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FRANKART, Jeanne Delpierre, 1927-
GRAMMATICALNESS: ITS PSYCHOLOGICAL DIMENSION AND RELATION TO HABIT.

The Ohio State University, Ph.D., 1964
Psychology, general

University Microfilms, Inc., Ann Arbor, Michigan
GRAMMATICALNESS: ITS PSYCHOLOGICAL DIMENSION
AND RELATION TO HABIT

DISSERTATION
Presented in Partial Fulfillment of the Requirements
for the Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

By
Jeanne Delpierre Frankart, A.B., M.Ed.

*********

The Ohio State University
1964

Approved by

[Signature]
Adviser
Department of Psychology
ACKNOWLEDGMENTS

The writer wishes to thank Dr. John E. Horrocks for his constant encouragement and support throughout the writer's years of graduate study at Ohio State. Special thanks are due to Dr. Neal F. Johnson for much of the technical advice needed for the successful completion of this research.

The writer also wishes to express her appreciation to her co-workers, Ruth Baker and Charles Zartman, for their constant encouragement.

The successful completion of this research and of the writer's graduate studies could not have been possible without the help, patience and understanding of her family. Special thanks are due to Sherylee, Lillian and Jacqueline, the writer's daughters, for their willingness to act as pilot subjects during the early phases of the research.
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CHAPTER I

INTRODUCTION AND REVIEW OF THE LITERATURE

Statement of the problem

The study of language is a relatively new field in psychology, but some important milestones mark the birth and development of this interest. Lashley (1951) considered the structured nature of speech as a prime example of the general problem of the serial ordering of behavior. Lashley discounted the earlier theories whereby complex acts, including language behavior, were considered a chain of simple associations. Lashley proposed that "generalized schemata" of action determined the sequence of specific acts.

The development of information theory, and especially Shannon and Weaver's *Mathematical Theory of Communication* (1949) brought the hope that a possible meeting ground had been found for linguists and psychologists interested in language behavior. The 1953 Indiana University Seminar in Psycholinguistics (Osgood and Sebeok, 1954) represented an
early attempt by psychologists and linguists to launch a joint attack on the problem of language. More recently, Chomsky's (1957) development of a transformational grammar spurred a great deal of psychological research. The prominent position which the study of language has gained in the last decade can probably be best attested to by the fact that the last APA Presidential Address was devoted to a thorough review of the field (Osgood, 1963).

The present study belongs to the general area of discovery of psychological correlates of grammatical structure. Its purpose is to investigate the psychological reality of the concept of grammaticalness, and to interrelate the concepts of grammaticalness and habit.

Hypotheses

The research to be reported deals specifically with these hypotheses:

1. The degree of grammaticalness of a sequence of words should influence the ease of learning of this sequence. Specifically, degree of grammaticalness and ease of learning should be positively correlated.

2. Habit (i.e., word-to-word associations) plays a differential role in contexts of different degrees of
grammatical structure. As structure increases the influence of word-to-word associations should decrease.

3. The distribution of errors in word-to-word transitions is more random in ungrammatical sequences than in grammatical sequences where the pattern of errors is strongly influenced by grammatical structure.

If validated, the first hypothesis will demonstrate that grammaticalness is a psychologically meaningful dimension. The second and third hypotheses stem from recent research which suggests a re-evaluation of the relationship between grammar and association. The prediction of differential effects of habit in contexts of different degrees of structure may be considered an extension of Lashley's (1951) attack on simple associative chains as the explanatory mechanism for language sequencing. Word-to-word associations are important in rote learning of unstructured material, (Johnson, 1963) but as structure is introduced, Lashley's "generalized schemata" may take precedence over simple word-to-word associations.
Significance of topic

Grammar has traditionally been the domain of the linguist and grammarian. However, if grammar can be shown to have close psychological correlates, the implications of recent developments in linguistic theory (Chomsky, 1957) for behavior theory can be made more explicit.

This study should increase the amount of knowledge now available concerning the role of habit in language production and perception. It should partially resolve such questions as the relative importance of associations in different structures and where, within the structure, the influence should occur.

As we begin to discover more and more about language units and the attributes of the bonds that shape them into a structure, we should become more able to provide an efficient route to the acquisition of this structure. This increased efficiency could be utilized in young children's first language learning and in second language learning.

This research should also have theoretical implications for other areas in psychology, such as memory processes, the nature of the thinking process and perception. The processes implied in sentence retention and perception should provide some information on memory phenomena.
Furthermore, the influence of structure on language encoding and decoding may provide implications for research on thinking processes.

Review of the literature

Grammaticalness has been, and will be, used in this paper in a linguistic sense, i.e., based on informants' judgments. This concept of grammaticalness was explored by Maclay and Sleator (1960). These investigators collected a number of judgments on grammaticalness, meaning, and common occurrence of different types of sequences. Six types of sequences were used. Type A was composed of sequences defined by the authors as not grammatical, not meaningful, not ordinary. They consisted of random strings of words, with the added restriction that no three word combination would normally occur in English sequences (e.g., A keeps changed very when). Type B sequences were characterized as grammatical, not meaningful, not ordinary. The basic structure of English was preserved, but meaning destroyed (e.g., Appointments can mow winters generously). Type C sequences were modeled on examples of bilingual construction and were typified as not grammatical or ordinary but meaningful. Sentence structure was partially
destroyed but meaning remained clear (e.g., Yesterday I the child a dog gave). Type D might be described as incomplete sentences; the authors describe them as not grammatical, but meaningful and ordinary and typical of responses to questions (e.g., Sometime early in the morning). Types E and F are both qualified as grammatical, meaningful, and ordinary, with type E being comprised of sentences which show some infraction to formal grammar, such as the incorrect use of I for me (e.g., Send one to Harry and I). Type F sentences were completely grammatical. Maclay and Sleator presented these sequences on a tape recorder to three different groups of subjects. Each group was asked to make a "yes" or "no" judgment about each sequence along one of these dimensions: grammatical, meaningful, ordinary. Judgments made proved to be largely independent of one another. Especially significant were the responses for type B where the preponderance of grammatical judgments over meaningful and ordinary ones was quite marked. The pooled judgments of those subjects who were asked to judge for grammaticalness showed a rather marked gradation with good differentiation between most groups. The following proportions are reported
by the authors: type F, .960; type E, .492; type B, .421;
type D, .341; type C, .262; and type A, .072. They regard
their data as suggesting that the linguistic and
behavioral meanings of grammatical are generally similar,
although the overlap is not complete and that grammatic-
calness and meaningfulness are independent concepts.

In the same vein, but clearly less experimental in
nature, is an article by Hill (1961) in which he disputes
the idea put forward by Chomsky (1957) that informants
can give a reliable judgment of grammaticality. Hill
failed to get much agreement among his subjects when they
were asked to judge ten sequences of words as to grammati-
calness. Hill included in his sample of sequences two
anomalous sentences, including Chomsky's (1957) famous
*Colorless green ideas sleep furiously*. Also included were
some doubtful forms and scrambled sentences. The founda-
tion for Hill's conclusion that informants can not give
reliable judgments of grammaticality appears inadequate.
Hill used only ten subjects. By the author's own
recognition this number does not constitute a reliable
sample of the English-speaking world.

Maclay and Sleator (1960) and Hill (1961) asked their
Ss to make a dichotomous judgment on grammaticalness, but showed a tendency to regard the pooled judgments as giving some measure of degree of grammaticalness. A more direct approach to the problem of degrees of grammaticalness was taken by Johnson and Frankart (1963). Ss were asked to rate 150 sequences on a nine-point scale along the dimension of grammaticalness. The ratings were distributed fairly evenly over the scale, indicating that Ss could make judgments of degree when instructed to do so. However, the reliability of the ratings at intermediate points of the scale was not as high as it was at the extreme points.

The influence that grammaticalness as such has on learning has not been systematically investigated. However, a number of studies have dealt with dimensions that are related to grammaticalness in varying degrees.

Miller and Selfridge (1950) reported a now-classic study on the immediate recall of material of different degrees of approximation to English. As their zero-order approximation, they used words drawn at random from the Thorndike and Lorge (1944) list of the 30,000 commonest words. First order approximations were constructed by scrambling the words used in the higher orders. A group
of sentences taken from actual English text formed another group. Miller and Selfridge also included groups of intermediate approximations to English. These degrees of approximation were designed to reflect contextual restraint imposed by different numbers of preceding words. Miller and Selfridge used a total of seven different degrees of approximation to English in sequences of differing lengths, testing immediate recall after a single presentation. Results were scored in terms of percentage of words recalled. This percentage increased as the order of approximation increased, and it decreased with length of list. However, very small differences were apparent between the higher order approximations and full English text. An examination of the material used by Miller and Selfridge clearly indicates that, as statistical approximation to English increased, so did grammatical structure. The fourth and higher orders of approximation are easily divisible into phrases of varying lengths. This observation can be illustrated by the following fourth-order sequence: saw the football gang will end at midnight on January.

Miller and Selfridge made an important contribution
in that they attempted to quantify meaning, to define operationally quantitative differences between meaning and nonsense. Several important criticisms have been leveled at their study. The most outstanding of these criticisms is that it lacks statistical analysis. In a partial replication of Miller and Selfridge, Jahnke (1960) performed some direct-difference t-tests between the various orders of contextual restraint and different list lengths. These results confirmed statistically those which Miller and Selfridge presented graphically.

Another criticism of the Miller and Selfridge study involved its failure to employ any counter-balancing procedure (Marks and Jack, 1952). A zero-order approximation was presented first for all sequence lengths, thereby introducing the possibility of a practice effect on higher order approximations.

Miller and Isard (1963) asked subjects to repeat sentences immediately after hearing them through earphones. In a second study, masking was used with the same material. In both cases Miller and Isard used three basic types of sequences which they labeled as grammatical, anomalous, and ungrammatical. The anomalous sentences were constructed
from the grammatical sentences by interchanging words so that "meaning" would be destroyed without upsetting syntactic structure, as in the sequence: trains steal elephants around the highways. Ungrammatical strings were constructed by haphazardly permuting the positions. The three types of sequences were presented in heterogeneous lists in random order. Responses were scored both for the number of principal words and for the number of complete sentences which were repeated correctly immediately after presentation. Differences between the three types of sequences were significant under both conditions for both measures used. In order to evaluate the effect of set on sentence intelligibility, another experiment was conducted in which the same materials were used, but this time in homogeneous lists. This procedure resulted in increased intelligibility for all sequences, with a noticeably greater improvement for anomalous sentences.

The studies reported by Miller and Selfridge (1950) and Miller and Isard (1963) involved a single presentation method, and, as such, cannot be considered as investigations of learning phenomena. Learning was incorporated in a series of experiments reported by Epstein (1961, 1962).
The studies attempted to determine whether different rates of learning exist for structured and unstructured material. Epstein's (1961) Group I material consisted of strings of nonsense words in which function words were inserted to follow the usual grammatical pattern of English. The degree of structure was further increased by adding grammatical tags such as *s or *ed to some of the nonsense words in the correct grammatical position, as in *A haky deeb*s *reciled the dison tofently um flutest pay*. The operations used by Epstein to generate Group I sequences had been previously suggested by Osgood (1957). Group II was similar to Group I except the grammatical endings were omitted. Group III utilized the same words (with the same endings) as Group I, but the words were now arranged randomly. Group IV was also similar to Group I, but the grammatical tags were put in positions which would be incorrect in an English sequence. Groups V and VI utilized actual English words rather than nonsense material. In Group V these words were arranged in grammatical order but did not form meaningful sentences. In Group VI the same words occurred in random order. The subjects were instructed to write as much of each sequence as they could
remember after its presentation. For each sequence, trials proceeded until one perfect recitation was achieved. Using the mean number of trials to criterion as the measure of learning, the investigator found a significant difference in speed of learning between "integrated" nonsense sentences and those randomly arranged. A significant difference was also found between the structured and random sentences using words. Epstein also noted that grammatical sentences using nonsense material were learned slightly faster than those employing random sequences of words.

Epstein (1962) partially replicated the above experiment, but used only the equivalents of Groups I, III, V and VI. Two measures of learning were used: trials to criterion and number of errors. The differences between structured and the corresponding random sequences were significant. In contrast to the previous experiment, these data showed a considerable difference in learning speed between structured nonsense and random words, the words being learned faster.

Epstein (1962) used the same materials which comprised the same four groups (I, III, V, VI) in a serial learning experiment in which only one word (meaningful or nonsense)
was exposed at a time. No significant differences were found between structured and unstructured material under these conditions. The author concluded that the effect must be dependent on the perception of structure as a unit.

The studies reported so far have been most closely related to Hypothesis 1, i.e., the relationship between degree of grammaticalness and ease of learning. Epstein (1961, 1962) and Miller and Isard (1963) adequately handled sequences at what could be considered the extreme poles of grammaticalness. Miller and Selfridge (1950) represented an attempt to introduce degrees; however, these degrees were designed to reflect meaning, not structure.

The relation between habit and grammaticalness has also failed to attract experimental attention. However, there have been several investigations into the structure of language and the establishing of associations between different language units. Some of these studies formed the groundwork from which Hypothesis 2 evolved.

Lounsbury (1954) provided the hypothesis that a strong relationship exists between hesitation pauses,
transitional structure, and units of encoding. That hypothesis was tested by Macclay and Osgood (1959). They analyzed a sample of over 50,000 words taken from a conference in which thirteen male speakers participated. Recorded hesitations were divided into four types: repeats (repetitions of any length), false starts (incomplete or self-interrupted utterances), filled pauses (occurrence of any hesitation device, such as *eh, er*) and unfilled pauses. Interesting differences were found between the occurrence of these different types of hesitations and the type of work involved; e.g., false starts occurred much more frequently in connection with lexical words (nouns, verbs, adjectives, adverbs), while repeats occurred much more frequently with function words (articles, auxiliaries, connectives, prepositions, etc.). Pauses were found to occur within phrases about as often as between phrases; however, filled pauses were found to occur more frequently at phrase boundaries and unfilled pauses at word boundaries within phrases. Macclay and Osgood view their results as implying that the speaker is operating with units at least as large as words, and that two levels of organization are present in encoding; one
lexical, the other grammatical. The investigators also suggest that the length of the pause determines whether it is filled or unfilled, the longer pause requiring some fill-in signal. The longer pauses would occur at the points of greatest uncertainty, i.e., those points where the speaker must make a double choice, lexical as well as structural. These structural choices would of course occur at phrase transitions.

Miller (Underwood and Postman, 1963) relates a series of studies in which different techniques were used to study units of speech perception. One of these techniques involved recording the length of the strings of words which a subject will hold in mind while copying an English text. By comparing the number of words thus retained with the immediate memory span for unrelated words, the average length of the units can be determined. This average length was found to be from 2 to 2.5 words per unit. Miller also reported that when a factor analysis was made of correlations between words retained, phrase units emerged as groups of words that are either recalled or forgotten as a unit.

Mandler (Postman and Underwood, 1963) reports two
experiments which have a bearing on the present problem; they concern the behavioral and physiological effects of the interruption of well-integrated verbal sequences. In the first experiment, subjects learned four different kinds of material: seven-word sentences, random strings of seven words, and two series of digits. These were auditorially presented as a serial task. One group learned the material to a criterion of one perfect recitation, while another group was given 15 overlearning trials. Interference was produced by replacing the last word or digit by a new one on the trial immediately following the criterion trial. Six trials on the original material were then given. For the sentences and seven-word sequences, overlearning resulted in significantly fewer errors as the result of the interruption. More arousal due to interruption (as measured by GSR) was found in the overlearning group, and was higher in word sequences than in the series of digits. The second study reported deals with the locus of interruption in overlearned seven-word sentences, and the relevance of the substituted word (a relevant word was defined as semantically substitutable). A relevant interruption produced
a higher number of errors in position 1, while an irrelevant interruption caused more errors in positions 3 and 5. It was discovered that the serial position curve reflected both semantic and syntactic aspects of the sentence; those words which can be said to carry the meaning produced fewer errors. The relevance of Mandler's findings to normal speech is put somewhat in doubt by the studies carried out by Epstein (1962) mentioned earlier, as his findings intimated that structure had to be perceived as a whole to give maximum effects. Mandler used serial anticipation; the sentence had to be reconstructed in the subject's mind in order for the structure to become apparent. It is also unfortunate that no details are given as to the relation of locus of interruption to the structure of each sentence used.

Johnson (1963) had subjects learn sentences of two different grammatical types, consisting of either two main phrases or three main phrases. The sentences were presented to Ss on a memory drum as a paired-associate task, using the sentences as responses. All errors were recorded over a fixed number of trials and probabilities
of transitional errors in recall computed. The probability of a transitional error was defined as the probability of getting a word wrong when the preceding word was correct.

Johnson predicted that probability of a transitional error would be greater across phrase boundaries than within. This prediction was confirmed by the data. A decrease in the probability of a transitional error within a phrase also showed decreases in a left-to-right direction, apparently reflecting intra-phrase structure. In this and similar experiments, Johnson (1963) performed an immediate constituent analysis of the sentences. The transitions were then placed in rank order in terms of the level at which they represent a constituent division. Kendall rank correlations between that order and the rank order of probabilities of transitional error ranged from .60 to .95. When using the number of decoding operations necessary for the utterance of the word immediately following the transition as one measure, and actual observed probability of an error as the other, the rank correlations obtained were slightly higher. When those transitions showing the highest transitional error
probabilities were taken out of the sentence and learned as paired associates, their rate of learning was found to be no different than transitions with a low transitional error probability.

The studies reported by Maclay and Osgood (1959), Miller (Underwood and Postman, 1963) and Johnson (1963) suggest the psychological reality of phrases as units of verbal behavior. They also shed considerable doubt on the importance of the role of word-to-word associations in structured speech.

Glanzer (1962) paired words of the traditional grammatical categories with nonsense syllables, using words as stimuli for half the subjects, and as responses for the other half. Content words (nouns, verbs, adjectives) were learned more readily in the paired associate setting than function words (adverbs, pronouns, prepositions, conjunctions). When the word classes were embedded as the middle item of a complex response consisting of two nonsense syllables as the terminal items, function words gave more correct answers than content words. The number correct was negatively correlated with the number correct in the paired associates experiments, giving a rank order
correlation with Experiment I of -.821. The author concluded that function words are incomplete as units, but form a unit when minimal context is added.

Johnson (1963), using a paired-associate technique, had subjects memorize strings of words. When grammatical structure was absent (seven-word random strings) pre-existing associations between words lowered the probability of a transitional error on those particular transitions. The pre-existing associations were determined by using a primary associate of the preceding word, taken from the Russell and Jenkins (1954) norms. However, in a second study using grammatical sentences, he showed that the influence of a prior association on transitional errors depended on the structural characteristics of the transition.

Johnson interprets the results as giving strong support to a proposed model of language whereby associations would be formed between operations rather than between responses. Only when these operations are contiguous would associations be formed between two classes of word responses.
Summary

Some of the studies which have been reviewed here have demonstrated the influence of structure or lack of structure on learning. The matter of gradation in grammatical structure was touched upon by Epstein (1961, 1962) but these gradations were based on a priori decisions. The importance of the dimension of grammaticalness has not been made explicit in most of the studies reviewed, but the data of Maclay and Sleator (1960) and Johnson and Frankart (1963) suggest that it is a psychologically meaningful dimension.

Support for Lashley's (1951) "generalized schemata" was indicated by Johnson (1963), Maclay and Osgood (1959) and Mandler (1963). These studies refute the concept that sentences are produced by the simple mechanism of associations between adjacent words. The present study hopes to shed some light on the dimension of grammaticalness and its possible interaction with habit strength manifested as associations between words, and on the manifestations, in a learning situation of varying degrees of structure.
CHAPTER II

EXPERIMENTAL PROCEDURE

Subjects

The subjects were 82 college students (22 males and 60 females) enrolled in an introductory psychology course at Ohio State University. They participated in the experiment to satisfy a course requirement. The Ss were assigned randomly to one of eight experimental conditions. Most of the Ss were freshmen; some had one previous participation in a verbal learning experiment. Two Ss (one male, one female) were discarded because of failure to learn enough of the task to score their performance.

Materials

The materials consisted of four sets of word sequences. The four sets were chosen at both extremes and at two intermediate points on a continuum of grammaticality. The actual sequences used were drawn from a pool of 150 sequences used by Johnson and Frankart (1963) in an earlier study. The 150 sequences formed an attempt to
span the possible range of grammaticalness from random strings of words to completely grammatical sentences. They included "anomalous" sentences, scrambled sentences, bilingual constructions, incomplete sentences and incorrect usage. The sequences were administered to several groups of college students, along with a nine-point rating scale for each sequence. The Ss were asked to rate each sequence along the dimension of grammaticalness. The Ss were cautioned to consider grammaticalness alone and not meaning. Mean ratings were computed for each sequence.

Eight sequences were chosen from among the lowest ratings; these sequences comprised List I. Eight sequences with high ratings formed List IV. Lists II and III were formed from among the sequences with average ratings. List I sequences had ratings ranging from 1.49 to 1.88, with a mean rating of 1.74. List II ranged from 3.56 to 4.44, with a mean of 4.12. List III's range extended from 4.58 to 5.44, with a mean of 4.97. List IV extended from 7.83 to 8.64, with a mean of 8.31. The actual sequences used, along with their rating on grammaticalness, can be found in Appendix A. Each list was constructed in such a
manner as to equate as much as possible the number of words and the number of letters in each group.

All words used were from the Thorndike and Lorge (1944) list of 30,000 commonest words. All words except those in one sequence of List I were A or AA words. One of the sequences from List I was adapted from Miller and Selfridge's (1950) zero-order approximation. No function words were included in List I.

Sequences in Lists II and III were similar in kind, differing only in degree. Two sequences in each group were devoid of meaning, but structurally similar to English. Two sequences in each were incomplete sentences. The other four were clear in meaning, but faulty in construction. Three of the sequences used in List II, two used in List III, and one in List IV, were adapted from Maclay and Sleator (1960). Each sequence within a list was randomly assigned a digit from one to eight which was used as the stimulus during learning.

The sequences in Lists II, III, and IV were divided into two major phrases according to an immediate constituent analysis.¹ The two words within each sequence that bound

¹. The writer is indebted to Mr. Dale Elliott for this analysis.
the major between-phrase transition were placed in a paired-associate list. The last word of the first major phrase was used as the stimulus and the first word of the second major phrase as the response. The main transition within each sequence was chosen to maximize effects. It has been shown (Johnson, 1963) that the probability of a transitional error is significantly greater for between-phrase transitions than it is for within-phrase transitions. A larger transitional error probability should make any changes due to the previous formation of associations more apparent.

Each random string used in List I was also divided into two major parts. The locus of this division, however, was randomly determined for each sequence. The words forming this transition were also used as a pair in a paired-associate list. The words used as pairs were randomized to construct one sixteen-item list to be used for familiarization. The sixteen-item lists were used in each familiarization group to control the total number of exposures to the words bounding the manipulated transition.

To sum up, each list of eight sequences was
complemented by a paired-associate list consisting of eight pairs, and a random arrangement of these 16 items to be used in familiarization. All lists are included in Appendix A.

**Experimental design**

Eight groups of 10 Ss each were used. Each of the four sequence lists was learned by two subgroups. One subgroup (habit group) learned the corresponding PA list before learning the sequences. The other subgroup (familiarization group) received familiarization trials on the corresponding sixteen-item list. The familiarization groups were used to provide a control against which changes in transitional error probability (TEP) of the manipulated transitions could be evaluated.

**Procedure**

Each S was randomly assigned to one of the eight experimental conditions. Ss in the habit groups were given standard paired-associate instructions. The eight pairs of words were exposed on a Lafayette memory drum, at a 2 sec. rate and a 4 sec. intertrial interval. Four randomizations were used. Ss were instructed to pronounce both stimulus and response words every time they appeared.
At least 15 trials were used for all Ss. In the event that at least three perfect trials had not occurred by the fifteenth trial, more trials were given until the criterion was reached. Most Ss reached the criterion in less than 15 trials.

Immediately after learning the eight word-pairs on the first PA list, the Ss learned the second PA task which used the complex word sequences as responses and digits as stimuli. A 4 sec. presentation rate was used. The Ss were instructed to read each sequence aloud. They were encouraged to guess as soon as possible and to give any part of the response which they could recall. When the correct response appeared on the drum they corrected any mistakes they had made. Fifteen trials were given for these sequences and all responses were recorded.

Ss in the familiarization groups were told that their first task would be to memorize a list of 16 words. These words were presented in different orders to prevent serial memorization. The words were read aloud on every trial. After three learning trials, the memory drum was stopped and the Ss asked to recall as many of the words as possible. Free recall was again used after the sixth, ninth, twelfth and fifteenth trials. If any S failed to recall all 16
words after the fifteenth trial, three more learning trials were given. The free recall trials and the learning instructions were used to insure active participation by the Ss (Underwood and Schultz, 1960). They were then instructed to learn the eight sequences of the list to which they had been assigned. Paired-associate instructions were given, with a strong emphasis on guessing. The procedure after familiarization was the same as for the habit groups.

Summary

Eight groups of 10 Ss each were assigned to the following experimental conditions: low grammaticalness-habit, low grammaticalness-familiarization; medium low grammaticalness-habit, medium low grammaticalness-familiarization; medium high grammaticalness-habit, medium high grammaticalness-familiarization; high grammaticalness-habit, high grammaticalness-familiarization. After learning a paired-associate or familiarization task involving words bounding the manipulated transition within each sequence, each S received 15 trials on a paired-associate task where digits were used as stimuli, and responses were eight sequences of the same degree of grammaticalness. All anticipated responses were recorded.
CHAPTER III

ANALYSIS OF RESULTS

Hypothesis 1: The degree of grammaticalness of a sequence of words should influence the ease of learning the sequence. Specifically, degree of grammaticalness and ease of learning should be positively correlated.

One of the most obvious measures of learning is the total number of words correctly emitted over 15 trials for the eight sequences within each list. This procedure is justifiable insofar as the total number of words in each list is approximately the same. For each familiarization group (which, for the purpose of this study, can be regarded as a control group), the total number of words emitted by all Ss across 15 trials was computed. These totals can be found in Table 1. The corresponding percentage of words correct is also included.
Table 1
Total Number of Words Emitted and Percentage Correct for Each List

<table>
<thead>
<tr>
<th>List</th>
<th>Number of words</th>
<th>Percentage correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>1203</td>
<td>17.89</td>
</tr>
<tr>
<td>II</td>
<td>3540</td>
<td>47.73</td>
</tr>
<tr>
<td>III</td>
<td>4135</td>
<td>55.59</td>
</tr>
<tr>
<td>IV</td>
<td>4784</td>
<td>60.89</td>
</tr>
</tbody>
</table>

The total number of words emitted in each trial, for each list, was also compiled. The number of words emitted in any one trial was divided by the total number of words that could have been emitted (on a perfect trial). The percentage of words correct for each trial and for each list has been plotted in Figure 1. These percentages can also be found in Appendix B. The significance of the difference in learning rate between all possible lists pairs was computed, using the Mann-Whitney U test (Siegel, 1956). The results of these tests are summarized in Table 2.
Figure 1

Learning Curves for Lists I, II, III, IV
Table 2

Differences in Learning Between Lists

<table>
<thead>
<tr>
<th>List Pairs</th>
<th>I-II</th>
<th>I-III</th>
<th>I-IV</th>
<th>II-III</th>
<th>II-IV</th>
<th>III-IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>U value</td>
<td>32 *</td>
<td>30 *</td>
<td>22 *</td>
<td>72</td>
<td>62</td>
<td>84</td>
</tr>
</tbody>
</table>

* p < .001 (one-tailed test)

It is evident from an inspection of Table 1 and Figure 1 that there is a definite increase in learning with increasing degree of grammaticalness. It is also interesting to note that there is a considerable increase between List 1 (mean rating: 1.74) and List II (mean rating: 4.12) with only moderate increases thereafter. It can be seen in Table 2 that the only differences which are significant are those between List I and every other list. If Ss were asked to make a dichotomous division of all sequences included in the four lists, and the division had to be made between sentences and non-sentences, it appears probable that the division would occur between List I and the other three lists, corresponding to the large difference in learning rate.
Another measure of degree of learning can be obtained by using the percentage of words correct for each sequence. This percentage was obtained by dividing the total number of words emitted for one sequence across Ss and across trials by the total number of words that could have been emitted. A rank order correlation was obtained between the percentage of words correct for each sequence and its rating on the grammaticalness scale. The Spearman rho between these two measures was found to be .828 (t: 5.473, p < .001). The percentages obtained for each sequence can be found in Appendix B.

The above results indicate that Hypothesis 1 can be accepted with a high degree of confidence. Hypothesis 2: Habit plays a differential role in contexts of different degrees of grammatical structure. As structure increases the influence of word-to-word associations should decrease.

The main concern in testing the validity of this hypothesis will be centered around the manipulated transition i.e., the transition which was the object of experimental manipulation. Changes in the correct occurrence of this transition as a function of previously established associations were determined by comparing the
probability of a transitional error in the habit group with
the transitional error probability (TEP) of the same transi-
tion in the familiarization group. The TEP can be defined
as the probability of getting the second word of the transi-
tion wrong when the preceding word occurred correctly.

A preliminary examination of the data revealed that
large differences in TEP existed between the different
lists (mean TEP in List I: .713; in List IV: .104). These
differences were due in part to the differential learning
rate of the lists. To eliminate to some extent the effect
of learning ease, the following measure was adopted. For
each S, the last trial counted was the trial on which all
eight manipulated transitions were correct. The transition
was considered correct if both words involved in the transi-
tion occurred correctly in the right order. If all eight
transitions did not occur correctly in any one trial, then
trial 15 was counted as the last trial.

Another possible measure would have involved counting
as the last trial the one on which all eight transitions had
occurred at least once. The above measure was chosen
instead because it also takes into account the stability of
the transition, once it has occurred.
The TEP were arrived at in the following manner. After the last trial for any one S had been established by the above criterion, the probability of an error on the manipulated transition was recorded in the form of a fraction, e.g., if the first word occurred five times, and an error (of omission or substitution) on the second word occurred twice (provided that the first word had occurred correctly), the score for that S, for that sentence, for that transition, was recorded as $2/5$.

For the purpose of this analysis, only one transition in each sequence was considered, i.e., the manipulated transition. One total TEP score was computed for each S by combining the scores of the manipulated transitions across the eight sequences. These total scores were computed by adding the numerators and the denominators of the eight manipulated transition scores. The total score thus reflects the proportion of errors made for all manipulated transitions viewed as a function of the total number of opportunities for a correct transition to occur for one S across the eight sequences learned by the S.

The scores thus obtained for each S were entered in a $4 \times 2$ table, with 10 Ss in each cell. This table can be found in Appendix B. An analysis of variance for random
groups with two variables of classification was performed (Walker and Lev, 1953). The dimension of grammaticalness was entered in the columns while habit and familiarization conditions were entered in the rows. This analysis of variance is summarized in Table 3.

Table 3

Analysis of Variance of TEP of Manipulated Transitions

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Squares</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Habit (rows)</td>
<td>248,645</td>
<td>1</td>
<td>248,645</td>
<td>14.104**</td>
</tr>
<tr>
<td>Grammaticalness</td>
<td>2,611,872</td>
<td>3</td>
<td>870,624</td>
<td>49.383**</td>
</tr>
<tr>
<td>Interaction</td>
<td>147,415</td>
<td>3</td>
<td>49,138</td>
<td>2.787*</td>
</tr>
<tr>
<td>Within</td>
<td>1,269,406</td>
<td>72</td>
<td>17,631</td>
<td></td>
</tr>
</tbody>
</table>

** p < .01  
* p < .05

As can be seen in Table 3, both main effects are highly significant. The interaction between degrees of grammaticalness and habit is also significant at the .05 level. In spite of the partial correction for differences in learning rates which was introduced by the use of the measure described above, considerable differences in TEP
still appeared to exist. Therefore, a Bartlett's test for homogeneity of variance was performed (Edwards, 1960, pp. 125-126). This test resulted in a Chi Square of 18.47, which is significant at the .01 level. However, as Edwards (1960, p. 132) points out:

There is considerable evidence to indicate that in the common case in experimental work where the number of observations is the same for the various treatments, the $F$ test for the means in the analysis of variance is little influenced by heterogeneity of variance. As Box (1953) has emphasized, since the $F$ test is very insensitive to nonnormality and since with equal n's it is also insensitive to variance inequalities, it would be best to accept the fact that it can be used safely under most conditions. The $F$ test of the analysis of variance, in other words, remains a robust test under a variety of violations of the assumptions on which it is mathematically based.

Individual $t$ tests were computed to determine the influence of habit on the manipulated transition in the four degrees of grammaticalness. Homogeneity of variance was found to exist between the two conditions (habit and familiarization) within one list. Table 4 lists the $F$ obtained between variances within each list, as well as the $t$ obtained for each degree of grammaticalness.
Table 4

Test for Homogeneity of Variance and Test of Significance of Effect of Habit

<table>
<thead>
<tr>
<th>Degree of Grammaticalness</th>
<th>F</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>List I</td>
<td>1.075</td>
<td>2.75 **</td>
</tr>
<tr>
<td>List II</td>
<td>1.481</td>
<td>1.73 *</td>
</tr>
<tr>
<td>List III</td>
<td>1.829</td>
<td>1.42</td>
</tr>
<tr>
<td>List IV</td>
<td>1.747</td>
<td>1.49</td>
</tr>
</tbody>
</table>

** p < .01  
* p = .05

As can be seen in Table 4, the difference between the habit group and the familiarization group was significant only for Lists I and II. This difference was highly significant for List I, but barely reached the .05 level for List II. These findings, combined with the significant interaction obtained in the analysis of variance shown in Table 3, lend strong support to Hypothesis 2.

The highly significant column effect obtained can also be related to Hypothesis 1. Not only does learning proceed faster as grammaticalness increases, but the TEPs
become smaller (at least for the transitions with which we are concerned in this analysis). The TEP may be regarded as an index of integration difficulty. Viewed in this light, the decrease in TEP and the increase in percentage of words correctly emitted may be regarded as a manifestation of the same phenomenon. In other words, the sequences of low grammaticality are harder to learn because the units of which they are composed are harder to integrate.

As degree of grammaticality increases, the influence of a previously established association between adjacent words becomes less pronounced. It is interesting to note the rather sudden change in the \( t \) values recorded in Table 4. Even though the \( t \) value for List II still reaches significance, it is considerably lower than that obtained for List I. A parallel might be drawn here with the large increase in number of words emitted and percentage of words correct observed between List I and List II.

**Hypothesis 3.** The distribution of errors in word-to-word transitions is more random in ungrammatical sequences than in grammatical sequences, where the pattern of errors is strongly influenced by structure.

The TEPs were computed for all familiarization groups.
These probabilities were computed across Ss and across trials for each transition within each sequence. The probability was arrived at in essentially the same fashion as the probability score for each S described earlier, with the exception that fractions obtained for each transition were summed across Ss, whereby the earlier measure was summed for one S across the manipulated transitions in the eight sequences within the S's list. The probabilities obtained reflect the number of times a transition was correct in light of the total number of possible occurrences for that particular transition, i.e., the number of times the first member of the transition pair occurred. The scores obtained are listed in Appendix B.

For purpose of comparison, the TEPs for Lists I and IV have been plotted on Figure 2. The distributions of errors for lists II and III are fairly similar to that of List IV; however, they have a wider range and a lower peak at .00 probability. While the distribution for List I appears to be more random than that of List IV, the effect might be caused only by the spreading of the scores over a wider possible range, and may be an artifact caused by inadequate sensitivity of the measure used. It is felt,
Figure 2
Distribution of Transitional Error Probabilities in Lists I and IV
therefore, that no conclusions regarding Hypothesis 3 can be reached on the basis of these data.

**Further aspects of the data**

List I sequences, for the familiarization groups only, were also analyzed in an attempt to find if they would follow a typical serial curve. Four of these sequences were composed of five words. The other four sequences had seven words each. The number of words correct in each position was summed across five-word sequences, and across seven-word sequences. The curves obtained by plotting the number of words correct in each ordinal position can be seen in Figure 3. Due to the difficulty of proving statistically that these curves are, in fact, typical bowed serial curves, such an analysis was not performed. However, a visual inspection suggests that they do resemble the typical serial curve. Epstein (1962) failed to obtain a typical serial curve when the words were presented as a whole sequence rather than serially.

A few typical sequences within each list were also singled out for an examination of the pattern of TEPs, and profiles of these sequences were constructed. The profile of Sequence 3, List IV, can be found in Figure 4. A high
Figure 3

Number of Words Correct in Each Position for Five and Seven Word Sequences in List I
Mary beautiful poems were written by this man.

Figure 4
Profile of Transitional Error Probabilities
Sequence 3, List IV
TEP (.319) coincides with the subject-verb transition (poems-were), with a much smaller peak indicating the first word of the prepositional phrase (by this man). While other sentences in List IV may not have such striking profiles, higher TEPs tend to occur at between-phrase transitions than at within-phrase transitions. Sequences 1 and 3 of List IV were selected because their phrase structure was not uncommon and average-length phrases occurred. The between-phrase and within-phrase transitions were compared in these two sequences. Using a Sign test (Siegel, 1956) the difference in TEP for these two types of transition was significant at the .002 level. These results concur with those of Johnson (1963).

It was mentioned in Chapter II that two "anomalous" sentences were included in both Lists II and III. The profile obtained for Sequence 5, List III is shown in Figure 5. This profile of errors appears to follow closely the grammatical structure of the sentence; the highest TEP (.209) is found between subject and verb (horse-was). Three of the anomalous sentences were analyzed in terms of difference in TEP between and within phrases. Sentence 3, List III was not included in this analysis because it is in question form. TEPs at between-phrase transitions were
A greenish horse was heard smoking orange

Figure 5
Profile of Transitional Error Probabilities
Sequence 5, List III
significantly higher than TEPs at within-phrase transitions (Mann-Whitney $U = 9.5$, $p < .01$). This similarity between sentences picked as highly grammatical and those sequences (of a lower rating on grammaticalness) in which structure was preserved, but "meaning" absent, would lend strong intuitive support to the notion that the pattern of errors is determined by structure, not meaning.

The interference caused by unusual constructions is also shown in the pattern of errors found in those sequences where phrases occur in positions not usually found in English. Sequence 3, List II, might be taken as an example of this type of construction. Figure 6 shows the profile of the sequence: They will come today back home. The highest peaks (.4150 and .4260) occur between come-today and today-back, where there is a reversal of usual English sequence. The TEPs at these two points were compared with the TEPs in the rest of the sequence for all Ss in the familiarization group. Using a Sign test, the TEPs at these two points were found to be significantly higher ($p = .008$).
Figure 6

Profile of Transitional Error Probabilities

Sequence 3, List II
Summary

The data were analyzed along the lines of the hypotheses put forth in Chapter I. Hypotheses 1 and 2 were confirmed; the more grammatical sequences were learned faster, and a definite interaction was found between the degree of grammaticalness and the influence of previously established associations.
CHAPTER XV

INTERPRETATION OF DATA AND DISCUSSION

Relationship between degree of grammaticalness and speed of learning

The data presented in Chapter III show rather unequivocably that speed of learning is related to degree of grammaticalness. These findings are consistent with those of Epstein (1961, 1962) and Miller and Selfridge (1950), but are more specific. The important dimension in the present study was grammaticalness as measured by Ss' judgments. Epstein (1961) developed groups of sequences in an attempt to introduce different degrees of grammatical structure. While the operations by which he derived his sequences undoubtedly did change the degree of structure, an independent judgment of grammaticalness seems to be closer to the linguistic meaning of grammar than a a priori decision.

The criticism of lack of counterbalancing leveled at the Miller and Selfridge study (Marks and Jack, 1952)
does not apply to the present experiment. Homogeneous lists were used and only one list of sequences was learned by any one S. The present study differed from the Miller and Selfridge research in several other important aspects. Miller and Selfridge were investigating meaning, not structure, and introduced degrees by using statistical approximations to English. It will also be recalled that immediate recall was measured, and not learning.

What are some of the alternatives that can account for the influence of grammaticalness on learning? As all words used were chosen from the Thorndike and Lorge (1944) list of 30,000 commonest words, the hypothesis of differential learning because of frequency of previous exposure to individual response items can be discounted. The following possibilities are offered:

1. Memorization is facilitated by encoding the material into "chunks" (Miller, 1956). Function words (used only in Lists II, III, and IV) may provide markers for the unit boundaries which form a chunk (Braine, 1963). In random strings of words, no fixed marker occurs; not only is it harder to divide into chunks, but the boundaries
of these chunks probably fluctuate a great deal from trial to trial, thus making for less efficient encoding.

2. Function words were shown by Glanzer (1962) to be learned as the middle item of an association more rapidly than content words. Glanzer concluded that function words were incomplete as units, but formed a unit when minimal context was added. If function words form units with other words, then those sequences in which function words were included actually consisted of fewer units than those in which content words only were used. As mentioned earlier, all sequences in List I were composed only of content words. The greater number of units present in List I sequences could account for the differential learning rates.

3. Each S was required to read each sequence aloud, thereby providing auditory as well as visual stimuli. The rhythm provided by stress and intonation patterns may have furnished an added dimension which could facilitate learning. The added presence of rhythm could work in a manner similar to that of a compound stimulus. It has been shown (Hill and Wickens, 1962) that compounding a stimulus facilitates learning.
The effect of rhythm may be differential in the different types of sequences used. In random strings, the rhythm may not be consistent from trial to trial. As mentioned in alternative 1, the absence of markers (function words) removes a source of consistency in successive readings. Furthermore, the rhythm obtained when reading a list of random words may sound strange, not having been experienced many times previously. Function words are typically unaccented whereas content words are stressed. The usual alternation of stressed and unstressed words is absent in random strings. Of course, intonation and stress patterns also provide readily available unit "markers".

The above alternatives are far from being mutually exclusive, even though they reflect different points of view. The possibility exists that the experimental situation used in the present study is not an accurate representation of actual language behavior. If the results obtained reflect only differences in learning strategy (Johnson, 1963) then the first alternative might prevail.
Alternative 2 would tend to present a view of language as a left-to-right progression rather than a hierarchical arrangement. It would also tend to reduce function words to a status similar to that of an inflectional ending (grammatical tag) rather than a marker for unit boundaries.

A combination of alternatives 1 and 3 would be acceptable to present views on language learning. That intonation patterns form a great part of our concept of "grammatical" is suggested by both Chomsky (1957) and Hill (1961). In discussing the difference between grammatical but nonsensical sequences and ungrammatical ones, Chomsky remarked that an ungrammatical sequence of words would be read "with a falling intonation on each word; in fact, with just the intonation pattern given to any sequence of unrelated words" (Chomsky, 1957, p. 16). This view was challenged by Hill (1961) who superimposed a phrase-like intonation pattern on Chomsky's ungrammatical string. This intonation pattern made the sequence more acceptable to Hill's informants.

**Differential role of habit**

The analysis of variance summarized in Chapter III indicates a significant interaction between habit and
degree of grammaticalness. The tests performed between the habit and familiarization groups for each degree of grammaticalness confirmed the interaction hypothesis and established its direction.

In random strings, a previously established association between two adjacent words lowered the probability of a transitional error. This probability was also significantly lowered (but at a lower confidence level) in List II. Little difference was observable when grammatical sentences were involved.

These findings offer strong support for the view that language involves something besides simple word-to-word associations. Most current discussions on the structure of language propose a hierarchical arrangement of units. (Braine, 1963; Johnson, 1963; Osgood, 1954, 1957, 1963.) Braine advances the view that associations are established between "primary phrases". Johnson proposes that operations, rather than phrases, are involved in these associations. The present data are compatible with either interpretation.

**Grammaticalness: continuous or discrete?**

Whether grammaticalness should be considered as a continuous or dichotomous variable seems to have been
treated ambiguously by linguists. Chomsky (1957) for example, advanced the idea that there are degrees of grammaticalness, but continued his discussion by treating it as an either-or proposition. Maclay and Sleator (1960) required their Ss to make a yes-no judgment on the dimension of grammaticalness, but wrote about the proportion of positive judgments received for different categories of sequences as though they reflected some difference in degree.

The data presented in this paper do not provide a clear-cut answer to this question although they do indicate some trends. On the one hand, the high rank correlation (.828) obtained between learning and judged degree of grammaticalness tends to support the view that a continuum exists. On the other hand, attention was focused earlier on the relatively sudden increase in number of words correct and percentage correct occurring between Lists I and II, with smaller increases thereafter. It will also be recalled that only differences in learning rate between List I and the other three lists were significant. Rather than view the sequences as either differing quantitatively or being part of a grammatical-ungrammatical dichotomy, an alternative view might be held.
A three-way classification could be used: ungrammatical, unstructured (List I); grammatical, structured (List IV); structured, but incorrectly (Lists II and III). The sequences with faulty structures might be considered a special case of transformation. In the case of faulty structure, the structurally correct form of the sequence could be considered the kernel sentence from which the sequence is derived. Miller (1962) in discussing an experiment in which he compared reaction time for kernel sentences and different transformations, advanced the view that Ss remember the kernel plus some kind of implicit code. This code enables them to make the transformations necessary for correct recitation of the sentence. The same mechanism might be invoked in the memorization of sentences with faulty structure. The S might remember the "kernel" sentence plus some kind of code which signifies that construction is incorrect in some particular way.

The hypothesis that Ss reacted to the sequences with faulty structure in Lists II and III as kinds of transformations receives some support from the actual performance of the Ss while learning. The sequence was often emitted in a correct form (i.e., grammatically correct) in the
early trials. The extra step involved in remembering the "transformation code" would easily account for the difference in learning between Lists II and III and List IV.

The apparent disruption in learning caused by an uncommon structure can be explained without recourse to a transformational hypothesis. It can be accounted for by the influence of perceptual habits. In this respect it can be considered similar to a study reported by Postman, Bruner and Walk (1951) in which they found that embedding a single reverse-printed letter in a meaningful word lengthened the tachistoscopic exposure time more than embedding this same letter in a nonsense sequence.

Similarly, Miller, Postman and Bruner (1954) reported that varying the sequential probabilities of orthographic materials affected their recognition time. Both of these studies clearly suggest that disruption of perceptual habits influences learning. Braine (1963) has suggested that speech perception is a special case of Gibsonian perceptual learning.

Other aspects of the data

Osgood (1963) implies that phrases have no psychological reality. However, the profiles of TEPs pictured in Figures 4, 5 and 6 strongly suggest the psychological
reality of phrase structure rules. The reality of phrase structure rules was also clearly demonstrated by Johnson (1963). At an earlier date, Maclay and Osgood's (1959) research on hesitation phenomena also lent strong support to the reality of phrase structure rules. Maclay and Osgood's data showed longer pauses (filled pauses) occurring at phrase transitions, with shorter pauses (unfilled pauses) occurring before content words. These investigators conducted their research on spontaneous speech, where both semantic and syntactic decisions had to be made. The shorter pauses were thought to reflect only one kind of decision (before content words, a semantic decision). Longer pauses combined syntactic and semantic decisions. In the present study, the object of analysis was not spontaneous speech, but material which had been previously prepared and which the Ss had to reproduce. The fact that reproduction, and not production, of speech was involved could presumably have eliminated most semantic decisions. The errors recorded could therefore be regarded as reflecting structural decisions to a higher degree than would be the case in a natural speech situation. As an examination of the sequences will show,
widely differing sentence constructions were used, thereby maximizing the uncertainty of the decisions involved, especially at between-phrase transitions.

The similarity in profile of errors between grammatical and anomalous sentences was reported in Chapter III. Judgments made of the grammaticalness of anomalous sentences show a low degree of reliability (Johnson and Frankart, 1963). The present research would indicate that, in a learning situation, Ss do respond to these sequences as though they were grammatical. Correct structure, and not meaning, appears to be the determining factor in the pattern of errors obtained.

The present research also offers some intuitive support to the psychological reality of a transformational grammar. A transformational account of grammatical phenomena has been receiving wide support in linguistic circles (Chomsky, 1957; Lees, 1964; Maclay, 1964). An observation of the Ss' behavior and a record of their responses revealed that, when a passive construction was involved, there was a strong tendency for the kernel sentence to occur, especially in the early trials.
A theory of language

No attempt will be made to arrive at a large-scale theory of language behavior, but a combination of several outstanding theories will be proposed.

Braine (1963) proposes a theory which he restricts to the learning of the kernel grammar. This theory states that what is learned are the locations of units. There is a hierarchy of units, and the location which is learned is the location of a unit within the next-larger unit. As mentioned earlier, Braine considers the learning of location a special case of perceptual learning.

The question of what goes into these locations, or of what units are interchangeable within the structure, seems adequately handled by Jenkins's (1964) mediation theory. Jenkins proposes that these units emerge into classes through the mechanisms of stimulus and response equivalence. Equivalence paradigms are formed by the occurrence of the same type of unit in the same context.

Support for Jenkins's views can be found in the word-association data of Brown and Berko (1960) and Ervin (1961). These investigators have shown that word associations in children tend to shift to same-class words as a function of age. Ervin (1961) proposed a model
based on a number of erroneous anticipations to account for the change in strength of association between same-class units found as a function of age. This model was tested by McNeil (1963). As predicted by the model, strength of paradigmatic associations increased with frequency of previous exposure in similar contexts. The model can be viewed as a mediation paradigm, where the antecedent context shared by same-class words serves as the mediator.

The area of transformations could be handled in the manner proposed by Miller (1962) who theorized that a transformation can be conceptualized as a kernel sentence plus some implicit code. This implicit code would vary for different types of transformations. Multiple transformations would require the use of several codes. The increase in complexity of decoding operations caused by the use of multiple codes is reflected in the longer latency required for multiple transforms (Miller, 1962; Postman and Underwood, 1963).

While the above account can be accused of oversimplification, it is believed that it could fit a larger amount of data on language, including the ones presented in this paper.
SUMMARY AND IMPLICATIONS FOR RESEARCH

Summary

The present study purported to investigate the psychological reality of the concept of grammaticalness, and to relate the dimensions of habit and grammaticalness. Four lists of eight sequences were constructed. One list was composed of random strings that had been judged as very low on a scale of grammaticalness. Highly grammatical sentences formed a list at the other extreme. Two lists were constructed from sequences in the middle range of grammaticalness.

These lists were presented as a paired-associate task, using digits as stimuli and the sequences as responses. Two subgroups of 10 Ss each learned each list. These subgroups differed in the task which was required of them before memorizing the sequences. One subgroup, called the habit group, learned as a paired-associate task the words forming the major between-phrase transition of each
sequence. These same words were presented in random order to the other group, called the familiarization group. The degree of grammaticalness of each list was found to influence its ease of learning in the expected direction, the more grammatical sequences being easier to learn. The probability of a transitional error was computed for each manipulated transition. The words bounding these transitions formed the first paired-associate task, for the habit group and the familiarization list for the familiarization group. The transitional error probability (TEP) showed a significant change as degree of grammaticalness increased. An interaction between degree of grammaticalness of the list and the influence of habit through previously established associations was also evidenced.

The data were interpreted as indicating that word-to-word associations (at least at between-phrase transitions) are relatively unimportant when grammatical structure is present. This supports a view of language as a hierarchy of units, with associations between larger units at the higher levels. The dimension of grammaticalness was further examined to determine whether it was continuous or discrete. As large differences were observed between the random sequences and those with some grammatical
structure, (with relatively minor changes between somewhat ungrammatical and completely grammatical sequences) the theory was proposed that perhaps a three-way classification should be used. The three categories included in this classification would be unstructured, correctly structured and incorrectly structured. (Correct is used here in the sense that the construction is usual in the language population.) Sequences with faulty structure strongly resemble correct sequences in their pattern of error, but tend to show a lower rate of learning.

Implications for research

Several close variations of the procedure used in this study could provide basis for research. Glanzer (1962) found that function words were learned more slowly than content words when learned as a member of a pair but were learned faster when embedded in a triad. The paired-associate lists used in the habit group might be replaced by triads. The habit built by the formation of these triads may interact with grammaticalness in a different fashion.

A study, similar to the present one, but with somewhat simplified material, could be focused on children at different age levels. It would be predicted that the
influence of word-to-word associations in grammatical sequences becomes less and less marked as a function of age, as the pattern imposed by grammatical structure becomes more firmly established. Would a certain age group emerge as a "turning point"? Would there be a parallel with the word association data?

The sequences with median rating on grammaticalness which were included in the present study involved a destruction of structure at the phrase level, i.e., phrases were interchanged in some of the sequences. The destruction of structure within phrases might be an interesting topic to study. What effect would we find on the pattern of TEP's if the order of phrases is preserved, and order within phrases changed?

The idea that sentence construction can be conceived as a hierarchy of units forming a kind of tree has been presented. There is some question whether this "tree" builds up or down. Does the child start with a sentence as just a string of words and gradually group these words into larger units? The evidence at the present time points to the opposite view. Brown and Fraser (1963) found a selective reduction occurred by omitting function words that carry little information. How, then, are these
higher order units bound together? Perhaps those words which carry most of the meaning are used as "code" words, and it is these words which enter into associations. A technique similar to the one used in the present study could be used to explore this possibility. The paired-associate task, in this case, would involve the code words. These words could be determined by a canceling-out method (instructing Ss to keep crossing out the least important words) or some other suitable means.

When emitting a sentence, all "code" words may be readily available because of the intended meaning. However, function words, which are almost devoid of meaning, may have to be chosen at the time of emission, thereby giving rise to hesitation or to a high rate of error. If there are only a few alternatives available (e.g., the or a) the hesitation should be very minor; however, if more alternatives are available (e.g., prepositions or conjunctions) hesitation or rate of error should be more marked.

This hypothesis could be checked by a procedure similar to that described in this paper. In the same manner, subject-verb transitions (which usually have a high TEP) would be compared in sequences where the verb is high in meaning and those in which the verb is closer to the function-word class
(e.g., auxilliary verbs). The relative influence of habit as word-to-word association on these two types of transitions might give some insight into the kinds of units that enter into associations to form grammatical sequences. The whole field of transformations could also be brought under analysis by similar means.

As Miller (1963) reports in the Second California Conference on Verbal Learning and Verbal Behavior:

A psychologist has a variety of experimental techniques that he can bring to bear on these problems (of linguistics)........less than half the cells (of a problem-by-approach matrix) have as yet received any study at all, and many others have only been considered in a preliminary way.

Let us hope that the filling of these cells will be fruitful.
List I

Prose nestle raisin liner chafe mirage loop.

1.49

Pick grew dark wrong town produce suppose.

1.74

Leg remember field declare movement mount today.

1.81

Human door matter grant street century inch.

1.79

Reason pull month watch iron.

1.74

Queen move receive ill earth.

1.84

Joy position stand people neck.

1.60

Modern turn purpose given matter.

1.88
List II

Tired windmills rested a lot of elephants.

4.42

Probably although he may surprise us.

4.19

They will come today back home.

4.06

The small child seems very sleeping.

4.25

Six intuitions ate highly across the right.

3.90

John found in the house the boy.

4.14

About the time that better models appeared.

4.44

Bill reads books and so reads John.

3.56
List III

The man saw not the danger.

5.23

The young policeman brought in him.

5.28

What do recent stones invest?

5.44

Those children who appear with the natives.

4.58

A greenish horse was heard smoking oranges.

4.81

It's certainly better to drive than walking.

4.60

In order to avoid any future complications.

4.81

Those plants ought not to be watered much.

5.00
<table>
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<tbody>
<tr>
<td>The chairman's most important job is timing. 8.58</td>
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<tr>
<td>He should recognize her abilities in music. 8.05</td>
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<tr>
<td>Many beautiful poems were written by this man. 8.32</td>
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<tr>
<td>Several other couples will also be invited. 8.44</td>
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<tr>
<td>Was the automobile repaired when they left? 7.83</td>
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<tr>
<td>The dog was hit by a big truck. 8.34</td>
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<td>Did you water the flowers today? 8.64</td>
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<td>We will be home next week. 8.26</td>
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## Paired Associate Lists

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<td>move</td>
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<td>stand</td>
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<td>come</td>
<td>today</td>
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<td>time</td>
<td>that</td>
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<tr>
<td>books</td>
<td>and</td>
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| job      | is     |
| recognize| her    |
| poems    | were   |
| couples  | will   |
| repaired | when   |
| be       | home   |

*Note: The table above contains random word pairs that do not form coherent sentences.*
### Random Lists

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APPENDIX B
## Percentage of Words Correctly Emitted

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## Percentage of Words Correct by Trial

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<th>Trial 12</th>
<th>Trial 13</th>
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<th>Trial 15</th>
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### Transitional Error Probability Scores for Manipulated Transitions

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*(All scores have been multiplied by 1,000)*
# Transitional Error Probabilities

## List I

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## Transitional Error Probabilities

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AUTOBIOGRAPHY

I, Jeanne Delpierre Frankart, was born in Jumet, Belgium, December 4, 1927. I graduated from the Lycee de l'Etat in Charleroi, Belgium, in 1945. In 1946 I attended Western College for Women, Oxford, Ohio, under the auspices of the Institute for International Education. I received an A.B. degree in chemistry from this institution in 1948, having served as student assistant in the French Department for one year. I taught in secondary and elementary schools for several years while attending Miami University, Oxford, Ohio, as a part-time student. I received my Master's degree in Elementary Education from Miami University in 1960. I was appointed teaching assistant in the Department of Psychology of Ohio State University in 1961 and held this position for one year. While at Ohio State University, I was a National Science Fellow during the summer of 1962.

I am now employed as a School Psychologist in the City Schools of Springfield, Ohio.