphemes. Greenberg (1966) has suggested that in the vast majority of languages, the dominant order in declarative sentences is almost always one in which the subject precedes the object.

The present experiment was designed to examine some of these questions. A MLS was made up consisting of four word classes, with certain restrictions with respect to when they could occur. This MLS was correlated to an environment which consisted of objects, relations between objects, and changes in objects, so that the word-classes were not only defined in terms of their selection restrictions and combination possibilities but also in terms of their semantic content. The first question to be examined was whether the interaction of these word-classes with their specific positions in sentences would have an effect on the learning process. To test this question, groups of Ss were run in all possible order permutations of the three major classes of words. The second question to be examined was whether this external semantic referent would help or hinder or somehow interact with the language learning process. Thus some groups of Ss were tested using the sentences only, without the external referents. The third question to be looked at was whether or not such a fairly complex language could be taught in a short laboratory period and,
if so, exactly what was learned. Thus several tests were designed
to attempt to discover exactly how the learning process progressed.
**METHOD**

An artificial language was constructed utilizing 14 different words, all words being CVCs with an association value of 73 according to Glaze (1928) and between 80 and 90 according to Krueger (1934). The 14 words were grouped into 4 classes, with 4 words each occurring in classes A, B, and C, and 2 words occurring in class D. The syntactic structure of the language could be described by the following five rules:

1. A sentence must contain one A-word.
2. A sentence must contain one B-word.
3. A sentence containing a $B_z$-word can have 1 or 2 C-words.
4. A sentence containing a $B_y$-word can have 0 or 1 C-words.
5. A D-word can only follow an A- or C-word.

These five rules can be described in terms of a phrase-structure model of language as follows. (Contrary to general usage the following rewrite rules are to be interpreted as rewriting symbols into unordered sets of symbols, rather than into ordered strings. The order was a variable which was manipulated in the experiment.)

1. $S \rightarrow AP + BP$
2. $AP \rightarrow A + (D)$
3. $BP \rightarrow \{B_z + CP + (CP)\}$
   \[\{B_y + (CP)\}\]
4. $CP \rightarrow C + (D)$

Thus in accordance with these rules, a correct sentence in the MLS could range from a minimum of 2 words ($AB_y$) to a maximum of 7 words ($ADB_zCDCD$).
Some aspects of this language could be considered similar to English syntax. The A-class is somewhat comparable to the subject category in English sentences; the B-class best corresponds to the verb category, with $B_z$-words being somewhat similar to transitive verbs which must be accompanied by a direct object, and $B_y$-words bearing a resemblance to intransitive verbs which cannot be accompanied by a direct object. The C-class in this MLS is more difficult to translate into English because in this respect the two languages are really not comparable. C-words actually serve two functions. First they can act as direct objects and this function is marked by the fact that a C-word must occur with a $B_z$-word. The other C-class function can best be described as that of a prepositional phrase which may or may not be added to any sentence; this function is marked by the fact that a C-word may or may not occur in a $B_y$-sentence and may or may not occur as a second C-word in a $B_z$-sentence. The D-class of words is similar to the adjective class in English, with D-words acting as modifiers of A- and C-words.

As well as the similarities, the differences between this MLS and English structure should be stressed. In English, words serving subject and object functions are interchangeable, but prepositional phrases must be marked by a preposition; in this MLS the words serving subject and object functions are not interchangeable but those serving as direct objects and prepositional phrases are, and the "prepositional phrase" is not marked by the addition of a preposition or morpheme affix. The reason for these differences was to make the language learning situation as new as possible for the $S$. Thus, although it was possible to translate the MLS into English structure as described, it was not necessary for the $S$ to employ this reasoning in order to
learn the language. All that was necessary to learn the language was to learn the five rules described above, plus the order in which the A, B, and C words were presented.

Ten groups of Ss were tested in this study. Seven of these groups were under the environmental condition in which sentences were correlated to specific objects and object-relations, while three groups were in a words-only condition. With the exception of one group (Random), the word-classes were defined by their order in the sentence as well as by their privileges of occurrence.

For the environmental groups, A-words were correlated with rounded figures, B_y-words with a relationship between A- and C-figures, B_z-words with a change in A-figures, C-words with angular figures, and D-words with a change in the character of A- or C-figures. Thus the different classes of words were defined by semantic differences as well as by privileges of occurrence. An illustration of all figures and relations used is shown in Figure 1. Looking at Figure 1, it can be seen that some of the restrictions of the language are built into the environment. The very nature of the referent of a B_z-word necessitates the inclusion of at least two other words, whereas the referent of a B_y-word does not necessitate such an inclusion. (There is nothing in the environment, however, which precludes the use of two C-words with a B_z-word or the use of a C-word as the "subject" of a B_y-sentence; the learning of the language rules might be assisted by the semantic properties of the environment but is not necessitated simply by the acquisition of the word-figure vocabulary.) The C-object in a B_y-picture or the second C-object in a B_z-picture was placed either to the right or the left of the AB grouping (five were on the left and five on the right). Thus in this case, also, the semantic properties of the
FIGURE 1
AN ILLUSTRATION OF THE ENVIRONMENTAL MLS

A-WORDS
- BEF
- RIZ
- PUM
- NEP

Bz-WORDS
- MUL (two figures joining)
- CAG (one figure on top of another)

By-WORDS
- VOY (elongation of base)
- TOB (upside down)

C-WORDS
- WAF
- DEX
- JOW
- CIM

D-WORDS
- SAN (double line)
- KAS (blacked in
environment may have assisted the S to understand this "prepositional phrase" function of the C-class.

The seven groups in the environmental condition consisted of every possible order permutation of A, B, and C words (ABC, ACB, BAC, BCA, CAB, and CBA) plus a random group utilizing stimuli from all order classes so that the order of words varied from slide to slide. The three groups in the words-only condition utilized only the ABC, ACB, and BAC orders. If two C-words occurred in a sentence the second followed immediately after the first, except that the D-word "modifying" the first C-word could intervene. In all orders the D-word always immediately followed the A- or C-word that it "modified".

Subjects: The Ss were 90 undergraduate student volunteers from the McGill University psychology subject file. Seven female and three male Ss were assigned to each group. The Ss were either tested individually or in groups of two. All Ss were native speakers of English.

Materials: The stimulus materials consisted of black and white slides projected on a 2½' X 2' screen by a Kodak 850 projector set to automatically change the slides every 8 seconds (the slides were actually projected for 6.5 seconds with a .8 second interval between them). For the environmental groups, the pictures occupied the upper two-thirds of the slides and the words the lower one-third (the same pictures were used, with only the word order in sentences changed for each group). For the words-only groups, the sentences were centered.

There were 20 different sentences used, ranging from two to four words in length. Each word was presented 5 times in this group of 20, and all sentences were grammatically correct. A copy of the
20 sentences presented is given in Appendix A. In each presentation of 80 sentences there were 4 different series of 20 sentences, with the slides randomly arranged within each series except that no word appeared on two consecutive slides. Each of the 10 groups received the same random order of slides.

Three tests were employed at three different points during the experiment to measure the S's progress in learning the language. The three tests were identical in form, but differed in terms of the words used. A copy of the three tests is shown in Appendix B. Each test consisted of four parts. Part I simply asked the Ss to write 5 different sentences in the language they had just learned. Part II was a multiple-choice vocabulary test in which the Ss in the environmental groups were shown a figure or a relationship (see Figure 1 for examples of the methods used to illustrate B-words and D-words) and were asked to choose the word which best described the picture. Four choices were given, the correct answer, a word from the same word class as the correct answer, and two words from different word classes. All 14 words in the language were tested in this way. The Ss in the words-only groups were given a similar test, but because no pictures could be provided from which to form word-referent associations, the Ss were simply asked to choose the words which had appeared in the MLS from amongst similar but incorrect words. The Part II tests for the environmental and words-only groups were not meant to be comparable. Part III of the tests investigated class position learning and consisted of 4 multiple-choice questions, each having 6 choices; these choices consisted of the same three words in the six possible orders, ABC, ACB, BAC, BCA, CAB, and CBA. Ss were required to choose the group of words in the correct order. The four questions utilized
all words (except D-words) in the language. This part of the test was omitted in the Random group.

Part IV of the tests examined the learning of the five language rules. It consisted of 33 pairs of multiple-choice questions from which the Ss were requested to choose the correct sentence in each pair. All sentences were in the correct order for that S, and only one error was made in each incorrect sentence. There were three questions in each test which examined each of the following eleven sub-rules:

1. KAS (a D-word) cannot follow a B-word.
2. SAN (a D-word) cannot follow a B-word.
3. MUL (a B-word) must be accompanied by at least one C.
4. CAG (a B-word) must be accompanied by at least one C.
5. VOY (a B-word) can only appear with 0 or 1 C.
6. TOB (a B-word) can only appear with 0 or 1 C.
7. An A-word must appear in the sentence.
8. A B-word must appear in the sentence.
9. Only one A-word can appear in the sentence.
10. Only one B-word can appear in the sentence.
11. Only two C-words can appear in the sentence.

In terms of the five rules mentioned previously, sub-rules 1 and 2 are covered by rule 5, sub-rules 3 and 4 by rule 3, sub-rules 5 and 6 by rule 4, sub-rules 7 and 9 by rule 1, sub-rules 8 and 10 by rule 2, and sub-rule 11 by rules 3 and 4.

All subjects were asked to guess and to answer all questions. The sentences used in Parts III and IV of the tests had not been previously seen by the Ss.
Procedure: As soon as the Ss were comfortably seated on chairs in front of the screen, they were told:

"This is a language-learning experiment involving an artificial language. You will be shown slides with groups of words on them. Each slide represents one complete sentence in the language you are to learn. Each slide will be presented to you a number of times so that you can learn the language."

The environmental groups were told, in addition:

"The sentences which are printed on the slides refer to the pictures above them."

Then the projector was started and the Ss watched while 80 slides were shown. At the end of the 80-slide presentation the Ss were given Test 1 and asked to complete it; no time limit was placed on the test. When the Ss completed the test, they were shown the same 80 slides again and given Test 2. This procedure was repeated a third time utilizing Test 3.
RESULTS

Environmental Groups: The mean scores and standard deviations for the six ordered environmental groups on all sections of the three tests are shown in Tables I, II, III, and IV.

Table I shows the number of correct sentences found in the production (Part I) section of the tests. It can be seen that all groups showed a tendency to produce more correct sentences as the experiment progressed, but that there is little difference among the groups on this part of the tests. A two-way analysis of variance comparing the groups and the separate tests indicated that only the difference among the first, second, and third tests was significant \((F(1,48) = 54.11, p < .001)\). (In all analyses of variance with repeated measures reported on in this experiment the degrees of freedom used in finding the critical values were adjusted by dividing them by \(q-1\) in accordance with Winer's (1962, p. 306) recommendations on repeated measures designs.) There was no significant difference among the groups on the production scores.

In Table II the vocabulary (Part II) scores are given for all groups. As in the case of the production scores, there seem to be few differences among groups, although the mean scores for group CBA are a bit lower than the other group means on the second and third tests and the mean score for group ABC is a bit higher. There are no significant differences among the groups, however, and again a two-way analysis of variance shows only significant differences among the tests \((F(1,48) = 74.33, p < .001)\). Chance score for the vocabulary tests was 3.5. T-tests showed that the scores for all groups were significantly \((p < .01)\) above chance on all tests except the scores of
TABLE I
THE PRODUCTION (PART I) SCORES FOR THE SIX ORDERED ENVIRONMENTAL GROUPS

<table>
<thead>
<tr>
<th>GROUP</th>
<th>1st TEST</th>
<th>2nd TEST</th>
<th>3rd TEST</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>ABC</td>
<td>1.67</td>
<td>0.87</td>
<td>2.89</td>
</tr>
<tr>
<td>ACB</td>
<td>1.67</td>
<td>1.66</td>
<td>3.22</td>
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<tr>
<td>BAC</td>
<td>0.78</td>
<td>0.83</td>
<td>3.33</td>
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<tr>
<td>BCA</td>
<td>1.67</td>
<td>1.23</td>
<td>3.11</td>
</tr>
<tr>
<td>CAB</td>
<td>1.44</td>
<td>1.51</td>
<td>3.00</td>
</tr>
<tr>
<td>CBA</td>
<td>1.29</td>
<td>1.09</td>
<td>3.00</td>
</tr>
</tbody>
</table>

TABLE II
THE VOCABULARY (PART II) SCORES FOR THE SIX ORDERED ENVIRONMENTAL GROUPS

<table>
<thead>
<tr>
<th>GROUP</th>
<th>1st TEST</th>
<th>2nd TEST</th>
<th>3rd TEST</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>ABC</td>
<td>8.00</td>
<td>2.96</td>
<td>12.22</td>
</tr>
<tr>
<td>ACB</td>
<td>6.11</td>
<td>3.26</td>
<td>9.78</td>
</tr>
<tr>
<td>BAC</td>
<td>6.33</td>
<td>5.00</td>
<td>9.33</td>
</tr>
<tr>
<td>BCA</td>
<td>6.44</td>
<td>2.83</td>
<td>9.56</td>
</tr>
<tr>
<td>CAB</td>
<td>7.22</td>
<td>1.72</td>
<td>9.89</td>
</tr>
<tr>
<td>CBA</td>
<td>7.00</td>
<td>3.31</td>
<td>7.89</td>
</tr>
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</table>
groups BAC and ACB on test 1.

Table III gives the order (Part III) scores on the tests, and in it the differences among the groups are more pronounced. Again group CBA shows a lower mean score than the other groups on tests 2 and 3. Also again there are considerable differences among the tests for all groups, showing a learning effect as the experiment progresses. A two-way analysis of variance on the order scores, comparing the groups and the separate tests, showed a significant difference among the three tests ($F(1,48) = 31.62, p < .001$), and in addition, a significant difference among the groups ($F(5,48) = 2.41, p < .05$). Individual comparisons between groups using Tukey's (a) method (Winer, 1962, p. 87) showed, however, no significant individual differences on any test. Chance score on the order section of the tests was 4. All groups exceeded chance level on all tests at the .01 level of significance, except for groups ACB and CBA on the first test which reached only the .05 level of significance.

A look at Table IV, showing the rules (Part IV) scores, also reveals considerable differences among the three tests and among the six groups, with again group CBA showing a considerably lower mean score than the other groups on the third test. A two-way analysis of variance on the rules scores indicated a significant difference among the three tests ($F(1,48) = 47.04, p < .001$) and a significant difference among the six groups ($F(5,48) = 3.52, p < .01$). Individual comparisons using Tukey's (a) method revealed no significant individual differences on the first or second tests, but on the third test there were significant differences between group CBA and groups ABC ($p < .01$), CAB ($p < .01$), BAC ($p < .05$), and ACB ($p < .05$). The chance score on the rules was 16.5. T-tests showed that all groups exceeded chance at the
### TABLE III

THE ORDER (PART III) SCORES FOR THE SIX ORDERED ENVIRONMENTAL GROUPS

<table>
<thead>
<tr>
<th>GROUP</th>
<th>1st TEST</th>
<th>2nd TEST</th>
<th>3rd TEST</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>ABC</td>
<td>8.11</td>
<td>2.21</td>
<td>7.89</td>
</tr>
<tr>
<td>ACB</td>
<td>6.00</td>
<td>2.92</td>
<td>9.89</td>
</tr>
<tr>
<td>BAC</td>
<td>7.56</td>
<td>1.59</td>
<td>9.11</td>
</tr>
<tr>
<td>BCA</td>
<td>6.44</td>
<td>1.59</td>
<td>8.44</td>
</tr>
<tr>
<td>CAB</td>
<td>7.11</td>
<td>2.26</td>
<td>7.56</td>
</tr>
<tr>
<td>CBA</td>
<td>6.00</td>
<td>2.12</td>
<td>6.78</td>
</tr>
</tbody>
</table>

### TABLE IV

THE RULES (PART IV) SCORES FOR THE SIX ORDERED ENVIRONMENTAL GROUPS

<table>
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<th>GROUP</th>
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<th>3rd TEST</th>
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<td>M</td>
<td>SD</td>
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<tr>
<td>ABC</td>
<td>21.22</td>
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<td>24.56</td>
</tr>
<tr>
<td>ACB</td>
<td>20.56</td>
<td>3.05</td>
<td>23.89</td>
</tr>
<tr>
<td>BAC</td>
<td>21.11</td>
<td>5.09</td>
<td>24.67</td>
</tr>
<tr>
<td>BCA</td>
<td>19.67</td>
<td>2.65</td>
<td>19.67</td>
</tr>
<tr>
<td>CAB</td>
<td>20.22</td>
<td>3.19</td>
<td>25.22</td>
</tr>
<tr>
<td>CBA</td>
<td>19.00</td>
<td>3.08</td>
<td>19.44</td>
</tr>
</tbody>
</table>
.01 significance level on all tests, except for group CBA which only reached the .05 level of significance on the first and second tests and group BCA which also only reached the .05 level of significance above chance on the second test.

In an attempt to get more information about possible differences in learning the rules, the total rules scores were analyzed in terms of the 11 separate sub-rules. It was found that there was a significant difference among the scores obtained on the rules ($F(1,48) = 12.38, p < .01$) and a significant interaction effect between the rules and the groups ($F(5,48) = 2.42, p < .05$). Thus some rules proved more difficult to learn than others, and the specific difficulties varied from group to group. In Appendix C, a table showing the mean scores for each group on the 11 different sub-rules is presented.

Correlations between the total scores on the four parts of the tests were computed and are shown in Table V. From this table it can be seen that three correlations are significant at the .01 level, the correlation of .56 between the production and order scores (Part I and III), that of .68 between the vocabulary and rules scores (Parts II and IV), and that of .47 between the order and rules scores (Parts III and IV).

Analyses were also performed to see if the class of word (A, B, or C) or the position of a class in a sentence (first, middle, or last), or an interaction of these two variables significantly affected the way in which the words were learned. In the production section of the tests there was a significant difference ($F(2,153) = 19.31, p < .001$) in respect to the type of word produced. There were an average of 4.34 A-words, 4.51 B-words, and 3.23 C-words produced per test; thus many fewer C-words were produced than A- or B-words. There were no
### TABLE V

**CORRELATIONS BETWEEN THE TOTAL SCORES ON THE FOUR PARTS OF THE TESTS FOR THE SIX ORDERED ENVIRONMENTAL GROUPS**

<table>
<thead>
<tr>
<th>SECTION</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>-</td>
<td>.14</td>
<td>.56*</td>
<td>.22</td>
</tr>
<tr>
<td>II</td>
<td>-</td>
<td>-</td>
<td>.26</td>
<td>.68*</td>
</tr>
<tr>
<td>III</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>.47*</td>
</tr>
<tr>
<td>IV</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

* Significant at the .01 level
significant differences due to the positions of the word-classes in the sentence nor due to an interaction between class of word and its position. All groups produced fewer C-words than A- or B-words. However similar analyses on the vocabulary scores and the order scores revealed no significant differences. Neither the word-figure learning of the vocabulary nor the learning of the position of a word in a sentence was affected by the class of word or its sentence position or an interaction of these two variables. The Ss learned to associate A, B, and C words with their picture referents with equal facility no matter what position the word-classes occupied in a sentence; they also learned to associate A, B, and C words with their sentence positions with equal facility no matter what position the word-classes occupied in a sentence. The recognition learning for order and reference of the words in the language seemed to be unaffected by class membership or sentence position.

Random Group: Because Part II (order) on all tests was eliminated for the Random group, this group was analysed separately from the other environmental groups. The scores for the Random group on the three tests are shown in Table VI. A comparison of Table VI with Tables I, II, and IV reveals that there is little difference between the Random group and the six ordered environmental groups in terms of scores on the tests, although the mean rules score for the third test was lower than five of the ordered groups. Analyses of variance comparing the Random group with the six ordered groups taken as a whole were performed on the production, vocabulary, and rules scores. In all of these the F was non-significant. Thus the scores of the Random group on the three tests do not differ significantly from the scores obtained by the six ordered environmental groups. Individual comparisons using
### TABLE VI
THE MEAN SCORES ON PRODUCTION, VOCABULARY, AND RULES FOR THE RANDOM GROUP

<table>
<thead>
<tr>
<th>SECTION</th>
<th>1st TEST</th>
<th></th>
<th>2nd TEST</th>
<th></th>
<th>3rd TEST</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Production</td>
<td>2.33</td>
<td>0.50</td>
<td>2.67</td>
<td>0.87</td>
<td>3.44</td>
<td>1.42</td>
</tr>
<tr>
<td>Vocabulary</td>
<td>7.56</td>
<td>2.19</td>
<td>11.00</td>
<td>3.46</td>
<td>12.44</td>
<td>3.09</td>
</tr>
<tr>
<td>Rules</td>
<td>19.44</td>
<td>3.09</td>
<td>20.00</td>
<td>2.83</td>
<td>23.89</td>
<td>4.53</td>
</tr>
</tbody>
</table>
the Tukey (a) method between the Random group and the other six environmental groups showed no significant differences on any test in the three sections.

The mean vocabulary and rules scores obtained by the Random group were found to be significantly (p < .01) above chance on all tests. The Random group also showed a learning effect as the experiment progressed on all parts of the tests. For the production scores the difference between tests was significant at the .05 level (F(2,16) = 3.74); for the vocabulary scores it was significant at the .001 level (F(2,16) = 25.88); and for the rules scores it was significant at the .01 level (F(2,16) = 5.74).

Words-Only Groups: The means and standard deviations for the three words-only groups on the four sections of the tests are shown in Tables VII, VIII, IX, and X.

As with the environmental groups, the production, vocabulary, order, and rules scores were analyzed in terms of the differences among the groups and the differences among the tests. On the production, vocabulary, and order scores no significant differences among groups were found, and in all three sections significant differences among the tests were found at the .001 level (for the production scores, F(2,24) = 26.75, for the vocabulary scores F(2,24) = 23.86, and for the order scores F(2,24) = 15.88).

With regard to the rules scores, the difference among tests was not significant (F = .38); in other words, on the rules section of the tests a general improvement in performance did not take place with an increased number of trials for the words-only groups. On the rules scores, however, the difference among groups was significant (F(2,24) = 4.47, p = .05). The interaction between the different
### TABLE VII
THE PRODUCTION (PART I) SCORES FOR THE THREE WORDS-ONLY GROUPS

<table>
<thead>
<tr>
<th>GROUP</th>
<th>1st TEST</th>
<th>2nd TEST</th>
<th>3rd TEST</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>ABC</td>
<td>3.22</td>
<td>1.00</td>
<td>4.22</td>
</tr>
<tr>
<td>ACB</td>
<td>2.30</td>
<td>1.21</td>
<td>3.44</td>
</tr>
<tr>
<td>BAC</td>
<td>1.88</td>
<td>1.20</td>
<td>3.22</td>
</tr>
</tbody>
</table>

### TABLE VIII
THE VOCABULARY (PART II) SCORES FOR THE THREE WORDS-ONLY GROUPS

<table>
<thead>
<tr>
<th>GROUP</th>
<th>1st TEST</th>
<th>2nd TEST</th>
<th>3rd TEST</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>ABC</td>
<td>13.11</td>
<td>0.93</td>
<td>13.56</td>
</tr>
<tr>
<td>ACB</td>
<td>11.22</td>
<td>2.11</td>
<td>13.33</td>
</tr>
<tr>
<td>BAC</td>
<td>11.78</td>
<td>2.05</td>
<td>13.11</td>
</tr>
</tbody>
</table>
### TABLE IX

THE ORDER (PART III) SCORES FOR THE THREE WORDS-ONLY GROUPS

<table>
<thead>
<tr>
<th>GROUP</th>
<th>1st TEST</th>
<th>2nd TEST</th>
<th>3rd TEST</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M  SD</td>
<td>M  SD</td>
<td>M  SD</td>
</tr>
<tr>
<td>ABC</td>
<td>7.56 2.56</td>
<td>9.44 1.51</td>
<td>9.22 2.11</td>
</tr>
<tr>
<td>ACB</td>
<td>8.00 2.78</td>
<td>9.89 1.97</td>
<td>11.22 1.20</td>
</tr>
<tr>
<td>BAC</td>
<td>6.78 3.63</td>
<td>8.78 3.47</td>
<td>9.56 2.13</td>
</tr>
</tbody>
</table>

### TABLE X

THE RULES (PART IV) SCORES FOR THE THREE WORDS-ONLY GROUPS

<table>
<thead>
<tr>
<th>GROUP</th>
<th>1st TEST</th>
<th>2nd TEST</th>
<th>3rd TEST</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M  SD</td>
<td>M  SD</td>
<td>M  SD</td>
</tr>
<tr>
<td>ABC</td>
<td>19.44 2.35</td>
<td>20.22 2.59</td>
<td>20.33 3.74</td>
</tr>
<tr>
<td>ACB</td>
<td>22.44 3.09</td>
<td>24.00 2.92</td>
<td>23.56 2.65</td>
</tr>
<tr>
<td>BAC</td>
<td>21.78 2.95</td>
<td>21.00 2.74</td>
<td>20.67 3.61</td>
</tr>
</tbody>
</table>
groups and the 11 sub-rules was not significant. Thus there was little difference among the groups with regard to the learning of the individual sub-rules. Among the different sub-rules themselves, however, there was a .001 significant difference ($F(1,24) = 18.09$).

All groups showed means significantly ($p < .01$) above chance on all vocabulary, order, and rules tests, except group BAC on the order section of test 1 which was only at the .05 level above chance.

Correlations between the total scores for the four sections of the tests are shown in Table XI. Three correlations are significant at the .01 level, that between the production and order scores ($r = .51$), that between the production and rules scores ($r = .53$), and that between the order and rules scores ($r = .75$).

As in the case of the environmental groups, it was found that the words-only groups produced more A- and B-words than C-words. There was a mean of 4.52 A-words, 4.73 B-words, and 3.52 C-words produced per test. This difference was significant at the .01 level ($F(2,78) = 10.80$).

**Environmental/Words-only Comparisons:** Several analyses were performed in an attempt to examine any differences between the two experimental conditions. Only the ABC, ACB, and BAC groups from the environmental condition were included in these analyses as only these three groups appeared in the words-only condition. The vocabulary scores could not be compared as the tests were different for the two conditions.

Comparing Table I to Table VII it can be seen that on the production section of the tests, the words-only groups produced a greater number of correct sentences than the environmental groups, particularly on the first test. The difference between the conditions
TABLE XI

CORRELATIONS BETWEEN THE TOTAL SCORES ON THE FOUR PARTS OF THE TESTS FOR THE THREE WORDS-ONLY GROUPS

<table>
<thead>
<tr>
<th>SECTION</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>-</td>
<td>.30</td>
<td>.21</td>
<td>.53*</td>
</tr>
<tr>
<td>II</td>
<td>-</td>
<td>-</td>
<td>.75*</td>
<td>.51*</td>
</tr>
<tr>
<td>III</td>
<td>-</td>
<td>-</td>
<td>.21</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Significant at the .01 level
is not significant but the interaction between the conditions and the tests is significant (F(1,48) = 4.31, p < .05). Thus although the environmental groups reached as high a criterion as the words-only groups on the final test, they were not as good on the first test.

A comparison of Tables III and IX indicates that there is little difference between the conditions on the order scores. An analysis of variance showed no significant differences between the conditions (F = .003).

However the differences between Tables IV and X, containing the rules scores for the two conditions, are considerable. Although there are no differences between conditions on the mean group scores for the first test, on the second test the means of groups ABC and BAC in the environmental condition are somewhat higher than the means of the same groups in the words-only condition, and on the third test, all three environmental groups have higher mean scores than their corresponding words-only groups. An analysis of variance showed that the difference between conditions was significant at the .01 level (F(1,48) = 9.49) and the interaction between the two conditions and three tests was significant at the .001 level (F(1,48) = 16.94). This interaction is shown in Figure 2. It can be seen that in the words-only condition the Ss did not improve from test to test, while in the environmental condition there was a substantial improvement.

In the analysis of variance on the 11 individual sub-rules, no significant interaction between the rules and the conditions was found.

A comparison of the production scores in terms of the number of each word-class produced revealed no significant differences between conditions. It was noticed, however, that the words-only groups
FIGURE 2
THE INTERACTION BETWEEN CONDITIONS AND TESTS ON THE RULES SCORES

- Environmental Condition
- Words-Only Condition

MEAN SCORE ON TESTS

ABC  ACB  BAC
TESTS
produced many more incorrect syllables than did the environmental groups. This might have been due to the fact that because of their different vocabulary tests, the words-only groups were exposed to incorrect words while the environmental groups were not. However, a comparison of the number of incorrect words produced on the first production test (which occurred before the words-only groups had seen any incorrect words) revealed that there was a significant difference between the conditions ($F(1,53) = 4.64, p < .05$). For some reason, the words-only Ss seemed to have a more difficult time in learning the actual words used in the experiment.
DISCUSSION

**Order Effect:** The first question asked in this experiment was whether a difference in the order of word-classes would somehow affect the way in which the MLS was acquired. From the results it is obvious that it has. In comparing the six ordered environmental groups, there were significant differences among groups on both the order and rules sections of the tests; in the words-only condition, there was a significant difference among the three groups on the rules section of the tests.

Among the three words-only groups, the significant difference on the rules scores was due to the fact that one group, ACB, did considerably better than the other two groups on all three tests. This could be at least partially explained by the fact that in group ACB, simply learning the position of the words in a sentence entailed the learning of sub-rules 1 and 2; in other words, learning the fact that only one of four B-words could appear at the end of a sentence incorporated the rule that a D-word could not follow a B-word. Thus group ACB performed considerably better on sub-rules 1 and 2 (mean = 15.9) than did group ABC (mean = 10.0) or group BAC (mean = 13.2). There were no other significant differences among groups in the words-only condition.

In the environmental condition there were significant differences among groups on both the rules scores and the order scores. Glancing at the means in Table IV, it can be seen that the lowest rules scores were obtained from those two groups in which the A-word appeared in the final sentence position. The CBA group showed especially poor
results, having a lower mean on the final test than the Random group. There may have been something about the nature of the A-class in this MLS which made it easier for learning to occur when the A-word appeared earlier in the sentence. Group CBA also performed very poorly on the order and vocabulary sections of the tests; for some reason this particular word-class order seemed to be very detrimental for the learning of the MLS.

The question now arises as to why some class orders should prove more difficult for language acquisition than others. One possibility was that some word-classes might be more easily learned, or that some word-classes might be more easily learned in specific sentence positions. However this was not found to be the case. No specific word-class showed any better word-referent association learning than any other word class. Nor was there an interaction effect between word-class and the position in a sentence in terms of learning the vocabulary; all specific word-referent associations in the word-classes were learned with equal facility in any position. All Fs were less than 1.

Also tested was the possibility that the learning of the word order might somehow be affected by the classes of words, or the sentence position, or an interaction of the two variables. No significant differences were found in this case either.

Another suggestion considered was that the learning of the 11 different sub-rules might be affected differently by the order of the word-classes. There was a significant interaction effect found between the 11 sub-rules and the 6 ordered environmental groups. Mainly this was due to the fact that sub-rules 1 and 2 (a D-word cannot follow a B-word) were extremely easy for the two groups with the B-word in the
final sentence position (mean = 16.1), moderately difficult for the
two groups with the B-word in the first sentence position (mean = 13.5),
and very difficult for the two groups with the B-word in the middle
sentence position (mean = 10.5). On the other sub-rules the groups
more-or-less followed the same pattern; although there were some group
differences these were not significant. Furthermore those differences
between groups which existed could not be explained in terms of a
difficulty arising because of the position of a particular word-class
in a sentence as could be done with sub-rules 1 and 2.

Thus the differences found between the groups are not wholly
explainable. It cannot be ignored that all of the Ss in this experiment
spoke English and this fact may have influenced the language learning.
It is true that if one assumes that A-words are subjects, B-words
verbs, and C-words objects, the ABC group, the best group in this
experiment, would duplicate English order. However the CAB group,
which is very different from English order, performed almost as well
as the ABC group (actually CAB had a higher total rules score). Also
the ABC group in the words-only condition was the poorest group. This
problem can only be resolved by cross-cultural comparisons.

Also it should be noted that in the environmental condition,
the differences among groups could have been due to the syntactic
properties of the language or the semantic properties of the language,
or an interaction of the two. A successful investigation of this
problem would have to test all six ordered groups in a words-only
condition and, in addition, at least one other set of environmental
groups having the same language but a different reference system.

The Random group was included in this experiment to see if
word-class order was a necessary prerequisite for learning to occur.
It was not. Word-referent learning of the vocabulary took place just as quickly in the Random condition as in the ordered conditions. The learning of the rules was slower than most of the ordered groups, but it did occur, and at least two Ss showed evidence of having learned most of the language rules. Braine (1962) has suggested that language learning occurs by the learning of the positions of words in sentences, thereby learning which words can be substituted for each other to form new combinations. However the evidence from the Random group indicates that language learning can occur in some other way as well.

Effect of Environment: The second question asked by this experiment was whether those Ss given an external semantic referent to the MLS would differ in some way from those Ss who were exposed only to the words. Again the answer was affirmative. In two of the three comparable sections on the tests significant differences between the environmental condition and the words-only condition were found.

First, in the production of correct sentences there was a significant interaction between the conditions and the three tests, indicating that the Ss in the environmental groups were unable to produce as many correct sentences as the Ss in the words-only groups during the first test, but as the experiment progressed the Ss in the environmental groups improved faster than those in the words-only groups, and by the third test both groups were equal. An analysis of the sentences produced and interviews with the Ss after the experiment was finished indicated that the Ss nearly always responded to the production section of the tests in terms of what they remembered rather than in terms of what rules they had learned. Thus this part of the test tended to reflect the ability to remember strings of words rather than the acquisition of syntactical rules.
In accordance with this suggestion, it must be noted that in the environmental condition the correlation between the production scores and the rules scores was insignificant (.22); however in the words-only condition the correlation between the two scores was .53. This indicates that Ss in the words-only condition may have tended to use somewhat the same processes in answering the questions in these two sections, whereas Ss in the environmental condition answered the two sections utilizing different processes. For both conditions the production scores were significantly correlated with the order scores, and there were no differences between the conditions in terms of order scores; thus word-class position learning likely occurs in both conditions in much the same way.

Another interesting difference between the two groups was with respect to the number of incorrect words produced on the production test. Although Ss in the words-only groups had to concentrate only on the words while Ss in the environmental groups had to concentrate on both the words and figures, the Ss in the words-only groups produced almost twice as many incorrect words on all tests. Words may be more easily learned when they can be attached to a referent.

The most important difference between the two conditions appears from the comparison of the rules scores. In the words-only condition no learning of the rules occurred past the first test, whereas in the environmental condition there was a definite improvement as the experiment progressed. Three additional Ss were run in the ABC words-only group given 80, 160, and 160 exposures between tests, for a total of 400 exposures to the stimuli. Their mean score on the first test was 21.00, on the second test 19.33, and on the third test 19.33; no improvement occurred between tests. From these results it
can be seen that in learning this MLS under a words-only condition, rapid initial learning took place, and then the process halted, so that the finer details of the language were not learned even when considerable exposure to the stimuli was given. No individual S in a words-only group received a score above 27 on the rules section of any test; in the corresponding three environmental groups, 12 Ss received scores of over 27 on their final test.

The tests from the very best Ss in the words-only condition were looked at to see what they could not learn. Essentially they were unable to pick up sub-rules 5 and 6 (B can only have 0 or 1 C), 9 (only 1 A), 10 (only 1 B), and 11 (only 2 C's) with more than chance frequency. In other words they were able to learn that words of certain classes must be included in the sentence, but they were unable to learn the restrictions on the number of words of each class that could appear. To the writer's knowledge such rules have never been tested before using an artificial language in which the sentences varied in length. The reason that the pattern of individual sub-rule learning was not different between the two conditions was probably because these 5 sub-rules were also the most difficult for the Ss in the environmental groups as well; however some Ss in the environmental groups were able to learn them; no S in the words-only groups was able to do likewise.

Several Ss in both conditions were questioned after the experiment was over as to the general strategy they used to learn the language. In addition two tape recordings were taken, one of a S in the ACB words-only condition and one of a S in the ACB environmental condition, in which the Ss were asked to comment aloud on their learning as the experiment progressed. The tape-recordings support
the answers of the other Ss questioned. In general, Ss in the words-only condition concentrated on word position in a sentence. Following is a copy of the tape recording of the words-only Ss:

- RIZ SEEMS TO COME AT THE BEGINNING AND SO DOES BEF, AND VOY SEEMS TO COME AT THE END.
- CAG SEEMS TO COME AT THE END.
- CIM IS ALWAYS IN THE MIDDLE, IT'S NEVER AT THE BEGINNING OR THE END.
- SAN IS IN THE MIDDLE.
- MUL IS PRACTICALLY ALWAYS AT THE END.
- PUM IS ALWAYS AT THE BEGINNING AND TOB IS ALWAYS AT THE END WHEN IT'S PRESENT.
- ONLY NEP, RIZ, BEF, AND PUM COME AT THE BEGINNING.
- I CAN'T EVEN TELL ONE FROM THE NEXT ANY MORE.
- ALL THE WORDS ARE THREE LETTERS LONG, WITH A VOWEL IN THE MIDDLE AND THEY ARE EASY TO MIX UP.

The results of the tape recording, the interviews, and the tests indicate that in learning a language in which only words are used what is acquired is essentially word placement and class membership based on word placement.

The Ss in the environmental condition, on the other hand, concentrated on learning to associate the syllables with the figures. As one S stated, he "zeroed in on one word until he got it". Following is a copy of the tape recording of the environmental S:

- NEP HAS SOMETHING TO DO WITH ROUNDNESS, I THINK.
- NEP IS THE ROUND FIGURE.
- KAS I THINK IS BLACKNESS.
- VOY IS ASSOCIATED WITH NO COLOR.
- VOY IS ASSOCIATED WITH ORIENTATION UPWARDS.
- MUL IS THE ASSOCIATION OF THE RECTANGLE AND THE SEMI-CIRCLE.
- NEP IS THE SEMI-CIRCLE.
- SAN IS TWO MIRROR SORT OF IN EACH OTHER.
- MUL IS THE ASSOCIATION OF TWO FIGURES.
- NEP IS THAT FIGURE.
- SAN IS TWO FIGURES, WITHIN EACH OTHER.
- VOY IS BLACKNESS, SAN IS EACH THING ASSOCIATED WITH EACH OTHER, MUL IS ASSOCIATION.
- VOY IS RIGHT SIDE UP.
- DEX IS TRIANGULARITY.
- TOB IS A DARK LINE.
- KAS IS BLACKNESS.
- RIZ IS TRIANGLE.
- BEF IS SEMI-CIRCLE; PUM IS DOUBLE-TRIANGLE.
- CAG IS ONE ON TOP OF THE OTHER; RIZ IS AN OBJECT; VOY IS A DIRECTION.
- WUP IS TRIANGLE; YOW IS RECTANGLE.
- YOW IS RECTANGLE.
- CAG IS ONE ON TOP OF THE OTHER.

As can be seen, the environmental Ss proceeded essentially by a form of hypothesis testing, sometimes making incorrect hypotheses which later had to be corrected. The words that were learned first probably depended largely on chance and individual peculiarities.

Although Ss in the environmental condition concentrated on learning the association between words and figures, their scores on the order section was no poorer than the words-only Ss who concentrated
on position learning. Thus it may be true, as Ruber states, that some language learning occurs implicitly.

Learning Process: The third question asked in this experiment was whether Ss could learn a fairly complex language system in a short laboratory period, and, if so, how this learning proceeded.

As was mentioned in the results, all groups showed evidence of having learned something on every section by the third test. Part of this learning process may have been assisted by the fact that similar repeated tests were used, i.e., after the first test was given the Ss may have known in more detail what they were expected to learn. However, although this knowledge could have been helpful for the first three sections of the tests (production, vocabulary, and order) where most Ss understood what the tests were trying to measure, it was of little assistance on section IV (rules). No S who was questioned understood what this section was testing. Also the use of repeated tests did not help the words-only Ss improve their performance on this section.

In this experiment, the rules section of the tests was regarded as the most important because it was from their performance on this section that the Ss showed whether or not they had learned the selection restrictions. Therefore several ways of analyzing the rules section were attempted.

As was stated in the methods section of this paper, the 11 sub-rules could be grouped under the five main rules which were used to describe the MLS. The correlation coefficients were calculated for the sub-rules in order to see if the Ss had learned the main rules or if they had learned each of the sub-rules independently. (The
sub-rule correlation matrix is shown in Appendix D.) In analyzing these data, because of the high number of correlations, statistical significance was not considered to be an adequate criterion of meaningfulness. Visually inspecting the intercorrelation matrix for the environmental groups it was seen that only three correlations were above .50. Sub-rules 1 and 2 (main rule 5), sub-rules 3 and 4 (main rule 3), and sub-rules 5 and 6 (main rule 4) showed considerably greater correlations than the others (r was above .70 in all cases). Thus this data suggests that the Ss in the environmental groups learned main rule 3 (a $B$-word is accompanied by 1 or 2 Cs), main rule 4 (a $B$-word is accompanied by 0 or 1 Cs), and main rule 5 (a $D$-word can only follow an $A$- or C-word). However the correlation coefficients between sub-rules 7 and 9 (main rule 1) and 8 and 10 (main rule 2) were insignificant. Therefore it is possible that for the environmental groups main rule 1 (a sentence must contain one $A$-word) and main rule 2 (a sentence must contain one $B$-word) were actually learned as four rules as follows:

1. An $A$-word must occur.
2. Only one $A$-word can occur.
3. A $B$-word must occur.
4. Only one $B$-word can occur.

For the words-only groups, the correlation coefficients were not as high as in the environmental condition but three were above .50, that between sub-rules 1 and 2 ($r = .52$), 3 and 4 ($r = .51$), and 7 and 8 ($r = .68$). All other correlations did not reach the .01 level of significance. As sub-rules 5, 6, 9, 10, and 11 were not learned above chance frequency by the words-only Ss it is possible that they only learned main rules 3 (covering sub-rules 3 and 4) and 5 (covering
sub-rules 1 and 2), plus an additional rule to the effect that a sentence contains an A-word and a B-word (covering sub-rules 7 and 8).

Another way of approaching the question of how the language was learned is to study the results of the best Ss. A score of 29 or better (5 errors) on the rules section of the final test was taken as an arbitrary criterion of having learned most of the language rules. Twenty Ss met this criterion. They differed in several ways from the Ss who did not meet this criterion:

1. All were in an environmental group. As stated above, no S in the words-only condition received a score above 27. Eighteen of the twenty Ss were in one of the ordered environmental groups (each group had at least one); two Ss were in the Random group.

2. All received perfect vocabulary scores of 14. As was mentioned in the results section, the correlation between vocabulary and rules scores was .68. However no S received a high rules score without a perfect vocabulary score, although some Ss received perfect vocabulary scores with low rules scores. Thus it may be proposed that the word-referent learning of the vocabulary was a necessary prerequisite to the learning of at least some of the rules of the MLS.

3. Three of the twenty Ss showed a tendency to draw pictures of the environment beside the questions, suggesting that they might be using the pictures to mediate their rule learning. None of the other Ss performed likewise.

4. The errors which these Ss made tended to reflect environmental possibilities (i.e., choosing a C-word as the "subject" of a
sentence rather than non-possibilities (i.e., a D-word "modifying" a B-word). In a question testing sub-rule 10 (only one B-word), one S actually drew a picture which showed that the two B-words TOB and VOY could pictorially be represented together.

A third way of looking at the question of how the Ss learned the MLS is to look at the correlations between the various sections of the tests. In the environmental condition, the highest correlations occurred between the vocabulary and rules scores. Also significantly correlated were the production scores with the order scores and the order scores with the rules scores. If, for the reasons discussed previously, we assume the production scores to reflect a memory for learning strings of words, and if we consider the vocabulary scores to reflect word-figure learning, then it seems likely that the ability to learn strings of words is important for learning the order of words but not for learning the rules of selection restriction, while word-referent learning is important for learning the selection restrictions but not the order of words. In addition the order scores and the rules scores were somewhat correlated with each other but not with their respective correlates, production and vocabulary scores.

One thing which was not tested in this experiment was the learning of words which belong to the same class—in other words, learning which words may be substituted for which other words. This may be the factor which is responsible for the correlation between order and rules scores. A substitution test should also be included in the next investigation into this problem.

In the words-only condition, significant correlations were found between production and order scores, production and rules scores, and order and rules scores, suggesting that in this condition
the same variable—learning the places of words in sentences—was important for all three sections. Thus Braine's hypothesis that language learning occurs by learning the positions of words in sentences seems to be supported by the evidence from the Ss who received only the words of the MLS, but none of these Ss were able to learn the more complex selection restrictions. The present experiment indicates that the learning of some selection restrictions must also involve the use of a mediator such as supplied by a physical referent and which may make such selection restrictions more intelligible to the S.

**Conclusion:** Although artificial language experiments using adult Ss cannot yield direct information about how natural languages are learned by infants, they do provide a valuable tool for studying some of the factors which affect language behavior. The present experiment has found that varying the order of word-classes in a sentence can affect the learning process. Also it has shown that Ss given a language which is semantically empty respond differently from Ss given a language which is correlated to a visual reference system; there are indications that the language learning strategies employed in these two conditions differ. The language learning processes were also examined in this experiment. There are indications that some phrase structure rules might be learned via separate sub-rules and that the syntactic features of the language may be learned via the semantic properties which they encode.

The present experiment has suggested several possible questions which can be explored. First, were the differences between the orders due to the particular aspects of the reference system used? Were they
due to the fact that only English-speaking Ss were tested? Additional experiments can be run testing words-only Ss in all possible word-class order permutations, testing Ss using a different referent system, and testing Ss whose native language employs a word order which differs from that found in English. Second, would the words-only Ss be able to learn the selection restrictions which they were unable to learn in this experiment if the MLS was made simpler, i.e., if the D-class was removed? A test of this question can be made utilizing a MLS with only three word-classes. Third, would the language learning strategies found in this experiment differ with the age of the Ss or with the cultural background of the Ss? How can these learning strategies best be tested? Cross-age and cross-cultural comparisons can be made to see whether learning strategies discovered in this experiment can be generalized to other language learning situations. In addition to the types of tests used, a substitution test could be employed in order to test the S's ability to recognize words belonging to the same word-class. Also a test of the S's ability to recognize environmental regularities could be employed to see if this preceded the ability to recognize sentence regularities. Fourth, did mediation through the reference system actually occur and was it a factor in helping to assist the Ss in learning the MLS? A possible test of this question might involve instructing some Ss to draw pictures next to the sentences and see how they differed from Ss not so instructed.

Thus it can be seen that the present experiment has suggested many more questions than it has answered.
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APPENDIX A

THE TWENTY SENTENCES PRESENTED TO THE SUBJECTS (GIVEN IN ABC ORDER)

1. BEF MUL WAF JOW
2. RIZ CAG CIM DEX
3. PUM MUL JOW
4. NEP KAS VOY
5. PUM CAG DEX SAN
6. RIZ MUL JOW WAF
7. NEP TOB
8. BEF MUL JOW SAN
9. NEP TOB WAF KAS
10. RIZ SAN VOY
11. PUM KAS TOB CIM
12. BEF VOY DEX
13. NEP CAG WAF JOW
14. RIZ TOB DEX SAN
15. BEF KAS CAG CIM
16. PUM VOY
17. RIZ CAG WAF
18. NEP MUL DEX CIM
19. BEF SAN TOB
20. PUM VOY CIM KAS
APPENDIX B

AN EXAMPLE OF THE TESTS USED

On the following pages are exact copies of Sections I, II, and III of the three tests given to the subjects. The examples shown for Section IV are exact copies of the tests presented to subjects given the ABC word order. For subjects given other word orders, the same sentences were used but the words were presented in the correct order for the subject being tested.
APPENDIX B

AN EXAMPLE OF THE TESTS USED

SECTION I (PRODUCTION) FOR BOTH CONDITIONS, TESTS 1, 2, AND 3.

Please write out five different sentences in the language you have just learned (please guess).

1. __________________________________________________

2. ________________________________________________

3. __________________________________________________

4. ________________________________________________

5. ________________________________________________
APPENDIX B
AN EXAMPLE OF THE TESTS USED

SECTION II (VOCABULARY) FOR ENVIRONMENTAL GROUPS, TEST 1

Please circle the word which best describes the figure (please guess).

1. 
   a. BEF  
   b. RIZ  
   c. MUL  
   d. DEX
2. 
   a. VOY  
   b. PUM  
   c. WAF  
   d. CAG
3. 
   a. TOB  
   b. BEF  
   c. DEX  
   d. JOW
4. 
   a. PUM  
   b. DEX  
   c. VOY  
   d. WAF
5. 
   a. BEF  
   b. SAN  
   c. CIM  
   d. WAF
6. 
   a. NEP  
   b. KAS  
   c. SAN  
   d. VOY
7. 
   a. WAF  
   b. CAG  
   c. MUL  
   d. JOW
8. 
   a. RIZ  
   b. KAS  
   c. MUL  
   d. DEX
9. 
   a. JOW  
   b. KAS  
   c. PUM  
   d. TOB
10. 
   a. MUL  
    b. VOY  
    c. NEP  
    d. CIM
11. 
    a. CAG  
    b. JOW  
    c. PUM  
    d. CIM
12. 
    a. SAN  
    b. RIZ  
    c. NEP  
    d. KAS
13. 
    a. NEP  
    b. RIZ  
    c. CIM  
    d. TOB
14. 
    a. TOB  
    b. CIM  
    c. BEF  
    d. CAG
APPENDIX B

AN EXAMPLE OF THE TESTS USED

SECTION II (VOCABULARY) FOR ENVIRONMENTAL GROUPS, TEST 2

Please circle the word which best describes the figure (please guess).

1. △
   a. BEF
   b. VOY
   c. SAN
   d. MUL

2. △
   a. CIM
   b. JOW
   c. WAF
   d. TOB

3. △
   a. BEF
   b. RIZ
   c. MUL
   d. TOB

4. △
   a. CAG
   b. PUM
   c. RIZ
   d. DEX

5. △
   a. SAN
   b. NEP
   c. TOB
   d. WAF

6. △
   a. DEX
   b. RIZ
   c. WAF
   d. KAS

7. △
   a. PUM
   b. BEF
   c. DEX
   d. TOB

8. △
   a. MUL
   b. NEP
   c. CAG
   d. CIM

9. △
   a. VOY
   b. TOB
   c. NEP
   d. CAG

10. △
    a. CIM
    b. WAF
    c. JOW
    d. SAN

11. △
    a. DEX
    b. KAS
    c. PUM
    d. JOW

12. △
    a. CAG
    b. KAS
    c. RIZ
    d. BEF

13. △
    a. PUM
    b. MUL
    c. JOW
    d. KAS

14. △
    a. VOY
    b. NEP
    c. SAN
    d. CIM
APPENDIX B
AN EXAMPLE OF THE TESTS USED

SECTION II (VOCABULARY) FOR ENVIRONMENTAL GROUPS, TEST 3

Please circle the word which best describes the figure (please guess).

1.  
   a. VOY  
   b. PUM  
   c. BEF  
   d. MUL

6.  
   a. BEF  
   b. CAG  
   c. WAF  
   d. PUM

11.  
     a. SAN  
     b. TOB  
     c. VOY  
     d. KAS

2.  
   a. RIZ  
   b. TOB  
   c. CIM  
   d. WAF

7.  
   a. DEX  
   b. RIZ  
   c. WAF  
   d. JOW

12.  
     a. RIZ  
     b. KAS  
     c. JOW  
     d. CAG

3.  
   a. CIM  
   b. RIZ  
   c. CAG  
   d. NEP

8.  
   a. CAG  
   b. MUL  
   c. BEF  
   d. VOY

13.  
     a. DEX  
     b. PUM  
     c. WAF  
     d. MUL

4.  
   a. CIM  
   b. SAN  
   c. TOB  
   d. KAS

9.  
   a. SAN  
   b. BEF  
   c. NEP  
   d. JOW

14.  
     a. DEX  
     b. MUL  
     c. NEP  
     d. PUM

5.  
   a. CIM  
   b. SAN  
   c. TOB  
   d. KAS

10.  
    a. KAS  
    b. DEX  
    c. VOY  
    d. JOW
APPENDIX B
AN EXAMPLE OF THE TEST USED

SECTION II (VOCABULARY) FOR WORDS-ONLY GROUPS, TEST 1

Please circle the word which belongs in the language you have just learned (please guess).

1. a. BIF  
   b. YOW  
   c. NAS  
   d. MUL  

2. a. CIN  
   b. JIW  
   c. WAF  
   d. VOB  

3. a. BEV  
   b. RIT  
   c. MEL  
   d. TOB  

4. a. CIG  
   b. PUM  
   c. REZ  
   d. DET  

5. a. SAN  
   b. MEP  
   c. TAB  
   d. FAW  

6. a. DEX  
   b. REZ  
   c. WAT  
   d. KAS  

7. a. POM  
   b. BEF  
   c. DIX  
   d. TOV  

8. a. MUN  
   b. NEZ  
   c. CAG  
   d. SIM  

9. a. VAY  
   b. TIB  
   c. NEP  
   d. CAQ  

10. a. CIM  
    b. WEF  
    c. JOL  
    d. SAZ  

11. a. DAX  
    b. KOS  
    c. POM  
    d. JOW  

12. a. CAJ  
    b. KAZ  
    c. RIZ  
    d. BAF
APPENDIX B
AN EXAMPLE OF THE TESTS USED

SECTION II (VOCABULARY) FOR WORDS-ONLY GROUPS, TEST 2

Please circle the word which belongs in the language you have just learned (please guess).

1. a. BIF 7. a. WEF 13. a. NEP
   b. RIZ       b. COG       b. PIZ
   c. MOL       c. MUL       c. SIM
   d. DOX       d. GOW       d. JOP

2. a. VUY 8. a. RIS 14. a. TOB
   b. FOM       b. KAZ       b. SEN
   c. WEF       c. NUL       c. BAF
   d. CAG       d. DEX       d. CAQ

3. a. TIB 9. a. JUW
   b. BEF       b. KUS
   c. DAX       c. FUM
   d. JOV       d. LOB

4. a. TUM 10. a. MAL
   b. PEX       b. VOY
   c. VAY       c. NOP
   d. WAF       d. CEM

5. a. BEP 11. a. CEG
   b. ZAN       b. JOW
   c. CIM       c. PEM
   d. WIF       d. CAM

6. a. NEB 12. a. ZAN
   b. KES       b. RAZ
   c. SAN       c. NEJ
   d. VEY       d. KAS
APPENDIX B
AN EXAMPLE OF THE TESTS USED

SECTION II (VOCABULARY) FOR WORDS-ONLY GROUPS, TEST 3

Please circle the word which belongs in the language you have just learned (please guess).

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<td>1. a. VOY</td>
<td>7. a. DIX</td>
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<td>14. a. DES</td>
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<td>c. BEP</td>
<td>c. NEP</td>
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<td>d. VOW</td>
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<td>3. a. CEM</td>
<td>9. a. SAL</td>
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<tr>
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<td>d. JOU</td>
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<td>4. a. COM</td>
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<td>b. VEY</td>
<td>b. DEX</td>
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<td>c. SAN</td>
<td>c. TAB</td>
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<tr>
<td>d. NEB</td>
<td>d. JUW</td>
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<td>5. a. CAM</td>
<td>11. a. SON</td>
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<td>b. SIN</td>
<td>b. TOB</td>
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<td>c. TOP</td>
<td>c. VOE</td>
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<td>d. KAS</td>
<td>d. KOS</td>
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<tr>
<td>6. a. BEV</td>
<td>12. a. ROZ</td>
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<tr>
<td>b. CIG</td>
<td>b. KEX</td>
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<tr>
<td>c. WAP</td>
<td>c. JOW</td>
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<tr>
<td>d. PUM</td>
<td>d. CAJ</td>
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APPENDIX B
AN EXAMPLE OF THE TESTS USED

SECTION III (ORDER) FOR BOTH CONDITIONS, TEST 1

Only one sentence in each question below is correct. Please circle the correct sentence.

1. a. BEF JOW CAG
   b. CAG JOW BEF
   c. BEF CAG JOW
   d. JOW CAG BEF
   e. CAG BEF JOW
   f. JOW BEF CAG

2. a. RIZ WAF MUL
   b. MUL WAF RIZ
   c. WAF MUL RIZ
   d. MUL RIZ WAF
   e. RIZ MUL WAF
   f. WAF RIZ MUL

3. a. TOB PUM CIM
   b. PUM TOB CIM
   c. PUM CIM TOB
   d. CIM TOB PUM
   e. CIM PUM TOB
   f. TOB CIM PUM

4. a. DEX VOY NEP
   b. NEP DEX VOY
   c. VOY NEP DEX
   d. NEP VOY DEX
   e. VOY DEX NEP
   f. DEX NEP VOY
APPENDIX B
AN EXAMPLE OF THE TESTS USED

SECTION III (ORDER) FOR BOTH CONDITIONS, TEST 2

Only one sentence in each question below is correct. Please circle the correct sentence.

1. a. PUM WAF VOY
    b. PUM VOY WAF
    c. VOY WAF PUM
    d. WAF VOY PUM
    e. VOY PUM WAF
    f. WAF PUM VOY

2. a. BEF CIM TOB
    b. TOB CIM BEF
    c. CIM TOB BEF
    d. TOB BEF CIM
    e. CIM BEF TOB
    f. BEF TOB CIM

3. a. CAG RIZ JOW
    b. RIZ JOW CAG
    c. RIZ CAG JOW
    d. JOW CAG RIZ
    e. JOW RIZ CAG
    f. CAG JOW RIZ

4. a. DEX MUL NEP
    b. NEP DEX MUL
    c. MUL NEP DEX
    d. MUL DEX NEP
    e. NEP MUL DEX
    f. DEX NEP MUL
Appendix B
An Example of the Tests Used

Section III (Order) for Both Conditions, Test 3

Only one sentence in each question below is correct. Please circle the correct sentence.

1. a. RIZ TOB JOW
   b. JOW RIZ TOB
   c. RIZ JOW TOB
   d. TOB JOW RIZ
   e. TOB RIZ JOW
   f. JOW TOB RIZ

2. a. MUL PUM CIM
   b. MUL CIM PUM
   c. CIM PUM MUL
   d. PUM MUL CIM
   e. CIM MUL PUM
   f. PUM CIM MUL

3. a. VOY WAF BEF
   b. BEF WAF VOY
   c. VOY BEF WAF
   d. WAF VOY BEF
   e. BEF VOY WAF
   f. WAF BEF VOY

4. a. DEX CAG NEP
   b. CAG DEX NEP
   c. NEP DEX CAG
   d. NEP CAG DEX
   e. DEX NEP CAG
   f. CAG NEP DEX
APPENDIX B

AN EXAMPLE OF THE TESTS USED

SECTION IV (RULES) FOR BOTH CONDITIONS, TEST 1 (GIVEN IN ABC ORDER)

Only one sentence in each question below is correct. Please circle the correct sentence.

1. a. BEF VOY SAN
   b. BEF SAN VOY

2. a. RIZ VOY
   b. RIZ VOY WAF CIM

3. a. PUM MUL
   b. PUM MUL JOW CIM

4. a. BEF CAG WAF CIM
   b. BEF NEP CAG WAF

5. a. RIZ VOY WAF
   b. RIZ VOY TOB

6. a. NEP CAG
   b. NEP CAG DEX JOW

7. a. NEP MUL CAG JOW
   b. NEP CAG JOW

8. a. BEF TOB
   b. BEF TOB JOW DEX

9. a. RIZ VOY DEX KAS
   b. RIZ VOY KAS DEX

10. a. PUM CAG JOW CIM KAS
    b. PUM CAG JOW CIM WAF

11. a. TOB DEX
    b. BEF TOB

12. a. RIZ CAG WAF KAS CIM
    b. RIZ CAG WAF DEX CIM

13. a. NEP VOY
    b. NEP VOY JOW WAF

14. a. CAG WAF SAN DEX
    b. BEF CAG WAF DEX

15. a. NEP VOY DEX KAS
    b. NEP DEX WAF KAS

16. a. BEF MUL
    b. BEF MUL DEX CIM

17. a. RIZ SAN MUL JOW
    b. RIZ MUL SAN JOW

18. a. PUM RIZ TOB
    b. PUM TOB

19. a. BEF MUL DEX
    b. BEF DEX JOW

20. a. RIZ TOB
    b. RIZ TOB JOW WAF
## APPENDIX B

AN EXAMPLE OF THE TESTS USED

SECTION IV (RULES) FOR BOTH CONDITIONS, TEST 1 (CONTINUED)

<p>| | | |</p>
<table>
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<tbody>
<tr>
<td>21. a.</td>
<td>RIZ KAS MUL WAF</td>
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</tr>
<tr>
<td>b.</td>
<td>RIZ MUL KAS WAF</td>
<td>b.</td>
</tr>
<tr>
<td>22. a.</td>
<td>PUM CAG</td>
<td>32. a.</td>
</tr>
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**APPENDIX B**

**AN EXAMPLE OF THE TESTS USED**

**SECTION IV (RULES) FOR BOTH CONDITIONS, TEST 2 (GIVEN IN ABC ORDER)**

Only one sentence in each question below is correct. Please circle the correct sentence.

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APPENDIX B
AN EXAMPLE OF THE TESTS USED

SECTION IV (RULES) FOR BOTH CONDITIONS, TEST 2 (CONTINUED)

21. a. RIZ MUL  
   b. RIZ MUL CIM SAN

22. a. BEF CAG CIM DEX WAF  
   b. BEF CAG CIM DEX SAN

23. a. BEF TOB  
   b. BEF TOB DEX WAF

24. a. NEP MUL SAN CIM  
   b. NEP SAN MUL CIM

25. a. BEF CAG  
   b. BEF CAG DEX JOW

26. a. NEP SAN MUL DEX KAS  
   b. NEP MUL DEX CIM JOW

27. a. NEP VOY  
   b. VOY KAS WAF

28. a. NEP VOY JOW  
   b. NEP JOW CIM

29. a. PUM CAG CIM  
   b. PUM CAG VOY CIM

30. a. PUM VOY CIM JOW  
   b. PUM KAS VOY

31. a. PUM TOB CIM SAN  
   b. PUM TOB MUL CIM

32. a. PUM MUL JOW KAS  
   b. PUM KAS MUL

33. a. NEP TOB KAS CIM  
   b. NEP TOB CIM KAS
APPENDIX B
AN EXAMPLE OF THE TESTS USED

SECTION IV (RULES) FOR BOTH CONDITIONS, TEST 3 (GIVEN IN ABC ORDER)

Only one sentence in each question below is correct. Please circle the correct sentence.

1. a. BEF CAG
   b. BEF CAG CIM JOW

11. a. NEP WAF JOW
     b. NEP VOY JOW

2. a. NEP BEF VOY
     b. NEP VOY

12. a. NEP MUL WAF JOW CIM
     b. NEP KAS MUL WAF CIM

3. a. PUM SAN CAG DEX
     b. PUM CAG SAN DEX

13. a. MUL WAF JOW KAS
     b. PUM MUL WAF JOW

4. a. PUM TOB VOY DEX
     b. PUM KAS TOB DEX

14. a. RIZ TOB
     b. RIZ TOB JOW CIM

5. a. RIZ MUL WAF
     b. MUL WAF SAN

15. a. RIZ CAG JOW
     b. RIZ BEF CAG JOW

6. a. BEF DEX JOW KAS
     b. BEF TOB

16. a. PUM KAS CAG
     b. PUM CAG JOW

7. a. NEP MUL JOW KAS
     b. NEP MUL KAS JOW

17. a. RIZ VOY CIM
     b. RIZ VOY CIM DEX

8. a. NEP VOY
     b. NEP VOY WAF DEX

18. a. PUM CAG WAF DEX CIM
     b. PUM CAG WAF KAS CIM

9. a. PUM MUL DEX WAF
     b. PUM MUL

19. a. NEP TOB WAF SAN
     b. NEP TOB SAN WAF

10. a. BEF VOY TOB
     b. BEF VOY WAF

20. a. BEF CAG DEX
     b. BEF CAG MUL
APPENDIX B
AN EXAMPLE OF THE TESTS USED

SECTION IV (RULES) FOR BOTH CONDITIONS, TEST 3 (CONTINUED)

21. a. RIZ MUL  
   b. RIZ MUL WAF KAS JOW  

31. a. RIZ NEP TOB CIM  
   b. RIZ TOB CIM

22. a. BEF TOB CIM JOW  
   b. BEF TOB CIM  

32. a. BEF MUL DEX  
   b. BEF MUL

23. a. NEP CAG WAF KAS  
   b. CAG WAF DEX KAS  

33. a. BEF VOY  
   b. BEF VOY JOW DEX

24. a. PUM WAF  
   b. PUM TOB

25. a. PUM KAS TOB  
   b. PUM TOB KAS

26. a. NEP CAG DEX CIM  
   b. NEP CAG

27. a. BEF KAS MUL DEX CIM  
   b. BEF MUL DEX CIM JOW

28. a. RIZ VOY CIM SAN  
   b. RIZ VOY SAN CIM

29. a. NEP TOB JOW CIM  
   b. NEP TOB JOW

30. a. RIZ CAG CIM KAS  
   b. RIZ CAG KAS CIM
APPENDIX C

MEAN SCORES FOR EACH GROUP ON THE ELEVEN DIFFERENT SUB-RULES

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**APPENDIX D**

**SUB-RULE CORRELATION MATRIX FOR ENVIRONMENTAL GROUPS**

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** p .01
### APPENDIX D

**SUB-RULE CORRELATION MATRIX FOR WORDS-ONLY GROUPS**

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