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The Role of Syntax Markers and Semantic Referents in Learning an Artificial Language

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In a recent study using a meaningless artificial language, T. R. G. Green (*Journal of Verbal Learning and Verbal Behavior*, 1979, 18, 481–496) found that subjects could easily learn a relatively complex set of phrase structure rules provided the language contained a well-organized system of markers. Green's result was replicated in this paper. However, once a reference field was added to the artificial language, the organized marker system lost its effectiveness. Subjects ignored the marker system to concentrate on learning the reference system even when the reference system did not contain regularities whereas the marker system did. The learning strategies used by subjects in these experiments suggest that language learning occurs by learning the regularities inherent in the semantic system and not by learning any regularities present in the syntax system.

One method used to investigate language learning has been to study the acquisition of miniature artificial languages. Artificial languages resemble natural languages in that they contain a set of verbal symbols and a set of rules for combining these symbols into sentences. Like natural languages, the set of rules can specify class membership, order, and co-occurrence constraints on the linguistic structure of the artificial language. Unlike natural languages this set of rules is fairly limited in scope, thus making it possible to observe a language learning situation wherein various language features can be studied in isolation from the complex interactions found in natural systems. It is this ability to systematically manipulate all features that might influence language learning mechanisms that makes the study of artificial languages an important tool in psychological research (cf. Moeser, 1977; Morgan & Newport, 1981).

Artificial language research attempts to simulate the natural language learning situation. Like children learning their first language, subjects are presented with a limited subset of all grammatically correct utterances in the languages. These subjects are presumed to have learned the language when they can apply the rules they have induced from this subset both to produce novel utterances that are grammatically correct and to identify ungrammatical utterances. Although we cannot automatically assume that the adult subjects in these experiments utilize the same mental facilities as children learning their first language (cf. Bever, Fodor, & Weksel, 1965), these

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studies at a minimum provide information about how humans acquire rule-governed systems that are similar to natural languages. This information should help us to understand the general cognitive processes that must underlie natural language acquisition.

Most of the early studies of artificial language learning concentrated on investigating syntax acquisition. These studies used languages that contained syntax rule systems but no semantic reference systems. A systematic investigation of the interaction of semantic and syntactic factors in artificial language learning was first carried out by Moeser and Bregman (1972, 1973). In their first study, Moeser and Bregman found that subjects shown a system containing semantic referents learned the syntax rules better than subjects shown the same system without semantic referents. They also found that the language without semantic referents was learned in a different way from the language containing referents. In their second study, Moeser and Bregman found that subjects could not learn a more complex version of the artificial language unless semantic referents were presented in conjunction with the syntactic structure. Thus it appeared that not only did semantic referents facilitate syntax acquisition, but that they might be necessary for such learning to occur.

Recently Green (1979) has criticized the Moeser and Bregman studies by showing that a complex artificial language can be learned without semantic referents as long as there are markers to show how the syntax is structured. According to Green, the subjects in the Moeser and Bregman studies failed to learn the semantically empty language because they were given no cues to show how the words of the language were to be grouped into constituent structures. Green also criticized the experimental procedure used by Moeser and Bregman. First, he argued that the CVC trigrams that were used were not easily discriminable in phonetic terms. The words in an artificial language, Green suggested, should be highly discriminable and easily pronounced so as to make them more like a natural language situation. Second, Green argued that the method of presentation used in the Moeser and Bregman studies was a pure reception regime and that this method is less efficient for learning than a selection regime.

In Green's (1979) study, subjects learned various artificial languages by interacting with a computer that supplied example sentences, parsed the sentences that subjects typed, and provided feedback regarding the acceptability of these sentences. Green compared six dialects of an artificial language and found that those dialects with more complex marker systems were learned better than those with less complex marker systems. Thus he argued that a complex syntactic structure can be learned, even if meaningless, as long as there are markers to define its structure. Taking both the Moeser and Bregman results and his own into account, Green concluded that effective language learning requires either a well-organized semantic system or a well-organized syntax marker system.

As the goal of the Green study was to provide evidence for the effectiveness of syntax markers, he did not continue in his research to compare the effectiveness of an organized marker system with that of an organized semantic system. In an attempt to compare these two systems, a pilot study was carried out by the first author of the present paper, comparing the acquisition of an artificial language with an organized semantic system to the acquisition of one with an organized marker system. In this pilot study, both languages used a set of phrase structure rules that was similar, although not identical, to the phrase structure rules used in the studies carried out by Moeser and Bregman (1972, 1973), Morgan and Newport (1981), and Mori (1980, 1981). The semantic system used in this pilot study was based on Moeser and Bregman's (1972) syntax correlation condition. Moeser and Bregman had found that subjects could easily learn the rule system in the syntax

correlation condition but that they were unable to learn these rules when the language was presented without a semantic reference system. However, in the pilot study, the artificial language with the organized marker system (and no semantic reference system) was actually learned faster than the artificial language with the organized semantic system (but no marker system).

The fact that the artificial language with the organized marker system was learned more easily than the artificial language with the organized semantic system left several unanswered questions. First, it might be that an organized marker system is easier to learn than an organized semantic system. However, the amount of information that had to be learned in these two conditions was not identical. Those subjects who learned the language with an organized semantic system had to acquire not only the syntax of the language but also the correlation between the words and their referents; those subjects who learned the language with an organized marker system had to acquire only the language syntax. Therefore the two conditions were not truly comparable. Second, the language with an organized marker system had no semantic system whereas all natural languages contain not only a syntax but also a semantic system. Therefore the condition with the organized marker system was not as similar to the natural language learning situation as was the condition with the organized reference system. Consequently the pilot study did not realistically assess the effectiveness of an organized marker system versus that of an organized semantic system.

Experiment 1

The present study was designed to assess the importance of a marker system in a language containing a semantic system. In the first experiment four language conditions were compared. The first contained a well-organized semantic system and a well-organized marker system, the second a well-organized semantic system and an arbitrary marker system, the third a well-organized marker system and an arbitrary semantic system, and the fourth neither a well-organized semantic system nor a well-organized marker system. By comparing the learning levels in these four systems, we can assess the relative importance of an organized marker system versus an organized semantic system. If the two are equally effective, performance in the organized marker system should equal performance in the organized semantic system. If the two are additive, performance in the semantic plus marker system should be better than performance in the other conditions. The fourth system, which contains neither an organized semantic system nor an organized marker system, serves as a base control. This system is equivalent to the arbitrary figures condition in the Moeser and Bregman (1972) study wherein little learning of the language syntax was observed.

In designing the experiment, Green's criticisms of the earlier experimental procedures were also kept in mind. The words used in the study were highly discriminable and easily pronounced by English-speaking subjects. Also, rather than using a pure reception regime, the subjects learned the language through an interactive training process.

Method

Description of the artificial language system. There were four language systems used in this experiment. All four contained a syntax that could be generated by the following phrase structure rules:

$$S \rightarrow AP + BP + (CP)$$
$$AP \rightarrow A + (D)$$
$$BP \rightarrow \begin{Bmatrix} B_1 \\ B_2 + CP \end{Bmatrix}$$
$$CP \rightarrow C$$

Sentences generated by these rules have the following characteristics: Each sen-

tence must begin with one A word and must include either one B_1 word or one B_2 word. If a B_1 word is used, it can be the last word in the sentence or it can be followed by one C word. If a B_2 word is used, it must be followed by one C word and can be followed by two C words. The D word is optional; if used, it must follow the A word. Thus there are eight possible sentence types that can be generated from these phrase structure rules, ranging in length from two to five words. All eight possible sentence types were used in the experiment.

The vocabulary used in this experiment consisted of 16 CVC trigrams to which were attached one of five suffixes: -A, -IE, -I, -O, or -U. In two of the language systems, organized marker and organized reference/marker, the suffixes were affixed according to the word classes. For these systems, all A words ended in -A, all B_1 words ended in -IE, all B_2 words ended in -I, all C words ended in -O and all D words ended in -U. In the other two language systems, organized reference and arbitrary correspondence, the suffixes were affixed irrelevant to the word classes, as shown in Table 1.

Each of the language systems was presented in correspondence with a reference field consisting of four colored rectangles and four geometric figures. The rectangles changed their border lines and orientations and the geometric figures changed their positions in relation to the rectangles. This reference field was similar to the one used by Moeser and Bregman (1972) in the syntax correlation condition. However, in the Moeser and Bregman study the optional geometric figure was always placed to the right of the colored rectangle. This consistent placement could possibly have been more advantageous to subjects in the organized reference and organized reference/marker conditions than to subjects in the other conditions since Moeser (1975) has shown that the position of the referents has an effect on learning the order of the words. Thus, in the present experiment, half of the small optional geometric figures were placed to the right and the other half were placed to the left of the rectangle so that any position factors would not affect the language learning process.

TABLE 1
VOCABULARY USED IN THE FOUR LANGUAGE SYSTEMS

Systematic marker systems
A-class words: GAVA, DEPA, FETA, and KUSA
B_1-class words: BIFIE and ZORIE
B_2-class words: PAXI and MULI
C-class words: LIMO, NAKO, COZO, and RUDO
D-class words: SIVU, YOWU, NESU, and FALU
Arbitrary marker systems
A-class words: GAVA, DEPI, FETO, and KUSU
B_1-class words: BIFU and ZORIE
B_2-class words: PAXA and MULO
C-class words: LIMA, NAKI, COZO, and RUDU
D-class words: SIVA, YOWIE, NESO, and FALU

Two of the language systems, organized reference and organized reference/marker, contained systematic relations between the syntactic and semantic structures. All A words referred to changes in the colors of the rectangles, all B_1 words referred to changes in the orientation of the rectangles, all B_2 words to vertical relations between the rectangles and geometric figures, all C words to the type of geometric figure, and all D words to border variations of the rectangles. This systematic reference system is illustrated in Figure 1. The other two language systems, organized marker and arbitrary correspondence, contained identical referents, but the word classes did not correspond to the reference classes. This arbitrary reference system is also illustrated in Figure 1.

To summarize, there were four language system conditions in this experiment: (1) the *organized reference/marker* condition in which both the word order and the suffix markers described the reference field in a systematic fashion, and the suffix markers systematically corresponded to the syntax rules; (2) the *organized reference* condition in which the word order described the reference field in a systematic fashion but the

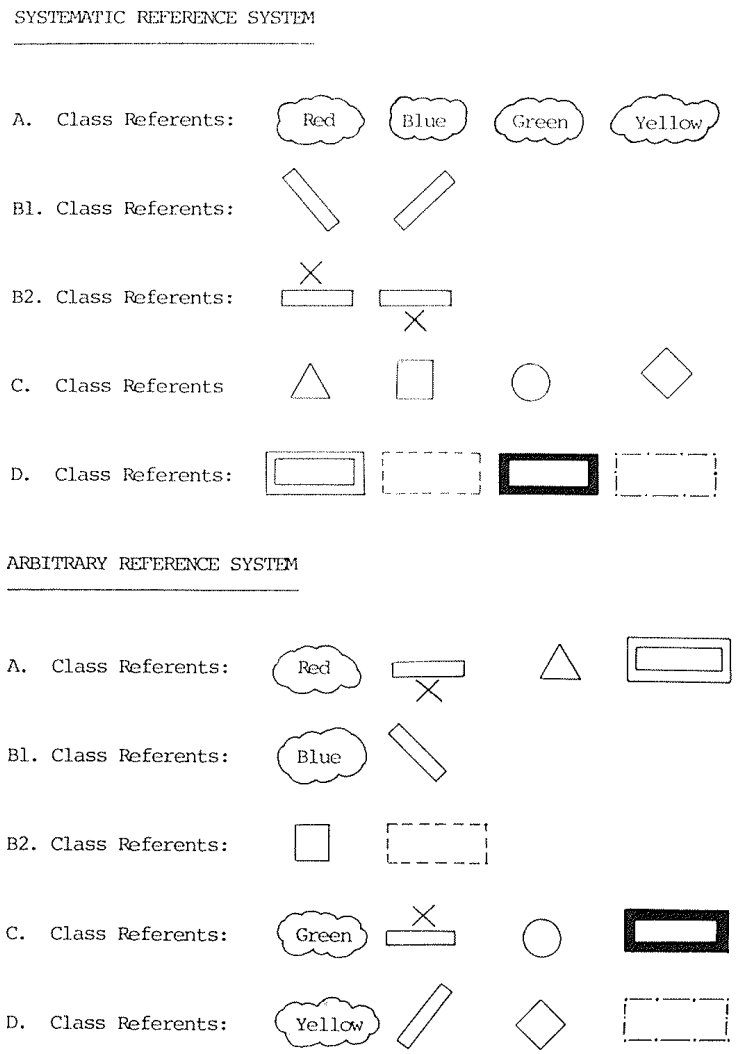

FIG. 1. The referents used in the four language systems in Experiment 1.

suffix markers were not coordinated with either the reference field or the syntax rules; (3) the *organized marker* condition in which neither the word order nor the suffix markers described the reference field in a systematic fashion but the suffix markers were systematically correlated to the syntax rule; and (4) the *arbitrary correspondence* condition in which neither the word order nor the suffix markers described the reference field in a systematic fashion, nor did the suffix markers correspond to the syntax rules in any systematic way.

Some examples of how sentences would be represented in each of these conditions are shown in Figure 2. In all four systems the words in the language corresponded to a particular aspect of the reference system. Thus in all four conditions the subjects could learn the language vocabulary (i.e., what word described what referent). In the organized reference/marker system the subjects could learn the phrase structure rules either by learning the reference field rules and mapping the words onto these reference rules or by learning the marker system rules. In the organized reference system the subjects could learn the phrase structure rules only by learning the reference field rules and mapping the words onto these reference rules. In the organized

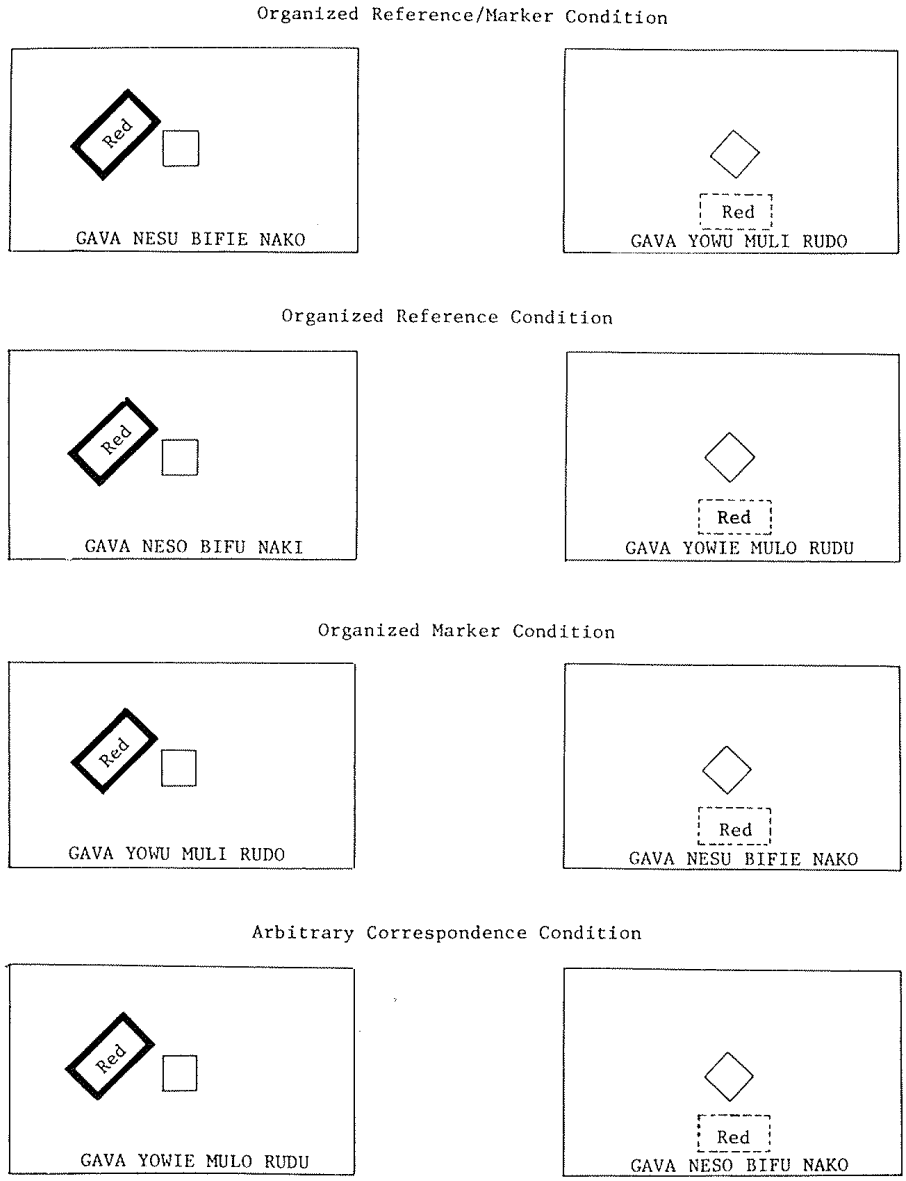

FIG. 2. Some examples of how sentences would be represented in each of the four language systems used in Experiment 1.

marker system the subjects could learn the phrase structure rules only by learning the syntax marker rules. In the arbitrary correspondence condition the subjects could learn the phrase structure rules only by learning the arbitrary correspondence that existed between the words and the word classes, or between the referents and the word classes.

Materials. The acquisition materials consisted of 60 colored slides in each encoding condition. These 60 slides contained 30 different reference field arrangements. Thirty of the slides showed only a reference field and 30 showed the reference field with the corresponding sentence printed beneath it. The same 30 sentences were used in all four language conditions and they were presented in the same order in all four conditions.

In the organized reference/marker and organized reference conditions, all sentences consistent with the phrase structure rules also would reflect a systematic set of

semantic rules (i.e., there can only be one colored rectangle in any picture and this rectangle can only have one type of border; if the rectangle is in a diagonal position there can be only one geometric figure; if the rectangle is in a horizontal position there must be one geometric figure and there can be two). In the organized marker and arbitrary correspondence conditions, sentences consistent with the phrase structure rules would not reflect any systematic semantic rules. However, there was a subset of sentences in these latter two conditions that would be consistent with the semantic rules as well as the phrase structure rules. This subset was used during the acquisition phase of the experiment so that subjects in all four conditions would see the same reference field arrangements. Naturally the sentences corresponding to the reference fields were different in each condition.

Similarly, in the organized reference/marker and organized marker conditions, all sentences consistent with the phrase structure rules would reflect a systematic set of marker rules (i.e., each sentence would contain one -A suffix; one -IE or -I suffix; zero, one, or two -O suffixes; and zero or one -U suffix). In the organized reference and arbitrary correspondence conditions, sentences consistent with the phrase structure rules would not reflect any systematic marker system. However, again there was a subset of sentences in these latter two conditions that would be consistent with the marker rules as well as the phrase structure rules. This subset was also used during the acquisition phase of the experiment. Thus, during the acquisition phase, subjects in all four conditions learned a set of sentences that had both a systematic reference field and a systematic marker arrangement.

The following four tests were given after the acquisition phase of the experiment:

(1) *Transfer test:* Ten slides containing new pictures were presented to test whether the subjects could correctly use the artificial language in a novel situation. Each of the ten slides was shown for 15 seconds while the subjects provided the sentence that described the picture. The same ten slides were presented in the same order to all subjects. This test also used the subset of sentences that reflected systematic semantic rules in all conditions.

(2) *Vocabulary test:* This test was designed to see how well the subjects had learned to associate each word with its referent. The subjects were shown pictures of the 16 individual referents as illustrated in Figure 1 and asked to provide the most suitable word to describe each picture. They were given 3 minutes to complete this test.

(3) *Rule test:* Rule tests were given to measure how well the subjects had acquired the syntactic rules of the artificial language. The tests were presented on paper and no pictures were shown, only sentences. Two versions of this test were used, one for the organized reference/marker and organized marker conditions, and one for the organized reference and arbitrary correspondence conditions. These tests were identical in terms of the sentences presented except that the suffixes attached to the words were correct for the particular condition being tested. The rule test consisted of 14 pairs of multiple-choice questions from which the subjects were required to choose the correct sentence in each pair. No sentence used in this test had previously been seen by the subjects. There was only one syntax error in each incorrect sentence. Not all of the correct sentences were part of the subset of sentences reflecting the systematic semantic rules in the organized marker and arbitrary correspondence conditions or the systematic marker rules in the organized reference and arbitrary correspondence conditions. The subjects were given 5 minutes to complete this test.

(4) *Acceptability judgment test:* In the organized marker and arbitrary correspondence conditions, all sentences in the acquisition phase were consistent with a set

of systematic semantic rules. Likewise, in the organized reference and arbitrary correspondence conditions, all sentences in the acquisition phase were consistent with a set of systematic marker rules. The acceptability judgment test was designed to see whether subjects in these groups could recognize syntactically correct sentences that were inconsistent with these systematic rules. The subjects were shown ten sentences, three of which reflected the systematic rules presented during the acquisition phase, four of which were correct in syntax but did not reflect these systematic rules, and three of which contained syntax errors. (For subjects in the organized reference/marker condition, all seven syntactically correct sentences also reflected systematic reference and marker rules.) The ten sentences were randomly ordered and typed on a test paper. Subjects were asked to judge whether or not each of these sentences was correct. They were given 5 minutes to complete this test.

Procedure. At the beginning of the experiment, the subjects were told that they were to take part in a language learning experiment and that they would see two types of slides, slides containing only a picture and slides containing a picture with a sentence that described that picture. They were told that their task was to learn what each word in the sentence referred to and that they should attempt to provide the sentence that went with a picture-only slide whenever they could.

After this introduction, the subjects were shown an example of a picture-only slide and a picture-and-sentence slide. Then they were shown a list of the 16 words in alphabetical order and learned how to pronounce these words. The words were pronounced by the experimenter in accordance with English phonological conventions. After these instructions, the subjects were shown a set of 60 slides. These slides were projected on a screen by a Kodak slide projector that automatically changed the slides every 15 seconds. They were arranged so that each picture-only slide was followed by its corresponding picture-and-sentence slide. When a picture-only slide appeared, the subjects were encouraged to provide the verbal description of this picture and their oral responses were recorded by the experimenter. The same set of 60 slides was presented repeatedly six times or until the subjects provided the correct sentence for 27 out of 30 consecutive pictures. Then the four tests were given to measure what the subjects had learned. For the transfer test the oral responses provided by the subjects were recorded by the experimenter; for the other three tests the subjects made written responses on the test papers.

Subjects. Thirty-two subjects took part in this experiment. All were students at Memorial University of Newfoundland and all were native speakers of English. They were assigned at random to one of the four language conditions, with eight being assigned to each condition. Each subject was tested individually during a 2-hour period and was paid $6 for participating in the experiment.

Results

There were five performance measures that could be used in comparing how well the subjects learned the four types of language system. The first of these was the number of trials a subject took before reaching the acquisition criterion of 27 correct sentences in a series of 30 consecutive trials. This number was converted into a reciprocal number which in turn was multiplied by 10^3 to produce an integral number. This could be called the acquisition speed score. For those subjects who failed to reach the learning criterion after seeing the set of slides six times, the number of trials needed to reach the criterion could be from 210 to infinite, which would be converted into 5 to 0, respectively. In the analyses the larger figure was used to provide a conservative estimate of the acquisition speed score for subjects who failed to reach the criterion. The other

four performance measures used in the analyses were the number of correct answers on each of the four tests. The mean scores for all five performance measures are shown in Table 2.

A two-factor multivariate analysis of variance was performed on the five measures obtained from each of the subjects. This analysis indicated that only the main effect of the organized reference system was significant, $F(5,24) = 19.66$. Neither the main effect of the organized marker system nor the interaction between these two main effects was significant. (In all statistical tests, $p < .05$ was the accepted level of significance.) Univariate F tests on each of the performance measures showed the same results. Only the effect of the organized reference system was significant: For the acquisition speed score, $F(1,28) = 23.33$, $MS_e = 3.76$; for the transfer test, $F(1,28) = 47.68$, $MS_e = 7.50$; for the vocabulary test, $F(1,28) = 12.01$, $MS_e = 15.42$; for the rule test, $F(1,28) = 38.18$, $MS_e = 2.30$; and for the acceptability test, $F(1,28) = 53.10$, $MS_e = 2.88$. In none of the univariate F tests were there significant results due to the effect of the organized marker system or to the interaction among main effects.

We can also take a more detailed look at how the individual subjects performed of these tests. Sixteen subjects reached the learning criterion, seven from the organized reference/marker condition, six from the organized reference condition, two from the organized marker condition, and one from the arbitrary correspondence condition. The 13 subjects in the conditions with an organized reference system who reached the learning criterion also performed very well on the four other measures as illustrated in Table 3. The three subjects in the conditions without an organized reference system who reached the learning criterion performed well on the vocabulary test, reasonably well on the transfer and rules tests, and below chance level on the acceptability test. The three subjects in the conditions with an organized reference system who failed to reach the learning criterion performed reasonably well on all four tests. The 13 subjects in the conditions without an organized reference system who failed to reach the learning criterion performed poorly on all four performance measures. These results are also illustrated in Table 3.

These results showed that a well-organized reference system was necessary for learning the rules of the language syntax. Most of the subjects in the organized reference/marker and organized reference conditions performed well on all of the five measures of learning. In contrast, most of the subjects in the organized marker condition performed poorly on these five measures. In fact there was no overall difference between those subjects in the organized marker condition and those subjects in the arbitrary correspondence condition,

TABLE 2
MEANS AND STANDARD DEVIATIONS FOR THE FIVE PERFORMANCE MEASURES OBTAINED IN EXPERIMENT 1

	Language system condition							
	Organized reference/marker		Organized reference		Organized marker		Arbitrary correspondence	
Performance measure	*M*	SD	*M*	SD	*M*	SD	*M*	SD
Acquisition speed	9.88	3.31	7.25	1.83	5.25	0.46	5.25	0.71
Transfer test	8.88	3.18	9.75	0.71	3.13	3.76	2.13	2.30
Vocabulary test	15.25	2.12	15.50	0.93	10.25	5.55	10.88	5.06
Rule test	13.50	1.07	12.88	0.99	9.75	2.12	10.00	1.60
Acceptability test	9.63	0.52	8.63	1.51	5.25	1.83	4.25	2.38

TABLE 3
PROPORTION OF CORRECT RESPONSES MADE BY SUBJECTS IN VARIOUS CATEGORIES IN EXPERIMENT 1

Subject breakdown	Test performance measure			
	Vocabulary	Transfer	Rule	Acceptability
Subjects reaching criterion with organized reference	0.99	1.00	0.97	0.95
Subjects reaching criterion without organized reference	1.00	0.83	0.81	0.40
Subjects not reaching criterion with organized reference	0.83	0.63	0.86	0.73
Subjects not reaching criterion without organized reference	0.58	0.13	0.68	0.48

even though the latter had no organized system for acquiring the language syntax.

Two of the subjects in the organized marker condition and one subject in the arbitrary correspondence condition reached the acquisition criterion and consequently performed reasonably well on the vocabulary, transfer, and rule tests. They performed poorly, however, on the acceptability judgment test which was designed to measure their knowledge of the syntactical rules independently of their knowledge of semantic rules. It appeared that these three subjects acquired some knowledge of the artificial language by using the same learning strategy as those subjects in the organized reference conditions. That is, they learned to associate each word with its referent and they learned how the reference field was structured. They then used this reference information to map the words onto their sentence positions. This strategy helped their performance on the vocabulary, transfer, and rule tests. Unfortunately it was of no value in the acceptability judgment test, wherein most of the correct choices consisted of sentences that did not describe the structured reference field presented during the acquisition phase of the experiment. It might be noted in comparison that the subjects in the organized reference condition had also seen only sentences containing a structured marker system in the acquisition phase of the experiment. Yet these subjects performed well on the acceptability judgment test even though most of the correct choices in this test violated the structured marker rules. These subjects were easily able to ignore any marker regularities that they may have learned and make their choices in terms of the reference field regularities. The two subjects in the organized marker system who reached the learning criterion either were unable to ignore reference field regularities in favor of marker regularities, or more likely, never learned the marker regularities in the first place.

EXPERIMENT 2

During the acquisition phase of Experiment 1, the experimenter recorded the verbal responses made by subjects to the picture-only slides. There were two types of possible learning strategies that could have been observed at this time, a reference strategy and a word order strategy. If the subjects used the reference strategy, they would first attempt to learn the word–referent correspondences, then try to arrange the words into a grammatically correct sentence. This was the type of learning strategy observed by Moeser and Bregman (1972, 1973) in their reference conditions. If the subjects used the word order strategy, they would first attempt to learn the word order rule, then try to learn the referents associated with each word. In this case, there would have been a stage where only the rules were acquired. In that stage, a

subject might say "mmmA mmmU mmmI mmmO" which was correct in terms of the word order but not in terms of the words. There were no such responses. On the other hand, subjects in all four language conditions produced a lot of responses in which the correct words were used but these words were ordered incorrectly. Therefore the acquisition records show that subjects in all four language conditions used the reference learning strategy. This conclusion is further supported by the test results. Since they learned the vocabulary first, there were some subjects who got full marks on the vocabulary test but not on the other tests. There was not a single subject who got full marks on the rules test but not on the vocabulary test.

One factor that could have affected the results of Experiment 1 was the fact that the word–referent associations were easier to learn in the organized reference/marker and organized reference conditions because the order of words in a sentence corresponded to a particular order of elements in the reference field. For instance, in these organized reference conditions, the first words in the sentence referred to the color of the rectangle, the second word to a border variation of this rectangle, if such occurred, the third word to the orientation of the rectangle, and so on. In the organized marker and arbitrary correspondence conditions, the word order did not correspond to a particular order of elements in the reference field. The word describing the color of the rectangle, for example, could occur in any position in the sentence. This would make the task of acquiring word–referent associations more difficult for subjects in the organized marker and arbitrary correspondence conditions than in the two organized reference conditions.

The subjects in the organized marker condition did not need to learn the word–referent associations to acquire the phrase structure rules of the language. They only needed to pay attention to the marker regularities. However, because vocabulary learning is so basic in any language containing a semantic component, these subjects may have devoted all their attention to learning the word–referent associations and consequently ignored other types of relevant linguistic information.

Experiment 2 was designed to see whether the subjects in the organized marker condition would discover the marker regularities once they had acquired the language vocabulary. This experiment used three language conditions—an organized reference condition, an organized marker condition, and an arbitrary correspondence condition. Subjects were shown the same set of acquisition slides used in Experiment 1. However, before the slides were presented, the subjects were taught to associate each word with its individual referent. If the problem facing the subjects in the organized marker condition was mainly caused by the difficulty in learning the vocabulary, their performance on the test measures should be better than that of subjects in the arbitrary correspondence condition. If an organized marker system is as effective for learning syntactical rules as an organized reference system, the subjects in these two conditions should perform equally well on the performance measures.

Method

Materials. The three artificial language systems used in this experiment were identical to the organized reference, organized marker, and arbitrary correspondence conditions used in Experiment 1. The acquisition materials, the transfer test, the rule test, and the acceptability judgment test were also identical to those materials used in Experiment 1.

Procedure. The procedure was the same as that used in Experiment 1 except that subjects were given a vocabulary training session prior to the presentation of the slides. This session consisted of providing the subjects with sixteen 3 by 5-in. index cards, each containing one of the 16 words and its referent. The subjects were allowed

to examine these index cards for 10 minutes, then were shown cards containing only pictures of the referents. As each picture was shown, the subject was required to state the word describing it. If an error was made, the experimenter corrected the subject. The 16 pictures were shown repeatedly until the subject provided the correct word for each of the pictures on two consecutive trials. No subject failed to learn the vocabulary. It took about 15 minutes to complete this training session.

Once the vocabulary training session was completed, the subjects were told that their task was to provide the sentences that described the picture-only slides. The rest of the procedure was identical to that used in Experiment 1.

Subjects. The subjects were 24 students attending Memorial University of Newfoundland and all were native speakers of English. Eight subjects were assigned randomly to each language condition. Each subject was tested individually during a 2-hour period and was paid $6 for participating in the experiment.

Results

There were four performance measures in this experiment, the acquisition speed score, the transfer test, the rule test, and the acceptability judgment test. These four measures were scored in the same way as they were scored in Experiment 1. The mean scores for each language condition are shown in Table 4.

We can compare the results shown in Table 4 with those shown in Table 2 for Experiment 1. In all three conditions, the acquisition speed score was higher in Experiment 2 than in Experiment 1, as might be expected given that the subjects in Experiment 2 did not have to induce the word–referent associations during the acquisition phase of the experiment. In the organized marker and arbitrary correspondence conditions, however, scores on the rules test and on the acceptability test were no higher in Experiment 2 than they were in Experiment 1. Univariate F tests were used to compare the three encoding conditions on each of the four performance measures: For the acquisition speed score, $F(2,21) = 44.93$, $MS_e = 17.54$; for the transfer test, $F(2,21) = 8.56$, $MS_e = 8.55$; for the rule rest, $F(2,21) = 13.38$, $MS_e = 2.56$; and for the acceptability test, $F(2,21) = 42.58$, $MS_e = 1.74$. Scheffe's post hoc method was used to compare the three encoding conditions on each univariate analysis. These post hoc comparisons showed that the subjects in the organized reference condition were significantly better than subjects in the other two conditions on all four performance measures, and that there were no significant differences between the organized marker and arbitary correspondence conditions on any of the four performance measures.

Thus even when the subjects in the organized marker condition no longer had to devote their attention to learning the word–referent associations, they did not discover the marker regularities. They persisted in

TABLE 4
MEANS AND STANDARD DEVIATIONS FOR THE FOUR PERFORMANCE MEASURES OBTAINED IN EXPERIMENT 2

	Language system condition					
	Organized reference		Organized marker		Arbitrary correspondence	
Performance measure	*M*	SD	*M*	SD	*M*	SD
	M	SD	*M*	SD	*M*	SD
Acquisition speed	24.38	7.21	7.13	0.35	7.25	0.71
Transfer test	10.00	0.00	5.50	3.82	4.25	3.33
Rule test	13.38	0.74	9.63	1.92	10.00	1.85
Acceptability test	9.75	0.46	4.75	1.98	4.25	1.04

attempting to process the language by using a semantic mediation strategy (i.e., by mapping the syntactic structure onto the reference field). Because they used this strategy, they were no better on the four performance measures than subjects in the arbitrary correspondence condition.

EXPERIMENT 3

The results of Experiments 1 and 2 appear to contradict the findings of Green (1979). Green reported that his subjects were easily able to learn a meaningless artificial language provided it contained a well-organized marker system. The subjects in the previous experiments did not learn the language containing a well-organized marker system even when they were first taught the word–referent associations. There were, of course, differences between the two marker systems used in these two experiments. Green used marker words instead of marker suffixes, and in Dialect I (the best learned dialect system) he used phrase markers, items which were absent from the marker system used in Experiments 1 and 2. However, Dialect II, which had no phrase markers, was also acquired quite easily by Green's subjects. Furthermore, the pilot study mentioned in the introduction to this paper used a marker system identical to that used in Experiments 1 and 2, and in the pilot study the subjects easily learned the organized marker system.

In Experiments 1 and 2, it was the presence of a semantic field in the organized marker condition that provided the major difference between this system and the meaningless marker systems used in the other experiments. It is possible that the subjects in the organized marker condition failed to learn this marker system because it was presented in conjunction with a reference system that did not reflect the marker rules. It may be that a marker system is only effective when it does not contradict the language reference system.

Experiment 3 was designed to test whether the organized marker system used in Experiments 1 and 2 could be learned when it was presented without a reference system. It compared the acquisition of two artificial languages. The first of these was identical to the organized marker system used in Experiments 1 and 2 except that the reference system was eliminated. The second was identical to the arbitrary correspondence system, again with the reference system eliminated. When these two language conditions were presented with reference systems there were no significant differences between them on any of the performance measures. This may have occurred because the presence of a reference system interfered with learning in the organized marker condition. If so, subjects learning an organized marker system should perform better than subjects learning an unorganized system when reference systems are not shown.

Method

Description of the artificial language systems. There were two artificial languages in Experiment 3, the marker/words only condition and the arbitrary/words only condition. The first of these was identical to the organized marker condition used in Experiment 1 except that it lacked a reference field. The second language was identical to the arbitrary correspondence condition used in Experiment 1 except that it also lacked a reference field.

Materials. The acquisition materials consisted of 60 slides in each encoding condition, 30 of which contained a set of words arranged into a sentence generated by the phrase structure rules and 30 which contained these same words in a random order. These 30 sentences were the same as those used in the acquisition phase of Experiment 1. The 60 slides were identical in both conditions except for the differences in suffix markers. As per the acquisition sentences used in Experiments 1 and 2, the 30 sentences were drawn from a subset that reflected systematic marker rules in the ar-

bitrary/words only condition. Thus in both conditions the subjects saw a set of slides containing a systematic marker rule. The only difference was that in the marker/words only condition, the marker rule occurred in conjunction with an order rule whereas in the arbitrary/words only condition, the marker rules did not occur in conjunction with an order rule.

Three tests were given after the acquisition phase of the experiment. The transfer test consisted of 10 slides containing word groupings that had not appeared in the acquisition phase. The word groupings were presented in random order and the subjects were asked to state the correct arrangement of these words. Each of the slides was shown for 15 seconds while the subject stated the correct sentence. As per the earlier experiments, sentences used in the transfer test were drawn from the subset of sentences that reflected the systematic marker rule in the arbitrary/words only condition. The rule test and the acceptability judgment test were identical to those used in Experiments 1 and 2. In these tests, the correct choice did not always reflect the systematic marker rule in the arbitrary/words only condition.

Procedure. The basic procedure was the same as that used in Experiment 1 except that the subjects were told that they would see two types of slides, one containing a list of words ordered at random, and one containing these same words correctly ordered. They were told that their task was to learn how to arrange the words into a correct sentence, and that they should provide the correct order of a randomly ordered list of words whenever they could.

After this introduction, the subjects were shown an example of the two types of slides. Then they were shown a list of the 16 words in alphabetical order and learned how to pronounce them. The presentation set of 60 slides was arranged in the same order as those in Experiment 1, except that the randomly ordered slides were shown in place of the picture-only slides.

The set of 60 slides was presented repeatedly four times or until the subject provided the correct sentence for 27 out of 30 consecutive randomly ordered slides. Then the three tests were administered. For the transfer test, the oral responses were transcribed by the experimenter. The rule and acceptability judgment tests were presented in written form and subjects marked their answers on the test paper.

Subjects. Sixteen subjects took part in the experiment. All were students at Memorial University of Newfoundland and all were native speakers of English. Eight subjects were assigned randomly to each condition. Each subject was tested individually for about a 1-hour period and was paid $3 for participating in the experiment.

Results

There were four performance measures in this experiment, the acquisition speed score, the transfer test, the rule test, and the acceptability judgment test. These four measures were scored in the same way as they were scored in Experiment 1. Their mean scores are shown in Table 5.

We can compare the results shown in Table 5 with those shown in Table 4 for Experiment 2. Subjects in the marker/words only condition in Experiment 3 had much higher scores on all four performance measures than subjects in the organized marker condition in Experiment 2. On the other hand, subjects in the arbitrary/words only condition in Experiment 3 performed only

TABLE 5
MEANS AND STANDARD DEVIATIONS FOR THE FOUR PERFORMANCE MEASURES OBTAINED IN EXPERIMENT 3

Performance measure	Language system condition			
	Marker/words only		Arbitrary/words only	
	M	SD	*M*	SD
Acquisition speed	19.50	7.76	10.38	4.78
Transfer test	9.75	0.71	6.38	2.93
Rule test	12.00	1.85	9.38	2.50
Acceptability test	7.63	1.69	5.50	1.60

slightly better than subjects in the arbitrary correspondence condition in Experiment 2. It might be noted that three of the eight subjects in the arbitrary/words only condition had a fairly high acquisition speed score, and that these three subjects also did quite well on the transfer test. It appeared that these three subjects might have learned the marker rule that was present in the subset of sentences they saw during the acquisition phase of the experiment and learned to apply it to the transfer test. These subjects did no better on the rule or acceptability tests, however, than the five subjects who had much lower acquisition speed scores.

Univariate F tests were used to compare the two encoding conditions on each of the four performance measures. These tests showed a significant difference between the two conditions on all four measures: For the acquisition speed score, $F(1,14) = 8.01$, $MS_e = 41.56$; for the transfer test, $F(1,14) = 10.07$, $MS_e = 4.53$; for the rule test, $F(1,14) = 5.69$, $MS_e = 4.85$; and for the acceptability test, $F(1,14) = 6.68$, $MS_e = 2.71$. Thus on all four performance measures, the subjects in the marker/words only condition were significantly better than subjects in the arbitrary/words only condition.

These results replicate the findings reported by Green (1979). The subjects were able to learn a complex syntax when the artificial language contained a well-organized marker system. However, the results of Experiment 3 in conjunction with those of Experiments 1 and 2 suggest that subjects in an artificial language situation will not pay attention to a systematic marker system unless this is the only type of information they have about the language. When they are required to learn a language with a semantic system, as occurs in any natural language learning situation, they adopt a learning strategy that is consistent with this semantic system rather than one that is consistent with the marker system.

Discussion

Based on results obtained from artificial language experiments, Green (1979) concluded that effective language learning requires either a well-organized semantic system or a well-organized marker system. He used two experimental findings to support this conclusion. The first finding, reported by Moeser and Bregman (1972, 1973), was that subjects needed a well-organized semantic system to learn the syntax rules of a language without a marker system. The second finding, obtained by Green, was that subjects could learn the syntax rules of a semantically empty language as long as this language contained a well-organized marker system.

In Experiment 3 of the present paper Green's findings were replicated. Subjects were easily able to learn the phrase structure rules of a semantically empty artificial language that contained an organized marker system. However, when a semantic structure was incorporated into this language, the subjects did not make use of the constituent information contained in the marker system.

The records taken from subjects in the organized marker condition during the acquisition phase of Experiment 1 showed that they faced two problems. First, they found it difficult to learn the correspondence between the words and their referents. Second, they did not notice the relevance of the suffix markers, and instead tried to remember the positions of words by rote. In Experiment 2, we attempted to eliminate the first problem by teaching these subjects the vocabulary before they were exposed to any well-formed sentences. Now at this stage they only had to learn how the word classes were grouped. Yet these subjects still did not notice the relevance of the suffix markers; they continued to seek grouping cues from information in the reference field. And when the reference field did not provide them with systematic

grouping information they resorted to learning the position of words by rote.

These results suggest that the organized marker system loses its effectiveness when it is inconsistent with the organization of the reference system. It appears that when presented with an artificial language containing a semantic system, subjects concentrate on learning how to map the words onto the structure of the reference field; they do not pay attention to how the words of the language are grouped into constituent structures. Thus on the basis of these findings we must conclude that effective language learning requires more than a well-organized marker system. It requires a semantic system that is somehow consistent with the syntactic constraints of the language.

The findings reported in the present paper serve to reinforce the position taken by Moeser and Bregman (1972, 1973). Moeser and Bregman compared the learning of an artificial language containing a semantic structure with one that did not contain a semantic structure. They argued that the two types of languages were learned in different ways: When a semantic structure was present, the language learner concentrated on learning the structure of the reference field and on learning to associate the words of the language to the things these words described in the reference field. When a semantic structure was not present, the language learner concentrated on learning how the words of the language were grouped into ordered structures. Because of these differences in learning strategies, Moeser and Bregman suggested that all studies using artificial languages should contain a semantic structure, in order that they more closely correspond to the natural language learning situation.

The goal of artificial language investigations is to provide information that might help us to understand the natural language learning process. However, the validity of using this paradigm to investigate language learning has been questioned on two basic grounds. The first argument is that the adults used as subjects in these experiments possess a different set of language processing abilities than the children they are supposed to represent. The second argument is that the process of simplification that takes place in creating an artificial language alters the language learning process in such a way as to make the findings meaningless.

With regard to the first argument, early criticism focused on the possibility that children bring to the language learning process special linguistic skills which adults no longer possess (e.g., Bever et al., 1965). Little evidence has been found to support this claim (e.g., Moeser, 1977; Smith & Braine, Note 1). A more relevant criticism, however, is the fact that the adults used in these studies will have at their disposal a set of special strategies that they will have acquired through their experience as a language user. The fact that subjects in these experiments ignored the marker information when it was presented in conjunction with a reference field might possibly have been due to the fact that these subjects were all native speakers of English and therefore adopted a strategy of attending to reference and word order variables rather than to marker classes. The counterargument to this proposal is that subjects easily picked up the marker regularities when no reference system was present. Given that the marker strategy was readily accessible, there is no reason why it should continue to be ignored when the other sources of information were inconsistent. Furthermore, there is no evidence to suggest that adult subjects in artificial language experiments adopt learning strategies that are unique to the linguistic conventions of their native language. Mori (1980, 1981) has found that native speakers of Japanese use the same learning strategies as native speakers of English.

A natural language learning situation provides additional evidence to support the argument that adults in these experiments did not adopt an unusual strategy in their attempts to learn the artificial languages. Slobin (1966) reports that children learning Russian—a marker system—as their native language are slowest at acquiring those markers that arbitrarily correspond to semantic referents. Although the children quickly learn the markers that describe easily identified semantic classes, it takes them several years to learn the markers that do not correspond to easily identified semantic classes. Like the Russian children, the adult subjects in the present experiments adopted a semantic processing strategy rather than a marker processing strategy. Because the markers in the organized marker condition were uncorrelated to the classes of reference objects, these subjects could not have acquired the marker rules through use of this semantic processing strategy.

The second major criticism of artificial language studies concerns the difficulty of generalizing results obtained from a restricted rule-governed system to a rule system as complex as a natural language. For example, only one type of syntactic marker system was used in these experiments. Other types of marker systems might conceivably be acquired more easily in conjunction with this particular type of reference system. Furthermore, in natural languages there are many exemplars in each word–class category. The restricted number of exemplars in the artificial language may have made the markers less salient than they would be in a larger category. The salience of the markers may also have been affected by the fact that each base word appeared with only one marker whereas in natural languages base words appear with several markers.

Such specific points as those raised above could be investigated in additional studies. The artificial language paradigm by necessity narrows our scope of investigation to allow for the independent manipulation of variables that in natural languages are not independent. Complexity is added to a system only if we can show that this complexity changes the way in which the language is processed. In the present experiments evidence was obtained to suggest that the addition of a semantic component to the artificial language system changes the learning strategies adopted by subjects. Thus we can argue that all artificial language studies should include at least one experiment to show that the addition of a semantic system does not alter the acquisition strategy. If it could be shown, for example, that increasing the class categories affected the learning strategy adopted by subjects, category size should also become a relevant factor in artificial language studies. At the present time, however, we have no evidence to suggest that subjects will adopt a marker strategy to learn a language system with a semantic component.

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