The effect of reference field organization on language processing

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Subjects were exposed to a miniature artificial language in which auditorily presented nonsense words were correlated to a visually presented reference field. Both the organization of the reference field and the order of words were manipulated to test whether subjects were encoding on the basis of an English-based semantic code or a code based on the nonverbal reference field. Results indicated that the code used was based on the organization of the nonverbal reference field.

In a number of recent studies, the author and her colleagues (Moeser, in press; Moeser & Bregman, 1972, 1973; Moeser & Olson, 1974) have found that the nonverbal objects and relations to which a language refers can affect how that language is acquired and processed. These studies have used a miniature artificial language containing both a set of nonsense words ordered to reflect a linguistic organization and a reference field of geometric designs employing a perceptual organization. Subjects were initially exposed to the words of the miniature language in conjunction with the reference field; later they were tested on their knowledge of the linguistic organization when the visual stimuli were not present. Results showed that the organization of the reference system influenced the learning and processing of the linguistic system.

In the most recent set of experiments, Moeser (in press) used a very simple language organization: Sixteen words were divided into four word classes, and a correct sentence in the language consisted of one word from each of the four word classes in a specific word class order. The reference system consisted of two two-dimensional objects, with each of the dimensions varying on four attributes (see Figure 1a for an example). Each word class in the language corresponded to one of the dimensions and each word referred to one dimension attribute.

Subjects were exposed to a language order in which either (1) words referring to both dimensions of an object occurred sequentially, or (2) sequential words referred to dimensions on different objects. In the first case, linguistic sequencing encouraged the encoding of both dimensions of an object at the same time (*objects code*); in the second case, linguistic sequencing encouraged the processing of the visual stimuli on a dimensional basis (*dimensions code*). Subjects exposed

to a language order in which the objects were encoded as holistic entities were significantly more accurate at judging correct and incorrect sequences than were subjects exposed to a language order in which the encoding was in the form of separate dimensions.

The design of this experiment was similar to experiments reported by Harris and Haber (1963) and Haber (1964) using natural language coding. In these experiments, it was also found that subjects required to encode the visual stimulus using an objects code made fewer encoding errors than subjects required to use a dimensions code. Haber (1966) explained these results in terms of a set effect which stemmed from the organization of the memory representation in terms of English word order habits. He suggested that the visual stimuli were remembered by being translated into verbal memory codes, and the encoding system which more nearly reflected verbal organization was more efficient.

Paivio (1971, pp. 129-132) has suggested an alternative explanation to the verbal encoding hypothesis offered by Haber (1966). Paivio proposed that coding stimuli as whole objects results in a more concrete imagery representation than coding them as dimensions. Thus, the objects code is more effective because it is associated with a more efficient arousal of the nonverbal memory representation system.

Similarly, Moeser and Bregman (1972, 1973) and Moeser (in press) have proposed that nonverbal memory representations were used by subjects to mediate their processing of the verbal sequences in the artificial language experiments. However, in a personal communication, Sam Glucksberg suggested that rather than using a nonverbal memory coding system, the subjects in these experiments were using the nonverbal stimuli to translate the nonsense words into their English equivalents, and then storing this information in terms of a verbal semantic coding system.

Thus two explanations have been offered regarding the processing of this type of task. One stresses the use of a verbally based code, the other of mediation through a nonverbal memory representation. The present

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Figure 1. An illustration of the two reference fields used in the experiment: (a) integrated reference field, (b) nonintegrated reference field.

experiment was designed to compare these two hypotheses by using reference fields which varied in perceptual organization while retaining identical English verbal descriptions.

These reference fields are illustrated in Figure 1. They resemble the two types of stimuli used by Asch and his colleagues (Asch, 1969; Asch, Ceraso & Heimer, 1960; Prentice & Asch, 1958), in their studies of associational learning. In the Asch studies, it was found that associative recall was significantly superior when attributes were presented in an integrated form as opposed to their being presented as separate elements. Asch (1969) has suggested that the unitary perceptual display is stored as a single organized unit while the separate attributes are stored as isolated units.

Thus, with regard to the results of the Moeser (in press) study, it could be argued that the two dimensional objects were stored as single entities, and the use of the dimensions coding strategy was more difficult because it necessitated a breaking up of information stored holistically. If this interpretation is correct, then attributes presented singly should be encoded as isolated units, and the processing of verbal sequences should not be affected by the correspondence between iconic factors and language word order. On the other hand, if an English semantic code is being used to encode the referential field, the order in which the semantic referents occur, rather than whether or not they are presented in a unitized or sequential fashion, should affect the processing of the language.

METHOD

Design

The design was similar to that used in Experiment III of the Moeser (in press) paper. Subjects were first taught to associate nonsense words with separately illustrated dimension attributes. Then they were exposed to sentences of the language in conjunction with the complex reference field. Half the subjects received a language order which reflected an objects coding strategy, the other half received one which incorporated a dimensions coding strategy. They were all tested on their ability to judge acceptable sequences when the reference field was not present.

The present experiment differed from the earlier experiment

by using two reference fields. One consisted of two two-dimensional objects and was identical to the one used in the Moeser (in press) experiments. It was called the *integrated* reference field. The other reference field contained the same attributes that were used in the integrated field, but illustrated as separate elements in a row. It was called the *nonintegrated* reference field. An illustration of how the two conditions compare is shown in Figure 1. (In the nonintegrated field, a color was always shown first on the left, an oriented rectangle second from the left, a geometrical figure third from the left, and a line fourth from the left.)

The English verbal labels which could be applied to the attributes in the integrated field could also be used in the nonintegrated field. Also, in both fields the sequential relationships of dimensions were equated: The two dimensions comprising the left object in the integrated field were the same as the two dimensions occupying the left side of the nonintegrated field, and the two dimensions comprising the right object in the integrated field were the same as the two dimensions occupying the right side of the nonintegrated field. Thus, if verbal semantic codes were used to mediate the processing of the artificial language, the same codes should be used with both fields.

The nonsense words used and the attributes to which they referred are illustrated in Figure 2. One class of words was represented by different colors and a second class by changes in the orientation of a rectangle. In the integrated reference system, these two dimensions formed one object (a colored rectangle in a

(Red)	Bif		Krow
(Green)	Vaht		Rud
(Yellow)	Rez		Nem
(Black)	Lawr		Snil
	Dæk		Wug
	Hib		Gutč
	Paž	...	Ziv
	Yow	- - -	Tep

Figure 2. The words and referents used in the experiment. (The words are written in standard phonemic symbols.)

specific orientation) which always appeared on the left side of the reference field. In the nonintegrated reference system, a color was always shown first in the row (counting from the left) and an oriented rectangle always shown second. A third class of words always referred to differently shaped figures and a fourth class to line variations. In the integrated reference system, these two dimensions formed one object (a figure with a specific border) which always appeared on the right side of the field. In the nonintegrated reference system a figure was shown third (counting from the left) and a line was shown in the fourth position.

The miniature artificial language consisted of 16 nonsense words, grouped into four word classes of four words each. A correct sentence in the language contained one word from each of the four classes in a specific order.

The language and reference fields were correlated so that in the objects coding condition, the first two word classes in the language referred to the two dimensions on the left side of the field, color and orientation, in that order, and the third and fourth word classes referred to the two dimensions on the right hand side of the field, shape and line, in that order. In the dimensions coding condition, the first word class of the language referred to the color dimension, the second to the shape dimension, the third to the orientation dimension, and the fourth to the line dimension. Each word order was matched with the integrated field and the nonintegrated field for a total of four experimental groups as follows: (1) *Integrated reference field, objects coding strategy*, in which the reference field contained two two-dimensional objects and the language sequence referred to the two dimensions of the left object, then the two dimensions of the right object; (2) *Integrated reference field, dimensions coding strategy*, in which the reference field contained two two-dimensional objects and the language sequence referred to one dimension on the left object, then one dimension on the right object, then one dimension of the left object, then one dimension of the right object; (3) *Nonintegrated reference field, objects coding strategy*, in which the reference field contained four separate elements and the language sequence referred to the first attribute on the left, followed by the second attribute from the left, followed by the third attribute from the left, followed by the fourth attribute from the left; (4) *Nonintegrated reference field, dimensions coding strategy*, in which the reference field contained four separate elements and the language sequence referred to the first attribute on the left, followed by the third attribute from the left, followed by the second attribute from the left, followed by the fourth attribute from the left.

Apparatus and Materials

The reference stimuli appeared on colored Kodachrome slides projected on a screen by a Kodak 800 Carousel projector. The sentences were recorded on a Sony 250 stereo tape recorder using the left channel only. The tape recordings were the same as those used in the Moeser (in press) experiment. When the sentences were presented with the slides, a 6-sec cycle was used: During the first second, the slide was changed and there was no sound on the tape, during the next 4 sec, the words were given at the rate of one word per second, and during the sixth second there was silence on the tape but the slide remained. The slides were changed by a tone-operated relay system which responded to a tone recorded on the right channel of the tape. The subjects heard the sentences through earphones hooked to the left channel of the recorder (and thus did not hear the tones).

Forty different slides were used such that each of the 16 referents were presented 10 times in this group of 40 (4 referents per slide). Each of the 40 slides was duplicated so there was a total of 80 slides altogether, arranged in a series so that a given attribute appeared on two consecutive slides exactly twice. The same order of slides was used for all groups.

The test tapes were played on a second Sony 250 stereo tape recorder. They also were the same tapes used in the Moeser (in press) experiment. (In that study, a verbal control experiment was run to show that the differences between groups could not be attributed to differences in the test tapes.)

There were two test tapes, one for each word order. In other words, both of the objects coding groups heard the same tape and both of the dimensions coding groups heard another tape. Both tapes were identical except for the order of words in the sentences.

The tests examined the subject's ability to use his knowledge of the language structure. Each test consisted of 24 sentences, none of which had been presented before. One-half the sentences were grammatically incorrect; they duplicated one word class and omitted another. (These sentences were also semantically incorrect; they described reference fields in which there were two objects in one perceptual class and only three perceptual classes shown.) Each word class was duplicated in three sentences and each word class was omitted in three sentences, so all possible combinations of this type of incorrect sentence were presented. The correct sentences and incorrect sentences were randomly ordered. Both the objects coding and dimensions coding tests had the same correct sentences, incorrect sentences, and order of sentence presentation, except that the order of words in the sentences was in the correct order for the group being tested.

There were two tests for each group, both following the form outlined above. The test tapes were recorded on the right channel only and a new sentence was presented every 1.3 sec.

Subjects

Forty undergraduate student paid volunteers attending classes at Memorial University of Newfoundland served as subjects. None had been used in the Moeser (in press) experiment. Five females and five males were assigned to each group. They were tested in groups of two to four and were paid \$4.00 for participating in the experiment. In addition, there was one subject who did not complete the experiment because he failed to acquire all the word-referent associations in the first part of the experiment.

Procedure

After subjects were seated, they were told that they were participating in a language learning experiment and that they would first have to learn to associate the 16 words used in the language with their 16 pictures. They were shown slides which illustrated the separate attributes (as they are illustrated in Figure 2) while the experimenter pronounced the word which corresponded to each referent. After two such showings, they were given a vocabulary test. The experimenter read the words in a different order, and they were required to draw pictures that illustrated the referents (they were requested to write the names of colors). The experimenter marked the test and then went through the procedure again until the subject had a perfect score. A subject who acquired all the word-referent associations before the other subjects went into another room to wait until all the subjects in his group had reached criterion. No more than five trials were given. (All subjects except one learned the task within five trials, and he was eliminated from the experiment.)

There was a 5-min break, and the second part of the experiment began. Subjects were presented with 80 sentences and their corresponding slides. This was followed by the first test tape; subjects were required to indicate which sentences were correct and which were incorrect by circling C or I on an answer sheet. Then the 80 sentences and slides were repeated, and the second test was given.

Table 1
Group Means for Correct Answers on the Tests, Broken Down
According to the Number of Grammatically Correct Sentences
(C) and Grammatically Incorrect Sentences (I) Properly Identified

Group	Test 1		Test 2		±
	C	I	C	I	
Integrated					
Objects Code	10.9	9.9	12.0	11.0	23.0
Dimensions Code	9.3	7.2	11.2	8.8	20.0
Nonintegrated					
Objects Code	10.7	9.6	11.8	11.0	22.8
Dimensions Code	10.3	10.1	12.0	11.3	23.3

RESULTS

Table 1 shows the mean number of correct responses for each group broken down according to the type of correct response. An analysis of variance on this data comparing the two reference conditions, two coding strategies, two types of correct responses, and two tests revealed significant main effects due to reference condition ($F(1,36) = 5.95$, $p < .05$), response type ($F(1,36) = 23.01$, $p < .001$), and test number ($F(1,36) = 30.90$, $p < .001$) and a significant interaction between reference condition and coding strategy ($F(1,36) = 8.07$, $p < .01$). There were no other significant main effects or interactions.

Thus all groups showed improvement from Test 1 to Test 2 at approximately the same rate. The significant effect due to reference condition and the significant interaction between reference conditions and coding strategies reflect the same cause, namely, that the mean score of the integrated/dimensions coding group was considerably lower than the mean scores for the other three groups. A Scheffé comparison of means found no significant differences among the integrated/objects coding, nonintegrated/objects coding, and nonintegrated/dimensions coding groups, but all of these groups differed significantly from the integrated/dimensions coding group at the .05 level.

In all groups, the subjects' identification of incorrect sentences was significantly poorer than their identification of correct sentences. This probably reflected a response bias to assume the sentence correct unless a definite error was located.

The group means for number of trials taken to acquire the word-referent associations were as follows: Integrated/ABCD, 3.3; integrated/ACBD, 3.9; nonintegrated/ABCD, 3.9; nonintegrated/ACBD, 3.6. An analysis of variance on this data showed that the group effect was not significant ($F(1,36) = 0.22$, $p > .10$). The correlation between number of trials to criterion on the word-reference acquisition task and score on the sentence identification tests was also not significant ($r = -.15$). Thus the differences obtained between conditions cannot be accounted for in terms of

differential effectiveness of word-reference learning.

DISCUSSION

The significant difference among groups does not appear to be due to a verbal semantic factor. With the nonintegrated reference field, varying the order in which "concepts" occurred did not affect memory of the language rule. Changes in the organization of the reference field, however, did affect the subjects' ability to judge grammatically (or semantically) correct sequences.

Nor does it appear likely that these differences were due to differences in the acquisition of the simple language rule. In the Moeser (in press) experiment, subjects were specifically taught the semantic rule before they were shown the set of 80 slides, yet subjects in the integrated/dimensions coding groups were significantly poorer than subjects in the integrated/objects coding groups on the tests. In the present experiment, the organization of the nonintegrated field was actually more amenable to representation of the incorrect sequences than was the integrated field. (Two elements of the same perceptual class could easily be illustrated in the nonintegrated field but would have been very difficult to represent in the integrated field.) However, subjects in the nonintegrated groups were not poorer on the tests than subjects in the integrated groups. Thus it is doubtful that *knowledge* of the rule structure differed among groups. The difficulty experienced by the integrated/dimensions coding group appeared to lie in the differences between the representation (or semantic) structure of the language and the word order (or syntactic) structure.

Paivio (1971) has postulated that visual (imaginal) information and verbal (linguistic) information are stored in separate memory codes. He suggests that Harris and Haber's (1963) subjects were less efficient at dimensions coding because they found it difficult to form concrete images of dimensions and thus relied more exclusively on their verbal code; objects coders were able to make use of both their imaginal and verbal coding systems. However, this account cannot be used for explaining the results of this experiment. The groups whose task was to remember the language in terms of dimensions and who were presented with a dimensional reference field were not poorer than the group whose task was to remember the language in terms of objects and who were presented with an objects reference field. The group that was significantly poorer than the others was the group that was presented with an objects reference field in conjunction with verbal sentences and required to decode sentences which required a breaking up of the integrated nonverbal representations. Thus the difficulty did not lie in making an abstract representation concrete, but in fragmenting a nonverbal

representation encoded holistically. After having experienced the verbal sequences in conjunction with an integrated reference field, the subjects experienced difficulty in dealing with verbal sequences which necessitated processing dimensions independent of form, even though they had initially learned to associate individual words to these independent dimensions.

These results raise interesting questions regarding the organization of the semantic memory system. Recently, a number of researchers (e.g., Anderson & Bower, 1973; Clark & Chase, 1972; Trabasso, 1972;) have proposed propositional models of memory that share in common the idea of an abstract memory base that encodes both perceptual and linguistic information in the form of semantic propositions. In these models, the memory representation of a sentence consists of neither verbal codes (words) nor perceptual codes (images) but a set of semantic elements.

In the present experiment, the artificial language structure could be broken down into four semantic propositions:

Proposition 1 – There is a color.

Proposition 2 – There is an oriented rectangle.

Proposition 3 – There is a geometrical shape.

Proposition 4 – There is a line (border).

Assuming that the list structure is order-free (e.g., Glucksberg, Trabasso, & Wald, 1973), there should have been no differences between word order groups. Thus, in order to explain the results, it is necessary to assume that additional information must have been encoded in terms of perceptual relationships which would affect the language processing. Both Clark (1973) and Anderson and Bower (1973) have suggested that relational propositions most likely reflect spatial information rather than verbal information. So Proposition 5 is added, but because there were two versions of the reference field, there must be two versions of Proposition 5, Proposition 5a for the integrated field and Proposition 5b for the nonintegrated field:

Proposition 5a – Proposition 2 is embedded in Proposition 1; Proposition 3 is embedded in Proposition 4, and to the right of Propositions 1 and 2.

Proposition 5b – Proposition 1 occurs on the far left, Proposition 2 is to the right of Proposition 1, Proposition 3 is to the right of Proposition 2, and Proposition 4 is to the right of Proposition 3.

The relational description of Proposition 5a is simpler and more compact than the relational description of Proposition 5b, and thus may be easier to store in

memory. In fact, this is the argument used by Anderson and Bower (1973, p. 53) to explain why Asch (1969) found unitary displays more easily remembered than nonunitary displays. However, such an argument would also predict that subjects shown the nonintegrated reference field should have had more difficulty remembering the language rules than subjects shown the integrated field. The results do not support this hypothesis.

Thus, the results of the experiment are difficult to explain in terms of a semantic element model. The memory system appears to involve the storage of entities which reflect more holistic organizations.

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