1979

Organization of movement in memory.

Sandra Kathleen Elizabeth White. Romanow

University of Windsor

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LA THÈSE A ÉTÉ MICROFILMÉE TELLE QUE NOUS L'AVONS RÉCUE
ORGANIZATION OF MOVEMENT IN MEMORY

by

Sandra Kathleen Elizabeth White Romanow

A Thesis submitted to the Faculty of Graduate Studies through the Faculty of Human Kinetics in Partial Fulfillment of the requirements for the Degree of Master of Human Kinetics at The University of Windsor

Windsor, Ontario Canada 1979
ABSTRACT

The principle objectives of the present research were to determine whether the basis for organizational processes in motor memory is phonetic or semantic in nature. In verbal learning research, the serial position curve has not been utilized with organizational studies, however motor learning researchers have used it to explain organization based on chunking. Since order of recall is irrelevant in the formation of the serial position curve and since order of recall is important in the analysis of organization, serial position effects were examined, not for evidence of chunking but rather to confirm whether or not secondary organization had occurred.

Twelve, female undergraduates from the Human Kinetics motor learning course participated in three sessions lasting 60, 60 and 30 minutes. The apparatus consisted of a pantograph which coupled the subjects' movements with those of the experimenter in a one-to-one correspondence.

For the entire first and half of the second session, the subject committed to motor memory the universal set of 20 movement patterns received passively by means of the pantograph. The universal set represented three different semantic categories: ten six-sided, closed figures; five curved, closed patterns; and the extents of five linear
movements. Only when the subject could recall the form and structure of the 15 closed patterns and the extents (within 1.5 cm of 10, 16, 22, 28, and 34 cm) of the five linear movements, three consecutive times in a randomly presented order was the criterion for having memorized the patterns attained. When the criterion was reached, the experimental or Testing Phase was administered.

After the subject received an 8 x 8 balanced square presentation of eight of the 10 closed, six-sided movement patterns in Experiment 1, which had previously been rated by the subjects and found to have similar high meaningfulness ratings; Tulving's (1962) recall matrix formula was employed to determine whether subjective organization had occurred. In Experiment 2 each subject received a single trial presentation of 12 randomly presented patterns representing the three semantic categories equally. The recall of these patterns was analyzed according to Bousfield's (1953) index of repetition formula and the clustering score for each subject was determined.

The per cent of correct recalls was plotted against serial position in both experiments to determine whether serial position effects were present. This provided the confirmatory check for the secondary organization measures.

In agreement with the verbal memory literature, both subjective organization and clustering based on semantic
categories of movement patterns was observed. The absence of the serial position curve was assurance that subjects' recall performance was indeed attributed to secondary organization of the movement patterns.

Either dual-coding or depth-of-processing theories could serve as adequate explanations for the organizing activity which took place. The dual-coding hypothesis suggests that visually imaging a pattern triggers the kinesthetic recall of that pattern, for although visual and kinesthetic codes are separate, they are interconnected. The depth-of-processing framework suggests that movements which are encoded at a semantic level are more deeply embedded into memory through elaboration. The attachment of labels or associations in the present study allowed such semantic processing to occur, thus resulting in a deeper encoding of patterns which evoked such labels. The linear movements on the other hand, were not encoded as deeply because recall was based on movement attributes rather than semantics. These results suggest the lexicon of movement has both semantic and phonetic dimensions. Future research should be directed toward manipulation of variables such as imagery and labelling which control the organizational process.
ACKNOWLEDGEMENTS

I would like to express my heartfelt gratitude to my mentor, Dr. Jack Leavitt for making this project not only a challenge but a most enjoyable and informative learning experience as well. His examples of expertise, kindness, encouragement and enthusiasm have and will continue to inspire me, not only in my schooling, but also in my education.

To Dr. T. Hirota and Dr. Wayne Marino I extend my sincere thanks for the pertinent advice and assistance which they offered me throughout the completion of this manuscript. The friendly encouragement and worthwhile suggestions given me by my colleague Tim Lee, were also greatly appreciated.

Finally I would like to thank Martin, my understanding husband, for bravely 'batching it' in Waterloo while I finished the thesis in Windsor.
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CHAPTER I

INTRODUCTION

Organization, or the mental grouping and relating of items or events, is fundamental to both learning and memory. Primary organization is the arranging of events based on a single exposure to those events, while secondary organization is the result of repeated exposures to the items which are to be remembered (Tulving, 1968). Secondary organization not only allows large amounts of information to be processed, thus increasing man's capacity as a limited information processor, but also permits a more efficient operation of search processes for recall. Consequently, secondary organization of information in memory has received concentrated attention, particularly in the area of verbal learning, because language, the basic experimental variable, with its syntax, phonetics, semantics and vocabulary, is subject to systematic manipulation and objective measurement. On the other hand, because the language or lexicon of movement is as yet unknown, a minimal amount of related research has been reported in psycho-motor learning. Since the performance and learning of motor skills are essentially based upon the organization of movement patterns in memory, the need to investigate the secondary organization of movement.
information is apparent and the purpose of this study. Specifically, the main objective of this research was to determine the basis of secondary organization of movement patterns in memory, in anticipation of initiating an understanding of the lexicon of movement.

The free recall technique, whereby the recall order of the to-be remembered list items is not specified by the experimenter, but left to the subject's own strategies and devices, is fundamental to the study of secondary organization, and has been used for this purpose in verbal learning (Bousfield, 1953; Jenkins & Russell, 1952; Rundus, 1974).

In analyzing the free recall of movements, researchers have employed the serial position curve (Magill, 1978; Toole & Pyne; 1979; Wilberg & Girard, 1977). The essential idea underlying the traditionally U-shaped serial position curve is the relation between the ordinal position of an item and the probability of its correct recall. It is comprised of a primacy effect over the first few items, an asymptote over the middle items and a recency effect over the last few items. While list length, presentation rates, modality and rehearsal effects are among the many verbal learning variables which have been manipulated to observe changes if any, in the serial position curve, the results have been discussed in terms of support for the hypotheses that at least two separate recall mechanisms are involved in free recall—recency
effects demonstrating primary or short term memory and primacy effects the result of secondary or long term memory.

While serial position effects have never been interpreted as evidence for organizational processes in the verbal learning literature, Magill (1977) and Toole & Pyne (1979) have used the serial position curve to investigate primary organization for the free recall of linear movements. By definition however, the order of recall is irrelevant to the formation of the serial position curve and statements about chunking or how a subject organizes are not possible from serial position data. The only information that serial position effects can offer is that organization has not occurred because an organized recall would show an increase in the per cent correct recall of all list items, thus eliminating the curve. However, the serial position curve should not be dismissed as an organizational research method but used differently. It can serve as a check for the presence of organization—for its occurrence is the antithesis of the presence of organization.

There is one condition which must be met if the serial position curve is to be used as an indication of organization— or lack of it. All list items must have an equal opportunity of being retrieved to avoid biasing a subject's recall. Thus, by ensuring all items have similar meaningfulness ratings and are consequently of equal saliency, control of this potentially confounding variable will be maintained.
There is also the problem of whether single trial presentation of list items from the same category should be employed to demonstrate a valid indication of secondary organization. The verbal learning research which has employed single trial presentations, has utilized lists which contain several categories of information which the subject organizes. This measure of secondary organization is called clustering and occurs when a subject free recalls "sequences of associates that have essential relationships between the members", more often than by chance (Bousfield, 1953, p.299). Items to be recalled are selected by the experimenter on the basis of categories for presentation and the subject need only observe what organization is present, store it, and transmit the structure to recall to facilitate performance. (Diewert & Stelmach, 1978, p.16).

Subjective organization, the second measure of secondary organization, refers to the "extent to which subjects' recall of verbal items presented in different orders on successive trials is structured sequentially" (Tulving, 1962). Since the experimenter provides only one category of list items and does not determine the grouping or categorization of the to-be-remembered items prior to the test, the subject is forced to generate his own organization, rather than merely recognizing that of the experimenter. Consequently, subjective organization measurements are better suited to the
investigation of organizational processes.

Nevertheless, there are still problems with the subjective organization approach. Researchers continue to have difficulty in identifying the basis of a subject's organization once it has been evidenced because discriminating between the functional stimulus, (that which the subject perceives) and the nominal stimulus, (that which is actually presented by the experimenter), is seldom possible. Further complications arise in assessments because each individual has a unique mode of organization. Furthermore, subjective organization is affected by whether the subject is learning or has already committed to memory a list of items. Tulving (1968) emphasizes the importance of ensuring that items are definitely in the subject's long term store prior to free recall.

There are no published data involving either subjective organization or clustering or the serial position curve in conjunction with these two measures for the free recall of movement patterns. Consequently, an initial experiment to determine whether subjective organization and the serial position curve, at trial one, are evident in the free recall of movement patterns is an important first step in establishing a potential measuring device for organization of movement in memory.

In order to determine whether the language of movement
is organized according to properties which are phonetic (based on the order of input of the movement patterns) or semantic (based on the form or figural image and the structure or geometric connections of the movement pattern) in nature, Experiment 2 was conducted.
CHAPTER II

METHODOLOGY

The present study involved two experiments. To avoid repetition the common components of the experiments will be presented with the distinctive features of each experiment outlined separately.

Subjects

Twelve right-handed University of Windsor female students served as subjects in both experiments and received credit towards their mark in the undergraduate Human Kinetics motor learning course. Their mean age was 22.7 with a standard deviation of 1.1 years. They were naive as to the purposes of both experiments.

Apparatus

The apparatus employed was identical for both experiments. It consisted of a pantograph secured to a 30 cm square metal frame (see Fig. 1) fastened to a table top 78 cm in height. The range of movement on both ends of the pantograph was a circumference of approximately 81 cm. Handles were attached to each end of the pantograph, thus the subjects' movement was coupled to the experimenter's
Figure 1. Kinesthetic apparatus (pantograph).
in a one-to-one correspondence.

**Stimulus Materials**

Ten closed, six-sided, and five closed, curved novel plexiglass patterns each 100 cm in perimeter and the extents of five linear movements, comprised the list of movement patterns to be remembered. Linear movements were 10, 16, 22, 28 and 34 cm. (See Figure 2 for the drawings of the 20 movement patterns.) The 20 patterns formed the universal set from which the patterns of Experiment 1 and 2 were chosen. At no time did subjects receive visual inspection of either the movement patterns or their recalls of the patterns, thus learning occurred through the kinesthetic system.

**Procedure**

All subjects were tested individually for a total of three sessions lasting approximately 60, 60, and 30 minutes respectively. The sessions were administered on either consecutive days or separated by a single day. The entire first session and half of the second session were devoted to the Learning Phase; the Testing Phases for Experiments 1 and 2 took place in the second and third sessions respectively.
Figure 2. Formed drawings of universal set of movement patterns.

* Acceptable range for item to be considered correctly recalled.
Learning Phase: The two sessions were occupied with the subject learning the 20 movement patterns. Upon the subject's arrival at the laboratory, the procedures for the Learning Phase were explained (see Appendix A for instructions). The blindfolded subject grasped the pantograph handle with her right hand which was then moved through each of the movement patterns by the experimenter, starting and terminating at the same point for each pattern. After the presentation of each pattern, the subject, while still blindfolded, drew the pattern on paper located on the table top to the right of the pantograph. Following each attempt at recall, the subject was informed of the correctness of the recalled pattern. For the closed figures, correctness was based on the form and structure of the pattern but not size. Correctness of linear movements was based on extent but not direction. Subjects were required to be within ±1.5 cm of the extents to be considered having correctly recalled. For example, recall of the 10 cm linear movement was considered correct provided the subject terminated the movement between 8.5 and 11.5 cm. If the movement was 34 cm, a recall ranging from 32.5 to 35.5 cm was deemed correct. The distance from 32.5 to 35.5 was termed an errorless category. To make each linear movement noticeably different from the others, a distance of 2 cm separated each errorless category. All linear movements were presented to the subjects at a 45° angle from the coronal plane.
Knowledge of results concerning either form and structure of the closed movement patterns or extent of the linear movements were verbally provided following each recall, but excluded any type of verbalization that may have acted as possible learning or recall cues for the subject.

When the subject was able to correctly recall the form and structure of the 15 closed patterns and the extents of the linear movements three consecutive times in a randomly presented order, the criterion for having learned the patterns was attained. After all movement patterns were learned to criterion, the subject left the laboratory with the understanding a recall of the universal set without knowledge of results would take place, after a review, in the next session.

Following the initial attempt at recall of each movement pattern, the subject gave a rating of the familiarity of the movement pattern on a scale from 1 (unfamiliar) to 9 (familiar). These scores provided an assessment of the meaningfulness for each pattern (Underwood and Schulz, 1960) and served as the basis for movement pattern selection in both experiments.1 At this time subjects were also required to verbalize for 30 seconds as many associations as possible.

1 In order to maintain the time between the Learning and the Test Phases only the ratings of the first six subjects could be used in determining the patterns to be used in Experiment 1 and 2.
Testing Phase: There were two testing sessions, one for each of the two experiments. In the second session after the Learning Phase was completed, and after a five minute rest, the subject was blindfolded for a review of the 20 movement patterns. She was required to draw correctly each of the randomly presented patterns after its first presentation or, if incorrectly recalled, more practice was provided until the learning criterion for each pattern was reattained. The blindfold was then removed and the recall procedures explained.

Experiment 1

Stimulus Materials

Based on the familiarity ratings of the first six subjects, eight of the 10 six-sided, closed movement patterns were selected as the list items. Subjects did not know which or how many of the 20 originally learned movement patterns they would be required to recall.

Procedure

Detailed instructions to the subject are in Appendix A. The subject was blindfolded and presented eight trials of the same eight movement patterns in a balanced square order plus a catch trial (Fig.3). This procedure ensured that no one pattern was preceded or followed by the same pattern more
than once. Each subject received the same order of the nine trials. To prevent the subject from anticipating that only six-sided movements would have to be recalled, a catch trial consisting of eight randomly-chosen patterns from the universal set was given following the fourth trial. The catch trial included extents, curved and six-sided patterns.

Within a trial, the eight movement patterns were presented to the subject in succession. To prevent rehearsal of previously presented patterns within the trial during the time required by the experimenter to change the pattern on the pantograph, the subject was given a randomly-chosen three-digit number from which she was required to count out loud and backwards by threes for ten seconds. Following the presentation of the eighth pattern, the subject, while still blindfolded, attempted to recall (by drawing) in any order, as many of the patterns she could remember. This procedure was maintained for each of the nine trials.

Data Analysis

The basis of the correctness of the recalled movement pattern was the form and structure of the drawing. Each pattern had to be unique and recognizable in order to be considered correct.

Two measures of organization were employed. The serial position curve if evidenced would indicate no organization
and if chance expectancy was exceeded, the subjective organization measure, outlined by Tulving (1962), would indicate secondary organization. The lack of serial position curve was used as a confirmatory measure of subjective organization. That is, if the subjective organization measure for intra-subject organization exceeded chance there should be no evidence of a serial position curve. If, on the other hand, the subjective organization measure did not exceed chance, a serial position curve should be evident.

Inter-subject subjective organization was also measured to assess the commonality of organization among subjects. Thus, the data were analyzed for both intra- and inter-subject subjective organization and the percent of correctly recalled movement patterns at each serial position of Trial 1.

Experiment 2

Stimulus Materials

From the universal set of 20 movement patterns—four curved, four six-sided and four extents—were selected based on their similarity of meaningfulness ratings. These 12 patterns represented three unique movement categories and constituted the list of to-be-remembered items. Subjects were not made aware of which or how many of the originally learned movement patterns they would have to remember.
Procedure

Detailed instructions to the subject are in Appendix A. A random order of the 12 movement patterns was presented sequentially to the blindfolded subject. (See Fig. 4). To prevent rehearsal while the experimenter changed patterns, the subject was required to count out loud and backwards by threes for ten seconds from a randomly determined three-digit number. The order of the movement patterns was identical for each subject and each subject received only one trial. Following the twelfth pattern, the subject recalled, in any order, as many patterns as she could remember, while still blindfolded.

One week after the last subject completed Experiment 2, all subjects were assembled in a group and requested to independently recall (draw), in any order, the universal set of movement patterns. Order of recall was recorded. A questionnaire reflecting the subject's thought processes during the study was also administered (See Appendix B for specific questions) to gain ancillary information concerning the organizational processes of movement patterns in memory.

Data Analysis

The basis of the correctness of the recalled movement patterns was the form and structure of the closed patterns
Figure 4. Random order presentation of 12 movement patterns representing three semantic categories.
and the extents of the straight movement patterns. Each pattern had to be unique and recognizable in order to be considered correct. Following Bousfield's (1953) example, categorical intrusions were considered correct.

Two measures of organization were employed—the serial position curve for the same reasons outlined in Experiment 1 and Bousfield's (1953) index of repetition which is a measure of clustering or grouping of items into categories. Each subject's index of repetition score was compared to a chance-clustering score and if the chance score was exceeded, it was considered to be an indication that categorical clustering had occurred. A descriptive frequency analysis of cluster sizes was also made.

Data from the final recall and questionnaire were analyzed in percentages.
CHAPTER III
RESULTS

The shape of the serial position curve and the degree of subjective organization and clustering were three dependent variables examined to determine the basis of secondary organization of movement patterns. Meaningfulness ratings of the patterns were utilized to ensure that saliency, a possible confounding variable in free recall, was controlled.

Controls

Since the serial position curve is influenced by the saliency of list items, meaningfulness ratings of the 20 movement patterns, based on familiarity ratings as recommended by Underwood and Schulz (1960), were generated by all subjects. However, because of time constraints, the ratings of only the first six subjects tested were used in selecting the patterns for the experiments. Table 1 contains the mean ratings of the two groups of six subjects. The six-sided pattern values were analyzed by a $2 \times 10$ repeated measures analysis of variance to determine if the patterns chosen as list items would have been different had the data from all subjects been used in the selection of the movement patterns. There was no significant difference between the two groups of subjects, $F(1, 10) = 0.73 < .05$, neither was there a significant
Table 1

Mean Ratings of Meaningfulness For Universal Set Of Movement Patterns

<table>
<thead>
<tr>
<th>Number</th>
<th>1</th>
<th>5</th>
<th>8</th>
<th>10</th>
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<th>6</th>
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<td></td>
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<td></td>
<td></td>
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<td>Δ</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>(First Six Subjects Tested)</td>
<td></td>
<td>7.3</td>
<td>8.7</td>
<td>8.5</td>
<td>8.3</td>
<td>8.7</td>
<td>6.2</td>
<td>8.0</td>
<td>7.7</td>
<td>7.7</td>
<td>8.2</td>
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<td>8.0</td>
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<td>6.7</td>
<td>8.5</td>
<td>6.3</td>
<td>7.0</td>
<td>7.3</td>
</tr>
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| Group 2 |    | 7.3 | 8.8 | 9.0 | 7.8 | 8.5 | 8.0 | 8.0 | 8.2 | 8.5 | 7.3 | 5.8 | 8.3 | 7.8 | 8.0 | 8.0 | 8.8 | 8.7 | 8.3 | 8.2 | 8.2 |
| (Second Six Subjects Tested) |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |

| Grand Mean | 7.3 | 8.8 | 8.1 | 8.1 | 8.6 | 7.1 | 8.0 | 7.9 | 8.1 | 7.8 | 6.5 | 8.2 | 7.8 | 7.8 | 7.3 | 8.6 | 7.5 | 7.7 | 7.8 | 8.0 |

* Patterns not used in Test Phase Exp. 1
Δ Patterns not used in Test Phase Exp. 2
difference among the meaningfulness ratings of the patterns, $F(9,90) = 1.40 \ p > .05$, nor a significant interaction, $F(9,90) = 1.16 \ p > .05$, between groups and meaningfulness ratings of the movement patterns (see Table 2). Since there were no significant differences, either between groups or between meaningfulness ratings of patterns, the control of maintaining equal saliency of all items was met. The mean number of associations reported for the linear movements was 0.7; for the patterns with form and structure it was 1.5.

Experiment 1

Serial Position Curve

In Experiment 1, the subject, after committing to memory a universal set of 20 movement patterns, was presented with eight trials of the same eight movement patterns in a balanced square order. The data do not reflect the presence of a typical serial position curve because of the absence of clearly defined primacy and recency effects. The recall at position one, which would normally be the best, is in fact the worst (50%), and the recall of the pattern presented in the last position, which would also be among the items most often recalled, is also one of the worst recalled (50%). This effect is not due to the saliency of the movement patterns since there were no significant differences either between subjects or among patterns. (See Figure 5 for serial position curve).
Table 2

Two Factor Analysis of Variance With Repeated Measures on Factor B For The Meaningfulness Ratings of Six-Sided Closed Movement Patterns

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<th>SS</th>
<th>dF</th>
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<td>Between Subjects</td>
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<td></td>
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<td>'A' Main Effects (groups)</td>
<td>1.9</td>
<td>1</td>
<td>1.90</td>
<td>.73</td>
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<td>Subjects within groups</td>
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<td>10</td>
<td>2.61</td>
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<td>Within Subjects</td>
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<td>'B' Main Effects (patterns)</td>
<td>17.8</td>
<td>9</td>
<td>1.98</td>
<td>1.40</td>
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<td>'AB' Interaction</td>
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<td>9</td>
<td>1.64</td>
<td>1.16</td>
</tr>
<tr>
<td>'B' x Subjects Within groups</td>
<td>127.7</td>
<td>90</td>
<td>1.41</td>
<td></td>
</tr>
</tbody>
</table>

required \( F(1,10) \) p .05 \( \geq 4.96 \)
required \( F(9,90) \) p .05 \( \geq 7.00 \)
Figure 5. Serial position curve for the free recall of eight movement patterns on trial one.
Subjective Organization

There are two methods of calculating subjective organization. The intra-subject subjective organization method measures the organization within subjects, while the inter-subject subjective organization method is used to calculate the similarity in organization among subjects.

Using Tulving’s (1962) recall matrix formula a perfect random recall of movement patterns would result in a subjective organization score of 0.08. This score identifies the distinction between organized and random recall. The intra-subject subjective organization scores ranged from 0.40 to 0.80 with a mean of 0.60, SD= 0.10, indicating subjects did indeed organize their recall of movement patterns. Appendix C provides a sample recall matrix (Table 4a, b), an intra-subject subjective organization score calculation (Table 5), as well as the intra-subject subjective organization scores of each subject (Table 6).

To determine the degree of commonality among the subjects’ mode of organization, an inter-subject subjective score of 0.87 indicated that the basis of subject’s organization was very similar. This recall matrix data is presented in Appendix C - Table 7.
Clustering

In Experiment 2, the subject was presented with a single trial of twelve randomly presented patterns representing three semantic categories. Each semantic category—six-sided movements, curved movements and linear movements, was made up of four to-be-remembered items. In accordance with the recommendations made by Bousfield (1953), the individual's single-trial recalls were analyzed in terms of the tendency toward repetition as well as the incidence of single (unclustered) items, and the clusters of varying size. Initially, a score based on chance clustering was calculated as 0.2 using the Bousfield tendency toward repetition index of repetition formula. A sample recall and index of repetition score calculation are illustrated in Appendix D-Table 8. The index of repetition scores ranged from -0.7 to 2.6 with a mean of 1.4, SD = 0.7 (see Appendix D-Table 9). Only one score was below the chance index of repetition score of 0.2. All other subjects' scores indicated they were organizing on the basis of semantic category.

The tabulation of the incidence of single (unclustered) items, and the clusters of varying size are shown in Table 3.
TABLE 3
Incidence of Single Items and Clusters of Varying Size for Subjects

<table>
<thead>
<tr>
<th>Cluster Size</th>
<th>1's</th>
<th>2's</th>
<th>3's</th>
<th>4's</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subjects Above Chance</td>
<td>15</td>
<td>9</td>
<td>17</td>
<td>5</td>
</tr>
<tr>
<td>Subjects Below Chance</td>
<td>7</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>All Subjects</td>
<td>22</td>
<td>11</td>
<td>17</td>
<td>5</td>
</tr>
</tbody>
</table>

While this tabulation allows only a descriptive analysis, it is interesting to note that there were more clusters of 3's (17) than 2's (11). The subjects who exceeded the chance index of repetition score (0.2) clustered almost twice as much in groups of 3's (17) as 2's (9), again indicating the presence of clustering according to semantic category. It is worth mentioning that 7 of the 22 single clusters (1's) for all subjects, can be attributed to the subject who received the -0.70 index of repetition score, suggesting that although there is a high incidence of single cluster's, the data for all subjects (Row 3) are not a true representation of what occurred in Experiment 2.
Serial Position Curve

The traditionally U-shaped curve was not evident as is illustrated in Figure 6. There is no evidence of a typical serial position curve characterized by primacy and recency effects and an asymptote. The data randomly fluctuate between 25.0% and 91.6% correct recall. The absence of this curve served as a check that categorical organization had in fact taken place.

Ancillary Information Questionnaire

The answers to the questions asked of the twelve subjects one week after the experimental sessions are presented in Appendix E-Table 10. The questionnaire was used as confirmatory information on the validity of the semantic clustering finding. A mode of three categories had been perceived by subjects and these categories conformed with those identified by the experimenter.

The easiest patterns to recall were the six-sided figures according to two thirds of the subjects. The same number of subjects (66.6%) reported the linear movements as being the most difficult to recall. All subjects reported that imaging the patterns aided them in recall. The use of movement attributes i.e. extent, location, was reported to have been an additional recall aid by 83.3% of the subjects. Imaging was used by 42.0% of the subjects for all patterns except the linear
Figure 6. Serial position curve for free recall of twelve movement patterns.
movements. The same subjects reported using the movement attribute aid in the recall of the linear movements. An identical number of subjects used a combination of imaging and movement attribute aids for the recall of all patterns and the remaining subjects reported using other aids, i.e., audition, counting, in the recall of the patterns.
CHAPTER IV

DISCUSSION

The purpose of this study was to investigate a measuring device for secondary organization of movement to determine whether the basis of such organization is semantic or phonetic in nature. A minimal amount of research and consequently few hypotheses and theories have offered simple guidance for the interpretation of the data, nevertheless certain theoretical frameworks exist which permit plausible explanations of the findings.

Experiment 1

The lack of serial position effects in the present study have been interpreted as being a confirmatory check for the presence of secondary organization. Conversely, Magill (1978) and Toole and Pyne (1979) have used the presence of serial position effects to explain organization based on the chunking of movements. There is one main reason for the discrepancy in serial position curve findings between the present study and Magill's (1978) study. Whereas Magill's subjects received no practice of the movements prior to recall, the present study, in keeping with Tulving's (1968) insistence, ensured that all movement patterns were in
long term storage prior to free recall. Thus, in Magill's study recall was based upon primary organization although no distinction between primary and secondary organization was made. List length and the nature of movement items are two additional factors which may have contributed to the difference in serial position results. Magill (1978) witnessed serial position effects only when 12 linear movements were presented, and only eight movement patterns were employed in the present experiment.

Toole and Pyne (1979) also used 12 linear movements and found evidence of a serial position curve. Although an attempt was made to ensure that items were in memory by having subjects practise the movements, only 10 trials of each movement were permitted, even if the criterion of making three consecutive, accurate reproductions for each movement was not attained. In essence, the results of the subjects who conceivably had not committed movements to long term store could account for the occurrence of the serial position curve, again reflecting primary rather than secondary organization. They also did not make the distinction between the two types of organization.

Both intra- and inter-subject subjective organization were found for the free recall of movement patterns. Since these measures have not been reported in the motor learning literature, the present data must be compared to those reported in the verbal learning research. The mean intra-subject
subjective organization score for movements was $0.61 \pm 0.13$, which is twice the value of the mean score reported by Tulving (1962) for the organization of verbal material. Researchers in the verbal domain, concerned with how low the subjective organization score was, even when recall was almost perfect, suggested that this measure only assesses part of the actual organization that is occurring. Possibly, subjective organization is more sensitive to the secondary organization of movement than to verbal material.

When list items are from the same semantic category, subjective organization exceeds chance (randomness). If the subjects were organizing on the basis of order of input presentation their subjective organization scores would be equal or near equal to chance since the input presentation order was random (balanced order). Not only do subjects organize on the basis of some factor other than order of input presentation, they practically all use the same mode of organization as indicated by the large inter-subject subjective organization score of 0.87. This result cannot easily be explained since, as mentioned previously, one of the problems in studying organizational processes is the concept of individual differences in the mode of organization, rendering generalization tenuous. However, if the basis of organization is founded on the total collection of information in long term store, then the universal set of 20 movement patterns in effect attenuates any individual differences in
the repertoire of movement patterns.

The low inter-subject subjective organization score of
0.35 reported by Tulving (1962) for verbal material, where
the universal set size exceeds that of the present study,
provides support for the interpretation of the attenuation
of individual differences as the reason for the commonality
in organizing movement patterns in motor memory.

Experiment 2

As with subjective organization, there is no motor
memory research to which the clustering results of Experiment
2 can be compared. Subjects in the present study clustered
according to semantic category but the mean index of rep-
etition score (1.4, SD= 0.7) was lower than the one reported
by Bousfield (1953) which was 2.38, SD= 3.11. The probable
reason for the difference between the two domains is again,
the universal set size.

General Discussion

With respect to the results from both experiments, two
heuristic explanations are available. The use of imagery
by subjects as an aid to organizing the movement patterns
supports Paivio's (1975) dual-coding model of memory which
assumes two independent but partially interconnected systems
for encoding, organization and retrieval of information.
The systems are independent because verbal codes and non-verbal (imagery) codes are available and activated independent of each other. They are partially interconnected however, because one code can activate another so that an image can be labelled or a word can evoke nonverbal images. In the case of the present experiments, the nonverbal kinesthetic sensory information activated images which formed the basis of organizing the movement patterns in memory. In some cases a number of subjects used the images to evoke labels. For example, 9 of the 12 subjects reported making associations between the movement pattern form and the verbal label such as "house" or "star". In fact, one subject whose index of repetition score fell below the chance level used a strategy precisely as described. From the kinesthetic images, she developed a story on their corresponding verbal labels.

The fact that imagery was not generally used in the organization of the linear movements in the clustering experiment provides support for the dual-coding theory because tasks that require only physical attribute processing may not activate an image and therefore subsequent recall will be poor. The serial position curve data supports this contention. The recall of the linear movements was much poorer (29%) than the recall of movement patterns with form and structure (72%). In fact, patterns that evoked an image were recalled 2.5 times as often as patterns without form or structure.
This data can also be interpreted from a depth-of-processing point of view. Within this framework, the memory trace is viewed as a product of encoding operations which proceeds in a sequence from physical analysis of the nominal stimulus to a semantic analysis of the functional stimulus. As the encoding operations progress to deeper levels of analysis, the functional stimulus is elaborated upon, thereby increasing the accessibility of the memory trace at the time of retrieval. This interpretation had been employed by Hall and Leavitt (1977) to explain the superiority of the recall of direction of movement over the extent of movement and by Ho and Shea (1978) to explain the use of labels in the coding of position cues in short-term memory. The fact that subjects organized movement patterns by clustering them into semantic categories (mean index of repetition score = 1.40, SD = 0.72), as well as the fact that they were able to perceive the categories as identified by the experimenter suggests definite cognitive operations were being performed in the recall of the movement patterns. The patterns which contained both form and structure were processed to a semantic level since labels or meanings were attached to them, while the movement extents were processed only to a phonetic depth since subjects were unable to or at least did not report attaching labels to them. For the linear movements subjects relied on the physical attributes of the movement for organization and
retrieval. Additional evidence is provided for this interpretation when the number of associations linked to each pattern is considered. There were twice as many associations linked to the patterns with form and structure (1.5) than those patterns lacking form and structure (0.7) suggesting the degree of elaboration was greater for the semantic level of processing.

Both theoretical frameworks mentioned are based upon the idea of elaboration of memory codes, both between and within levels of information processing. Either framework could be accepted to explain the results of the present study because both models account for the interpretation that the organization of movement memory is both phonetically and semantically based with better recall for the latter than the former. The present study not only provides strong evidence that subjects organize movement patterns in memory, but also suggests that the lexicon of movement has both semantic and phonetic dimensions.

Future research should be directed toward the manipulation of variables such as imagery and labelling which control the organizational process. The usefulness of subjective organization and index of repetition measures in the quantification and comprehension of secondary organization merits full consideration from motor learning researchers. With results of such research, the lexicon of movement will be more fully understood.
CHAPTER V

SUMMARY AND CONCLUSIONS

Summary

The principle objectives of the present research were to determine whether the basis for organizational processes in motor memory is phonetic or semantic in nature. In verbal learning research, the serial position curve has not been utilized with organizational studies, however motor learning researchers have used it to explain organization based on chunking. Since serial order of recall is irrelevant in the formation of the serial position curve and since order of recall is important in the analysis of organization, serial position effects were examined, not for evidence of chunking but rather to confirm whether or not secondary organization had occurred.

Twelve, female undergraduates from the Human Kinetics motor learning course participated in three sessions lasting 60, 60 and 30 minutes. The apparatus consisted of a pantograph which coupled the subjects' movements with those of the experimenter in a one-to-one correspondence.

For the entire first and half of the second session, the subject committed to motor memory the universal set of 20 movement patterns received passively by means of the pantograph. The universal set represented three different
semantic categories—10 six-sided, closed figures; five curved, closed patterns; and the extents of five linear movements. Only when the subject could recall the form and structure of the 15 closed patterns and the extents (within 1.5 cm of 10, 16, 22, 28 and 34 cm) of the five linear movements, three consecutive times in a randomly presented order was the criterion for having memorized the patterns attained. When the criterion was reached, the experimental or Testing Phase was administered.

After the subject received an 8 X 8 balanced square presentation of eight of the 10 closed, six-sided movement patterns in Experiment 1, which had previously been rated by the subjects and found to have similar high meaningfulness ratings, Tulving's (1962) recall matrix formula was employed to determine whether subjective organization had occurred.

In Experiment 2 each subject received a single trial presentation of 12 randomly presented patterns representing the three semantic categories equally. The recall of these patterns was analyzed according to Bousfield's (1953) index of repetition formula and the clustering score for each subject was determined.

The per cent of correct recalls was plotted against serial position in both experiments to determine whether serial position effects were present. This provided the confirmatory check for the organization measures.
In agreement with the verbal memory literature, both subjective organization and clustering based on semantic categories of movement patterns were observed. The absence of the serial position curve was assurance that subjects' recall of performance was indeed attributed to secondary organization of the movement patterns.

Conclusions

Either dual-coding or depth-of-processing theories could serve as adequate explanations for the organizing activity which took place. The dual-coding hypothesis suggests that visually imaging a pattern triggers the kinesthetic recall of that pattern, for although visual and kinesthetic codes are separate, they are interconnected. The depth-of-processing framework suggests that movements which are encoded at a semantic level are more deeply embedded into memory through elaboration. The attachment of labels or associations in the present study allowed such semantic processing to occur, thus resulting in a deeper encoding of patterns which evoked such labels. The linear movements on the other hand, were not encoded as deeply because recall was based on movement attributes rather than semantics. These results suggest the lexicon of movement has both semantic and phonetic dimensions. Future research should be directed toward manipulation of variables such as imagery and labelling which control the organizational process.
APPENDIX A

INSTRUCTIONS TO SUBJECTS
INSTRUCTIONS TO SUBJECTS

Experiment 1: Learning Phase

1. Thank you for coming to participate in the study. Before we start would you please give me your name and birth-date. (make sure subject is right-handed).

2. This is an experiment to see how well you can learn and remember various movement patterns. There are three parts to this experiment, the first session and the first half of the second session are learning sessions; the last half of the second session and the third session comprise the recall phase of the experiment.

3. The apparatus in front of you is called a pantograph. During the experiment I will ask that you sit squarely on your chair facing the pantograph. There is a handle on the pantograph which I will eventually ask you to lightly grasp with your right hand. Your left hand will rest on your lap at all times. You can see that I have a handle on the side where I am sitting as well. During most of the experiment we will both be grasping the handles, but I will be moving your hand around, and you will simply follow the movement pattern that I give you, like this. (Demonstrate, without pattern).

4. You will be blindfolded during the experiment which will
make it more difficult for you to learn the movement patterns I give you, but please try your best to learn them.

5. When the movement I give you ceases, you can take your hand away from the handle and rest it on your lap until the next trial. You will then be asked for a rating on a scale from one to nine on how familiar the pattern is to you: nine being familiar, and one being unfamiliar.

6. Would you please verbalize as many associations as you can for the pattern I just gave you within the next 30 seconds.

7. Then I will give you a pencil and I want you to draw the pattern on the piece of paper to the right of the pantograph. You will still be blindfolded; but you may take as many trials as necessary, recalling the pattern after each presentation.

8. I will teach you a number of patterns in this manner. In the test session you will be required to recall these movement patterns.

9. Do you have any questions before we start? If not, could you briefly explain what you will be doing during the experiment? (If subject is unsure or wrong re-explain procedure to her).

10. Could you please put on the goggles and we shall begin.
Experiment 1: Testing Phase

1. First, I am going to review the patterns that you learned to see if you can still draw them correctly. Then I will test how well you can recall them. Please put the goggles on and sit squarely on the chair. When I tell you, put your hand on the pantograph handle and we shall start the review. (Review all twenty patterns and have subject recall after each pattern until the learning criterion is met).

2. You may remove the goggles while I explain the recall phase.

3. Now I am going to give you a certain number of patterns, one right after the other, but I do not want you to draw them on the paper until all the movements have been presented. It is important that you draw only the patterns I am about to give you.

4. Leave your hand on the pantograph handle during the entire presentation of movement patterns. When each movement ceases I will say a number. I would like you to count out loud and backward by threes for ten seconds from that particular number. When I say stop you will cease to count and I will give you a new pattern.

5. I will tell you when I am finished giving you patterns and then you are free to recall or draw the patterns on the paper in any order you wish.
6. Do you have any questions? If not, could you briefly explain that which I want you to do? (If subject is unsure or wrong re-explain procedure to her).

7. Please put the goggles on and we shall begin. (Give test list comprised of eight patterns and have subjects free recall when presentation is finished. Record order of recalled patterns. Repeat for eight trial presentations).

8. Could you please draw the pattern which sticks out most in your mind?

9. You may take off your goggles. Thank you for participating in the study. (Remind subject to return for additional testing session).

Experiment 2: Testing Phase

The Testing Phase instructions for Experiment 2 are identical to those of Experiment 1.

Ancillary Information Collection (Given to Group of Subjects One Week After Testing Phase)

1. Thank you for returning to fill out the questionnaire.

2. Please find a seat in the classroom well away from other individuals and draw and number all the patterns you learned last week on the paper provided. (Wait until last subject is finished and collect drawings).

3. If you noticed any categories or groupings of patterns please write the word Yes on the paper provided; if not,
please write the word No. All subjects who answered Yes will answer the verbally administered questionnaire; those who did not may leave. When you have finished the questionnaire you may leave.
APPENDIX B

ANCILLARY INFORMATION QUESTIONNAIRE

FOR SECONDARY ORGANIZATION
ANCILLARY INFORMATION QUESTIONNAIRE

What were the categories of patterns? Please list them.

Were some categories easier to recall? List please.

Were some categories more difficult to recall? List please.

Did you use any mental tricks to learn patterns? Yes/No.
If so, what were they? Please list them.

During the learning of the patterns did you tend to:

a) make mental images (visualize)
b) attach verbal labels (verbalize)
c) use movement attributes (i.e. location, extent)
d) do something else (specify)
e) do nothing

Did you use the same mental tricks for learning all categories?
If not, which tricks did you use for which categories?
APPENDIX C

ANALYSIS OF SUBJECTIVE ORGANIZATION

(EXPERIMENT 1)
Table 4 (a)

Sample Recall Data for an Individual Subject
Experiment (1)

<table>
<thead>
<tr>
<th>Trial Number</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
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<td>1</td>
<td>3</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>

-the numbers within the matrix represent the numbers assigned to the patterns i.e. pattern 8 was recalled first in both Trials 1 and 2.

-the 0's represent mistakes and or deletions in the recall of the patterns
Table 4 (b)

A Sample Recall Matrix For An Individual Subject

<table>
<thead>
<tr>
<th></th>
<th>Y₀</th>
<th>Y₁</th>
<th>Y₂</th>
<th>Y₃</th>
<th>Y₄</th>
<th>Y₅</th>
<th>Y₆</th>
<th>Y₇</th>
<th>Y₈</th>
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<td>7</td>
<td>6</td>
<td>5</td>
<td>57</td>
</tr>
</tbody>
</table>

Note. - Recall is pooled over eight trials.
- Matrix is based on Tulving's (1962) paper.

Y₀ Column - no movement follows the last movement
X₀ Row - no movement precedes the first movement
X and Y represent successive positions of subjects recall
and the subscripts represent the content of the recall
i.e. movements.
Table 5

Sample Intero-Subject Subjective Organization

(50) Score Calculation

1. Calculate probabilities for row and column totals relative to total recall score (57). i.e. 8/57 = 0.14;
   7/57 = 0.12; 6/57 = 0.10; 5/57 = 0.09 (between column & row totals), 1/57 = 0.02; 2/57 = 0.04; 3/57 = 0.05 (between matrix cells).

2. Substitute these probabilities into the information theory formula illustrated in Tulving's (1962) paper.
   a) \( H(n) = \sum p_i \log_2 1/p = \text{information in the stimulus } H(n) \)
      \[ H(n+1) \]
      \[ \begin{align*}
          & 2(0.14 \log 1/0.14 = 2(0.3917) = 0.7842 \\
          & + 2(0.12 \log 1/0.12 + 2(0.3671) + 0.7342 \\
          & + 2(0.10 \log 1/0.10 + 2(0.3322) + 0.6644 \\
          & + 3(0.09 \log 1/0.09 + 3(0.3127) + 0.9381
      \end{align*} \]
      \[ H(n+1) = 3.1309 \]
      Between column and row totals.

   b) \( H_{n,n+1} = \text{total amount of information} \)
      \[ 30(0.02 \log 1/0.02) = 30(0.1129) = 3.3870 \]
      Between matrix cells.
      \[ + 9(0.04 \log 1/0.04) + 9(0.1656) + 1.4904 \]
      \[ + 3(0.05 \log 1/0.05) + 3(0.2161) + 0.6483 \]
      \[ = 5.5257 \]

   c) \( H_{n,n+1} = H(n) + H(n+1) - H_{n,n+1} = \text{information transmitted} \)
      \[ = 2(3.1309) - 5.5257 \]
      \[ = 6.2618 - 5.5257 \]
      \[ = 0.7361 \]

   d) \( H_x(y) = H(n) - H(n;n+1) = \text{information in n when (n+1) is known} \)
      \[ H_y(x) = \text{information in (n+1) when n is known} \)
      \[ = 3.1309 - 0.7361 \]
      \[ = 2.3948 \]

   e) SO score = \( H_x(y)/H(n) \)
      \[ = 2.3948/3.1309 \]
      \[ = 0.7649 \]
      \[ = 0.76 \]
Table 6
Intra-Subject Subjective Organization Scores
For Each Subject (Experiment 1)

<table>
<thead>
<tr>
<th>Subject</th>
<th>Inter-Subject Subjective Organization (SO) Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.73</td>
</tr>
<tr>
<td>2</td>
<td>0.60</td>
</tr>
<tr>
<td>3</td>
<td>0.78</td>
</tr>
<tr>
<td>4</td>
<td>0.43</td>
</tr>
<tr>
<td>5</td>
<td>0.56</td>
</tr>
<tr>
<td>6</td>
<td>0.51</td>
</tr>
<tr>
<td>7</td>
<td>0.77</td>
</tr>
<tr>
<td>8</td>
<td>0.58</td>
</tr>
<tr>
<td>9</td>
<td>0.45</td>
</tr>
<tr>
<td>10</td>
<td>0.74</td>
</tr>
<tr>
<td>11</td>
<td>0.71</td>
</tr>
<tr>
<td>12</td>
<td>0.44</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mean</th>
<th>0.61</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Deviation</td>
<td>0.13</td>
</tr>
<tr>
<td>Chance Score</td>
<td>0.08</td>
</tr>
</tbody>
</table>
Table 7

Inter-Subject Subjective Organization (SO) Recall Matrix

<table>
<thead>
<tr>
<th>(n+1)th Movement</th>
<th>( Y_0 )</th>
<th>( Y_1 )</th>
<th>( Y_2 )</th>
<th>( Y_3 )</th>
<th>( Y_4 )</th>
<th>( Y_5 )</th>
<th>( Y_6 )</th>
<th>( Y_7 )</th>
<th>( Y_8 )</th>
<th>( N_i )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( X_0 )</td>
<td>22</td>
<td>7</td>
<td>10</td>
<td>6</td>
<td>14</td>
<td>12</td>
<td>17</td>
<td>96</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( X_1 )</td>
<td>11</td>
<td>23</td>
<td>9</td>
<td>9</td>
<td>4</td>
<td>6</td>
<td>3</td>
<td>73</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( X_2 )</td>
<td>14</td>
<td>8</td>
<td>16</td>
<td>6</td>
<td>5</td>
<td>7</td>
<td>7</td>
<td>72</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( X_3 )</td>
<td>12</td>
<td>11</td>
<td>11</td>
<td>10</td>
<td>6</td>
<td>11</td>
<td>10</td>
<td>3</td>
<td>74</td>
<td></td>
</tr>
<tr>
<td>( X_4 )</td>
<td>9</td>
<td>7</td>
<td>4</td>
<td>10</td>
<td>18</td>
<td>8</td>
<td>6</td>
<td>7</td>
<td>69</td>
<td></td>
</tr>
<tr>
<td>( X_5 )</td>
<td>17</td>
<td>12</td>
<td>9</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>13</td>
<td>9</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>( X_6 )</td>
<td>11</td>
<td>5</td>
<td>4</td>
<td>6</td>
<td>15</td>
<td>12</td>
<td>10</td>
<td>12</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>( X_7 )</td>
<td>12</td>
<td>4</td>
<td>8</td>
<td>9</td>
<td>5</td>
<td>14</td>
<td>10</td>
<td>11</td>
<td>73</td>
<td></td>
</tr>
<tr>
<td>( X_8 )</td>
<td>10</td>
<td>4</td>
<td>6</td>
<td>9</td>
<td>13</td>
<td>8</td>
<td>10</td>
<td>9</td>
<td>69</td>
<td></td>
</tr>
<tr>
<td>( N_i )</td>
<td>96</td>
<td>73</td>
<td>72</td>
<td>74</td>
<td>69</td>
<td>75</td>
<td>75</td>
<td>73</td>
<td>69</td>
<td>676</td>
</tr>
</tbody>
</table>

Note: Recall is pooled over 96 trials, eight per subject.
Matrix is based on Tulving's (1962) paper.

The procedure for completing matrix cell scores is identical to that which is used for intra-subject subjective organization recall matrix. The calculation procedure for the inter-subject SO score is identical to the intra-subject SO calculation method except data from all subjects (12) and all trials (96) is pooled. The inter-subject subjective organization score is 0.87.
APPENDIX D

ANALYSIS OF INDEX OF REPETITION (CLUSTERING)
(EXPERIMENT 2)
Table 8
Sample Recall Data For An Individual Subject (Experiment 2)

<table>
<thead>
<tr>
<th>Subject</th>
<th>Subject's Recall Order of Movement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4 0 0 1 2 0 7 9 14 0 0 0</td>
</tr>
</tbody>
</table>

- These numbers within the row represent the number's assigned to the patterns i.e. pattern 4 was recalled first; pattern 14 was recalled last.
- The 0's represent mistakes and or deletions in the recall of the patterns.

Sample Index of Repetition Score Calculation

\[ Y = \left( \frac{c \cdot r}{\sqrt{3n-1}} \right) - \frac{\sqrt{n}}{3} \]
\[ c = \text{number of categories} \]
\[ r = \text{number of repetitions} \]
\[ n = \text{total number of items} - 1 \]
\[ Y = \text{index of repetition} \]

\[ Y = \left( \frac{3(8)}{\sqrt{3 \times 11}} \right) - \sqrt{11}/3 \]
\[ = \left( \frac{24}{5.7} \right) - 1.9 \]
\[ = 4.2 - 1.9 \]
\[ = 2.3 \]

- Based on Bousfield's (1953) paper.
Table 9

Index of Repetition Scores For All Subjects (Clustering)

<table>
<thead>
<tr>
<th>Subject</th>
<th>Index of Repetition (IR) Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.50</td>
</tr>
<tr>
<td>2</td>
<td>1.50</td>
</tr>
<tr>
<td>3</td>
<td>1.50</td>
</tr>
<tr>
<td>4</td>
<td>1.50</td>
</tr>
<tr>
<td>5</td>
<td>0.80</td>
</tr>
<tr>
<td>6</td>
<td>0.20</td>
</tr>
<tr>
<td>7</td>
<td>2.30</td>
</tr>
<tr>
<td>8</td>
<td>2.60</td>
</tr>
<tr>
<td>9</td>
<td>-0.70*</td>
</tr>
<tr>
<td>10</td>
<td>2.30</td>
</tr>
<tr>
<td>11</td>
<td>0.50</td>
</tr>
<tr>
<td>12</td>
<td>1.50</td>
</tr>
</tbody>
</table>

Mean \[ \bar{x} \] = 1.40

Standard Deviation = 0.72

Chance Score = 0.20

* Does not exceed chance
APPENDIX E

ANCILLARY INFORMATION

FOR SECONDARY ORGANIZATION
Table 10

Results From Ancillary Information Questionnaire

<table>
<thead>
<tr>
<th>Question Asked</th>
<th>Summary of Replies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of correctly recalled categories</td>
<td>2 subjects could recall only one category</td>
</tr>
<tr>
<td></td>
<td>4 subjects could recall only two categories</td>
</tr>
<tr>
<td></td>
<td>6 subjects could recall all three categories</td>
</tr>
<tr>
<td>Easiest Category to recall</td>
<td>8 subjects found the six-sided patterns easiest</td>
</tr>
<tr>
<td></td>
<td>2 subjects found the curved patterns easiest</td>
</tr>
<tr>
<td></td>
<td>0 subjects found the linear movements easiest</td>
</tr>
<tr>
<td></td>
<td>2 subjects found an incorrect category easiest</td>
</tr>
<tr>
<td>Most difficult patterns to recall</td>
<td>0 subjects found the six-sided patterns most difficult</td>
</tr>
<tr>
<td></td>
<td>3 subjects found the curved patterns most difficult</td>
</tr>
<tr>
<td></td>
<td>8 subjects found the linear movements most difficult</td>
</tr>
<tr>
<td></td>
<td>1 subject found an incorrect category most difficult</td>
</tr>
<tr>
<td>Use of Mental Tricks to Aid in Recall</td>
<td>12 subjects used imagery</td>
</tr>
<tr>
<td>-imaging</td>
<td>1 subject used verbalization (labels)</td>
</tr>
<tr>
<td>-verbalizing</td>
<td>10 subjects used movement attributes</td>
</tr>
<tr>
<td>-movement attributes</td>
<td></td>
</tr>
<tr>
<td>Same recall tricks used for all categories?</td>
<td>5 subjects used same &quot;mental trick&quot; to recall all categories</td>
</tr>
<tr>
<td></td>
<td>7 subjects used different &quot;mental trick&quot; for different categories</td>
</tr>
</tbody>
</table>
Table 10 Continued

Of the seven subjects who used different mental tricks for different categories--
Which tricks were used for which categories?

3 subjects used movement attributes to recall linear movements and imaging for all other patterns

3 subjects used both movement attributes and imaging for the recall of all patterns

1 subject used audition for the recall of linear movements.
REFERENCES


Tulving, E. Theoretical issues in free recall. In T. R.
Dixon & D. L. Horton (Eds.), Verbal behaviour and general-
behaviour theory. Englewood-Cliffs: Prentice-Hall,

Underwood, B. J. & Schulz, R. W. Meaningfulness and verbal

Wilberg, R. B. & Girard, N. A further investigation into
the serial position curve for short-term memory.
Proceedings: IX Canadian Psycho-Motor Learning and
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