Ph.D Psychology

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THE EFFECTS OF SEMANTIC REFERENTS
ON THE LEARNING OF SYNTAX

Variables of language acquisition were studied utilizing miniature linguistic systems correlated to reference systems whose visual form mirrored various syntactic rules. Results indicated that (1) language was more easily learned when word order duplicated the order inherent in the semantic referents; (2) a different learning strategy was employed when semantic referents were present from that used when they were not present; (3) all the syntax rules were acquired only when the reference field mirrored the syntactic constraints of the language; and (4) semantic referents were necessary for the initial acquisition of the basic grammatical relations but not for later language acquisition. It was suggested that language acquisition may best be interpreted in terms of the interaction between linguistic rules and perceptual-cognitive organization and that a semantically justified syntactic theory might offer a better model of language use than the present Chomskian model prevalent in psycholinguistics today.

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by

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INTRODUCTION

The theory of language has traditionally been divided into three descriptive components, (1) the phonetic component which deals with the speech sounds of the language, (2) the syntactic component which deals with the organization of these sounds into sentential structures, and (3) the semantic component which deals with the interpretation of the sentences into meaningful messages. Although it is possible that such logical distinctions can be successfully employed in descriptive linguistics, this does not necessarily mean that this approach represents the best method of analyzing the psychological processing of language. To say that the syntax of a language can be described independently of its semantics is not to say that these systems are processed or learned separately.

Yet this distinction has often been ignored. Few studies have been devoted to investigating the interaction between syntactics and semantics, although it is generally assumed that in the total psycholinguistic model these components must function in a highly integrated manner. It is possible that no acceptable analysis of the psychological processing of language can be given without taking this interaction into consideration. Thus the present paper will deal specifically with one aspect of this problem--the possible effect that an interaction between semantic development and syntactic development might have on the learning of language syntax.

LINGUISTIC THEORY:

Nearly all current research in language learning has concentrated on the acquisition of syntactical rules. This emphasis derives from Chomsky's (1957, 1965) argument that only the assumption that a speaker possesses a set of grammatical rules can account for his ability to produce and understand novel utterances. The adult has already internalized an intricate and highly complex set of rules which constitute the grammar of his language; the child has the task of constructing for himself the same set of rules on the basis of the limited corpus of utterances to which he is exposed in combination with learning principles which he brings to the language-learning situation.

Chomsky (1965) has described the learning principles brought to the language acquisition situation in terms of a model which he has called the "language acquisition device" or LAD. LAD must be so constructed that it can develop a theory of a grammar on the basis of the primary linguistic data to which it has been exposed. Thus it possesses "first, a linguistic theory that specifies the form of the grammar of a possible human language, and second, a strategy for selecting a grammar of the appropriate form that is compatible with the primary linguistic data." (Chomsky, 1965, p.25) In other words, as a precondition for language learning, the child must possess (1) a body of information which specifies the grammatical structures which are contained in universal linguistic theory and (2) a set of procedures for operating on the linguistic observations and discovering the specific grammar of the language he is learning.

In Chomsky's linguistic theory, the syntactic component of language consists of the surface structure and deep structure of sentences and the rules which generate these structures. Each sentence has a specific surface structure and a specific deep structure. The surface structure corresponds to the actual verbalization of the sentence--the acoustic sequence of elements produced by the speaker and received by the hearer. The deep structure specifies the 'abstract' information which is relevant to semantic interpretation of the sentence--the meaning intended by the speaker and understood by the hearer. The deep structure is 'abstract' in two senses. First, it is built up out of general abstract features (such as the noun-verb relation) that are realized in a multitude of ways on the surface structure. Second, it contains the universal aspects of language which are common to all languages (i.e., the universal constraints on deep structure) and which, being universal, are omitted from the speech itself.

Surface structures are generated from deep structures by means of successive applications of the appropriate transformational rules. Deep structures are generated by a base system consisting of a lexicon which "...specifies idiosyncratic properties of individual lexical items..." and a categorical system which "...defines the significant grammatical relations of the language, assigns an ideal order to underlying phrases, and...determines which transformations will apply." (Chomsky, 1967, p.433)

The significant grammatical relations or functions of the language (i.e., subjects, modifiers, main verbs, and objects) are explicitly represented only in the sentence deep structure and are to be distinguished from grammatical categories (i.e., nouns, verbs, adjectives, and noun phrases) which are used to describe the surface structure of a sentence. The former express a relational character which the latter do not. (Chomsky, 1965, p.68f) Thus the deep structure contains many properties which never appear in any simple, consistent way in the speech itself, yet knowledge of these properties is assumed to be possessed by every language user.

Linguistic theory provides a theoretical account of language and language acquisition--an idealized model of a language user independent of his actual observed use of language. Herein lies the distinction which Chomsky makes between competence and performance. The competence of an idealized speaker refers to the knowledge he possesses regarding the underlying system of rules which compose the grammar of his language; the performance of this speaker refers to how he actually uses language in concrete situations, and can be influenced by environmental and behavioral factors such as memory limitations, time restrictions, distractions, shifts of attention, organization of perceptual strategies, interpretation of extra-linguistic information, etc. Such factors can affect the psycholinguistic processing of language but, according to Chomsky, they do not affect the linguistic principles which determine the phonetic, semantic, and syntactic properties of an utterance and which underlie the psycholinguistic model.[1]

STUDIES OF EARLY SYNTAX ACQUISITION:

In recent years psycholinguistic investigations of the acquisition of language have devoted a great deal of attention to the study of syntax acquisition in isolation from the other aspects of language; it is hoped that the information derived in this manner can be incorporated into a model for the competence which underlies all language development. Many of the investigations have been observational studies devoted to exploring the developing child's acquisition of language rules independent of their use in a situation (i.e., Brown and Fraser, 1963; Fraser, Brown, and Bellugi, 1963; Braine, 1963; Miller and Ervin, 1964; Brown and Bellugi, 1964). On the basis of a sample of the child's utterances at a given stage, the researchers have attempted to write progressive 'miniature grammars' which picture the child's linguistic development as he progresses towards the end-point of adult grammar. By this method even the earliest two-word utterances of young children have been discovered to be systematic and rule-governed; on the basis of privileges of occurrence, the words in the children's speech were grouped into two classes, and the ordering of these classes was found to follow certain rules of combination (often called 'pivot grammar').

With reference to these studies, McNeill (1966, 1970) has argued that it is necessary for grammars of child language

1. "The generative grammar represents the information concerning sentence structure that is available, in principle, to one who has acquired the language. It indicates how, ideally--leaving out any limitations of memory, distractions, etc.--he would understand a sentence..." (Chomsky, 1963, p.326f)

to do more than simply describe the surface structure of the sentences which occur and he has attempted to organize the data into a more comprehensive theory which assumes that the initial grammatical distinctions made by the young child are actually the basic grammatical relations which form the noun phrases and predicate phrases of adult speech; the sentence structural complexity is increased by the addition of such structures to each other. At the earliest stages, says McNeill, a child's speech is a direct expression of the deep structure--the result of applying the phonological rules directly to the sentence's underlying structure; as language develops there is a constant elaboration of the relation between the deep and surface structures, i.e., a constant elaboration of the child's transformational rules.

Most of the studies of syntax acquisition have tacitly assumed that the major processes of language learning can be understood solely in terms of the speech input and output. But the language-learning environment consists not only of a corpus of speech but also of a correlation between features of this corpus and specific nonlinguistic events. It is possible that such correlations provide the language-learner with clues for learning some of the basic syntactic relations.

Only a few studies of children's language development have suggested that extra-linguistic factors may play a role in the acquisition of syntax. Brown (1957) suggests that in children's speech there are much clearer semantic definitions for grammatical parts-of-speech than there are in adult's speech and that this may be used as a basis for learning the syntactical categories. Slobin (1966) reports that Russian psycholinguists interpret the order of acquisition of particular morphological classes (for tense, number, case, etc.) in terms of the relative semantic or conceptual difficulty of the criteria used for defining the classes; thus, for example, those classes whose reference is clearly concrete (such as number) emerge first, whereas, gender, a category that is almost entirely lacking in semantic correlates, appears last, even though it is always present in adult speech. Bloom (1968) reported that as her three subjects acquired language there was a matching of different syntactic structures to specific semantic relations; the children used syntax to express variable relationships between specific meaningful words (i.e., agent-object, actor-agent relationships, etc.) or to place constant features on the speech they heard (i.e., 'pivot' words involving both constant meaning and constant syntactic function). Brown (1970) has suggested that children's early sentences reflect either (1) operations of reference (utterances made up of a constant term having a specific cognitive reference, appearing in conjunction with a wide range of lexical items), or (2) relations (utterances in which no constant word appears but an 'abstract' fundamental semantic relation such as agent-action, action-object, agent-object, etc. is intended). Smith and Braine (in press) have recently suggested that the reason for 'pivot' combination rules may lie in the existence of semantic rules; some words ('pivots') do not occur alone because the child's semantic rules provide no meaning for them in isolation.

MINIATURE LINGUISTIC SYSTEMS:

Most of the investigations of early language acquisition have used the method of naturalistic observation of first language learning in the young child. However, an attempt has been made to experimentally reproduce some of the processes of language learning employing the older child or adult as a subject by using artificial languages which form miniature linguistic systems (MLS's). In the MLS situation, the subject's task 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 how to create new grammatically correct utterances. By using a MLS the experimenter can control the subject's exposure to the language; this control is impossible with either first language learning or second language learning of natural languages.

One MLS situation commonly employed uses semantically empty MLS's in which subjects are exposed only to strings of words or letters (sentences) which are characterized by some regularities of construction. It is the subjects' task to discover what these regularities are.

Two versions of the semantically empty MLS have been used. In the first, the MLS consists of two or three word classes defined in terms of sentence position. Subjects are required to learn that a correct utterance consists of one word of one word class and one word of a second word class (and sometimes one word of a third word class) in a specific word class order. Several experimenters have found that such learning occurs (e.g., Braine, 1963b; Smith, 1963, 1966a). Attempts to teach subjects a more complex version of this MLS have shown inconclusive results. Smith (1966b) used a MLS consisting of four classes of letters (M, N, P, and Q) such that a sentence consisted of either MN or PQ structure, and reported that his subjects produced more intrusions of the types NQ and PN than could be expected by chance, but that they did not learn that N-letters followed M-letters, and Q-letters followed P-letters. However Braine (1965b) reported that subjects 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. In Braine's experiment, however, there was only one word in each of the classes A, B, P, and Q; in Smith's experiment there were three words in each of his classes. Similar experiments (Smith and Gough, 1969; Segal and Halwes, 1965, 1966) have also failed to find any learning of such grammatical contingencies or selection restrictions (i.e., the occurrence of one word-class in a sentence depending on the presence or absence of another word-class). Whether subjects could learn grammatical contingencies in the semantically empty MLS given classes with unlimited numbers of words has not yet been demonstrated; all that is certain is that subjects given this type of MLS can learn the positions of words in sentences.

The other version of the semantically empty MLS utilizes a finite state grammar. The MLS operates by moving from one state to another. At each shift of state (or choice point) a signal must be chosen from a finite set of possible signals determined by the previous state. The process continues until a particular sequence of signals has occurred. Many such sequences are possible depending on the signals chosen at the choice points and the task involves learning the set of rules which specify which signals can follow other signals. Reber (1967) has reported that subjects required to memorize samples of grammatical strings could learn to exploit grammatical constraints as the memorization process progressed and were able to efficiently apply the information they had learned to a transfer recognition task; however they were unable to explicitly verbalize the rules they were using and Reber reported that he was unable to uncover any explicit strategies that individual subjects used. Miller (1967) describes a series of experiments in which subjects were required to type strings of letters into a computer which told them whether or not the strings were grammatical. The subjects were required to continue producing these strings until they felt they had learned the rules of the grammar; then they were tested on their mastery of these rules by judging which of a number of new strings were grammatical and which were ungrammatical. Miller reported that the learning strategy employed consisted of a period of general search prior to the first correct string, and then a more focused search for specific instances; strategies were not organized in terms of individual random strings but in terms of testing a variety of possible rules. In this experiment subjects were able to learn relatively complex language rules but the learning situation was such that the subject had to construct rules to produce the strings which were judged as grammatical or ungrammatical before having been exposed to a grammatical string; in the normal language-learning situation the language learner is <u>first</u> exposed to a reasonably grammatical sample of the language from which he must construct a set of rules and he <u>then</u> tests his knowledge of the rules by producing sentences which are judged as grammatical or ungrammatical.

Another type of MLS which has been used by experimenters correlates the words of the language with various aspects of nonsense figures. In the most common design (Foss, 1968; Esper, 1925; Horowitz, 1955) the nonsense figures vary along two discriminable dimensions such as shape and color and the syllables are divided into two classes, A and B, so that those syllables in class A are systematically paired with each variation on one dimension of the figures (i.e., one syllable for each shape) and those syllables in class B are systematically paired with each variation on the other dimension of the figures (i.e., one syllable for each color). 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 subject in the form of learning the names for each individual figure and the subject 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. Subjects not only learn the specific variable to which each word refers but also learn that syllables referring to variables on a particular dimension precede syllables referring to variables on the other dimension, thus learning the syntactic rules of the MLS and not just the individual word-figure associations.

THE MOESER (1969) EXPERIMENT:

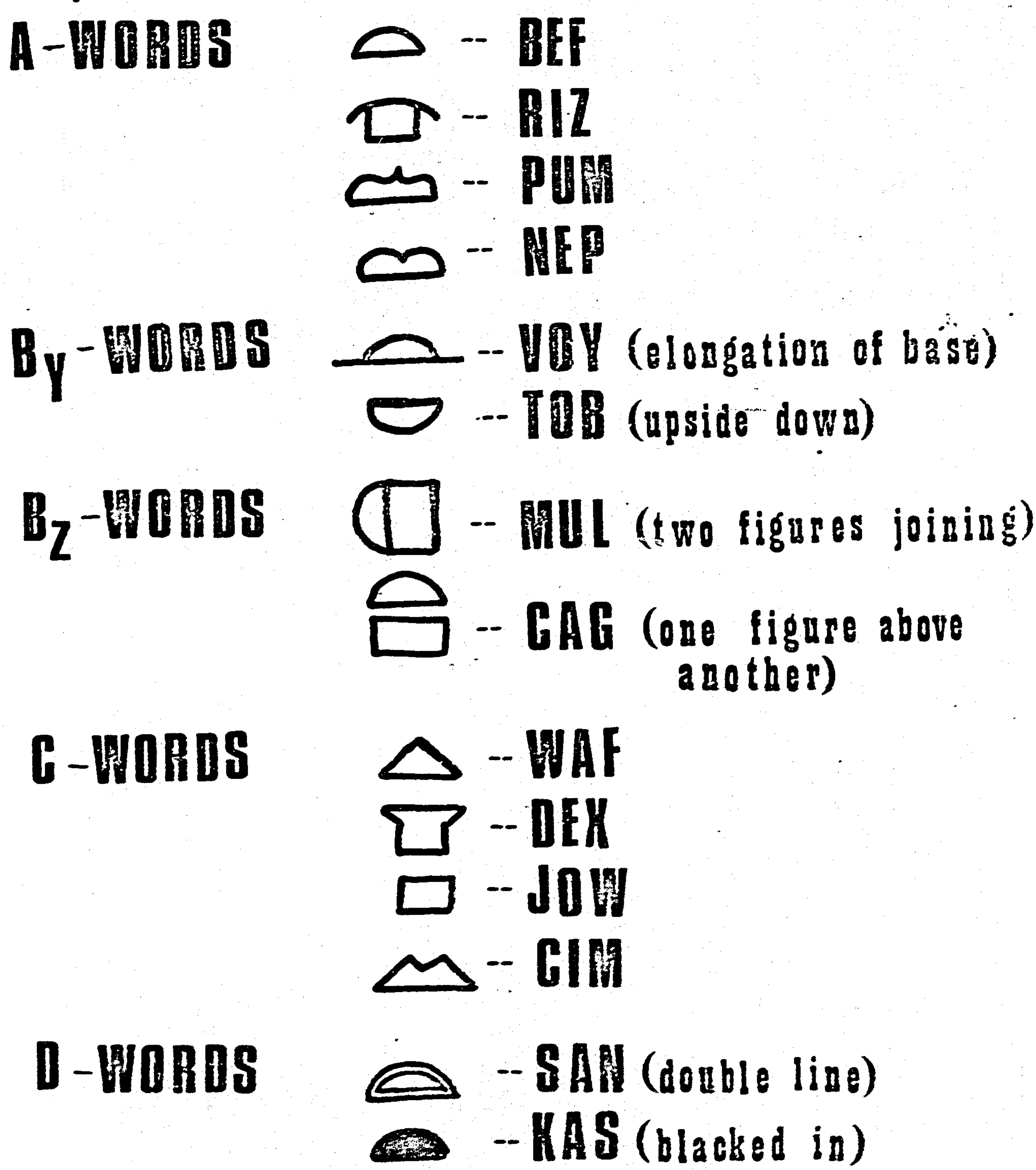
One type of MLS does not incorporate semantics into its design and the other does not investigate the problems of learning more complex syntactical functions such as grammatical contingencies. Combining both types, Moeser (1969) designed a MLS which utilized word classes defined both by sentence position and by privileges of occurrence (grammatical contingencies) and correlated these to a set of semantic referents. The MLS consisted of 14 words grouped into four word-classes, as is shown in Figure I-I, and contained a number of grammatical rules such that a correct sentence could range from a minimum of two words to a maximum of seven. A correct sentence had to contain one word from class A and one word from class B; zero, one, or two words from class C could appear in a sentence, depending on the B-word used (with VOT or TOB, zero or one C-word could appear, and with MUL or CAG, one or two C-words could appear); words from classes A and C could be followed by one word from class D. Thus the language could be described in terms of the phrase structure model of language as follows:

S ------> AP + BP + (CP)

AP ------> A + (D)

FIGURE I-I

AN ILLUSTRATION OF THE MOESER (1969) EXPERIMENT



$$BP \dashrightarrow \left\{ \begin{matrix} B_z \\ B_y \end{matrix} + CP \right\}$$

$$CP \dashrightarrow C + (D)$$

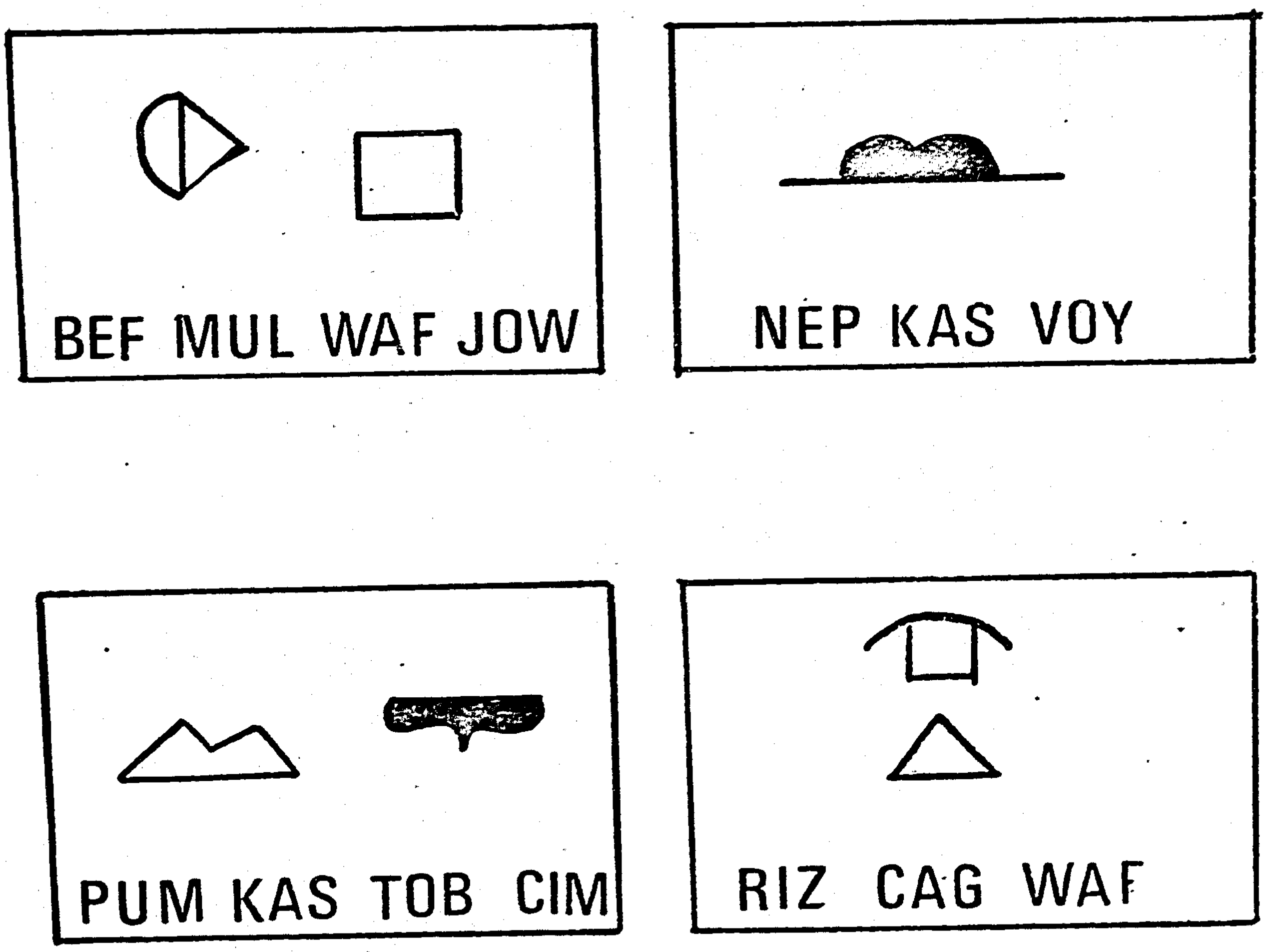
(Because in this experiment the order of word-classes was one of the variables which was manipulated, the above rewrite rules are to be interpreted as rewriting symbols into unordered sets rather than into ordered strings, contrary to common usage.)

Subjects were tested for their mastery of the rules of the language by exposing them to pairs of sentences which they had never seen before, one of which was grammatically correct and one of which was grammatically incorrect, and asking the subjects to mark the grammatically correct sentence. The subject's knowledge of specific rules could be tested in this manner, by making only one type of grammatical error in each sentence pair.

In the experiment some subjects were exposed only to grammatically correct sentences containing the words of the language, as has been done previously in similar studies. While these subjects did show some word-class learning, they were unable to perform at above chance levels on tests concerning the grammatical contingencies. However, some subjects were shown the same sentences as the words-only subjects, and in addition, were shown semantic referents (visual forms or relations correlated to the words of the language) which incorporated both word-class distinctions and grammatical contingencies into their design. Some of the sentences which were presented to these subjects are illustrated in Figure I-II, so that it can be seen how the restrictions of the language

FIGURE I-II

AN EXAMPLE OF SOME OF THE SENTENCES PRESENTED TO SUBJECTS IN THE SEMANTIC REFERENCE CONDITION IN THE MOESER (1969) EXPERIMENT



were built into the semantic referents. (For example, the very nature of the referent of a B_z-word necessitated the inclusion of at least two other words, whereas the referent of a B_y-word did not necessitate such an inclusion. Thus the referent to the B_y-word VOY could appear in a picture in which there was only one figure whereas the referent to the B_z-word CAG could only appear in a picture in which there were at least two figures.)

The subjects exposed to the semantic referents performed significantly better than those exposed to the words-only, and a few, at least, were able to show above chance learning of the grammatical contingencies. This raised the suggestion that the learning of the syntactic aspects of the language might be dependent upon the interaction of the semantic and syntactic aspects of the MLS.

THE PRESENT EXPERIMENT:

The present group of experiments is a clarification and extension of the earlier (Moeser, 1969) experiment. That experiment was designed to examine three questions. The first question asked whether the interaction of word-classes with their specific positions in sentences would effect the learning of the language. In other words, whether a MLS employing the word class order ABC, for example, would be easier or more difficult to learn than the same MLS employing the word class order BCA. In the Moeser (1969) experiment all six possible word-class orders were tested; an analysis of variance showed a significant interaction effect between word-class order and the ease with which the language was learned when semantic referents were present (and none when they were not present), but no adequate interpretation of these results could be given.

The second question examined whether semantic referents would help or hinder or somehow interact with syntax learning. As mentioned above, the results showed that the use of the semantic referents significantly improved syntax learning. It was also found that some subjects given the semantic referents appeared to learn the MLS in a different way from those subjects given the words only. It was suggested that subjects in the words-only condition were probably using a position learning strategy, i.e., learning the positions which words occupy in sentences and utilizing this knowledge to identify class membership. However at least some subjects in the semantic reference condition appeared to concentrate on learning to associate each syllable with its referent; they showed no interest in learning the grammatical relations of the words.

The third question asked whether a fairly complex language could be taught in a short laboratory period and, if so, how learning occurred. Although all groups of subjects performed at above chance levels, it was found that only 20 subjects out of 90 (all 20 being from the semantic reference condition) were able to achieve a criterion of 85% or higher on the final test of syntax learning. An examination of how these subjects differed in their overall performance from subjects who did not reach this criterion suggested that the best subjects might have been using the semantic referents to mediate their learning of the language syntax.

Thus there were some indications in the Moeser (1969) experiment that an important variable in language learning may have been overlooked in previous studies but no definite conclusions were reached. The present experiment will re-examine these above questions in light of the hypothesis which was suggested by the earlier experiment, i.e., that syntax learning occurs at least partially by mediation through the reference system.

EXPERIMENT A

INTRODUCTION

In the Moeser (1969) experiment an attempt was made to see if manipulation of the order of word classes in the sentence would have any effect on the learning process. In the semantic reference condition subjects learned the language under one of six set orders (ABC, ACB, BAC, BCA, CAB, or CBA) or under a random order in which the word-classes had no set sentence position. A significant difference was found among the six ordered semantic reference groups but it could not be wholly explained; there appeared to be no systematic effect. Learning was significantly poorer in the random group than in the six ordered groups but it did occur (2 of the 20 subjects who reached the performance criterion for learning were in this group), suggesting that a set word-class sentence position was not necessary for language learning to occur.

However, in the Moeser (1969) experiment the semantic referents had little or no order; thus the differences among groups may have been due to syntactic or semantic transfer from English. The effect of word-class order on the rate of learning will again be investigated, this time using a semantic reference system which also incorporates order into its design and using a spoken language instead of a written language. It is predicted that if syntactical learning occurs through mediation of the semantic system, it will be easier to learn a language in which word-class order follows the order inherent in the visual reference system.

METHOD

A miniature linguistic system was constructed utilizing 16 different words, all words being CVCs with an association value between 70 and 80 according to Archer (1960). All CVCs were words which, when pronounced, had no meaning in English. The 16 words were grouped into four classes (A, B, C, and D) with four words occurring in each class. A correct sentence in this MLS consisted of one word from each of the four classes occurring in a specific order. Thus the four word-classes contained an identical number of words and showed identical privileges of occurrence. All correct sentences were four words in length; the order of the four word-classes was the experimental variable manipulated.

Three word-class orders were compared: ABCD, DCBA, and DBCA.

DESCRIPTION OF THE REFERENCE SYSTEM:

Figures were presented along with the words of the MLS so that the figures incorporated class membership and word order in their design. An illustration of the words used (as pronounced) and figures used in the MLS for experiment A is shown in Figure A-I. From Figure A-I it can be seen that class A words were illustrated by colored rectangles, class B words by a change in the orientation of these rectangles, class C words by geometrical figures, and class D words by border changes on these geometrical figures. Thus the A-referents formed a perceptual unity with the B-referents and the C-referents did likewise with the D-referents. The A-B referents could be considered as one

FIGURE A-I

AN ILLUSTRATION OF THE MLS USED IN EXPERIMENT A

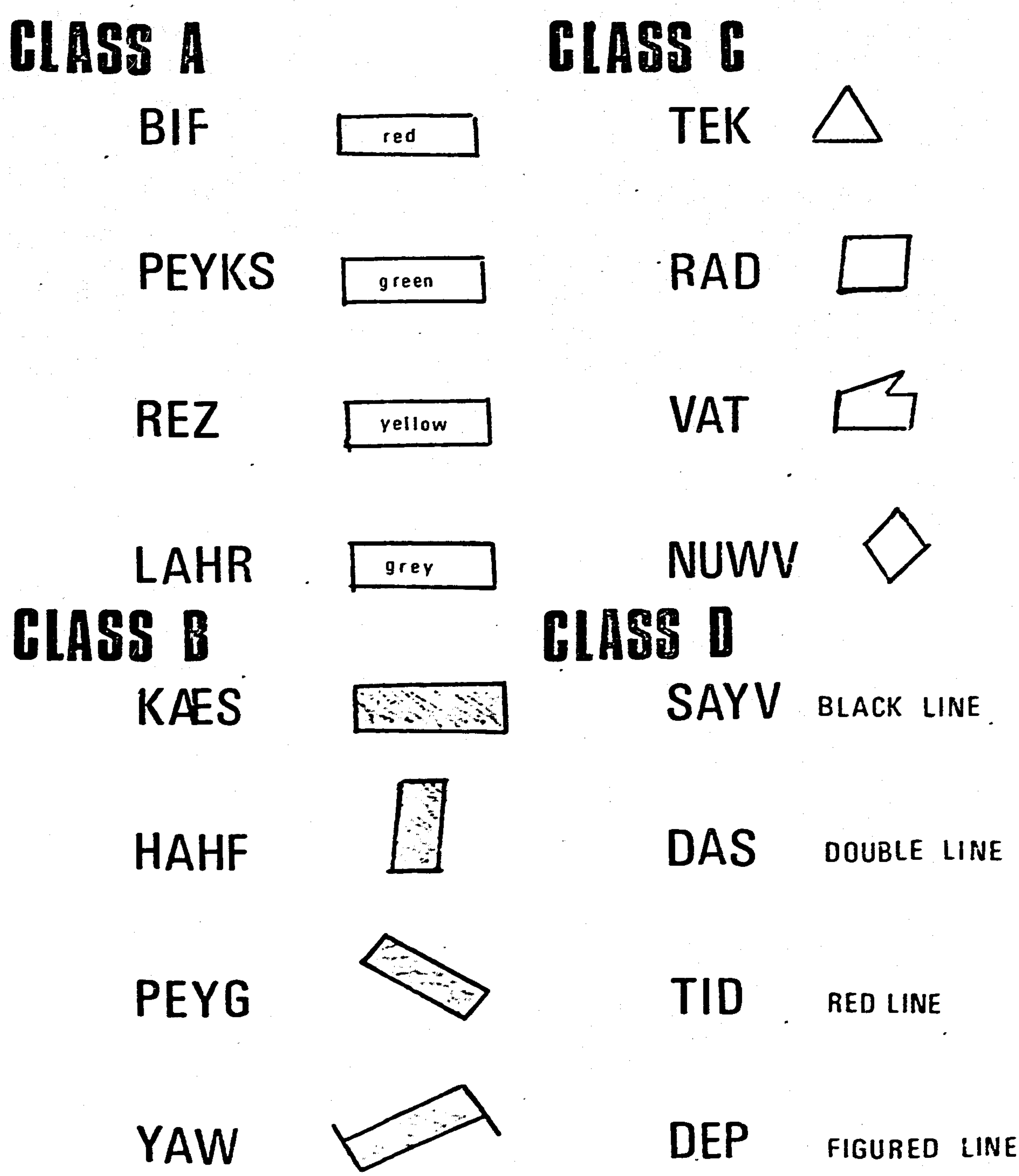


figure with two dimensions (color and orientation) and the C-D referents as another figure with two dimensions (shape and line design). The A-B referents always appeared to the left of the C-D referents. As the subjects tested in the experiment were college students experienced with a left-to-right reading order it was assumed that the most natural perceptual order for them would also be left-to-right. Therefore taking into consideration both the perceptual unities of the figures and the left-to-right sequencing, the logical perceptual order for the referents should be (AB)(CD) and subjects presented with the language in an ABCD order should learn it faster than those presented with either DCBA or DBCA order. Because the DCBA order corresponds to the perceptual unity of the referents (but not the left-to-right sequencing), subjects receiving the DCBA order should learn the language faster than those receiving the DBCA order (which corresponds to neither the perceptual unity nor the left-to-right sequencing).

(Horowitz and Jackson (1959) also used a MLS to study the effects of semantic referents on the learning of word order. They reported no significant results. However in their experiment only one figure was used which varied on two dimensions (color and shape) and Horowitz and Jackson were only interested in discovering whether color-shape order was learned more quickly than shape-color order. In the present experiment two figures are being used, both of which differ on two dimensions, and the question being tested is not whether the language is more easily learned when words referring to one dimension of a figure precede words referring to the other dimension of that same figure, but whether it is easier to learn a language when its word order follows the sequential pattern which is inherent in the perceptual processing of the referent figures.)

MATERIALS:

The stimulus materials consisted of colored Kodachrome II slides projected on a screen by a Kodak 850 projector set to automatically change the slides at times controlled by a Uher F-422 dia-pilot attached to a Uher 4000 Report-L tape recorder.

Forty different slides were used such that each referent was presented 10 times in this group of 40, and all slides contained one referent for each word-class. A list of the slides presented (using ABCD order) appears in Appendix A. In each presentation of 80 slides there were two differently ordered series of these 40 sentences, with the slides arranged within each series so that each word was permitted to appear on two consecutive slides only two times. All subjects received the same order of slides.

Three tape recordings were made by an assistant who was ignorant of the purpose of the experiment. The three tape recordings were recorded in a flat monotone voice and were identical in every way except for the order in which the words appeared in the sentences. The assistant used a visual metronome in order to space the words in each sentence exactly one second apart. The presentation of each slide took eight seconds: Each sentence took four seconds, there was a two-second silence, then the slide was changed (taking .5 seconds) and the reference for the new sentence was on the screen for 1.5 seconds before its sentence began on the tape. When each slide appeared on the screen, the words corresponding to the figures on the slides occurred on the tape recorder in the correct order for the particular group being tested.

Subjects were given two presentations of the 80-slide series. After each presentation of 80 slides a test was given to measure the subject's progress in learning the language. The tests were presented on the tape recorder without the corresponding figures on the screen and the Ss were requested to mark correct or incorrect on a sheet of paper. The two tests were identical in form but differed in terms of the sentences used. No sentence used in a test had previously been heard by the Ss. For the tests, the words in the sentences were again presented at one-second intervals and there was a 10-second interval between sentences.

Each test consisted of 24 sentences, one-half of which were grammatically incorrect. Subjects were requested to write down whether the sentence was correct or incorrect. Only one error was made in each incorrect sentence and all words were in the correct order (except for duplication of some word-classes) for the subjects being tested. In each test the 12 incorrect sentences took the following forms:

1) AABC
2) AACD
3) AABC
4) ABBC

5) ABBD
6) BBCD
7) ABCC
8) ACCD
9) BCCD
10) ABDD
11) ACDD
12) BCDD

Thus there were three incorrect sentences in which two A-class words were given, three incorrect sentences in which two B-class words were given, three incorrect sentences in which two C-class words were given, and three incorrect sentences in which two D-class words were given.

All subjects received identical sentences in the tests except that the order of the words was in the correct order for the particular subject being tested.

SUBJECTS:

Subjects were 42 undergraduate student volunteers from the McGill University psychology subject file taking a course in introductory biology. All were 17 or 18 years of age. Eleven female and three male subjects were assigned to each group. The subjects were tested in groups of two and three.

PROCEDURE:

As soon as the subjects were comfortably seated before the screen they were told:

"This is a language-learning experiment using an artificial language. I am going to present

> to you sentences in this language on this tape recorder. At the same time pictures will appear on the screen in front of you which are somehow correlated with the sentences that you hear. You must learn how they go together."

Then the projector and tape recorder were started and the subjects watched and listened while the 80 slides were shown. The projector was turned off during the test. The procedure was repeated for the second presentation and test.

RESULTS

The means and standard deviations of correct responses for the three experimental groups in the three tests are shown below in Table A-1:

TABLE A-1

MEANS AND STARDARD DEVIATIONS OF CORRECT RESPONSES FOR THE THREE GROUPS IN EXPERIMENT A

	ABCD		DCBA		DBCA	
TEST	M	S.D.	M	S.D.	M	S.D.
TEST 1	18.29	4.286	14.93	3.050	14.21	3.167
TEST 2	19.71	2.673	16.93	4.323	16.21	3.309
TOTAL	38.00	6.510	31.86	6.423	30.42	5.893

As can be seen from this table, the results were in the direction predicted in that ABCD$>$DCBA$>$DBCA. A two-way analysis of variance comparing the groups and tests showed a significant difference among the three groups ($F(2,39) = 6.015$, $p < .01$)

and a significant difference between the two tests ($F(1,39) = 11.47$, $p < .001$). There was no significant interaction ($F(1,39) = 0.13$, $p > .05$).

Comparisons of the total results of the three groups were made using Scheffé tests and the results are shown in Table A-2. It can be seen that the ABCD group was significantly different from both the DCBA group and the DBCA group, although these latter two did not differ significantly from each other.

TABLE A-2

SCHEFFÉ TESTS COMPARING THE THREE GROUPS IN EXPERIMENT A

PREDICTION	F	SIGNIFICANCE LEVEL
ABCD > DCBA	12.75	.05
ABCD > DBCA	21.71	.01
DCBA > DBCA	1.18	NS

DISCUSSION

The results of this experiment were as predicted; the more closely the word order of the language duplicated the order inherent in the semantic referents, the more easily it was learned.

Two types of semantic correspondence were tested in experiment A. One of these was a perceptual unity order: Two separate figures were used which differed on two dimensions (one figure used color and orientation; the other figure used shape and line design). When the language word order duplicated the order of the semantic referents, the two words which referred to the two dimensions of one figure appeared together, and then the two words which referred to the two dimensions of the other figure appeared (as in ABCA and DCBA). In the non-duplicated language order, the two words which referred to the two dimensions of one figure alternated with the two words which referred to the two dimensions of the other figure (as in DBCA). The results showed a tendency towards sequential order being easier to learn than alternating order but when considered separately, this tendency was not significant (comparison of order DCBA with order DBCA).

The second type of order used in the reference system of this experiment was a left-to-right figure order. Because the subjects were college students, it was assumed that they generally use a left-to-right perceptual scanning order and thus would focus first on the left-hand figure. This assumption was supported by the results; it was significantly easier for subjects to learn the language when left-to-right order was used than when right-to-left order was used (comparison of order ABCD with order DCBA).

It appears that even more important than a sequencing effect is the effect of the initial focusing; the MLS was easier to learn when the first word in the sentence correlated to the semantic referent which was first noticed. This statement, however, is open to criticism. Because not all possible orders were tested the experiment did not control for all possible sequencing orders (it might have been better to compare ABCD with CDBA, keeping the order of AB and CD constant since their order is not determined by scanning). Also the experiment did not control for the possibility that the subjects may have been predisposed to notice some of the reference categories before the others. (The semantic referents of the four word-classes employed cognitive categories with which all subjects would have had previous experience. It is possible that one or more of these cognitive categories may have been more emphatic than the others.) To test these variables additional experiments would have to be performed.

However, the fact remains that the learning of language syntax was influenced by the correlation of linguistic and contextual features. These results cannot be explained in terms of a learning transfer from English syntax. In the Moeser (1969) experiment, the results may have been affected by the fact that the MLS syntactical structure bore some resemblance to English syntactical structure. In the present experiment, however, this was not the case; the syntax consisted simply of four word-classes, each possessing the same number of words and each defined by the same privileges of occurrence; they differed only in sentence position. The adult subjects would probably already possess the idea that word classes can be defined by sentence position but there is nothing in English syntax which could be used to show that one particular word class order should be favored over any other if all word classes contain identical numbers of words and show identical privileges of occurrence. Thus the explanation of the results cannot be made in terms of strictly formal considerations of syntax; the effects of the semantic referents must be included in any explanation.

A few syntactical aspects of word order have been discussed in the literature. First, Greenberg (1961) has shown that in the vast majority of natural languages, the dominant word order of declarative sentences is almost always one in which the subject precedes the object; he could discover only three exceptions to this fundamental S-O order. Furthermore, Greenberg has stated that languages in which the verb is separated from the object are much rarer than those in which the verb and object appear together; thus by far the most common orders of simple, active, affirmative, declarative (SAAD) sentences are SVO (subject-verb-object) and SOV (subject-object-verb). Second, some languages, such as Russian and Finnish, do not use a fixed word order at all but instead use a highly inflected language with relatively flexible word order to express grammatical relations. Instead of learning the morphological markers for word classes and combining word classes randomly, it is reported that many children learning such languages begin with unmarked forms and a fixed word order (e.g., Slobin, 1966; McNeill, 1970). Third, Brown and Hanlon (1970) have reported that, in English, SAAD sentences are the first present in child speech and they suggest that the English SAAD is more simply derived from its deep structure; that is, it is closer in some way to its deep structure than are other sentence types. In discussing these results, Watt (1970a) has suggested that the only significant way in which the SAAD can be closer to its base is that the order of the SAAD's main elements (subject, verb, and object) must accord more closely with the order of these elements in the base; since generally the effect of transformations is to reorder elements of the base, the SAAD must represent the minimal reordering.

In general there appears to be some consensus of agreement with regard to the semantic influence on word order. Jakobson (1961) has stated that Greenberg's statements on universal orders should be interpreted in terms of 'iconic' aspects: The order of elements in a sentence parallels the orders that occur in perceptual experience; the initial position of a word may reflect precedence in time or priority in emphasis as whatever first focuses the attention is generally the first word reflected in speech. Chomsky (1965), also mentions that the order of words may be determined by factors outside the language[2]; he, however, states that when this is the case it is not necessary to describe such factors in a universal grammar. Thus he writes: "...order is significant in determining the grammatical relations defined by surface structures (not surprisingly), though it seems to play no role in the determination of grammatical relations in deep structures." (Chomsky, 1965, p.221) However this is not to say that order

2 "The unacceptable grammatical sentences often cannot be used, for reasons having to do, not with grammar, but rather with.. .'iconic' elements of discourse (for example, a tendency to place logical subject and object early rather than late)..." (Chomsky, 1965, p.11)

is not important in the deep structure. It only means that grammatical relations are represented so uniquely by the groupings of terms under nodes that the order is unnecessary to represent the grammatical relation. But an order of the deep structure is necessary to derive an order in the surface structure; this assignment of sequential order to the constituents of deep structures is language specific rather than universal. Thus one of the functions of the categorical component of the base (which generates the deep structure) is to specify the underlying ideal order of the elements in a sentence. If word order is part of the deep structure and if it is strongly influenced by semantic factors, it may be that the perceptual-cognitive organization of the language user plays a part in determining the form of the deep structure.

EXPERIMENT B

INTRODUCTION

Experiment A supported the hypothesis that semantic referents can affect the acquisition of language syntax but it offered no test of the hypothesis that semantic referents must be present in order to learn language syntax. In experiment A, the language structure was such that subjects were required to learn that a correct sentence consisted of one word from each of four word classes in a specific word class order. As has been mentioned, previous experiments have shown that some learning occurs using a similar language structure and a semantically empty MLS. However, with regard to more complex language structures in which word classes have different privileges of occurrence, this question is still unanswered. In the Moeser (1969) experiment no subject in the semantically empty condition was able to perform at above chance level on the tests involving the learning of grammatical contingencies. However only a few of the subjects in the semantic reference condition showed any better performance. The process of learning the language appeared to be so difficult that no conclusive statements could be made about the results.

There were two experimental factors in the Moeser (1969) experiment which might have hindered the learning process. First, the presentation of sentences in the language was arranged such that no word which appeared in one sentence was followed or preceeded by the same word in another sentence. In other words, no overlapping of words occurred from one presented sentence to the next. However Foss (1968) has found that such overlapping greatly enhances the prospect of learning a MLS. The second factor was the one-hour limit on the time in which the language was to be learned. Subjects in the semantic reference group showed considerable progress as the experiment progressed and may not have had time to complete this process. Thus, in experiment B overlapping was introduced and the time period allowed for language learning was extended to two hours.

REFERENCE CONDITIONS:

The MLS used in experiment B was very similar to that used by Moeser (1969). Like that experiment, subjects were run under (1) a semantically empty condition (hereafter called words-only) in which the different classes of words and their syntactical relations are defined only by their positions in a sentence and their privileges of occurrence; and under (2) a semantic reference condition (hereafter called syntax correspondence) in which the different classes of words and their syntactical relations are defined not only by their sentence positions and privileges of occurrence but also by semantic referents which incorporate syntactic class distinctions and grammatical contingencies in their visual appearance. Unlike the Moeser (1969) experiment, subjects were run under two additional conditions. These were (3) a class correspondence condition in which semantic referents are used which incorporate in their visual appearance syntactic class distinctions but not grammatical contingencies and (4) an arbitrary figures condition in which semantic referents are present but they incorporate neither class distinctions nor grammatical contingencies in their appearance. Each of these latter three conditions (2, 3, and 4) contains semantic referents but the degree to which semantics reflects the syntactical rules is varied. This was done in an attempt to see whether the simple presence of a referent is enough to assist in the learning of the language or whether the rules of syntax are learned because they mirror the rules of the reference field.

To recapitulate, experiment B utilizes four different reference conditions:

1) Words-only -- no semantic referents.
2) Syntax correspondence -- semantic referents whose visual form mirrors syntactic class distinctions and grammatical contingencies.
3) Class correspondence -- Semantic referents whose visual form mirrors syntactic class distinctions but not grammatical contingencies.
4) Arbitrary figures -- semantic referents whose visual form mirrors neither class distinctions nor grammatical contingencies.

If, as proposed, subjects learn language syntax via mediation through the semantic referents, certain predictions can be made. <u>First</u>, those subjects in the syntax correspondence condition should learn the language better than subjects in the words-only, class correspondence, and arbitrary figures groups because the subjects in these three conditions will find it difficult or impossible to learn the rules of grammatical contingency. Only the syntax correspondence condition contains semantic information on grammatical contingencies. Second, subjects under the class correspondence condition should acquire the MLS with greater ease than subjects in the words-only or arbitrary figures conditions because in the class correspondence condition class is incorporated into the semantic referents. In the words-only condition class is defined strictly by word position, while in the arbitrary figures condition class is defined by word position and figure position but not by the visual appearance of the figure. Third, it is predicted that because the semantic referents used in the arbitrary figures condition contain no additional syntactic information, subjects under this condition should find learning at least as difficult as subjects in the words-only condition and possibly more so, because they will have to learn which word goes with which referent, and in addition, learn independently the syntactic relations.

LANGUAGE DIFFICULTY:

In the Moeser (1969) experiment there was some evidence from the discussions with the participants and from tape recordings taken while learning was taking place that the type of strategy used to learn the language depended on the reference condition under which the language was presented. To test this hypothesis, instead of one MLS as was used in the Moeser (1969) experiment, the present experiment utilized three MLS's in each reference condition, designed so that each language contained the same number of words but differed in syntactic difficulty. If different learning strategies are employed, additional predictions can be formulated:

It is predicted that subjects in the words-only condition will use a position-learning strategy, i.e., they will use the positions of words in a sentence to designate their syntactic class. Thus language learning should decrease as the language increases in complexity, because increases in syntax complexity also increases the variability of word-class sentence position.

Subjects learning the MLS's under the syntax correspondence condition should show little difference in their ability to learn a less-complex or more-complex language system. This is because it is assumed that learning the language under this condition consists of (a) learning to associate each word with its visual referent and (b) learning the specific rules of the reference field (the ways in which the visual referents are related). If these are held nearly constant, the subjects should experience almost equal difficulty even when the syntax differs in complexity.

Subjects in the class correspondence condition will probably attempt to learn the language using the same strategy as subjects in the syntax correspondence condition. Thus there should be no difference between MLS's with regard to the learning of class relations because the amount of things to be learned is held constant (subjects must learn to associate each word with its visual referent and learn that the visual referents can be arranged into groups on the basis of their appearance).

Grammatical contingencies, however, are not incorporated into the design of the visual referents in the class correspondence condition, and when these are added to the structure of the language in the case of the more complex MLS's, other strategies may be attempted, including, possibly, the use of positions of words and/or figures to determine syntactic regularities. As the language becomes more complex by the addition of more complex grammatical contingencies, the performance of these subjects should deteriorate.

Subjects in the arbitrary figures condition should employ a similar strategy as those in the words-only condition, using the positions of words and/or figures to discover syntactic regularities. They, also, should find it increasingly more difficult to employ this strategy as syntax complexity increases.

SUMMARY:

To summarize the introduction, experiment B has been designed as an extension and clarification of the earlier Moeser (1969) experiment. The method of presenting the MLS has been slightly changed in order to facilitate learning and two additional semantic reference conditions have been added in an attempt to show additional support for the two hypotheses which were proposed as possible explanations for the results of the 1969 experiment--(1) that language syntax is learned via mediation through semantic referents; and (2) that the strategy employed involves learning the referents which are associated with the words and learning how these referents are related.

METHOD

Experiment B utilized three miniature linguistic systems, designed in terms of increasing syntactical complexity, and four reference conditions, designed so that increasing amounts of syntactical correspondence were supplied. Thus the experiment was of a 3 X 4 design, with a total of 12 cells utilizing 10 different subjects for a total of 120 subjects.

DESCRIPTION OF THE MINIATURE LINGUISTIC SYSTEMS:

Each of the three MLS's utilized the same 14 words, all words being CVC's with a moderately high association value (between 70 and 80 according to Archer, 1960). Like the Moeser (1969) experiment, the 14 words were grouped into four classes, with four words each occurring in classes A, B, and C, and two words occurring in class D.

In the first degree of MLS complexity (MLS_1) the syntactic structure of the language can be described by the following rewrite rules as:

S -------> AP + BP + (CP)

AP ------> A + (D)

BP ------> B + (CP)

CP ------> C

In other words, a grammatical sentence in MLS_1 had to contain one word each from classes A and B; the class A word could be followed by one word from class D and the class B word could be followed by one or two words from class C. Thus six acceptable sentence structures were possible in MLS_1:

1) AB

2) ABC

3) ABCC

4) ADB

5) ADBC

6) ADBCC

In the second degree of MLS complexity (MLS_2) the syntactic structure of the language can be described by the following rewrite rules as:

$$S \longrightarrow AP + BP + (CP)$$

$$AP \longrightarrow A + (D)$$

$$BP \longrightarrow \begin{Bmatrix} B_1 \\ B_2 + CP \end{Bmatrix}$$

$$CP \longrightarrow C$$

This language is identical to MLS_1 except that the B-phrase (BP) contains an option. Either a B_1-word can be used alone or a B_2-word can be used in combination with a C-phrase (CP). Like MLS_1, a grammatical sentence in MLS_2 had to contain one word each from classes A and B, and the class A word could be followed by one word from class D. However, unlike MLS_1, the number of C-words used in a sentence depended on the type of B-word used. If a B_1-word was used, zero or one C-word could appear in the sentence; if a B_2-word was used, one or two C-words could appear in the sentence. There were two B_1-words and two B_2-words in MLS_2. Eight acceptable sentence structures were possible in MLS_2:

1) AB_1

2) ADB_1

3) AB_1C

4) AB_2C

5) ADB_1C

6) ADB_2C

7) AB_2CC

8) ADB_2CC

In the third degree of MLS complexity (MLS_3) the syntactic structure of the language can be described by the following rewrite rules as:

$$S \dashrightarrow AP + BP + (CP)$$

$$AP \dashrightarrow A + (D)$$

$$BP \dashrightarrow \begin{Bmatrix} B_1 \\ B_2 + CP \end{Bmatrix}$$

$$CP \dashrightarrow C + (D)$$

This language is identical to MLS_2 except that the C-phrase (CP) contains an option, either a C-word can be used alone or it can be followed by a D-word. Like MLS_1 and MLS_2, a grammatical sentence in MLS_3 had to contain one word each from classes A and B, and the class A word could be followed by one word from class D. Also, like MLS_2, the number of C-words appearing in a sentence depended on the type of B-word used. However, unlike both MLS_1 and MLS_2, a class C word could be followed by one word from class D. There were eighteen acceptable sentence structures possible in MLS_3:

1) AB_1

2) ADB_1

3) AB_1C

4) AB_2C

5) ADB_1C

6) ADB_2C

7) AB_1CD

8) AB_2CD

9) ADB_1CD

10) AB_2CCD

11) ADB_2CD

12) AB_2CCD

13) ADB_2CC

14) AB_2CDC

15) ADB_2CDC

16) AB_2CDCD

17) ADB_2CCD

18) ADB_2CDCD

Thus it can be seen that the three languages show increasing syntactic complexity. All three MLS's have the same S rule. MLS_2 differs from MLS_1 in that MLS_2 has a more complex BP rule. MLS_3 keeps the BP rule complexity of MLS_2 and complicates the CP rule as well. Another way of viewing the differences between these three languages is to see them as adding progressively more non-terminal elements. MLS_1 has no non-terminal elements (CP could simply be called C and BP simply B + (C) if we wished); MLS_2 requires BP but not CP; and MLS_3 requires both BP and CP.

DESCRIPTION OF THE REFERENCE CONDITIONS:

There were four reference conditions in each language under which subjects were tested:

1) Words-only, in which only the words of the language were presented to the subjects;
2) Arbitrary figures, in which figures were presented along with the words of the language but the correspondence between words and figures was arbitrary, so that the reference figures acted simply as a restatement of the information carried in the words of the language;
3) Class correspondence, in which the figures presented along with the words of the language incorporated into their design visual features defining class membership; and
4) Syntax correspondence, in which the figures presented along with the words of the language incorporated into their design both visual features defining class membership and visual reasons for the syntactic contingencies.

In the three reference conditions in which figures were presented, the order of the figures was identical to the order of the words.

An illustration of the words and referents used in the four reference conditions of MLS_1 is shown in Figure B-I and an example of how one sentence would appear in each of the four reference conditions in MLS_1 is given in Figure B-II. From these it can be seen that in the syntax correspondence condition all A-class words refer to colored rectangles, all B-class words refer to orientations of these colored rectangles, all D-class words refer to line variations of the colored rectangles, and all C-class words refer to separate geometrical figures. The A-D-B group of referents form a single perceptual entity and because of the very nature of these referents neither a B-referent nor a D-referent can appear unless an A-referent is also present (a fact which mirrors the syntactic constraints of the MLS). In the class correspondence condition words are illustrated by figures similar in design to those used in the syntax correspondence condition, but the referents for A-words, B-words, and D-words are presented as separate units, instead of as one perceptual entity. Thus there is nothing in the design of the visual field which would prevent a D-referent or a B-referent from appearing without an A-referent. In the arbitrary figures condition the same separate figures are used as are found in the class correspondence condition but there is no systematic pairing of a particular class of words with a particular class of figures. All pairings are random.

FIGURE 8-I

AN ILLUSTRATION OF THE FOUR REFERENCE CONDITIONS IN MLS_1 IN EXPERIMENT B

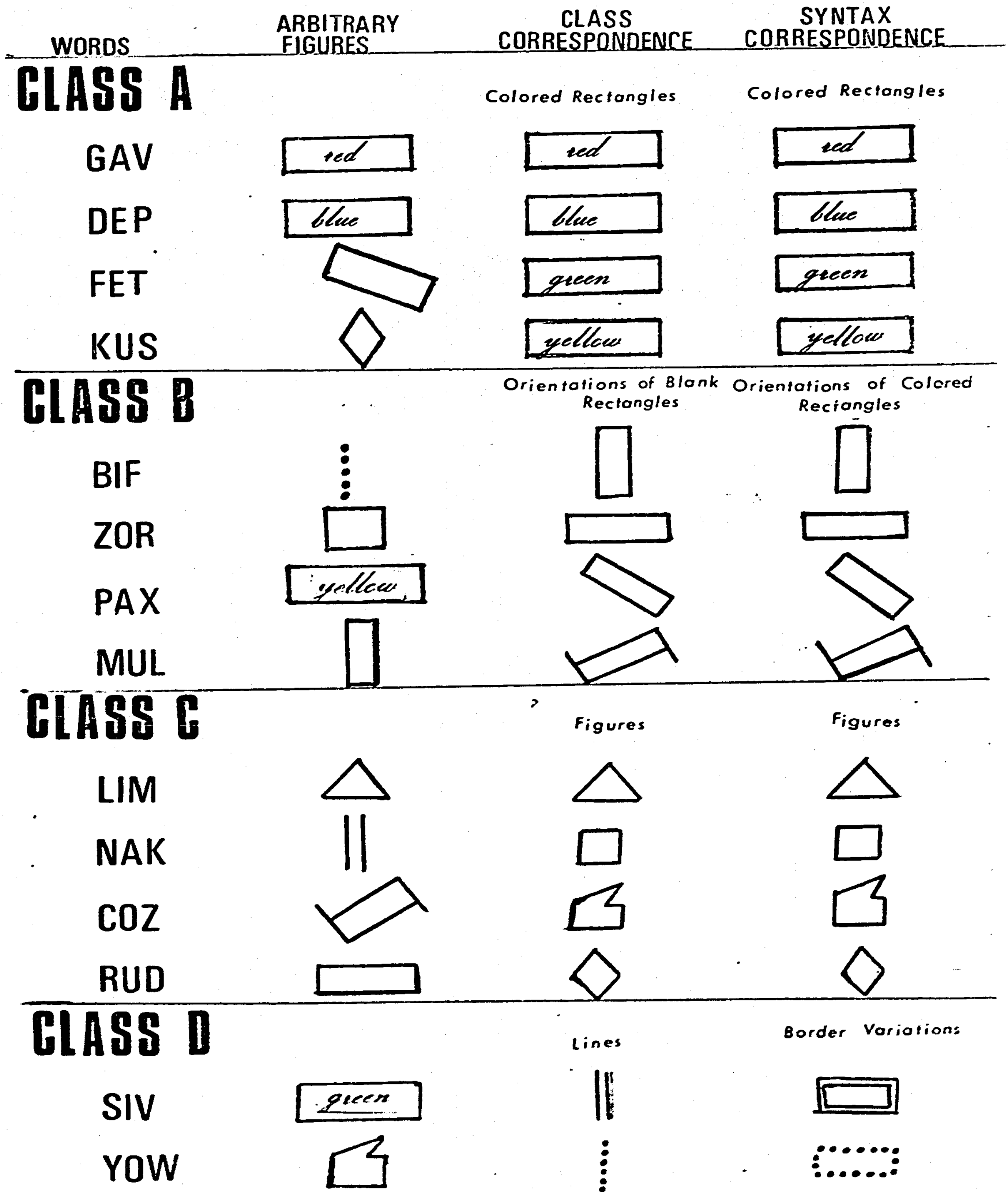
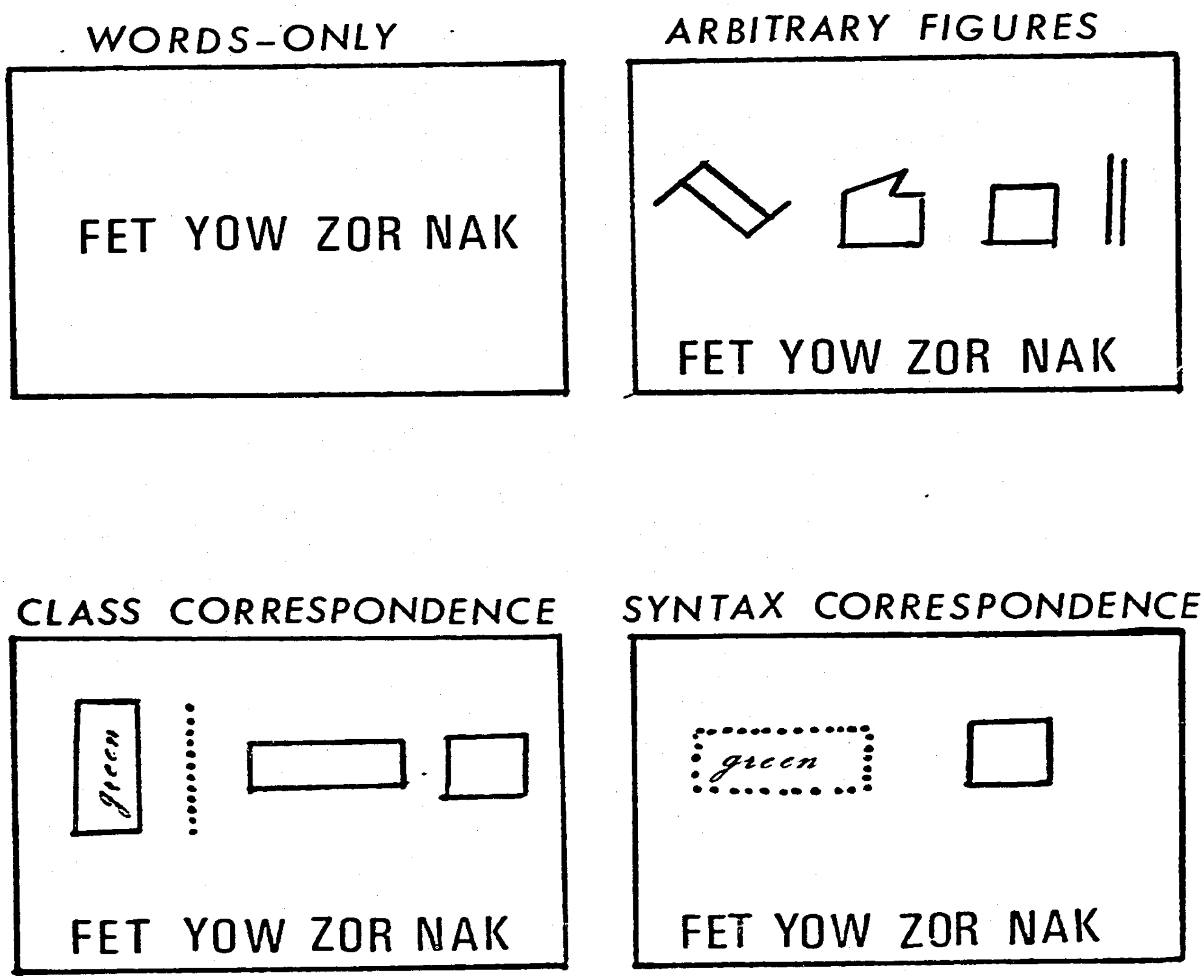


FIGURE 8-II

AN EXAMPLE OF HOW ONE SENTENCE WOULD APPEAR IN EACH OF THE REFERENCE CONDITIONS IN MLS_1

(In Experiment 8)



The words and figures used in the arbitrary figures and class correspondence conditions of MLS_2 and MLS_3 were identical to those used in MLS_1. An illustration of the figures used in the syntax correspondence condition of MLS_2 and MLS_3 is shown in Figure B-III. (Syntactically, MLS_3 differed from MLS_2 only in the fact that in MLS_3 D-words could follow C-words as well as A-words; thus identical referents were used in both MLS's with the only difference between them occurring in the combination possibilities of these referents.) From the illustration it can be seen that the referents for the A-words, C-words, and D-words are identical to those used in MLS_1. However, in the syntax correspondence condition, although the B_1-referents continue to be orientations of the colored rectangles, the B_2-referents now become relationships between A- and C-referents. Thus the very nature of the referent of a B-word necessitates the inclusion of at least two other figures, whereas the referent of a B_1-word necessitates only the presence of an A-referent. This corresponds with the syntactic requirements.

MATERIALS:

The stimulus materials consisted of 80 colored Kodachrome II slides projected on a screen by a Kodak 850 projector set to automatically change the slides every "8 seconds". (Although the interval timer on the projector was set for 8 seconds, subsequent measurement showed that the slides were actually projected for 6.5 seconds with a .8 second interval between them.) For the arbitrary figures, class correspondence, and

FIGURE B-III

AN ILLUSTRATION OF THE SYNTAX CORRESPONDENCE CONDITION IN MLS_2 AND MLS_3 IN EXPERIMENT B

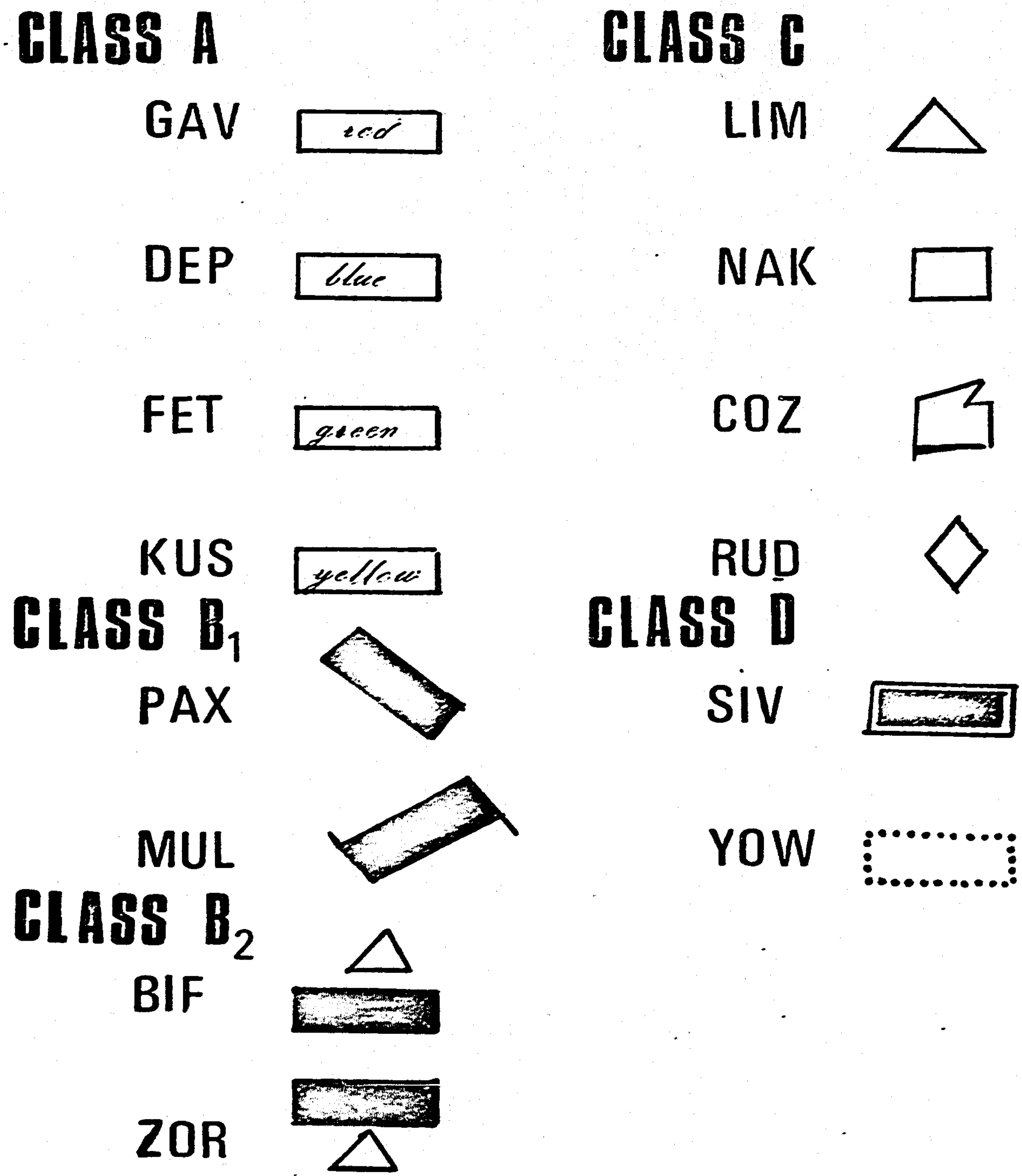
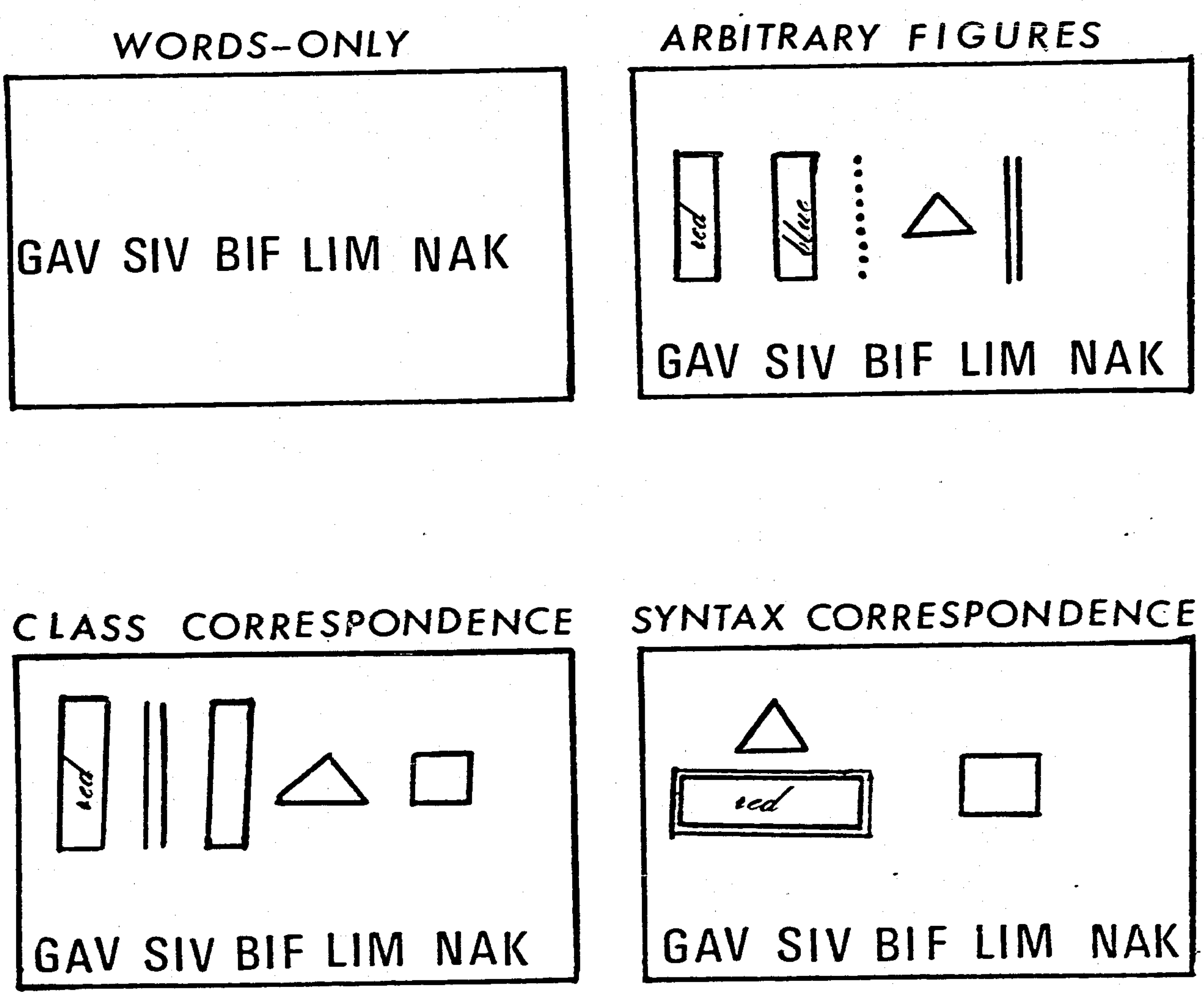


FIGURE 8-IV

AN EXAMPLE OF HOW ONE SENTENCE WOULD APPEAR IN EACH OF THE REFERENCE CONDITIONS IN MLS_2 AND MLS_3

(In Experiment 8)



and syntax correspondence groups, the pictures occupied the upper two-thirds of the slides and the words the lower one-third; for the words-only groups, the sentences were centered.

For each MLS, 40 different sentences were used, ranging from two to five words in length. Each word was presented ten times in this group of 40 and all sentences were "grammatically correct". In each presentation of 80 sentences there were two different series of these 40 sentences, with the slides arranged within each series such that each word appeared on two consecutive slides exactly two times. (Copies of the sentences used in each of the MLS's and the order in which they were presented is given in Appendix B-I.) All subjects given the same MLS received the same order of slides.

Subjects were given four presentations of the 80-slide series. After each presentation of 80 slides a test was given to measure the subject's progress in learning the language. The tests were presented on paper to the subject and no figures appeared in the tests, only sentences. The four tests were identical in form but differed in terms of the sentences used. No sentence used in a test had previously been seen by the subjects. Copies of one of the four tests for each of the three MLS's are shown in Appendix B-II.

Each test in MLS_1 consisted of 15 pairs of multiple-choice questions from which the subjects were requested to choose the correct sentence in each pair. Only one error was inserted in each incorrect sentence. In each test there were three questions testing each of the following rules:

1) An A-word must appear in a sentence.
2) Only one A-word can appear in a sentence.
3) A B-word must appear in a sentence.
4) Only one B-word can appear in a sentence.
5) A D-word can only follow an A-word.

Each test in MLS_2 consisted of 21 pairs of multiple-choice questions from which the subjects were requested to choose the correct sentence in each pair. Only one error was inserted in each incorrect sentence. In each test there were three questions testing each of the following rules:

1) An A-word must appear in a sentence.
2) Only one A-word can appear in a sentence.
3) A B-word must appear in a sentence.
4) Only one B-word can appear in a sentence.
5) A D-word can only follow an A-word.
6) Two C-words cannot appear with a B_1-word.
7) Zero C-words cannot appear with a B_2-word.

The tests used for MLS_2 were identical to those used for MLS_1 except for the addition of six questions to test rules (6) and (7). These two rules were concerned with grammatical contingencies.

Each test in MLS_3 consisted of 21 pairs of multiple-choice questions from which the subjects were requested to choose the correct sentence in each pair. Only one error was inserted in each incorrect sentence. In each test there were three questions testing each of the following rules:

1) An A-word must appear in a sentence.

2) Only one A-word can appear in a sentence.

3) A B-word must appear in a sentence.

4) Only one B-word can appear in a sentence.

5) A D-word can only follow an A-word or a C-word.

6) Two C-words cannot appear with a B_1-word.

7) Zero C-words cannot appear with a B_2-word.

The tests used for MLS_3 were identical to those used for MLS_2 except that in some sentences a D-word followed a C-word.

As can be seen from the above, for all MLS's rules 1, 2, 3, and 4 were concerned with learning that a correct utterance consists of one word of one word class and one word from a second word class; rule 5 was essentially a syntactic rule concerned with learning the position of a word-class in a sentence in relation to other word-classes in that sentence; and rules 6 and 7 were concerned with learning the grammatical contingencies contained in the two more complex versions of the language.

SUBJECTS:

Subjects were 120 college students between the ages of 20 and 26. All were native speakers of English. Five male and five female subjects were assigned randomly to each group. They were paid $2.50 to appear in the experiment.

PROCEDURE:

The subjects were tested in groups of two and three. As soon as they were comfortably seated, those subjects in the three reference conditions were told:

> "This is a language learning experiment using an artificial language which refers to an artificial environment. The language has a grammatical structure which is not English or French or any other real language. It is your job to discover what this grammatical structure is. I will present this language to you on slides which will be shown on the screen in front of you. Above the words of the language are pictures to which the words refer. I want you to learn what each word refers to."

In the words-only condition, subjects were told:

> "This is a language learning experiment using an artificial language. The language has a grammatical structure which is not English or French or any other real language. It is your job to discover what this grammatical structure is. I will present this language to you on slides which will be shown on the screen in front of you. After a while you should see a systematic pattern in the way the words are arranged. I want you to discover this pattern."

After this introduction the subjects were presented with the first set of 80 slides. Then they were given 15 minutes in which to complete the first test. When the 15 minutes had passed they were presented with the 80 slides again, then given the second test. This procedure was repeated for tests 3 and 4.

RESULTS

All subjects in MLS_2 and MLS_3 received 21 questions in each of their four tests, whereas those subjects given MLS_1 had only 15 questions in each test. These 15 questions in MLS_1 are, however, comparable to 15 questions in MLS_2 and MLS_3 if the questions testing rules (6) and (7) are omitted from the two more complex languages. Thus the total 3 X 4 cell matrix consisting of the three MLS's and four reference conditions can be compared on the set of 15 questions which test rules (1) to (5). Also a 2 X 4 matrix consisting of the two more complex languages (MLS_2 and MLS_3) and the four reference conditions can be compared on the set of 21 questions which test rules (1) to (7). For both the set of 15 questions and the set of 21 questions the means and standard deviations of the total test scores, total rules, and individual test scores of each cell are found in Appendix B-III. In Appendix B-IV are the analyses of variance comparing the cells on the total scores, rules scores and individual tests.

MEAN TOTAL SCORES:

The mean total correct scores on rules (1) to (5) over the four tests for all groups are shown in Table B-1 and the mean total correct scores on rules (1) to (7) over the four tests for the groups in MLS_2 and MLS_3 are shown in Table B-2.

TABLE B-1

TOTAL TEST MEAN SCORES ON THE 15 QUESTIONS

CONDITIONS	GROUPS* WO	AF	CC	SC
MLS_1	47	43	54	55
MLS_2	44	45	54	56
MLS_3	41	35	48	55

TABLE B-2

TOTAL TEST MEAN SCORES ON THE 21 QUESTIONS

CONDITIONS	GROUPS* WO	AF	CC	SC
MLS_2	58	59	67	79
MLS_3	54	59	59	79

* AF = Arbitrary Figures, WO = Words-only,
CC = Class Correspondence, SC = Syntax Correspondence

Several <u>a priori</u> hypotheses were made in the introduction regarding the ease with which the MLS's could be learnt under the different reference conditions. First, it was predicted that the difficulty in learning the language would be affected both by the reference conditions and by the complexity of the MLS. A two-way analysis of variance comparing the four reference conditions and the three levels of complexity on rules (1) to (5) indicated significant main effects due to reference conditions ($F(3,108) = 52.91$, $p < .001$) and levels of complexity ($F(2,108) = 12.41$, $p < .001$). The overall interaction between conditions and complexity was not significant ($F(6,108) = 2.06$, $p > .05$). Similarly, a two-way analysis of variance comparing the four reference conditions and two levels of complexity (MLS_2 and MLS_3) on rules (1) to (7) indicated significant main effects due to reference conditions ($F(3,72) = 77.96$, $p < .001$) and levels of complexity ($F(1,72) = 21.55$, $p < .001$). In addition, the overall interaction between conditions and complexity was significant ($F(3,72) = 3.09$, $p < .05$). With regard to the two more complex languages at least, the difficulty in learning involved an interaction between language complexity and type of semantic reference.

The *a priori* hypotheses not only predicted that there would be a difference among the different reference conditions and levels of complexity but predicted the direction in which these differences would occur. First, it was predicted that if language syntax is learned via mediation through semantic referents (1) subjects in the syntactic correspondence condition would have higher scores than subjects in the other three conditions, (2) subjects in the class correspondence condition would have higher scores than subjects in the arbitrary figures and words-only conditions, and (3) subjects in the arbitrary figures condition would perform as poorly or worse than subjects in the words-only condition. Second, it was predicted that if there were differences in the learning strategies employed by the subjects under the different reference conditions (1) in the syntax correspondence condition the level of language complexity would make little difference in the learning of the MLS's (learning of MLS_1 = learning of MLS_2 = learning of MLS_3); (2) in the class correspondence condition the level of language complexity would affect the learning of the MLS when rules testing grammatical contingencies were added (learning of $MLS_2 >$ learning of MLS_3); and (3) for both the arbitrary figures and words-only conditions the level of language complexity would directly affect the learning of the MLS's so that the more complex the language the more difficult it would be to learn (learning of $MLS_1 >$ learning of $MLS_2 >$ learning of MLS_3).

Because these predictions were *a priori* and included predictions of no difference as well as predictions of differences, t-tests were used to evaluate them. Using this statistic, out of 21 predictions 18 were supported by the data and of the three that were not supported only one was in the direction opposite prediction (but not significantly in that direction). Table B-3 shows the list of predictions made with regard to experiment A and the results of the t-tests.

TABLE B-3

LIST OF PREDICTIONS MADE WITH REGARD TO EXPERIMENT A

PREDICTION	t	df	PROBABILITY LEVEL	RESULT CONSISTENT WITH PREDICTION
SC(3) > CC(3)	7.62	72	.001	YES
SC(3) > AF(3)	12.30	72	.001	YES
SC(3) > WO(3)	9.75	72	.001	YES
CC(3) > AF(3)	4.68	72	.001	YES
CC(3) > WO(3)	2.13	72	.05	YES
SC(2) > CC(2)	3.19	72	.001	YES
SC(2) > AF(2)	7.85	72	.001	YES
SC(2) > WO(2)	8.09	72	.001	YES
CC(2) > AF(2)	3.87	72	.001	YES
CC(2) > WO(2)	4.10	72	.001	YES
WO(3) ≥ AF(3)	2.55	72	.02	YES
WO(2) ≥ AF(2)*	0.23	72	NS	YES
WO(1) ≥ AF(1)	1.86	108	NS	YES
SC(3) = SC(2)	0.08	72	NS	YES
SC(3) = SC(1)	0.13	108	NS	YES
SC(2) = SC(1)	0.53	108	NS	YES
CC(3) < CC(2)	3.56	72	.001	YES
AF(3) < AF(2)	4.37	108	.001	YES
AF(2) < AF(1)*	0.89	108	NS	NO
WO(3) < WO(2)	1.59	72	NS	NO
WO(2) < WO(1)	1.38	108	NS	NO

* Direction opposite prediction, but not significantly

SC = Syntax Correspondence, CC = Class Correspondence,
AF = Arbitrary Figures, WO = Words-only

TOTAL RULES SCORES:

In MLS_1, MLS_2, and MLS_3 there were five common rules which were tested:

1) An A-word must appear in a sentence.
2) Only one A-word can appear in a sentence.
3) A B-word must appear in a sentence.
4) Only one B-word can appear in a sentence.
5) A D-word can only follow an A-word. (In the case of MLS_3 this rule was changed to "A D-word can only follow an A-word or a C-word".)

It was considered possible that some of these rules might be more difficult to learn than others. Thus a three-way analysis of variance comparing the three levels of complexity, four reference conditions, and five types of rules indicated a significant main effect due to the rules ($F(1,108) = 71.94$, $p < .001$), a significant interaction between the levels and rules ($F(1,108) = 7.21$, $p < .01$), and a significant interaction between the reference conditions and rules ($F(1,108) = 5.16$, $p < .05$). The overall interaction among levels, conditions, and rules was not significant ($F(1,108) = 1.61$, $p > .05$).[1] Thus it appears that the ease with which the five syntax rules are learned is not equal and that the possibilities of learning these various rules is affected both by the reference condition and by the level of language complexity.

1. In all comparisons involving repeated measures, because of possible violations of homogeneity of covariance, the degrees of freedom used to determine significance was taken as $[1, p(n-1)]$ instead of $[(q-1), p(n-1)(q-1)]$ in accordance with Winer (1962), p.306.

For MLS_2 and MLS_3 there were seven rules tested, the five listed above, plus:

6) Only zero or one C-word can appear with a B_1-word.

7) Only one or two C-words can appear with a B_2-word.

A three-way analysis of variance comparing the two levels of complexity, four reference conditions, and seven types of rules indicated a significant main effect due to the rules ($F(1,72) = 46.17$, $p < .001$), a significant interaction between the levels and rules ($F(1,72) = 4.56$, $p < .05$), and a significant interaction between the reference conditions and rules ($F(1,72) = 5.36$, $p < .05$). The overall interaction among levels, conditions, and rules was not significant ($F(1,72) = 1.16$, $p > .05$).

Table 8-4 shows the mean correct scores for all seven rules under the four reference conditions. From this table it can be seen that in the syntax correspondence condition the rules scores were little affected by the type of error or the level of language complexity; the mean scores in all cells were roughly the same. (The maximum possible score for any rule was 15.) However in the other three conditions both type of rule and level of language complexity affected performance. In the class correspondence condition scores were relatively stable for all three MLS's for rules 1, 2, and 4, but rules 6 and 7 suffered considerably in MLS_2, and rules 3, 5, and 7 similarly showed lower performance levels in MLS_3. In the arbitrary figures condition rules 3 and 4 showed lower performance levels in MLS_1, rules 3, 6, and 7 showed lower performance levels in MLS_2, and performance on all of the rules in MLS_3 was only about chance level. In the words-only condition rules 3 and 4 showed lower performance levels in MLS_1, rules 3 and 7 showed lower performance levels in MLS_2, and rules 3, 5, 6, and 7 showed lower performance levels in MLS_3.

TABLE B-4*

MEAN CORRECT SCORES FOR THE SEVEN RULES

CONDITION	RULE 1	2	3	4	5	6	7
SC(1)	11.5	11.9	11.3	10.0	10.4		
SC(2)	11.5	11.6	11.0	11.0	11.5	11.7	10.6
SC(3)	11.9	11.6	11.3	10.4	10.2	11.7	11.0
CC(1)	11.5	11.9	8.9	9.7	11.5		
CC(2)	11.5	11.6	9.6	10.1	10.8	6.8	6.8
CC(3)	10.8	11.6	7.8	9.0	7.3	8.6	4.6
AF(1)	9.4	10.8	6.2	7.4	9.2		
AF(2)	9.3	10.8	7.7	8.4	8.8	7.5	6.1
AF(3)	7.3	6.6	6.7	7.1	5.6	6.8	5.2
WO(1)	10.6	11.0	7.9	7.9	9.8		
WO(2)	9.2	10.9	6.7	8.8	8.5	8.0	5.9
WO(3)	9.3	11.3	6.0	8.3	6.3	7.3	5.3

* Chance score is 7.5

SC = Syntax Correspondence; CC = Class Correspondence
AF = Arbitrary Figures; WO = Words-only

TEST PROGRESS:

It is to be expected that if learning occurs, the subjects will show increasingly higher test scores as they progress from test 1 to test 4. A three-way analysis of variance comparing the three levels of complexity, four reference conditions, and four individual tests on rules (1) to (5) indicated a significant main effect due to the tests ($F(1,108) = 53.42$, $p < .001$) but no significant interactions between the tests and levels ($F(1,108) = 0.61$, $p > .05$) or between the tests and conditions ($F(1,108) = 1.33$, $p > .05$). The overall interaction among tests, levels, and conditions was not significant ($F(1,108) = 1.41$, $p > .05$).

Table B-5 shows the mean correct scores for the four conditions on all four tests on rules (1) to (5). As can be seen from this table, generally there was a small amount of improvement as the subjects proceeded from each test to the next, although this continuous improvement was most stable under the syntax correspondence condition; in the other three conditions there was little or no improvement between tests 3 and 4. However, as mentioned above, this difference among the conditions was not significant.

TABLE 8-5*

TEST PROGRESS ON RULES 1 TO 5
(MEAN CORRECT SCORES FOR EACH TEST)

CONDITION	TEST 1	2	3	4
SC(1)	11.8	14.1	14.3	14.9
SC(2)	13.1	14.1	14.5	14.9
SC(3)	12.9	13.0	14.5	15.0
CC(1)	12.1	13.5	14.0	13.9
CC(2)	11.9	13.6	14.1	14.0
CC(3)	9.9	11.6	12.6	12.6
AF(1)	9.2	10.9	11.6	11.3
AF(2)	11.0	11.2	11.2	11.6
AF(3)	8.1	8.8	8.5	9.9
WO(1)	10.5	11.5	12.7	12.5
WO(2)	9.2	10.1	12.4	12.4
WO(3)	9.4	11.7	11.4	11.7

* Maximum score possible is 15.

SC = Syntax Correspondence; CC = Class Correspondence
AF = Arbitrary Figures; WO = Words-Only

A three-way analysis of variance comparing the two levels of complexity (MLS_2 and MLS_3), four reference conditions, and four individual tests on rules (1) to (7) indicated a significant main effect due to the tests ($F(1,72) = 18.56$, $p < .001$) but no significant interaction between the tests and levels ($F(1,72) = 1.56$, $p > .05$), no significant interaction between tests and conditions ($F(1,72) = 1.32$, $p > .05$), and no significant overall interaction among tests, levels, and conditions ($F(1,72) = 1.05$, $p > .05$).

Table 8-6 shows the mean correct scores of the four conditions on all four tests on rules (1) to (7).

TABLE 8-6*

TEST PROGRESS ON RULES 1 TO 7
(MEAN CORRECT SCORES FOR EACH TEST)

CONDITION	TEST 1	TEST 2	TEST 3	TEST 4
SC(2)	18.2	19.6	20.3	20.8
SC(3)	18.3	18.5	20.3	21.0
CC(2)	15.6	16.8	17.7	17.1
CC(3)	13.6	15.1	14.9	15.8
AF(2)	13.9	14.5	15.1	15.1
AF(3)	8.1	8.8	8.5	9.9
WO(2)	12.6	13.6	16.2	15.6
WO(3)	12.2	14.1	14.0	13.5

* Maximum score possible is 21.

SC = Syntax Correspondence; CC = Class Correspondence
AF = Arbitrary Figures; WO = Words-Only

Again it can be seen that generally there was a very small amount of improvement as the subjects proceeded from test to test. There were some reversals (decrements rather than improvements in performance as the experiment proceeded) in the class correspondence, arbitrary figures, and words-only conditions, but there were no reversals in the syntax correspondence condition. However, as mentioned above, there were no significant interaction effects between the test progress and reference conditions.

DISCUSSION

The results of this experiment support the hypothesis that the learning strategies employed when semantic referents are present differ from the learning strategies employed when semantic referents are not present.

Chomsky (1965, p.33) has written: "Thus it has been found that semantic reference may greatly facilitate performance in a syntax-learning experiment, even though it does not, apparently, affect the manner in which the acquisition of syntax proceeds; that is, it plays no role in determining which hypotheses are selected by the learner." (author's italics) From this, Chomsky concludes that the language acquisition device (LAD) may be put into operation in the child by certain kinds of situational information, but that its manner of functioning is not affected. Chomsky supports his argument by reference to the Miller and Norman (1964) experiment in which subjects were required to discover rules for generating admissible strings of letters which formed an artificial language. The subject was required to type on a computer what he believed to be a grammatical string of letters; if the string was grammatical the typewriter performed a specified set of indicated procedures corresponding to the letters which were used; if the string was ungrammatical, it typed the word WRONG. Subjects learned the language at about the same speed and in the same way as subjects learned the language without semantic referents. However semantic reference was incorporated into the Miller and Norman experiment only after the subject had already formed a perfectly syntactically correct sentence; only then did the teaching machine treat the sentence as an instruction to do something (and only then did the subject have any chance to discover the referent of each word). So naturally the hypotheses of subjects were unaffected by semantic referents since the semantic referents were mostly absent while subjects were forming their hypotheses.

The present experiment allows subjects to make correspondence between words and referents right from the start (as in real language learning) and the hypotheses are affected by the referents.

It appears that when semantic referents are present the learning strategy consists of (a) learning to associate each word with its referent, and (b) learning the specific rules of the reference field (the ways in which these referents are organized). Support for this hypothesis comes from: (1) the fact that subjects in the syntax correspondence condition learned more about the language syntax than subjects in the words-only condition, even though their instructions stressed vocabulary learning; (2) the patterns in which the rules were learned in the different conditions (there was a significant interaction between rules and conditions); and (3) the pattern in which the different languages were learned in the different conditions (there was a significant interaction between conditions and language complexity when the two more complex languages were compared).

In the words-only condition the semantic learning strategy could not be employed because there were no referents to associate with each word nor a field to perceptually organize. Thus in this condition it is most likely that the learning strategy employed consisted of (1) learning the positions of words in a sentence to designate their syntactic class and (2) learning that a correct sentence consists of one word from one class, one word from a second class, etc. This strategy is effective only in very elementary language systems; as syntax complexity increases the sentence position of a word class becomes increasingly variable. In the present experiment it was found that the more difficult the language the lower the overall performance in syntax learning. The pattern of rule learning also supported the position learning hypothesis. The only position constancy in all three languages was the fact that the initial word in every sentence consisted of one of four words (belonging to the A-class). Thus subjects performed at considerably above chance levels in all three languages only on rule 1 (an A-word must appear) and rule 2 (only one A-word can appear). Performance was slightly above chance on rule 4 (only one B-word can appear) in all three MLS's and on rule 5 (D-word position rule) in MLS_1 and MLS_2. There was a marked decrement in performance on rule 5 in MLS_3 when the D-word became able to considerably vary its position. Performance on the other rules approximately averaged chance level.

When information in the reference field provides no correlation between the semantic referents and the syntax relations, as in the arbitrary figures condition, the subject can employ either the words-only position learning strategy, or the semantic learning strategy. If he employs the semantic learning strategy he will find great difficulty in attempting to organize the field. Conversations with several of the subjects after they had been run in the arbitrary figures condition indicated that the semantic learning strategy was generally employed. Results showed that subjects in the arbitrary figures condition performed roughly identically to subjects in the words-only condition with respect to the patterns of rule learning and language learning on MLS_1 and MLS_2. In MLS_3, however, only rule 2 (only one A-word can appear, or in respect to the visual field, only one colored rectangle can appear) showed a performance level above chance. It can be assumed that in the most complex language, the task or organizing the reference field was so difficult that practically no learning could take place.

If information provided in the reference field corresponds to some, but not all, of the syntax rules, as in the class correspondence condition, the semantic learning strategy is likely to be employed. Thus the rules not present in the constraints of the reference system (rules 6 and 7 in MLS_2 and rules 5, 6, and 7 in MLS_3) will not be learned. In the experiment subjects in the class correspondence condition showed performance levels above chance on all rules in MLS_1 and on all rules in MLS_2 except rule 6 (B_1 rule) and rule 7 (B_2 rule). In MLS_3 performance was above chance on all rules except rule 5 (D-word must follow an A-word or C-word) and rule 7 (B_2 rule). Performance on rule 6 (B_1 rule) was above chance, contrary to expectation, but performance on rule 7 was considerably below chance, suggesting that subjects were simply utilizing a strategy of selecting the longer sentence as correct. If the scores on rules 6 and 7 are added together, the total for the two rules is below chance level.

Only when the information provided in the reference field corresponds to the language syntax (as in the _syntax correspondence_ condition) will the employment of the semantic learning strategy result in the acquisition of all grammatical rules. In the syntax correspondence condition performance on all rules was at above chance levels and there was practically no difference among rules or among languages.

Thus evidence indicates that when semantic referents are present, a different learning strategy is employed from that used when semantic referents are not present. Also the evidence indicates that it is only when the elements in the reference field mirror the syntactic constraints of the language that all of the basic grammatical relations are acquired.

EXPERIMENT C

INTRODUCTION

Experiment B showed that semantic referents can greatly influence syntax learning. Furthermore the results of the experiment give support to the position that without semantic referents, the syntax of more complex languages is unlearnable; in other words, that syntax can only be acquired via semantic referents. However, it can be argued that although semantic referents may greatly facilitate syntax learning, they are not necessary for syntax learning to occur. After all, in experiment B subjects in the words-only condition did perform at above-chance levels in all three MLS's, and there is the possibility that learning would have continued, albeit at a slower pace than in the semantic reference conditions.

Thus experiment C was designed to test this question by running a few subjects over a long period of time. Subjects were exposed to the language under a words-only condition and under a syntax correspondence condition. (Because it appeared from the results of experiment B that subjects given semantic referents will employ the semantic learning strategy, only one semantic reference condition was used in this experiment.) The MLS used in experiment C was very similar in syntax to the MLS_3 used in experiment B, but the vocabulary was expanded to allow for more possible combinations of words to be used.

Another question arises from the results of experiment B. If semantic referents are necessary in order to first learn the rules of the language, are they necessary once the language rules have been acquired? In other words, is language syntax forever tied to its semantic referents, or at some stage can it be separated from meaningful material to exist as a separate entity not only in descriptive linguistics but also in the mind of the speaker? If the study of the acquisition of miniature linguistic systems is a valid approach to the study of language acquisition, subjects should at least show the ability to generalize the rules learned to new vocabulary. Berko (1958) found that children were able to generalize their knowledge of English morphological rules to nonsense materials. In the Berko study, however, the nonsense words were given meaning by nonsense pictures. In our everyday use of language new words are often added to vocabularies without specific semantic referents; what meaning they have is acquired through their syntactic context. Also many aspects of syntax cannot be represented in perceptual terms. Anisfeld and Tucker (1967) have reported children's generalization of English morphological rules to nonsense materials when no pictures are involved. Therefore if this experiment is a valid replication of language learning, subjects should be able to acquire new vocabulary through verbal context alone; it should also be possible to test through this method whether or not semantic referents for these new words are visualized or imagined by the speaker.

Thus experiment C was also designed to test the generalization of class learning to new vocabulary which had not been paired with semantic referents. After acquiring the language, subjects were exposed to the new words only in verbal context, and they were tested to see whether they could use these words correctly. Also an attempt was made to see whether subjects must associate semantic referents to the new words before they can use them correctly or if the new words are defined simply in terms of an abstract class.

METHOD

The MLS used in experiment C was very similar in syntax to MLS_3 used in experiment B, the only difference being that class D words preceded, rather than followed, class A and class C words. (This was done because, as was mentioned in the discussion on experiment B, it appears fairly easy for words-only subjects to learn that one of a given number of words always appears in the initial position of a sentence. Thus by having class D words precede class A words, they are no longer able to employ this strategy. It may be that this was all that was acquired by the words-only subjects in experiment B.)

The syntactic structure of the language can be described by the following rewrite rules as:

$$S \dashrightarrow AP + BP + (CP)$$

$$AP \dashrightarrow (D) + A$$

$$BP \dashrightarrow \begin{Bmatrix} B_1 \\ B_2 + CP \end{Bmatrix}$$

$$CP \dashrightarrow (D) + C$$

Twenty-nine words were used in the MLS, with eight words each occurring in classes A, B, and C, and five words occurring in class D. All words were CVC's with a moderately high association value of between 70 and 80 according to Archer (1960).

Subjects were tested under only two reference conditions in experiment C, the words-only condition and the syntax correspondence condition. In the words-only condition, subjects were presented with only the words of the language; in the syntax correspondence condition figures were employed which incorporated into their design both visual features defining class membership and visual reasons for the syntactic contingencies. The words and figures used in experiment C are illustrated in Figure C-I. As can be seen, the referents used in experiment C were very similar to those used in MLS_3 of experiment B.

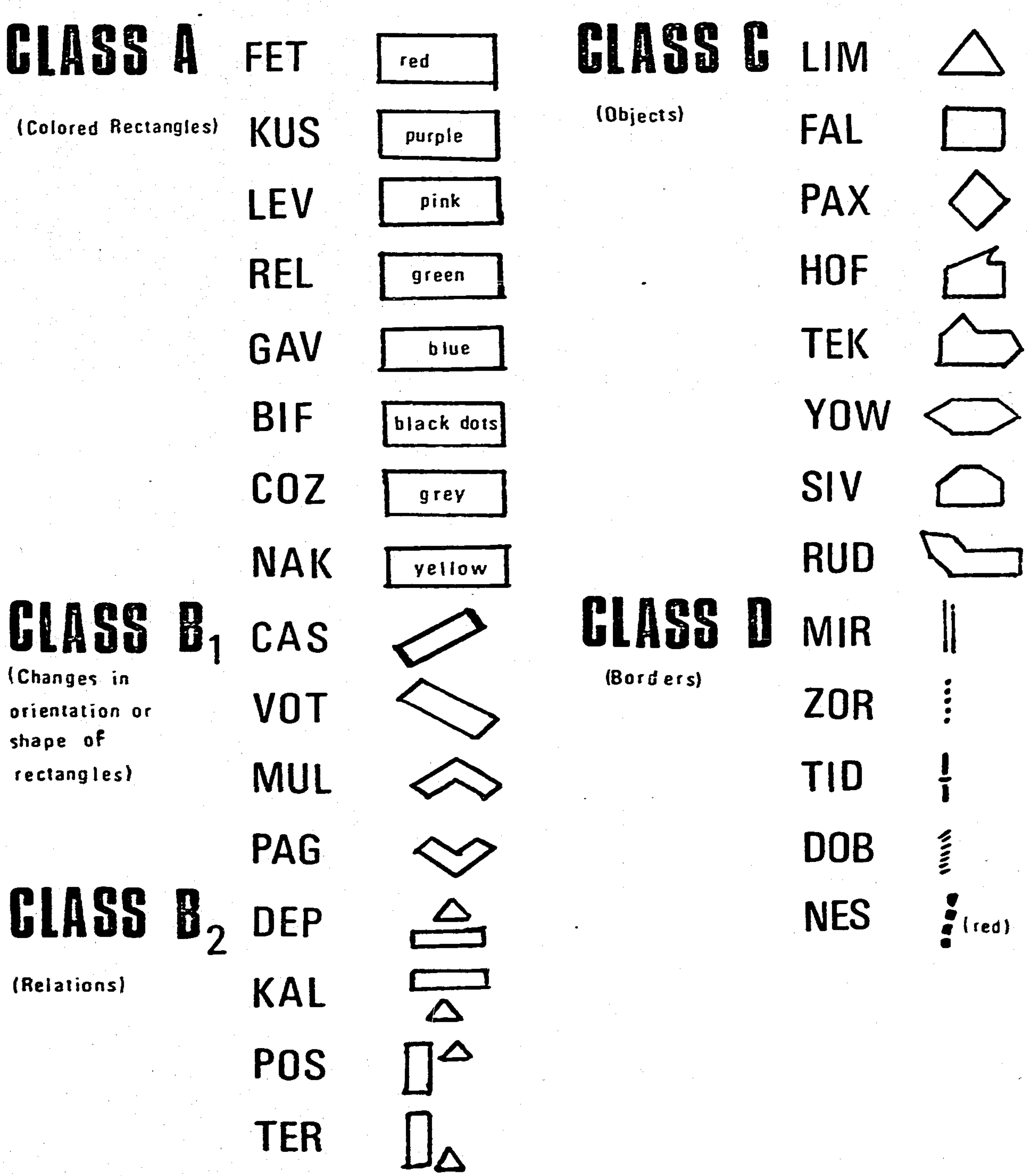
MATERIALS:

The stimulus materials consisted of 80 colored Kodachrome II slides projected on a screen by a Kodak 850 projector which was set to manual control. The subjects were instructed on how to change the slides through manual control and were allowed to change the slides at their own speed forward but were told that they could not change them backward. The pictures occupied the upper two-thirds of the slides and the words the lower one-third on the slides used in the syntax correspondence condition; the words were centered on the slides used in the words-only condition.

Eighty different sentences were shown, ranging from two to five words in length. Each word was presented ten times in this group of 80 and all sentences were "grammatically correct". In each presentation of 80 sentences the slides were arranged so that each word appeared on two consecutive slides exactly

FIGURE C-I

AN ILLUSTRATION OF THE MLS USED IN EXPERIMENT C



two times. All subjects received the same order of slides. (A copy of the 80 sentences in the order in which they were presented appears in Appendix C-I.)

Subjects were given 40 presentations of the 80-slide series. After each presentation a test was given to measure the subject's progress in learning the language. The 40 tests were identical in form but differed in terms of the sentences used; no sentence used in a test had previously been seen by the subjects. The tests were similar to those used in experiment B and an example of one of the tests appears in Appendix C-II.

Each test consisted of 21 pairs of multiple-choice questions from which the subjects were requested to choose the correct sentence in each pair. Only one error was made in each incorrect sentence. In each test there were three questions testing each of the following rules:

1) An A-word must appear in a sentence.
2) Only one A-word can appear in a sentence.
3) A B-word must appear in a sentence.
4) Only one B-word can appear in a sentence.
5) A D-word must preceed an A-word or a C-word.
6) Two C-words cannot appear with a B_1-word.
7) Zero C-words cannot appear with a B_2-word.

At the end of the experiment subjects were presented with a context vocabulary test. Both the words-only subjects and syntax correspondence subjects received five 5 x 7 cards in which one new word was introduced on each card. An illustration of one card is shown below in Figure C-II.

FIGURE C-II

AN ILLUSTRATION OF THE CONTEXT VOCABULARY TEST

(Introducing the word 'BUK')

Given that the following sentences are correct:

1) BUK MUL ZOR HOF
2) NES BUK KAL YOW
3) BUK DEP MIR FAL

Which one of the following sentences is correct:

1) BIF BUK MUL HOF
2) NES KAL BUK YOW
3) MIR BUK DEP FAL

In Figure C-II the new word introduced was BUK, used in the sentence position with the same privileges of occurrence as a class A word and the correct sentence was number 3. A total of five new words were introduced and tested in the same manner:

1) BUK - a class A word
2) WAP - a class B_2 word
3) SOG - a class C word
4) DAF - a class B_1 word
5) PIR - a class D word

In addition, the syntax correspondence subjects were presented with another five cards to see whether visual imagery was present while the new vocabulary was being acquired and utilized. An example of one of these five cards is shown in Figure C-III.

FIGURE C-III

AN ILLUSTRATION OF THE VISUAL IMAGERY QUESTIONS

Refer to question 1

Draw a BUK

Did you have this picture in mind while doing question 1, or did you just make it up now?

Each of these five cards referred to one of the new words introduced in the first five cards.

SUBJECTS:

Six subjects were used in the experiment, all being native speakers of English and living in the greater Vancouver area of British Columbia. The subjects were matched for age, sex, and scholastic standing: Two subjects were boys, aged 12 in grade 7 at F.W. Howay Elementary School in New Westminster, B.C.; two subjects were girls, aged 15 in grade nine at the New Westminster Junior High School in New Westminster, B.C.; and two subjects were girls, aged 18 attending an introductory psychology course at Simon Fraser University in Burnaby, B.C. One subject in each set was run under the words-only condition and the other was run under the syntax correspondence condition. Each subject was paid $40 for participating in the experiment.

PROCEDURE:

Each subject was tested individually. As soon as he was comfortably seated he was told:

> "This is a language-learning experiment. I am going to show you some slides on the screen in front of you and I want you to learn the language which is shown on them. You'll get to see these slides many times and each time you finish a set of slides I will give you a test to see how much you have learned. You can control the time you look at each slide with this button."

Then the projector was started and the subject was shown how to change the slides; he was allowed to take as long as he wished to look at any given slide but he was not allowed to return to a previous picture.

After each set of 80 slides, the subject was given a test, and each subject was given two 80-slide presentations and two tests each day for 20 consecutive days.

When the subject had completed test 40, he was given the new vocabulary test (without further presentation of the 80-slide series). The subject was asked to complete each card before going on to the next card.

RESULTS

The six subjects in this experiment are identified in the following discussion as follows:

1) S_1 - 12-year-old boy in the syntax correspondence condition.
2) S_2 - 15-year-old girl in the syntax correspondence condition.
3) S_3 - 18-year-old girl in the syntax correspondence condition.
4) W_1 - 12-year-old boy in the words-only condition.
5) W_2 - 15-year-old girl in the words-only condition.
6) W_3 - 18-year-old girl in the words-only condition.

ACQUISITION OF THE MLS:

In Table C-1 below are shown the total scores received by these six subjects on the 40 tests (in groups of 5 tests).

TABLE C-1

SCORES RECEIVED ON THE 40 SYNTAX TESTS*

	TESTS								
Ss	1-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	TOTAL
S_1	54	79	93	102	103	103	104	103	741
S_2	53	78	93	98	99	100	85	91	697
S_3	62	96	86	97	102	98	98	103	742
W_1	55	50	43	52	59	48	53	52	412
W_2	54	56	56	40	53	47	63	55	424
W_3	58	60	57	63	59	63	56	65	491

*Maximum score possible is 105 (each test totaled 21)

It is obvious that there were considerable differences in performance between those subjects in the semantic reference condition and those in the words-only condition. Although in the initial five tests all subjects performed at a chance level, in all other tests the subjects in the semantic reference condition showed considerably better performance than those subjects in the words-only condition.

The highest score obtainable for any 5 tests was 105; chance level would thus be 52.5. In the semantic reference condition both subject S_1 and S_3 appeared to be making only a few random errors after the 15th test; subject S_2 seemed to have slightly more difficulty, although her performance was well above chance level. In the words-only condition subjects W_1 and W_2 showed no performance above chance level; subject W_3 had an average of just slightly above chance level.

In Table C-2 are shown the scores received by the six subjects on the last 5 tests in terms of the seven rules which were to be learned. Only the scores of the last five tests were taken so as to more clearly delineate which rules had been acquired by the end of the experiment.

The highest score obtainable on any rule for the five tests was 15; chance level would be 7.5. As can be seen, in the semantic reference condition subjects S_1 and S_3 showed practically no differences in performance among the 7 rules; subject S_2 appeared to have some difficulty in learning rule 3 (a B-word must appear in a sentence) and rule 7 (B_2 rule). In the words-only condition subjects averaged out to roughly the same performance level on all rules except rule 7 which showed a very low level for all three subjects. (It may have been that these subjects were following a strategy of choosing the longer sentence as correct. If so, performance on rule 7 would be poorer than average and performance on rule 6 would be better.)

TABLE C-2

RULES SCORES ON THE LAST 5 TESTS*

Ss	RULES 1	2	3	4	5	6	7	TOTAL
S_1	15	14	15	14	15	15	15	103
S_2	13	15	9	14	15	14	11	91
S_3	15	14	15	14	15	15	15	103
W_1	6	8	10	8	7	6	8	52
W_2	7	9	4	7	12	11	5	55
W_3	13	8	7	11	10	12	4	65

*Maximum score possible is 15

Another way of looking at the rules scores is to see what rules, if any, may have been acquired first. In Table C-3 are shown the scores received by the six subjects on the seven rules on tests 6 to 10 (the period when language acquisition appeared to be taking place in the semantic reference condition).

From the results, it does not appear that the subjects in the syntax correspondence condition acquired one rule and then progressed to another; all rules appeared to be acquired more or less with equal speed. It is interesting to note that subject S_2 was doing poorly on rules 3 and 7 at this stage as well. The only difference between Tables C-2 and C-3 for the syntax correspondence subjects appears to be a general overall improvement on all scores. In the words-only condition, the total for all three subjects was only chance level.

TABLE C-3*

RULES SCORES ON TESTS 6-10

Ss	RULES 1	2	3	4	5	6	7	TOTAL
S_1	10	14	10	10	14	9	12	79
S_2	10	12	9	13	14	13	7	78
S_3	15	13	14	13	14	13	14	96
W_1	5	7	5	10	8	7	8	50
W_2	10	6	10	6	8	11	5	56
W_3	8	5	14	8	5	10	10	58

*Maximum score possible is 15

ACQUISITION OF THE CONTEXT VOCABULARY:

In Table C-4 are shown the results of the six subjects on the context vocabulary test. As can be seen, two of the subjects in the syntax correspondence condition received perfect scores on the new vocabulary test; subject S_2, however, was unable to learn the new B_1-word or B_2-word from verbal contex alone. Thus it appears that her poor performance on rule 3 (a B-word must appear in a sentence) and rule 7 (B_2 rule) was due to the fact that she had never accurately acquired privileges of occurrence of B-words. In the words-only condition, all three subjects performed at chance level on this test.

TABLE C-4

ACQUISITION OF THE NEW CONTEXT VOCABULARY

S	WORD CLASS A	B_1	B_2	C	D
S_1	Yes	Yes	Yes	Yes	Yes
S_2	Yes	No	No	Yes	Yes
S_3	Yes	Yes	Yes	Yes	Yes
W_1	Yes	No	No	No	No
W_2	No	No	Yes	No	Yes
W_3	No	Yes	No	No	No

The results of the picture drawing questions given to the syntax correspondence subjects are shown in Table C-5. A picture was judged correct if it followed the rules set down for the class (e.g., a B_2 word had to be illustrated as a relation between two things). As can be seen, subject S_1 was always able to draw a correct picture but stated that sometimes he had the picture in mind while doing the question and sometimes he just made it up when asked to do so. Subject S_2 did not draw correct pictures for three of the words (and two of these she got incorrect in the contex vocabulary test) but stated that she always had a picture in mind while doing the test. Subject S_3, on the other hand, stated that she never had the picture in mind while doing the question, and for one word she was unable to draw a picture even when asked to do so; however, she got all the questions correct.

TABLE C-5

RESULTS OF THE VISUAL IMAGERY QUESTIONS

S	WORD CLASS	PICTURE CORRECT	PICTURE IN MIND DURING QUESTION
S_1	A	Yes	Yes
	B_1	Yes	No
	B_2	Yes	No
	C	Yes	No
	D	Yes	Yes
S_2	A	No (drew only an object)	Yes
	B_1	No (drew only an object)	Yes
	B_2	No (drew only an object)	Yes
	C	Yes	Yes
	D	Yes	Yes
S_3	A	Yes	No (just a color)
	B_1	Yes	No
	B_2	No (did not draw anything)	No (just remembered the conditions
	C	Yes	No (necessary to find the correct
	D	Yes	No (one of the three answers)

DISCUSSION

WORDS-ONLY CONDITION:

After 40 presentations of the MLS, i.e., 3200 sentence presentations, two of the subjects in the words-only condition were still performing only at chance levels and the other subject showed only slightly above-chance performance. This latter subject was the college student and it may have been that she had acquired some knowledge about language structure which she employed in the task. By the conclusion of the experiment, no subject showed any evidence that he had acquired any one of the language rules to a high criterion. This was true even though rule 5 (D-word position rule) was strictly a syntactic rule, defined only in terms of its position in a sentence in relation to the other words in that sentence. Yet it was not acquired by the words-only subjects. The subjects did not show evidence of boredom; indeed subject W_3 was very interested in how she had done and in learning what the rules of the language were. Thus it does appear that semantic referents are necessary for the initial acquisition of syntactic rules in relatively complex languages.

SYNTAX CORRESPONDENCE CONDITION:

In the syntax correspondence condition all three subjects provided evidence that they had acquired considerable knowledge of the language syntax and two of these (the 12-year-old boy and 16-year-old girl) appeared to have learned all of the rules (they made only random errors on the syntax tests and were able to utilize the context vocabulary without difficulty). The question remains why the one subject (the 15-year-old girl) appeared unable to learn all of the rules of the language. An analysis of her comments on the context vocabulary test showed that she was thinking of this new language in terms of nouns, verbs, objects, and modifiers; she actually wrote comments such as "description, color, verb, object" and "color, noun, adverb, noun" along the side of the sentences. In spite of the fact that she stated that she visualized the new words while she was doing the questions, what she appeared to be doing was translating the MLS in terms of English grammar and then visualizing according to the rules of English grammar. She was in grade nine in school, a grade in which considerable emphasis is placed on traditional grammatical analysis and this possibly interfered with her ability to employ a more näive learning strategy.

It is interesting to note that subject S_1 (12-year-old boy) verbalized quite regularly during his acquisition period and that his verbalizations were consistent with the semantic learning strategy herein proposed. Subject S_1 first focused all of his attention on acquiring the vocabulary; his choice of words to focus on did not follow any set pattern (such as choosing all the words of one class first) but were selected arbitrarily. By the third presentation he could recognize all the words but it took another five presentations before he had all the words memorized (memorization proved the most difficult task for him). Then he concentrated on learning the regularities underlying the language. By the 20th presentation he was able to verbally state these regularities, although he stated them in perceptual terms, not in linguistic terms.

CONTEXT VOCABULARY:

The syntax correspondence subjects were able to acquire new words from sentence context and use these words correctly. Thus after syntax rules are acquired it does not appear to be necessary to use semantic referents to continue language development. Furthermore it appears that these new words are defined just as much in terms of their syntactic correlates as in terms of possible imaginary semantic characteristics. This was especially true of the older subject who defined them only in terms of their privileges of occurrence.

GENERAL DISCUSSION

IMPLICATIONS OF THE STUDY:

The results of all three experiments strongly support the hypothesis that there must be at least a partially semantic basis for the initial acquisition of syntax. Semantic referents appear to be necessary in order to acquire the basic grammatical classes and the ways in which these classes are related to each other. Once the syntactic functions have been acquired, however, semantic referents do not appear to be necessary in order for language development to continue; the semantic and syntactic aspects of a new lexical item can be acquired solely from that item's sentential context.

Chomsky has at various times mentioned the possibility of semantic correlates having an effect on language acquisition, but he has dismissed this as very unlikely or as unimportant to the overall process of language acquisition. For instance, he writes:

> "Similarly, it would not be at all surprising to find that normal language learning requires use of language in real-life situations in some way. But this, if true, would not be sufficient to show that information regarding situational context (in particular, a pairing of signals with structural descriptions that is at least in part prior to assumptions about syntactic structure) plays any role in determining how language is acquired, once the mechanism is put to work and the task of language

learning is undertaken by the child." (Chomsky, 1965, p.33)

Chomsky does admit that extra-linguistic factors do influence how speech is produced and understood, but he argues that these factors are irrelevant to our understanding the the underlying grammatical competence of the language user. According to Chomsky's view, the grammar constructed in accordance with linguistic principles is essentially equivalent to the mental grammar of an idealized speaker; the performance model--the grammar actually used in language situations--includes non-linguistic variables in addition to the mental linguistic model. However, according to Chomsky (1965, p.9): "...a reasonable model of language use will incorporate, as a basic component, the generative grammar that expresses the speaker-hearer's knowledge of the language..." Although the performance mechanism need not be identical to the linguistic model, any performance model must incorporate the linguistic model into its system; the performance mechanism can utilize the linguistic rules in whatever manner is most psychologically efficient. Thus language acquisition should be studied by isolating this independent underlying linguistic system which is central to language use. The emphasis in the literature has been placed on developing an explanation of language acquisition solely in terms of linguistic variables.

Chomsky (1965, 1967) has stated that the deep structure contains the basic grammatical relations of the language and assigns an ideal order to its underlying phrases. If a view of the deep structure as a wholly separate linguistic entity is maintained, an explanation of its origin must be found in assuming prior knowledge of these basic aspects of language structure. McNeill (1966, 1970) has argued that because the basic grammatical relations are not present in any simple consistent way in the surface structure of speech, children are never exposed to them; thus they must form part of an innate linguistic mechanism. Chomsky (1965) has stated that many aspects of the deep structure cannot be learned because they are not amenable to conditioning and reinforcement; the facts of universal linguistic structures and uniform language development in children necessitate the conclusion that there is an innate human language facility.

It is quite possible that the human being possesses some mechanism which predisposes him to the rapid acquisition of certain rule systems which are contained in natural languages. However the question arises as to whether this is a specific linguistic system geared solely to the acquisition of the highly specific rule system found in languages or whether it is a more general cognitive ability which can best be described in terms of the perceptual-cognitive organization.

The present group of experiments have shown that the acquisition of language syntax depends upon prior perceptual-cognitive organization and not necessarily on prior linguistic knowledge. (It may be that language acquisition depends on both prior perceptual-cognitive organization and prior linguistic knowledge because all subjects used in this experiment possessed both. However those subjects who were forced to depend <u>solely</u> on their linguistic knowledge were unable to learn the language.) Language universals may simply be reflections of cognitive universals, if, as has been stated in linguistic theory, most language universals are to be found in the deep structure, and if, as has been suggested by these experiments, those aspects of the deep structure such as order and the basic grammatical relations are determined by semantic considerations. If so, the acquisition of language may best be interpreted in terms of the interaction between linguistic rules and cognitive functioning.

The conclusions tentatively put forward by this experimenter are in agreement with recent arguments regarding the semantic basis for syntactical processing of language. Schlesinger (1968) has stated on the basis of his research regarding the influence of sentence structure on readability that the assumption that syntactic decoding proceeds in isolation from semantic factors is an untenable proposition. Clark and Clark (1968) and Clark and Card (1969) have proposed that sentences are remembered on the basis of their semantic features rather than their syntactic features. Fillmore (1968) has suggested a theory of grammar which incorporates semantic considerations. He writes:

> "If it is possible to discover a semantically justified universal syntactic theory...if it is possible by rules (beginning, perhaps, with those which assign sequential order to the underlying

order-free representations) to make these 'semantic deep structures' into the surface forms of sentences, then it is likely that the syntactic deep structure of the type that has been made familiar from the work of Chomsky and his students is going to go the way of the phoneme. It is an artificial intermediate level between the empirically discoverable 'semantic deep structure' and the observationally accessible surface structure, a level the properties of which have more to do with the methodological commitments of grammarians than with the nature of human languages." (Fillmore, 1968, p.88)

JUSTIFICATION FOR USING A MINIATURE LINGUISTIC SYSTEM:

The study of miniature linguistic systems uses the psychological experimental paradigm to investigate the problems of linguistic theory. It provides a better experimental analogue than the typical concept formation experiment, because complex sentences are matched to complex images, i.e., the rules are learned in a many-to-many match rather than a one-name to one-configuration-of-attributes match. However, because there are many differences between the acquisition of a MLS by adult subjects and the acquisition of a native language by children, there is often a question of interpreting the results of MLS studies in terms of the more fundamental aspects of language acquisition. Some experimenters (e.g., Miller, 1967) have argued that the justification for studying the acquisition of a MLS can simply be found in the knowledge that can be gained therein about human information processing, which is in itself inherently interesting. However this paper makes the much stronger claim that at least some of the processes being investigated are relevant to the question of how first language learning takes place.

Generally the validity of using a MLS to study natural language learning is challenged on two grounds (e.g., Bever, Fodor and Weksel, 1965). (1) It is suggested that the rule systems in natural languages have specific formal properties which correspond to the specific language learning mechanisms possessed by humans and which are altered or lost by the arbitrary selection and simplification of rules in the MLS. (2) It is suggested that young children possess these specific language learning mechanisms for only a limited time and lose them at or before adolescence.

With regard to the first criticism, there is no reason to suppose that the subject's special language mechanism will not work in a laboratory setting and there is no evidence to support the contention that only natural languages can contain those aspects of language which are necessary to set this specific psychological machinery in motion. Smith and Braine (in press) argue: "The criticism that work on miniature languages is irrelevant to questions of language acquisition because the rule systems are too simple is actually a criticism of an analytical approach to the study of linguistic rules. Such sweeping criticism would, it seems to us, rule out any scientific work on the psychological processes involved in language acquisition." As of yet it is uncertain as to whether any 'language universals' have been found. In fact it is possible that the existence of language universals (if indeed they do exist) can more easily be discovered by the systematic exclusion of specific variables from a MLS. (For example, the present experiment has shown that the presence of meaning is necessary for the apprehension of certain linguistic rules; thus it is probable that meaning is a language universal. However, the Moeser (1969) experiment showed that a fixed word order was not necessary for language acquisition to take place.) Miniature language acquisition does not seek to simulate exactly natural language acquisition but to investigate those variables which may have bearing on the acquisition of natural languages.

With regard to the second criticism of the use of MLS's to investiage first language learning, Smith and Braine (in press) have provided evidence to show that Israeli statistics on the learning of Hebrew show no support for the hypothesis that children have a special facility for acquiring grammar; Israelis between the ages of 15-29 show similar learning curves to pre-adolescents. Asher and Price (1967) reported that college students exposed to a small sample of Russian showed a significantly <u>better</u> comprehension of the language than did groups of children (aged 8, 10, and 14) exposed to the same sample. Smith and Braine (in press) have suggested that much of the evidence supporting the claim that children have a special language facility is anecdotal and is due to such extraneous variables as a special ability to acquire phonological (but not grammatical) rules, more time to spend in language learning, a smaller and less abstract lexicon to learn, etc. There is as yet no conclusive evidence to support the hypothesis that children and adults acquire language in fundamentally different ways.

A difficulty can arise, however, in the possibility that adults may bring to the language-learning task special learning strategies which have been acquired through experience with language and which are unavailable to the child. It is probably best to assume that both children and adults possess a basic language acquisition process but that adults have as well a variety of acquired, special skills which they can apply to the experimental situation. (The results of experiment C in the present paper support this position. The 18-year-old girl in the words-only condition performed slightly better in the experiment than did her two younger coherts and it is possible that she had acquired a special strategy for analyzing linguistic rules. However in the semantic reference condition the 12-year-old boy performed as well as the college student, suggesting that any special language learning skills possessed by the older subject were not applicable to this specific learning situation.)

The present writer feels that the use of a MLS to study language acquisition can yield a positive contribution both to the study of the process of language learning and to the discovery of new approaches which might form the basis for a new analysis of some of the problems of grammatical theory. This position is also the one taken by Smith and Braine (in press) who have written:

> "If information about human rule apprehension processes is relevant to understanding the acquisiton of natural language,...then it should also be of value in formulating the rules of natural language and in specifying a theory of language universals. From a psychological point of view, a theory of the form of a human language can be regarded as a theory of what (within the linguistic domain) is learnable and usable by a human subject. As such, it should be amenable to direct experimental investigation through miniature language research."

SUPPORT FOR THE PRESENT INTERPRETATION:

Smith and Braine (in press) have also suggested that to be applicable to the study of first language learning, the performance of subjects on the MLS must be comparable to the performance of young children learning their first language. On the basis of a longitudinal study of the acquisition of language by three children, Bloom (1968) has concluded that an adequate account of language development must specify at least three interrelated components, (1) linguistic experience, (2) non-linguistic experience, and (3) cognitive-perceptual organization; linguistic competence must include all three of these components. Schlesinger (1971) has recently suggested a model of language acquisition in which semantics plays a central explanatory role. On the basis of his analysis of children's linguistic productions, he has suggested that meanings come first--then the child learns how these meanings are realized in linguistic form. Schlesinger accords an important role to the semantic influence on learning the relations between words (such as agent-action, action-object, modifier-head noun, etc.). This approach is very similar to the approach taken by the present writer on the basis of the results of the present experiments.

CONTRIBUTIONS OF THE PRESENT STUDY:

In the recent literature on language acquisition a number of suggestions have been made regarding the possible effects of semantics on the learning of syntax. The present study has contributed to our understanding of how languages are acquired by providing experimental evidence to support the contention that some of the basic aspects of language syntax are learned more easily (and perhaps only) through semantic mediation. The present study has also shown that a new variation in the experimental design of artificial languages as introduced by Moeser (1969) is a valid and potentially important addition to the methodology of language investigation.

The findings reported in the present study can also have practical effects in terms of assisting in developing the best method of teaching both first and second languages, to both children and adults. The present study is especially relevant as a research tool in studying the most effective methods of second language acquisition.

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APPENDIX A-I

A COPY OF THE SENTENCES PRESENTED TO SUBJECTS IN EXPERIMENT A

(In ABCD order)

1. BIF CAS TEK DEP
2. BIF YOW NUV DUS
3. RES YOW RUD SIV
4. LAR CAS RUD DUS
5. LAR PAG TEK DEP
6. PAX HOF VOT DEP
7. BIF HOF NUV SIV
8. RES YOW NUV TID
9. PAX CAS TEK TID
10. PAX PAG RUD DEP
11. BIF PAG VOT TID
12. PAX CAS VOT DUS
13. RES PAG TEK DUS
14. RES CAS VOT TID
15. LAR CAS TEK DUS
16. PAX PAG TEK SIV
17. RES HOF NUV SIV
18. BIF HOF VOT DUS
19. BIF PAG TEK DEP
20. PAX CAS NUV DEP
21. LAR HOF NUV SIV
22. LAR PAG VOT DEP
23. BIF PAG RUD SIV
24. RES CAS RUD DUS
25. PAX YOW VOT DUS
26. BIF YOW TEK TID
27. RES HOF TEK DEP
28. RES PAG NUV TID
29. LAR HOF VOT TID
30. RES PAG VOT DEP
31. BIF YOW RUD SIV
32. PAX HOF NUV DUS
33. LAR YOW RUD TID
34. LAR CAS VOT DEP
35. BIF CAS RUD TID
36. LAR YOW TEK DUS
37. RES HOF RUD SIV
38. PAX YOW NUV TID
39. PAX HOF RUD SIV
40. LAR YOW NUV SIV

APPENDIX A-I

(Continued)

41. BIF CAS TEK DEP
42. LAR HOF VOT TID
43. RES HOF TEK DEP
44. PAX CAS NUV DEP
45. BIF HOF NUV SIV
46. BIF PAG VOT TID
47. PAX PAG RUD DEP
48. LAR CAS RUD DUS
49. RES PAG TEK DUS
50. RES YOW NUV TID
51. LAR YOW TEK DUS
52. PAX CAS TEK TID
53. RES PAG NUV TID
54. PAX HOF VOT DEP
55. LAR YOW RUD TID
56. BIF YOW NUV DUS
57. PAX CAS VOT DUS
58. LAR PAG VOT DEP
59. BIF YOW RUD SIV
60. LAR HOF NUV SIV
61. PAX YOW VOT DUS
62. PAX HOF RUD SIV
63. LAR YOW NUV SIV
64. LAR CAS TEK DUS
65. RES CAS VOT TID
66. BIF HOF VOT DUS
67. RES HOF NUV SIV
68. PAX YOW NUV TID
69. BIF CAS RUD TID
70. BIF PAG TEK DEP
71. LAR CAS VOT DEP
72. RES CAS RUD DUS
73. BIF PAG RUD SIV
74. RES PAG VOT DEP
75. RES HOF RUD SIV
76. LAR PAG TEK DEP
77. BIF YOW TEK TID
78. RES YOW RUD SIV
79. PAX HOF NUV DUS
80. PAX PAG TEK SIV

APPENDIX A-II

AN EXAMPLE OF ONE OF THE TESTS PRESENTED TO SUBJEXTS IN EXPERIMENT A

(In ABCD order)

(Sentences were read on a tape recorder. Subjects were asked to mark of a paper whether the sentence they heard was correct or incorrect.)

1. PAX YOW RUD DEP
2. RES BIF HOF VOT
3. PAX PAG VOT NUV
4. LAR YOW NUV DEP
5. BIF CAS NUV DUS
6. BIF YOW PAG SIV
7. RES HOF VOT TID
8. LAR VOT RUD DUS
9. LAR CAS VOT TID
10. RES PAG RUD DEP
11. PAX BIF RUD DEP
12. PAX PAG VOT TID
13. RES CAS DUS SIV
14. PAG YOW NUV DEP
15. BIF YOW VOT SIV
16. RES CAS TEK SIV
17. CAS RUD VOT DEP
18. RES PAG HOF RUD
19. LAR PAG RUD DUS
20. LAR PAX CAS TID
21. PAX CAS VOT DEP
22. CAS NUV DUS DEP
23. BIF HOF RUD DEP
24. BIF RUD DEP SIV

APPENDIX A-III

ANALYSIS OF VARIANCE COMPARING THE GROUPS IN EXPERIMENT A

SOURCE	df	MS	ERROR TERM	F	SIG. LEVEL
A Groups	2	113.29	S(A)	6.015	.01
B Levels	1	68.76	SB(A)	11.475	.001
A X B	2	.76	SB(A)	0.127	NS
S(A)	39	18.84			
SB(A)	39	5.99			

APPENDIX B-I

A COPY OF THE SENTENCES PRESENTED TO SUBJECTS IN EXPERIMENT B

(In MLS_1)

1. GAV SIV BIF LIM NAK
2. GAV PAX COZ
3. DEP SIV PAX
4. FET SIV MUL LIM RUD
5. KUS BIF NAK LIM
6. KUS MUL COZ
7. DEP PAX NAK COZ
8. DEP ZOR
9. GAV YOW ZOR RUD LIM
10. DEP YOW MUL
11. KUS SIV MUL RUD
12. FET YOW BIF RUD COZ
13. FET PAX
14. GAV BIF COZ
15. KUS SIV BIF
16. KUS ZOR NAK
17. FET BIF NAK
18. GAV YOW PAX RUD
19. FET YOW MUL COZ
20. KUS SIV PAX COZ LIM
21. GAV SIV ZOR NAK
22. GAV MUL
23. DEP MUL RUD
24. FET PAX COZ RUD
25. KUS YOW PAX NAK
26. DEP MUL NAK COZ
27. DEP SIV ZOR LIM RUD
28. KUS ZOR
29. FET MUL
30. FET SIV ZOR LIM
31. DEP YOW PAX LIM
32. GAV BIF
33. DEP BIF NAK
34. FET YOW ZOR NAK
35. KUS PAX
36. GAV SIV MUL COZ LIM
37. GAV ZOR
38. KUS YOW ZOR RUD LIM
39. DEP MUL RUD
40. FET YOW MUL COZ

APPENDIX B-I

A COPY OF THE SENTENCES PRESENTED TO SUBJECTS IN EXPERIMENT B IN MLS_1

(Continued)

41. DEP YOW BIF RUD
42. FET BIF
43. KUS SIV PAX COZ LIM
44. GAV BIF COZ
45. KUS ZOR
46. KUS YOW PAX NAK
47. DEP SIV PAX
48. GAV SIV BIF LIM NAK
49. FET BIF NAK
50. FET SIV ZOR LIM
51. DEP YOW PAX LIM
52. DEP ZOR
53. KUS YOW ZOR RUD LIM
54. FET PAX COZ RUD
55. GAV SIV MUL COZ LIM
56. GAV BIF
57. DEP BIF NAK
58. KUS PAX
59. KUS SIV MUL RUD
60. GAV SIV ZOR NAK
61. DEP PAX NAK COZ
62. GAV YOW PAX RUD
63. DEP YOW MUL
64. FET MUL
65. FET PAX
66. GAV YOW ZOR RUD LIM
67. KUS BIF NAK LIM
68. GAV PAX COZ
69. DEP YOW BIF RUD
70. DEP MUL NAK COZ
71. GAV ZOR
72. FET SIV MUL LIM RUD
73. KUS ZOR NAK
74. FET YOW BIF RUD COZ
75. GAV MUL
76. KUS SIV BIF
77. FET SIV ZOR NAK
78. KUS MUL COZ
79. FET BIF
80. DEP SIV ZOR LIM RUD

APPENDIX B-I

A COPY OF THE SENTENCES PRESENTED TO SUBJECTS IN EXPERIMENT B

(In MLS_2)

1. GAV SIV BIF LIM NAK
2. GAV YOW PAX
3. KUS SIV PAX COZ
4. FET SIV ZOR LIM RUD
5. DEP YOW PAX LIM
6. DEP BIF NAK COZ
7. GAV BIF RUD
8. KUS YOW ZOR RUD LIM
9. FET YOW MUL COZ
10. FET BIF NAK
11. GAV SIV ZOR NAK
12. KUS ZOR RUD
13. KUS MUL COZ
14. GAV PAX COZ
15. FET YOW ZOR NAK
16. DEP YOW MUL
17. FET MUL
18. FET YOW BIF RUD COZ
19. KUS YOW PAX NAK
20. DEP SIV PAX
21. DEP MUL RUD
22. GAV YOW ZOR RUD LIM
23. KUS SIV BIF LIM
24. DEP YOW BIF RUD
25. FET PAX COZ
26. DEP ZOR COZ
27. GAV ZOR LIM
28. GAV MUL
29. DEP MUL NAK
30. KUS BIF NAK LIM
31. KUS SIV MUL
32. DEP SIV PAX
33. GAV YOW PAX
34. FET YOW MUL COZ
35. GAV BIF COZ
36. FET BIF RUD
37. FET PAX
38. DEP SIV ZOR LIM RUD
39. DEP PAX NAK
40. KUS ZOR NAK

APPENDIX B-I

A COPY OF THE SENTENCES PRESENTED TO SUBJECTS IN EXPERIMENT B IN MLS_2

(Continued)

41. FET SIV MUL LIM
42. GAV SIV ZOR NAK
43. KUS PAX
44. GAV BIF COZ
45. GAV SIV MUL COZ
46. FET SIV ZOR LIM RUD
47. DEP YOW PAX LIM
48. KUS PAX
49. KUS YOW ZOR RUD LIM
50. DEP ZOR COZ
51. GAV SIV MUL COZ
52. DEP MUL RUD
53. FET BIF RUD
54. FET PAX COZ
55. KUS YOW PAX NAK
56. DEP YOW MUL.
57. DEP BIF NAK COZ
58. KUS ZOR NAK
59. DEP SIV ZOR LIM RUD
60. KUS SIV PAX COZ
61. KUS BIF NAK LIM
62. DEP YOW BIF RUD
63. GAV ZOR LIM
64. FET SIV MUL LIM
65. GAV MUL
66. GAV SIV BIF LIM NAK
67. FET PAX
68. GAV BIF RUD
69. KUS MUL COZ
70. FET BIF NAK
71. GAV YOW ZOR RUD LIM
72. DEP PAX NAK
73. KUS SIV MUL
74. FET YOW BIF RUD COZ
75. DEP MUL NAK
76. KUS ZOR RUD
77. FET MUL
78. KUS SIV BIF LIM
79. FET YOW ZOR NAK
80. GAV PAX COZ

APPENDIX B-I

A COPY OF THE SENTENCES PRESENTED TO SUBJECTS IN EXPERIMENT B

(In MLS_3)

1. GAV SIV BIF LIM NAK
2. GAV PAX COZ
3. DEP SIV PAX
4. FET SIV MUL LIM
5. KUS BIF NAK LIM
6. KUS SIV PAX COZ
7. DEP ZOR COZ
8. GAV NAK ZOR RUD LIM
9. FET BIF RUD
10. FET MUL
11. DEP MUL NAK YOW
12. FET BIF RUD YOW COZ
13. KUS BIF LIM SIV
14. DEP PAX LIM YOW
15. DEP BIF NAK COZ
16. GAV ZOR NAK SIV
17. GAV PAX
18. FET PAX COZ
19. GAV SIV MUL COZ YOW
20. KUS ZOR RUD YOW LIM
21. KUSSIV MUL
22. GAV MUL
23. KUS PAX NAK YOW
24. FET BIF NAK
25. FET ZOR LIM RUD SIV
26. KUS SIV MUL
27. DEP MUL RUD
28. KUS ZOR RUD
29. GAV ZOR LIM
30. DEP MUL
31. DEP BIF RUD YOW
32. GAV BIF COZ
33. DEP SIV ZOR LIM RUD
34. FET YOW MUL COZ
35. KUS PAX
36. GAV BIF RUD
37. FET YOW ZOR NAK
38. GAV MUL
39. KUS ZOR NAK
40. FET PAX

APPENDIX B-I

A COPY OF THE SENTENCES PRESENTED TO SUBJECTS IN EXPERIMENT B IN MLS_3

(Continued)

41. KUS MUL COZ
42. DEP PAX NAK
43. FET BIF NAK
44. FET YOW MUL COZ
45. KUS ZOR RUD YOW LIM
46. DEP ZOR COZ
47. GAV BIF COZ
48. GAV PAX
49. KUS SIV PAX COZ
50. FET SIV MUL LIM
51. KUS MUL COZ
52. KUS BIF LIM SIV
53. GAV YOW ZOR RUD LIM
54. FET BIF RUD
55. DEP BIF NAK COZ
56. DEP SIV PAX
57. GAV SIV MUL COZ YOW
58. GAV ZOR LIM
59. KUS ZOR NAK
60. KUS PAX
61. GAV PAX COZ
62. FET BIF RUD YOW COZ
63. DEP PAX LIM YOW
64. GAV SIV BIF LIM NAK
65. DEP BIF RUD YOW
66. DEP PAX NAK
67. FET YOW ZOR NAK
68. FET MUL
69. DEP MUL RUD
70. GAV BIF RUD
71. DEP MUL
72. GAV ZOR NAK SIV
73. FET PAX COZ
74. KUS ZOR RUD
75. DEP MUL NAK YOW
76. FET ZOR LIM RUD SIV
77. KUS PAX NAK YOW
78. DEP SIV ZOR LIM RUD
79. FET PAX
80. KUS BIF NAK LIM

APPENDIX B-II

AN EXAMPLE OF ONE OF THE TESTS PRESENTED TO SUBJECTS TESTED UNDER MLS_1 IN EXPERIMENT B

(With the addition of asterisks marking the correct sentences)

Below are 15 questions with two sentences in each question. Only one sentence in each question is correct; the other sentence contains an error. Please circle the <u>correct</u> sentence in each question. <u>Answer each question, guessing if necessary</u>.

1. a. FET BIF SIV LIM
   b. FET BIF LIM*

2. a. DEP SIV MUL COZ*
   b. DEP MUL PAX COZ

3. a. GAV SIV ZOR RUD*
   b. LIM SIV ZOR RUD

4. a. KUS FET MUL NAK
   b. KUS SIV MUL NAK*

5. a. DEP PAX NAK*
   b. DEP NAK LIM

6. a. FET GAV SIV ZOR COZ
   b. FET SIV ZOR COZ*

7. a. DEP BIF YOW LIM
   b. DEP YOW BIF LIM*

8. a. DEP SIV ZOR NAK*
   b. SIV ZOR NAK LIM

9. a. DEP BIF NAK*
   b. DEP SIV

10. a. GAV YOW BIF LIM*
    b. GAV YOW BIF ZOR LIM

11. a. GAV ZOR RUD*
    b. ZOR RUD

12. a. KUS YOW PAX LIM*
    b. KUS ZOR YOW LIM

13. a. KUS SIV BIF PAX RUD
    b. KUS SIV BIF RUD NAK

14. a. KUS SIV LIM COZ
    b. KUS PAX LIM*

15. a. GAV PAX LIM*
    b. GAV KUS PAX LIM

APPENDIX B-II

AN EXAMPLE OF ONE OF THE TESTS PRESENTED TO SUBJECTS TESTED UNDER MLS_2 IN EXPERIMENT B

(With the addition of asterisks marking the correct sentences)

Below are 21 questions with two sentences in each question. Only one sentence in each question is correct; the other sentence contains an error. Please circle the <u>correct</u> sentence in each question. <u>Answer each question, guessing if necessary</u>.

1. a. FET BIF SIV LIM
   b. FET BIF LIM*

2. a. DEP SIV MUL COZ*
   b. DEP MUL PAX COZ

3. a. GAV SIV ZOR RUD*
   b. LIM SIV ZOR RUD

4. a. KUS FET MUL NAK
   b. KUS SIV MUL NAK*

5. a. GAV BIF RUD NAK*
   b. GAV BIF

6. a. DEP PAX NAK*
   b. DEP NAK LIM

7. a. DEP PAX*
   b. DEP PAX LIM RUD

8. a. FET GAV SIV ZOR COZ
   b. FET SIV ZOR COZ*

9. a. DEP BIF YOW LIM
   b. DEP YOW BIF LIM*

10. a. DEP SIV ZOR NAK*
    b. SIV ZOR NAK LIM

11. a. FET ZOR NAK RUD*
    b. FET YOW ZOR

12. a. DEP BIF NAK*
    b. DEP SIV

13. a. GAV YOW BIF LIM*
    b. GAV YOW BIF ZOR LIM

14. a. GAV ZOR RUD*
    b. ZOR RUD

15. a. FET MUL LIM COZ
    b. FET SIV MUL*

16. a. DEP YOW ZOR
    b. DEP YOW ZOR COZ RUD*

17. a. KUS YOW PAX LIM*
    b. KUS ZOR YOW LIM

18. a. KUS SIV BIF PAX RUD
    b. KUS SIV BIF RUD NAK*

19. a. KUS SIV LIM COZ
    b. KUS PAX LIM*

20. a. GAV PAX LIM*
    b. GAV KUS PAX LIM

21. a. KUS MUL*
    b. KUS MUL COZ RUD

APPENDIX B-II

AN EXAMPLE OF ONE OF THE TESTS PRESENTED TO SUBJECTS TESTED UNDER MLS_3 IN EXPERIMENT B

(With the addition of asterisks marking the correct sentences)

Below are 21 questions with two sentences in each question. Only one sentence in each question is correct; the other sentence contains an error. Please circle the correct sentence in each question. Answer each question, guessing if necessary.

1. a. FET BIF SIV LIM
   b. FET BIF LIM*

2. a. DEP MUL COZ SIV*
   b. DEP MUL PAX COZ

3. a. GAV SIV ZOR RUD*
   b. LIM SIV ZOR RUD

4. a. KUS FET MUL NAK
   b. KUS MUL NAK SIV*

5. a. GAV BIF RUD NAK*
   b. GAV BIF

6. a. DEP PAX NAK*
   b. DEP NAK LIM

7. a. DEP PAX*
   b. DEP PAX LIM RUD

8. a. FET GAV SIV ZOR COZ
   b. FET SIV ZOR COZ*

9. a. DEP BIF YOW LIM
   b. DEP YOW BIF LIM*

10. a. DEP ZOR NAK SIV*
    b. ZOR NAK SIV LIM

11. a. FET ZOR NAK YOW RUD*
    b. FET YOW ZOR

12. a. DEP BIF NAK*
    b. DEP SIV

13. a. GAV BIF LIM YOW*
    b. GAV BIF ZOR LIM YOW

14. a. GAV ZOR RUD SIV*
    b. ZOR RUD SIV

15. a. FET MUL LIM COZ
    b. FET SIV MUL*

16. a. DEP YOW ZOR
    b. DEP ZOR COZ YOW RUD*

17. a. KUS PAX LIM YOW*
    b. KUS ZOR YOW LIM

18. a. KUS BIF PAX RUD SIV
    b. KUS BIF RUD NAK SIV*

19. a. KUS LIM SIV COZ
    b. KUS PAX LIM*

20. a. GAV PAX LIM*
    b. GAV KUS PAX LIM

21. a. KUS MUL*
    b. KUS MUL COZ RUD

APPENDIX B-III

MEANS AND STANDARD DEVIATIONS OF THE TOTAL TEST SCORES FOR EXPERIMENT B

CONDITION	15 QUESTIONS		21 QUESTIONS	
	M	S.D.	M	S.D.
SC(1)	55.1	3.665		
SC(2)	56.6	3.565	78.9	4.149
SC(3)	55.4	3.169	79.1	5.744
CC(1)	53.5	4.170		
CC(2)	53.6	2.951	68.6	5.892
CC(3)	47.7	7.484	59.4	6.802
AF(1)	43.0	3.590		
AF(2)	45.0	6.289	58.6	6.501
AF(3)	35.3	4.945	47.3	6.001
WO(1)	47.2	4.367		
WO(2)	44.1	6.350	58.0	7.288
WO(3)	41.2	7.099	53.9	6.740

APPENDIX B-III

MEANS AND STANDARD DEVIATIONS OF THE RULES SCORES FOR EXPERIMENT B

RULE		CONDITION SC(1)	SC(2)	SC(3)	CC(1)	CC(2)	CC(3)
1	M	11.5	11.5	11.9	11.5	11.5	10.8
	SD	0.850	0.850	0.316	1.269	1.080	1.476
2	M	11.9	11.6	11.6	11.9	11.6	11.6
	SD	0.316	1.265	0.699	0.316	0.516	0.699
3	M	11.3	11.0	11.3	8.9	9.6	7.8
	SD	0.823	1.247	0.949	2.378	1.174	2.201
4	M	10.0	11.0	10.4	9.7	10.0	9.0
	SD	1.247	1.054	1.430	1.889	1.449	2.749
5	M	10.4	11.5	10.2	11.5	10.8	7.3
	SD	1.955	0.527	1.033	0.707	1.229	1.703
6	M		11.7	11.7		6.8	8.6
	SD		0.483	0.483		2.044	2.319
7	M		10.6	11.0		6.8	4.6
	SD		1.506	1.054		2.658	1.265

RULE		CONDITION AF(1)	AF(2)	AF(3)	WO(1)	WO(2)	WO(3)
1	M	9.4	9.3	7.3	10.6	9.2	9.3
	SD	1.647	1.889	2.111	1.897	1.476	2.359
2	M	10.8	10.8	8.6	11.0	10.9	11.3
	SD	1.229	1.398	2.547	1.414	1.289	0.675
3	M	6.2	7.7	6.7	7.9	6.7	6.0
	SD	1.687	1.567	1.160	1.370	2.111	2.211
4	M	7.4	8.4	7.1	7.9	8.8	8.3
	SD	1.174	1.897	1.853	1.792	1.549	2.163
5	M	9.2	8.8	5.6	9.8	8.5	6.3
	SD	1.619	2.741	2.875	2.201	1.269	2.058
6	M		7.5	6.8		8.0	7.3
	SD		1.509	3.011		2.404	3.268
7	M		6.1	5.2		5.9	5.3
	SD		0.994	2.348		2.685	2.406

APPENDIX B-III

MEANS AND STANDARD DEVIATIONS OF THE INDIVIDUAL TESTS FOR EXPERIMENT B

(On 15 questions)

CONDITION	TEST 1 M	1 SD	2 M	2 SD	3 M	3 SD	4 M	4 SD
SC(1)	11.8	1.932	14.1	0.568	14.3	1.567	14.9	0.316
SC(2)	13.1	1.729	14.1	1.524	14.5	0.707	14.9	0.316
SC(3)	12.9	2.331	13.0	1.333	14.5	0.707	15.0	0.0
CC(1)	12.1	1.449	13.5	1.434	14.0	1.247	13.9	1.101
CC(2)	11.9	2.234	13.6	1.578	14.1	0.994	14.0	1.155
CC(3)	9.9	2.025	11.6	2.271	12.6	2.171	12.6	1.955
AF(1)	9.2	1.687	10.9	1.524	11.6	1.430	11.3	2.214
AF(2)	11.0	2.309	11.2	2.044	11.2	1.549	11.6	1.897
AF(3)	8.1	1.370	8.8	1.814	8.5	1.716	9.9	2.424
WO(1)	10.5	1.581	11.5	1.650	12.7	1.418	12.5	1.434
WO(2)	9.2	2.150	10.1	2.923	12.4	1.897	12.4	2.221
WO(3)	9.4	2.271	11.7	2.312	11.4	2.757	11.7	2.452

APPENDIX B-III

MEANS AND STANDARD DEVIATIONS OF THE INDIVIDUAL TESTS FOR EXPERIMENT B

(On 21 questions)

CONDITION	TEST							
	M	SD	M	SD	M	SD	M	SD
SC(2)	18.2	1.687	19.6	2.271	20.3	0.823	20.8	0.422
SC(3)	18.3	3.020	18.5	1.841	20.3	0.823	21.0	0.0
CC(2)	15.6	2.221	16.8	1.989	17.7	1.636	17.1	1.969
CC(3)	13.6	2.011	15.1	2.283	14.9	2.079	15.8	2.821
AF(2)	13.9	2.378	14.5	2.414	15.1	1.663	15.1	2.234
AF(3)	8.1	1.370	8.8	1.814	8.5	1.716	9.9	2.424
WO(2)	12.6	2.503	13.6	3.627	16.2	1.989	15.6	2.119
WO(3)	12.2	2.530	14.1	1.370	14.0	2.404	13.5	2.718

APPENDIX B-IV

ANALYSIS OF VARIANCE COMPARING THE TOTAL TEST SCORES ON RULES 1 TO 5

SOURCE	df	MS	ERROR TERM	F	SIG. LEVEL
A Complexity	2	315.40	S(AB)	12.41	.001
B Conditions	3	1344.74	S(AB)	52.91	.001
A X B	6	52.50	S(AB)	2.06	NS
S(AB)	108	25.40			

APPENDIX B-IV

ANALYSIS OF VARIANCE COMPARING THE TOTAL TEST SCORES ON RULES 1 TO 7

SOURCE	df	MS	ERROR TERM	F	SIG. LEVEL
A Complexity	1	720.00	S(AB)	21.55	.001
B Conditions	3	2604.15	S(AB)	77.96	.001
A X B	3	103.29	S(AB)	3.09	.05
S(AB)	72	33.40			

APPENDIX B-IV

ANALYSIS OF VARIANCE COMPARING THE RULES SCORES ON RULES 1 TO 5

SOURCE	df	MS	ERROR TERM	F	SIG. LEVEL
A Complexity	2	60.04	S(AB)	12.41	.001
B Conditions	3	257.66	S(AB)	52.91	.001
C Rules	4	143.70	SC(AB)	71.94	.001 (1,108)
A X B	6	10.04	S(AB)	2.06	NS
A X C	8	14.40	SC(AB)	7.21	.01 (1,108)
B X C	12	10.30	SC(AB)	5.16	.05 (1,108)
A X B X C	24	3.22	SC(AB)	1.61	NS (1,108)
S(AB)	108	4.87			
SC(AB)	432	2.00			

APPENDIX B-IV

ANALYSIS OF VARIANCE COMPARING THE RULES SCORES ON RULES 1 TO 7

SOURCE	df	MS	ERROR TERM	F	SIG. LEVEL
A Complexity	1	99.35	S(AB)	21.55	.001
B Conditions	3	359.40	S(AB)	77.96	.001
C Rules	6	136.47	SC(AB)	46.17	.001 (1,72)
A X B	3	14.24	S(AB)	3.09	.05
A X C	6	13.49	SC(AB)	4.56	.05 (1,72)
B X C	18	15.84	SC(AB)	5.36	.05 (1,72)
A X B X C	18	3.42	SC(AB)	1.16	NS (1,72)
S(AB)	72	4.61			
SC(AB)	432	2.96			

APPENDIX B-IV

ANALYSIS OF VARIANCE COMPARING THE INDIVIDUAL TESTS ON RULES 1 TO 5

SOURCE	df	MS	ERROR TERM	F	SIG. LEVEL
A Complexity	2	76.07	S(AB)	12.41	.001
B Conditions	3	324.34	S(AB)	52.91	.001
C Tests	3	111.19	SC(AB)	53.42	.001 (1,108)
A X B	6	12.63	S(AB)	2.06	NS
A X C	6	1.26	SC(AB)	0.61	NS (1,108)
B X C	9	2.76	SC(AB)	1.33	NS (1,108)
A X B X C	18	2.93	SC(AB)	1.41	NS (1,108)
S(AB)	108	6.13			
SC(AB)	324	2.08			

APPENDIX B-IV

ANALYSIS OF VARIANCE COMPARING THE INDIVIDUAL TESTS ON RULES 1 TO 7

SOURCE	df	MS	ERROR TERM	F	SIG. LEVEL
A Complexity	1	179.94	S(AB)	21.55	.001
B Conditions	3	650.97	S(AB)	77.96	.001
C Tests	3	62.39	SC(AB)	18.56	.001 (1,72)
A X B	3	25.64	S(AB)	3.09	.05
A X C	3	5.23	SC(AB)	1.56	NS (1,72)
B X C	9	4.43	SC(AB)	1.32	NS (1,72)
A X B X C	9	3.53	SC(AB)	1.05	NS (1,72)
S(AB)	72	8.35			
SC(AB)	216	3.36			

APPENDIX C-I

A COPY OF THE SENTENCES PRESENTED TO SUBJECTS IN EXPERIMENT C

(In order of presentation)

1. FET CAS SIV	21. FET POS HOF DOB PAX
2. FET PAG	22. DOB GAV TER LIM HOF
3. DOB REL PAG ZOR TEK	23. KUS MUL MIR HOF
4. NAK POS NES TEK	24. KUS CAS
5. NES BIF DEP RUD	25. TID LEV CAS TEK
6. BIF VOT TEK	26. REL TER TID HOF RUD
7. LEV VOT MIR PAX	27. NAK TER RUD
8. MIR COZ MUL PAX	28. BIF KAL HOF
9. MIR GAV VOT LIM	29. REL MUL
10. GAV DEP ZOR SIV YOW	30. NES REL POS SIV
11. REL DEP FAL	31. FET MUL NES YOW
12. NAK PAG MIR FAL	32. BIF DEP PAX TID YOW
13. NAK TER SIV DOB RUD	33. MIR BIF VOT
14. KUS KAL SIV POS SIV	34. LEV VOT
15. NES LEV KAL LIM	35. LEV POS TEK FAL
16. LEV POS ZOR YOW	36. FET TER TEK
17. COZ TER ZOR RUD	37. FET KAL PAX
18. REL TER LIM PAX	38. TID NAK HOF DOB PAX
19. COZ KAL TEK LIM	39. BIF PAG DOB FAL
20. NES COZ POS YOW	40. COZ DEP HOF FAL

APPENDIX C-I

(Continued)

41. LEV DEP PAX DOB LIM
42. COZ POS FAL DOB LIM
43. COZ CAS TID SIV
44. BIF POS SIV
45. ZOR KUS POS DOB PAX
46. ZOR NAK KAL PAX SIV
47. NAK CAS
48. TID GAV CAS
49. TID FET VOT
50. KUS DEP TEK
51. KUS PAG RUD
52. REL KAL RUD MIR RUD
53. MIR FET DEP LIM
54. KUS TER YOW LIM
55. LEV TER FAL
56. GAV MUL
57. GAV KAL HOF
58. BIF KAL ZOR LIM SIV
59. REL VOT
60. REL CAS HOF
61. BIF KAL HOF
62. COZ MUL
63. NES KUS MUL
64. NAK DEP YOW
65. KUS KAL RUD YOW
66. FET DEP ZOR FAL FAL
67. LEV PAG
68. REL CAS
69. COZ PAG
70. GAV DEP YOW
71. NAK MUL
72. FET PAG TEK
73. LEV MUL HOF
74. KUS VOT
75. BIF CAS
76. GAV POS FAL NES SIV
77. COZ VOT
78. GAV CAS
79. NAK VOT YOW
80. GAV PAG TEK

APPENDIX C-II

AN EXAMPLE OF ONE OF THE TESTS PRESENTED TO SUBJECTS IN EXPERIMENT C

(With the addition of asterisks marking the correct sentences)

Below are 21 questions with two sentences in each question. Only one sentence in each question is correct; the other sentence contains an error. Please circle the correct sentence in each question. Answer each question, guessing if necessary.

1. a. REL COZ VOT
   b. REL VOT HOF*

2. a. GAV VOT PAG TEK
   b. GAV VOT TEK*

3. a. KUS CAS MIR LIM*
   b. MIR CAS LIM

4. a. DOB NAK KAL NES FAL PAX*
   b. DOB NAK NES FAL PAX

5. a. COZ KAL DOB YOW*
   b. COZ DOB KAL YOW

6. a. NES KUS CAS*
   b. KUS CAS PAX TEK

7. a. TID FET POS TEK RUD*
   b. TID FET POS

8. a. BIF MUL DEP RUD
   b. BIF MUL ZOR RUD*

9. a. NAK DOB CAS PAX
   b. NAK CAS DOB PAX*

10. a. KUS POS TID SIV*
    b. KUS FET POS SIV

11. a. LEV CAS HOF FAL
    b. LEV CAS*

12. a. MIR COZ DOB YOW
    b. MIR COZ MUL DOB YOW*

13. a. LEV KAL HOF ZOR TEK*
    b. ZOR LEV KAL

14. a. FET MUL*
    b. FET MUL FAL HOF

15. a. NES GAV POS MIR RUD*
    b. NES GAV MIR RUD

16. a. ZOR DEP FAL
    b. LEV DEP ZOR FAL*

17. a. FET PAG FAL*
    b. FET PAG VOT FAL

18. a. BIF KAL DOB SIV*
    b. BIF DOB KAL SIV

19. a. LEV NAK MUL RUD
    b. LEV MUL MIR RUD*

20. a. ZOR KUS KAL
    b. KUS KAL YOW ZOR FAL*

21. a. TID POS HOF LIM
    b. TID REL POS HOF*