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Encoding specificity with multiple cues for movement extent: The nature of the memory trace.

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ENCODING SPECIFICITY WITH MULTIPLE CUES FOR MOVEMENT EXTENT: THE NATURE OF THE MEMORY TRACE

by

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ABSTRACT

The present experiment examined the encoding specificity principle for movement extent using the multiple cues of mode, direction, and speed in a linear positioning task. An attempt was made to generate a quantitative description of the memory trace using a percentage correct measure based on the difference limen for each subject (PCDL).

Thirty-two right-handed female volunteers were randomly divided into two groups, one using active slow criterion movements to the left, and the other using passive slow criterion movements to the left. Reproduction movements for both groups contained all possible combinations of mode, direction, and speed cues presented singly, in pairs, in total, or completely lacking.

The results supported Lee and Hirota's (1980) finding that the encoding specificity principle does apply for motor reproduction of extent, at least under some conditions. Speed cues had the most powerful effect, and interacted with many other cues. The direction of reproduction was a relatively independent cue, interacting only with speed of reproduction. There was a strong encoding specificity prin-

ciple effect for direction and speed but only a weak one for mode, more so at fast speeds than at slow.

The proposed PCDL measure was found to be too insensitive for use in quantitatively describing the memory trace. An alternative measure is proposed, and further research in this direction is suggested.

Some previous research which showed mixed results from the point of view of the encoding specificity principle is discussed, along with implications for caution in designing and interpreting experiments applying the encoding specificity principle.

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CHAPTER I

INTRODUCTION

The characteristics of memory for kinesthetic information has been a topic of great interest to contemporary researchers. During the past decade, much effort has been devoted to determining the retention characteristics of various sensory components of movement in an effort to gain some insight into the form in which these variables are encoded. Movement information that has been studied includes torque, direction, velocity, and the variables receiving the most attention from researchers, end-location (the position in space a limb occupies) and extent (the distance through which a limb is moved). The accuracy and precision of a reproduced movement is an indication of how well that movement has been remembered over time.

A typical motor short-term memory paradigm has been used to isolate and study the variables of end-location and extent. Visual cues are removed by preventing the subject from seeing either the apparatus or his arm, and white noise is used to mask auditory cues. A criterion movement (CM) is presented by having the subject move a slide with his arm from a starting position to a terminal position. This movement can be either preselected (subject-determined) or constrained (examiner-determined) and can be performed either actively (the subject moves the slide) or passively (the examiner moves the slide while the subject holds the carriage with a relaxed hand and arm). The subject is required to remember either the extent or the end-location of the CM so that, after a variable retention interval (RI), he can perform a reproduction movement (RM) in an effort to reproduce the required extent or location. Extent and end-location cues can be isolated by changing the starting position of the RM from that of the CM. Thus, if location is being reproduced the extent of movement is not reliable as a cue, and the end-location of movement is not reliable as a cue if extent is being reproduced. The RI can be manipulated to investigate the phenomena of encoding, interference, storage, retrieval time, and forgetting. The duration of the RI can be changed to determine the relative stability of the memory for extent or end-location over time. The RI can either be filled with an interpolated activity to prevent rehearsal or to study the effects of interference, or unfilled so that rehearsal of the information is possible. Errors due to overestimating or underestimating the criterion extent or location are measured. Three measures are typically used (Roy, 1976; Schutz and Roy, 1973): constant error (CE) is the mean algebraic error or response bias, variable error (VE) is the within-subject variance, and absolute error (AE) is the average error or mean deviation.

Posner (1967), using a short-term memory paradigm, claimed that retention of information depends on central processing. If information is capable of being coded for storage, rehearsal of that information should prevent decay over time. Keele and Ells (1972), finding that location information was rehearsable while other movement information was not, concluded that different movement variables have different retention characteristics.

Marteniuk and Roy (1972) isolated distance and end-location variables. Since the mean AE was significantly larger for distance reproduction than for end-location reproduction, they concluded that distance provides less precise information about arm displacement than does location. Subsequent researchers indicated that primacy of location information over extent exists for all types (active, passive, constrained, preselected) of movement reproduction (Marteniuk, 1973; Roy, 1977; Stelmach, Kelso, and Wallace, 1975).

Laabs (1973) found that over an unfilled RI, distance information showed spontaneous decay while location information showed little forgetting. However, with interpolated mental activity (filled RI), a severe loss of location information was found over that which was ascribed to decay. Laabs (1973) interpreted this to mean that location information can be centrally processed but is subject to forgetting when rehearsal is blocked, whereas extent information is not codable and so is subject to spontaneous forgetting.

Conflicting results were obtained by Marteniuk (1973): Both extent and location information were forgotten over a filled RI but neither were forgotten over an unfilled RI. Both extent and location information appeared to be centrally codable. A difference in methodology accounted for the contradictory findings. Marteniuk (1973), by employing a preselected CM rather than a constrained CM as was used in the Laabs (1973) study, obtained improved accuracy for extent.

Subsequent researchers held that preselected movements are more precisely encoded than constrained movements for end-location and extent combined (Jones, 1974; Marteniuk, 1977), for end-location (Stelmach et al, 1975), and also for extent (Roy, 1978; Roy and Diewart, 1975, 1978) unless a strategy is provided by prior information about the terminal position of the constrained CM (Roy and Diewart, 1975, 1978).

Using a similar paradigm, Carlton (1978) investigated the retention characteristics of speed for preselected movement. Both fast and slow preselected movement rates were retained as well over an unfilled RI as over an immediate RI. Reproduction errors increased with interpolated activity. This was interpreted to mean that speed was centrally codable.

The retention characteristics of direction for passive constrained and active preselected movements were studied by Hall and Leavitt (1977) using directions radiating from the subject's midline, one perpendicular to the frontal plane and two others situated 45 degrees to either side. Mental rehearsal improved performance relative to immediate reproduction, and interpolated activity removed the advantage. Direction information, then, was thought to be centrally processed.

Motor short-term memory research that is discussed henceforth will be limited to experiments employing constrained CMs in which extent of movement is reproduced.

The Encoding Specificity Principle

Bower (1967) and Tulving and Thomson (1973) have suggested that an episodic memory trace is composed of the mental storage of a set of interrelated components. The encoding specificity principle, which comes from the verbal literature (Thomson and Tulving, 1970; Tulving and Thomson, 1973), is a scheme for interpreting the relations between encoded memory traces and retrieval cues. The encoding specificity principle maintains that "specific encoding operations performed on what is perceived determine what is stored, and what is stored determines what retrieval cues are effective in providing access to what is stored"

(Tulving and Thomson, 1973, p. 353). Tulving contends that the more precisely the conditions during output match the conditions during encoding of the episodic memory trace, the better the retrieval. This view has been supported by numerous investigators in the verbal field (Fisher and Craik, 1977; Pellegrino and Salzberg, 1975; Tulving and Watkins, 1975).

An analogy can be drawn between the processes of motor short-term memory as exhibited by a linear positioning task and the encoding specificity principle in verbal short-term memory. The memory trace is created by the encoding of the perception of the CM. The RM, with its continuous sensory feedback, contains the retrieval cue. Remembering the event requires that information in the trace sufficiently matches the information in the RM. The closer the conditons of the RM resemble the conditions of the CM, the more accurate the retrieval.

Active and Passive Movement Conditions

Several researchers have found that there is a superiority in accuracy for the reproduction of the extent of active constrained CMs over the reproduction of the extent of passive constrained CMs (Hall and Leavitt, 1977; Marteniuk, 1973; Roy, 1978; Roy and Diewart, 1978). Recently, Lee and Hirota (1980) cast doubt on the supposed superiority of active movements when they recognized a methodological flaw in the aforementioned studies: Regardless of whether the CM was in the active or the passive mode, the RM was always in the active mode. The results of these experiments, they argued, were confounded because the encoding specificity principle was not taken into consideration.

Lee and Hirota (1980) correctly predicted that reproduction of extent would be more accurate when input and output modes match than when they differ. They found that active-active and passive-passive movements, while not significantly different from each other, were significantly more accurate than either active-passive or passive-active movements which had, themselves, equivalent reproduction accuracies. The RI (immediate, 20 sec. filled, and 20 sec. unfilled) had no effect. The findings suggest that when retrieval conditions match the conditions of encoding, there is no advantage to the memory trace provided by an active as opposed to a passive movement.

Probing the Memory Trace with Multiple Cues

Bower (1967) and Tulving and Watkins (1975) assume that the memory trace is multidimensional consisting of a mixture of encoded trace elements. According to Tulving and Thomson (1973) the effectiveness of a cue reflects the informational overlap between the memory trace and the cue in keeping with the encoding specificity principle. Given these assumptions, it follows that the trace can most completely and accurately be described in terms of the pattern of effectiveness of different types of retrieval cues in recalling target words in a memorized list of words (Anderson, 1972; Light, 1972; Nelson and Brooks, 1974). Although these studies provided additional information about the nature of memory traces, the work was done on a composite of many different items, and the experimenters could not determine to what extent different cues might contain the same information.

Tulving and Bower (1974) and Tulving and Watkins (1975) sought to improve the description of the memory trace. They advocated a successive probing of a given trace with two or more cues, taking into account the amount of information overlap, if any, between the retrieval cues. Using percentage of recall as a dependent measure, they were able, by their complicated reduction method, to describe and quantify the structure of the memory trace.

The basic prediction was that if the information contained in one cue is completely included in the information contained in a second cue, then the first cue will be ineffective as a supplement to the second cue. If the informational contents of the two cues do not overlap, they should exert separate additive effects on recall probability, and the extent to which this is not so determines the amount of the overlap. Two cues that overlap completely would be redundant. Thus relations among the retrieval cues with respect to the trace may be observed and recorded as a description of the memory trace.

In the reduction method, the successive probing, in original and reverse order, of two cues, was necessary because the verbal memory trace, by its nature, is changed by the act of probing with the retrieval cue. Such is not the case in a linear movement paradigm, since a new trace is provided for every attempt of retrieval. Probing a motor memory trace, then, should be a simpler process.

The Structure of the Memory Trace

Tulving and Bower (1974) and Tulving and Watkins (1975) quantitatively described the properties of a memory trace by determining the recall probabilities of the gross, common, and reduced valences of two or more retrieval cues. The valence of a cue is its effectiveness with respect to a defined trace of a certain event which occurred under certain conditions. The elements of the memory trace are defined in terms of the valences of the retrieval cues.

Using Tulving and Watkins' (1975) notation, the gross valence of a cue (X, for cue X) refers to the probability with which the encoded event can be recalled in the presence of that cue, and assumes a value between zero and unity. Reduced valence refers to a cue valence that has been reduced by some other cue. The valence of cue X reduced by cue Y ($X\overline{Y}$) is the probability that the trace can be retrieved by cue X and cannot be retrieved by cue Y. The common valence or intersect of two cues such as cue X and cue Y (XY) refers to the probability that the target can be recalled to cue X as well as cue Y. A certain amount of trace information overlaps with neither X nor Y ($\overline{X}\overline{Y}$).

By determining the valences of various cues, a trace can be depicted as consisting of its various elements in specified percentages. If a trace is being probed by two cues, X and Y, then $X\overline{Y} + XY + \overline{X}Y + \overline{X}\overline{Y} = 100\%$ where XY is the intersect of X and Y.

Measurement of Retrieval

Verbal short-term memory research typically employs percentage correct as a measure of the subject's ability to recall or recognize a previously encoded item. Motor short-term memory experiments, on the other hand, traditionally measure the subject's recall performance throught the use of three error measures. According to Ho and Shea (1978), retrieval accuracy, as measured by AE, can be more clearly interpreted when CE, an indication of response bias, and VE, a measure of the consistency or variability of within-subject performance, are considered.

The motor short-term memory model assumes that the reproduced movement (RM) should be equal to the to-be-remembered item (CM) when retrieval is perfect. But is this a valid assumption? Perhaps the reproduced movement represents not only the replication of the to-be-remembered item, but also the effects of context, systematic bias, and individual sensitivity to stimuli. If so, researchers may be attempting to precisely measure an entity which, by its very nature, is subject to error in measurement.

Another way of approaching the measurement of retrieval of motor short-term memory information would be to acknowledge the imprecise nature of the measurement of retrieval items as well as individual differences in subjects' retrieval capabilities. The just-noticeable-difference or difference limen (DL) could be estimated for each subject by using the psychophysical method of average error, adjustment, or reproduction. This is a procedure that is designed to measure the amount of error that occurs when the subject adjusts one stimulus until he judges it to be equal to another. Since a variation of the technique is typically used in the motor shcrt-term memory paradigm, the DL can easily be determined by calculating half the range obtained from several trials under optimum conditions using identical CMs and RMs with immediate RIs. If researchers could agree that the DL, by determining each subject's sensitivity, could be used to reasonably allow for errors in measurement, then, on an individual basis, that much flexibility could be allowed in determining a correct response. For example, for a subject with a DL of 2 cm for a 20 cm linear movement, a RM measuring within ±2 cm of the CM could be counted as correct, and any measurement outside of these limits would be counted as incorrect. Thus dependent measures of reproduction accuracy would be in terms of percentage correct based on the difference limen (PCDL).

Describing the Motor Memory Trace

A quantitative description of a motor memory trace could be generated using a percentage correct measurement in much the same way as Tulving and Watkins (1975) were able to do for verbal material. The memory trace of the movement could be constructed from its reproductions, using cues X, Y, and Z, in the following way:

1. A table would be constructed listing the conditions, the retrieval cues or gross valences, the experimental probabilities, and the corrected probability coefficients (see Table 1).
2. The elements of the memory trace are drawn and lettered to explain the computations (see Figure 1).

Table 1

Corrected Probability Coefficients

for Gross Valences of the Memory Trace

Condition	Retrieval Cue or Gross Valence	Experimental Probability**	Corrected Probability Coefficient***
	X		
	Y		
	Z		
	X&Y		
	Y&Z		
	X&Z		
XYZ	X&Y&Z		
	U*		

* U = uncontrolled cues or the portion of the memory trace with unknown relationship

** experimental probability = mean percentage correct divided by 100

*** corrected probability coefficient = experimental probability - U

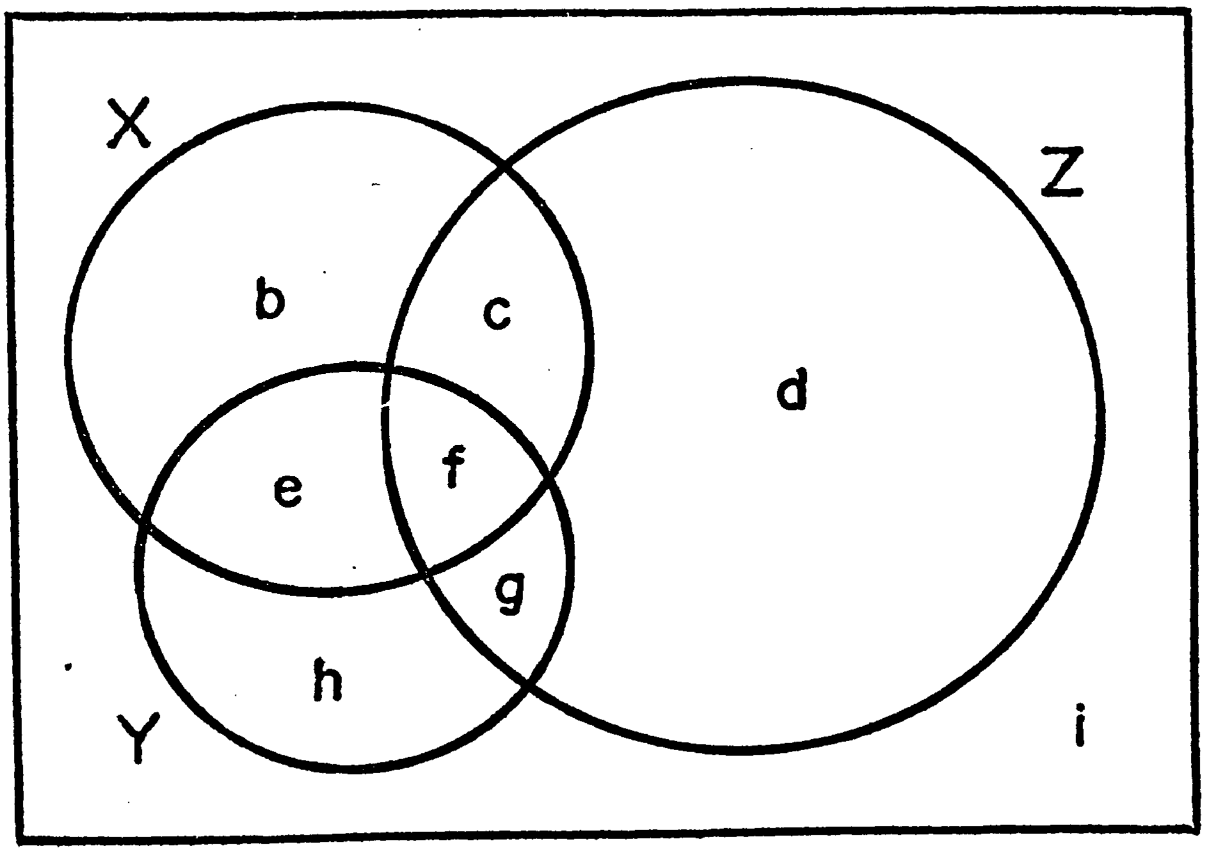

Figure 1. Elements of the memory trace.

The following equation would be used:

$$X\&Y\&Z=(b+c+e+f)+(e+f+g+h)+(c+f+g+d)-(e+f)-(c+f)-(g+f)+f$$

where, using corrected probability coefficients,

$b+c+e+f=X$	$e+f=(X)+(Y)-(X\&Y)$
$e+f+g+h=Y$	$c+f=(X)+(Z)-(X\&Z)$
$c+f+g+d=Z$	$g+f=(Y)+(Z)-(Y\&Z)$

where X&Y&Z is the union of X,Y, and Z, X&Y is the union of X and Y, X&Z is the union of X and Z, and Y&Z is the union of Y and Z.

Solve for f and substitute to find b,c,d,e,g,h.

$i=100-(X\&Y\&Z)-XYZ=$unmeasured variables of the trace e.g. location

where XYZ is the union of X, Y, and Z.

3. The relationship of U to the rest of the memory trace is unknown, but its value is an indication of the completeness of the measured portion of the memory trace: the lower the coefficient of U, the more complete the measured portion of the trace.
4. The coefficients of the elements can be added to quantitatively describe the memory trace in terms of its components, and these values can be entered in a table for purposes of comparison (see Table 2).

<u>The Problem</u>

The encoding specificity principle, as related to active and passive movements, has been demonstrated as

Table 2

Valences of the Memory Trace

Valence	Composition	Valence	Composition
Gross Valence		Reduced Valence	
X&Y&Z	b+c+d+e+f+g+h	X&Z$\overline{Y}$	b+c+d
X&Z	b+c+d+e+f+g	X&Y$\overline{Z}$	b+e+h
X&Y	b+c+e+f+g+h	Y&Z$\overline{X}$	h+g+d
Y&Z	c+d+e+f+g+h	X$\overline{Z}$	b+e
X	b+c+e+f	X$\overline{Y}$	b+c
Y	e+f+g+h	X$\overline{Y}\overline{Z}$	b
Z	c+d+f+g	Z$\overline{X}$	d+g
Common Valence		Z$\overline{Y}$	c+d
XZ	c+f	Z$\overline{X}\overline{Y}$	d
XY	e+f	Y$\overline{X}$	g+g
XZ	f+g	Y$\overline{Z}$	e+h
XYZ	f	Y$\overline{X}\overline{Z}$	h
Uncontrolled Extent Valence		Additional Trace Valence	
U		$\overline{X}\overline{Y}\overline{Z}$	i

Note: X&Y&Z = the union of X,Y, and Z

XYZ = the intersect of X, Y, and Z.

being applicable to motor short-term memory (Lee and Hirota, 1980). Verbal researchers (Tulving and Bower, 1974; Tulving and Watkins, 1975) have extended the application of the encoding specificity principle to include a method of probing a specific memory trace with multiple cues in order to provide a quantitative description of the structure of the memory trace in terms of its elements.

The proposed research is designed to:

1. replicate the results of Lee and Hirota (1980);
2. apply the encoding specificity principle to the retrieval cues of speed and direction as they relate to reproduction of movement extent;
3. extend the encoding specificity principle to the relationship of multiple cues for reproduction of movement extent;
4. provide a quantitative analysis of the memory trace for a specific movement with emphasis on the encoded extent information.

Hypotheses

The following hypotheses are related to the purposes stated above:

1(a) The accuracy of retrieval will be significantly better when the modes of the CM and the RM are the same than when they are different.

2(a) The accuracy of retrieval will be significantly better when the speeds of the CM and the RM are the same than when they are different.

(b) The accuracy of retrieval will be significantly better when the directions of the CM and the RM are the same then when they are different.

3(a) Reproduction accuracy for conditions in which the CM and the RM are made in the same mode, at the same speed, in the same direction will be significantly better than the accuracy of the reproduction of movements in which the RM is made in a different mode, at a different speed, and in a different direction than the CM.

(b) Conditions in which the RM contains one or two of the retrieval cues of mode, speed, or direction that duplicate information contained in the CM will result in reproductions between the two extremes of accuracy referred to in the above hypothesis.

4(a) It will be possible to use the PCDL results of hypothesis 3 to quantitatively describe the memory trace for an active slow movement to the left.

(b) It will be possible to use the PCDL results of hypothesis 3 to quantitatively describe the memory trace for a passive slow movement to the left.

CHAPTER II

METHODOLOGY

Subjects

Thirty-two right-handed females who were randomly chosen from a pool of volunteers enrolled in undergraduate psychology courses at the University of Windsor received credit towards their grade in one course. All subjects were naive as to the purposes of the experiment.

Apparatus and Materials

The subject and the experimenter were seated on opposite sides of a table approximately 122 cm long x 46 cm wide x 88 cm high. Attached to the top of the table along the edge closest to the subject was a linear slide apparatus consisting of an Ealing Optical Bench (cat. # 22-6894), one meter in length, and an Ealing Optical carrier (cat. # 22-4170) which served as a slide carriage with dimensions of 10 cm across the bench and 9 cm along the bench. A horizontal pointer attached by a set screw at the mid-point of the experimenter's side of the carriage jutted out 2 mm above a meter rule (in mm) which was attached to the table adjacent and parallel to the linear slide, permitting the experimenter to make accurate measurements. Passive movements could be controlled by the experimenter by moving the carriage with one hand while placing a finger from the other hand along the leading edge of the pointer. A quick stop of the carriage was ensured by dropping the finger the short distance to the ruler effectively blocking the movement of the carriage at the pointer. The contact surfaces of the bench were coated with Lubriplate to allow for near noisless and frictionless movements of the carriage. An adjustable stool served as the subject's seat.

On the subject's side of the slide and 109 cm above the floor, a 122 cm x 33 cm horizontal shelf could be adjusted towards or away from the subject. An adjustable chin-rest was mounted midway along the length of the shelf about 8 cm from the edge closest to the subject. At the edge of the shelf furthest from the subject, a 122 cm x 50 cm black visual shield tilted away from the subject at a 135 degree angle from the shelf, effectively blocking visual cues. A contrasting coloured dot 8 mm in diameter, affixed to the shield midway along the length and 13 cm below the top edge of the shield, defined the visual fixation point. The subject was provided with a set of Selfix stereo headphones, Model 6120, which was connected to equipment on the experimenter's side of the apparatus.

The limits within which the subject was able to move the carriage were defined on the experimenter's side of the bench by the use of plastic stops which could be rotated around a metal rod running parallel to the bench in such a way that the stops could be propped against the bench and rotated away. Silicone cement covered contact surfaces of the stops to minimize auditory cues. A small microphone and the earphones were connected to a non-commercial white noise generator with an output set at 82 dB so that either instructions or white noise could be relayed to the subject.

Experimental Design

The experiment consisted of 16 conditions arranged in a 2 x 2 x 2 x 2 design. There were two presentation (CM) conditions: active left slow (ALS) and passive left slow (PLS); two modes of retrieval: active (A) and passive (P); two directions of retrieval: to the left (L) and to the right (R); and two speeds of retrieval: slow (S) and fast (F); with repeated measures on the mode, speed, and direction of retrieval factors and independent groups on the presentation condition factor. Subjects were randomly assigned to groups so that half the subjects were in each group. Two subjects were discarded, one because she neglected to use the chin-rest for some of the conditions, and one because an electrical storm caused the lights to flicker erratically during the testing session. Replacement subjects were randomly selected from the original pool of volunteers.

A trial was defined as the presentation of a CM and its reproduction. Each subject received 64 trials broken down into two blocks of 32 trials, one under passive and one under active modes of retrieval. Each of these blocks was further broken down into two 16 trial blocks so that right and left directions were used in an ABBA order across the four 16 trial blocks. Each of these blocks was in turn broken down into two 8 trial blocks so that retrieval involved slow and fast movements in an ABBABAAB order across the eight 8 trial blocks. Each of these blocks represented one condition. All blocks were completely counterbalanced across subjects in each group (see Appendix A).

The CMs were all 20 cm long and started 10 cm to the right of the subject's midline and terminated 10 cm to the left of the subject's midline. Within conditions, starting positions of the RM were randomly presented so that each of four starting positions (±5 and ±10 cm from the beginning or end of the CM) appeared two times.

Procedure

The subject began the experimental session in a room adjacent to the test room where a brief written explanation of the task requirements was read (see Appendix B). After answering any questions raised by the subject, the experimenter led the subject into the test room. The subject was seated so that the saggital plane of the body was opposite the chin-rest and the midpoint of the slide, and the subject's stool was adjusted up or down so that the forearm was parallel to the floor when the carriage handle was grasped. The chin-rest apparatus was adjusted so that the subject felt comfortable with the head secured in the chin-rest. The shelf was adjusted so that when the carriage handle was grasped the subject would not feel cramped yet there would be freedom to complete the required lateral movements across the body. The subject wore the earphones through which the instructions and the white noise were presented.

Prior to the experiment, the rates at which fast and slow movements occurred had been practised by the experimenter until they were judged to be relatively consistent as well as clearly discriminable from each other. The fast movement, when conducted over a distance of 20 cm, was judged to take a minimum of 400 msec., more than double the 110 to 130 msec. required for reaction to kinesthetic feedback (Chernikoff and Taylor, 1952).

The experimental session consisted of two phases: a pretest and a test phase. During the pretest phase (see Appendix B) the examiner asked the subject to keep the chin secured on the chin-rest and to fixate on the coloured dot on the visual shield whenever a movement was made (as suggested by Marteniuk, 1978). The subject was given three 40 cm passive slow movements to the left and three to the right, during which she was instructed to totally relax the arm. This was followed by three active slow movements to the left and three to the right during which the subject was encouraged to move at the same speed as the passive movements. The same procedure was repeated using fast movements. A 30 cm CM was practised twice, followed by two practise trials of 30 cm with the RM in the same mode, direction, and speed as the CM and with random start positions ±5 and ±10 cm from the start of the CM, followed by two similar trials with the mode of the RM changed. The first time the subject used a passive RM, he was instructed to say "stop" when the required distance had been reached. The pretest concluded with a brief explanation of the test and assurances that there would be a practice before each condition.

The test phase consisted of eight blocks of eight trials, each with instructions (see Appendix B) and practice before each. There was a 5 min. break before the first condition and another between conditions four and five, at which time the subject was encouraged to leave the room and move around. All practise trials had extents of 30 cm, and starting positions of the RM were randomly selected. There were two practise trials before each condition. More practise trials were used if necessary to meet the criterion of speed as judged by the experimenter or if, in passive reproduction conditions, the subject was dissatisfied with the place that the carriage was stopped. The experimental trials, with extents of 20 cm and random RM start positions of ±5 and ±10 cm from those of the CM so that each occurred twice, were aborted and restarted if they were not properly carried out.

The entire experiment, including the reading of instructions and the two 5 min. breaks, took about 80 min.

Data Analysis

The mean CE was computed for each group across subjects for each of the eight successive trials of each of the eight conditions. These means were plotted on a graph to provide a visual check for possible confounding due to repetition effects.

In accordance with recent practice in the literature, three dependent measures were used: AE, CE, and VE.

A fourth dependent measure was also used: PCDL. A RM was deemed to be correct when its extent was ±DL (in cm) from the extent of the CM. The DL was estimated by calculating half the range across the eight trials of the condition in which the CM and RM were identical.

Each dependent measure was analyzed using a four-way analysis of variance (ANOVA) with repeated measures on the last three factors. Post-hoc comparisons were performed using Duncan's new multiple range procedure (Duncan, 1955; Edwards, 1972) to assess hypotheses 1 and 2. Post hoc comparisons of the zero-cue and three-cue conditions of each group were made to assess hypothesis 3 using Duncan's new multiple range procedure using the means for all 16 conditions of both groups. The means for the 8 conditions of each group were used to generate a qualitative description of the memory trace for both the ALS and the PLS groups to assess hypothesis 4.

CHAPTER III

RESULTS

Repetition Effects

The mean CE, averaged across subjects in each group, was plotted for each of eight successive trials on graphs representing each of the eight conditions (see Figures 2-3). A visual check of the graphs did not reveal any systematic repetition effects.

Absolute Error (AE)

Analysis of variance for AE is summarized in Table 3. The main effects for the direction of reproduction, $F(1,30) = 19.32$, $p < .0001$, and speed of reproduction, $F(1,30) = 47.29$, $p < .0001$, were significant. No other main effects reached significant levels. Interactions of mode of criterion by mode of reproduction, $F(1,30) = 16.45$, $p < .001$, direction of reproduction by speed of reproduction, $F(1,30) = 7.41$, $p < .01$, mode of reproduction by speed of reproduction, $F(1,30) = 6.12$, $p < .01$, and mode of criterion by mode of reproduction by speed of reproduction, $F(1,30) = 6.87$, $p < .01$, were significant. No other interactions were significant.

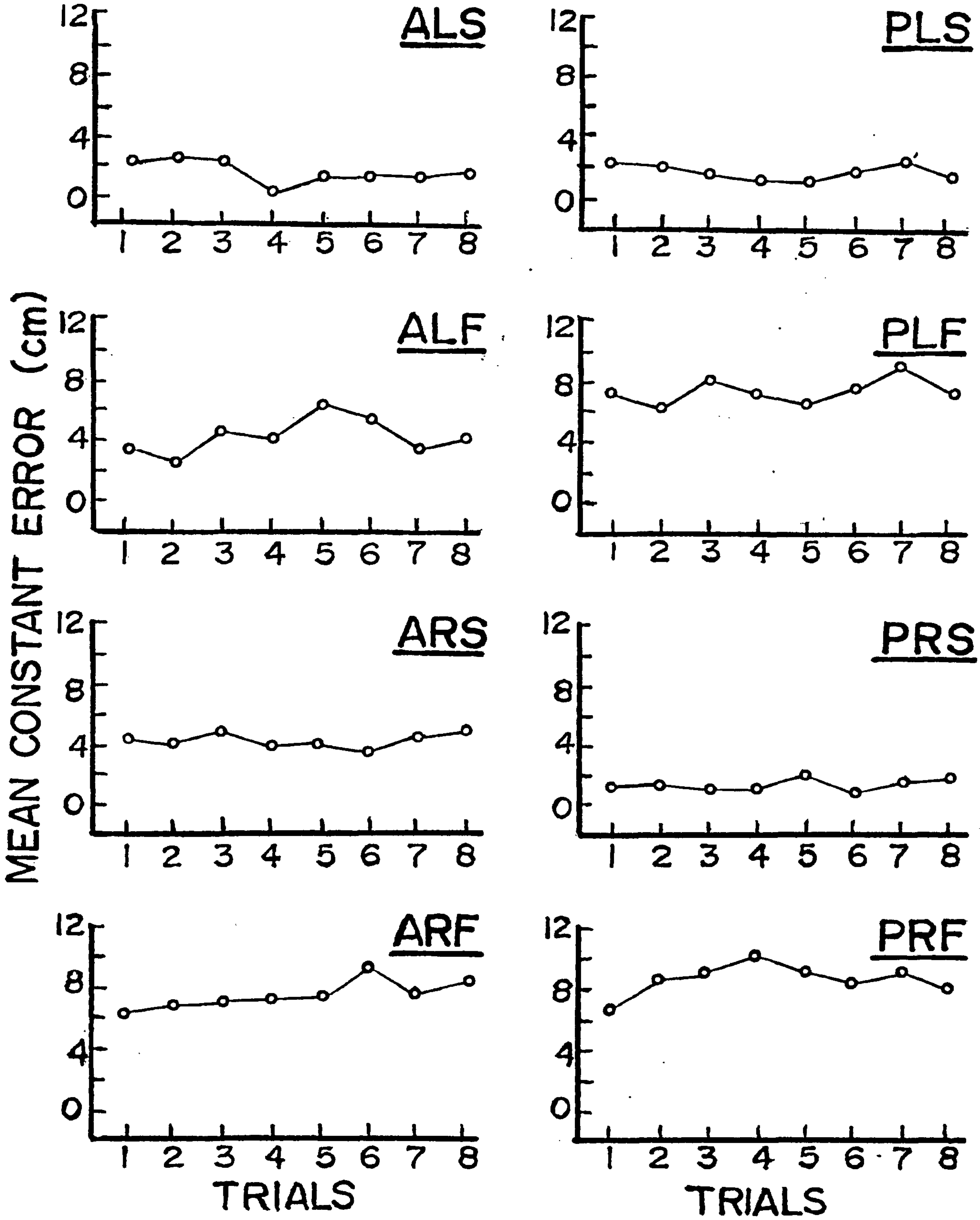

Figure 2. Mean constant error of each trial for all conditions of the active group.

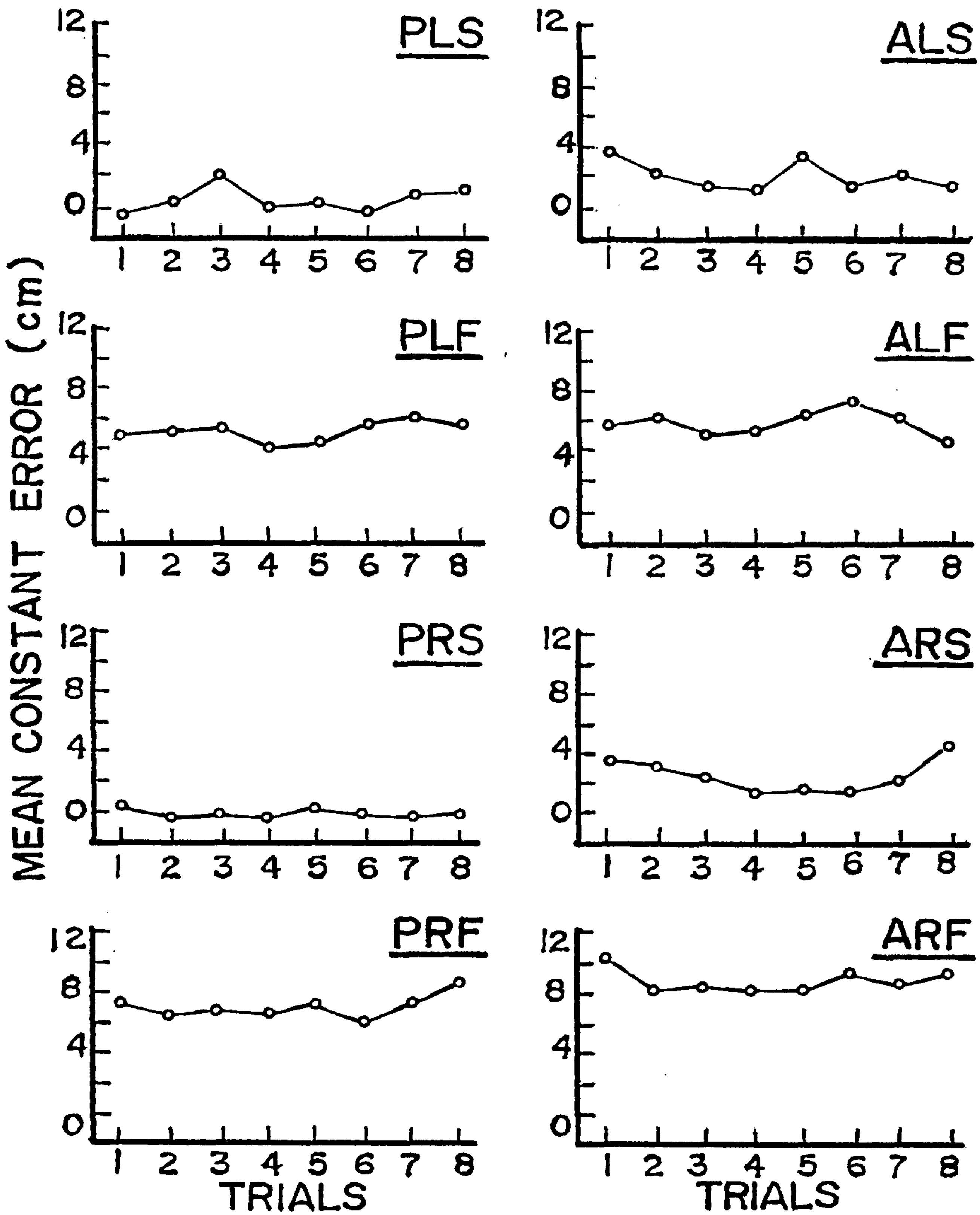

Figure 3. Mean constant error of each trial for all conditions of the passive group.

Table 3

Analysis of Variance Summary Table for Absolute Error

Source	SS	df	MS	F
Between Subjects	1294.34	31		
MC (mode of criterion)	6.32	1	6.32	0.15
Swg (subjects within groups)	1288.02	30	42.93	
Within Subjects	2475.74	224		
MR (mode of reproduction)	5.20	1	5.20	1.08
MC x MR	78.93	1	78.93	16.45***
MR x Swg	143.94	30	4.79	
DR (direction of reproduction)	127.40	1	127.40	19.32****
MC x DR	2.25	1	2.25	0.34
DR x Swg	197.87	30	6.59	
SR (speed of reproduction)	893.44	1	893.44	47.29****
MC x SR	0.02	1	0.02	0.00
SR x Swg	566.84	30	18.89	
MR x DR	17.58	1	17.58	3.59
MC x MR x DR	1.86	1	1.86	0.38
MR x DR x Swg	147.10	30	4.90	
DR x SR	17.48	1	17.48	7.41**
MC x DR x SR	0.83	1	0.83	0.36
DR x SR x Swg	70.79	30	2.35	
MR x SR	20.02	1	20.02	6.12**
MC x MR x SR	22.47	1	22.47	6.87**
MR x SR x Swg	98.18	30	3.27	
MR x DR x SR	0.29	1	0.29	0.14
MC x MR x DR x SR	0.00	1	0.00	0.00
MR x DR x SR x Swg	63.12	30	2.10	

** $p < .01$

*** $p < .001$

**** $p < .0001$

Post hoc comparisons are shown in Table 4. Analysis of the main effects showed that RMs to the left ($\bar{x}$ = 4.72 cm) were significantly more accurate than RMs to the right ($\bar{x}$ = 6.13 cm). Slow RMs ($\bar{x}$ = 3.56 cm) were performed with significantly better accuracy than fast RMs ($\bar{x}$ = 7.29 cm).

Duncan's analysis of the mode of criterion by mode of reproduction interaction revealed that when the modes of execution were the same there was significantly more accuracy (passive-passive $\bar{x}$ = 4.57 cm, active-active $\bar{x}$ = 5.17 cm) than when the modes of execution were different (passive-active $\bar{x}$ = 5.97 cm, active-passive $\bar{x}$ = 6.00 cm). The active-active and passive-passive conditons were not significantly different, nor were the passive-active and active-passive conditions.

Analysis of the direction of reproduction by speed of reproduction interaction indicated that left-slow ($\bar{x}$ = 3.11 cm) was significantly more accurate than right-slow ($\bar{x}$ = 4.00 cm) which was significantly more accurate than left-fast ($\bar{x}$ = 6.33 cm) which was significantly more accurate than right-fast ($\bar{x}$ = 8.26 cm).

Analysis of the interaction of mode by speed of the RMs showed that passive-slow ($\bar{x}$ = 3.14 cm) were significantly more accurate than active-slow ($\bar{x}$ = 3.98 cm) movements, and they were both significantly better than active-

Table 4

Duncan's Analysis of Significant Effects for Absolute Error

Effect	Duncan*								MS error	n
DR	L	R								
	4.72	6.13							6.59	128
SR	S	F								
	3.56	7.29							18.89	128
MC x MR	PP	AA	PA	AP						
	4.57	5.17	5.97	6.00					4.79	64
DR x SR	LS	RS	LF	RF						
	3.11	4.00	6.33	8.26					2.35	64
MR x SR	PS	AS	AF	PF						
	3.14	3.98	7.16	7.43					3.27	64
MC x MR x SR	PPS	APS	AAS	PAS	PPF	AAF	PAF	APF		
	2.71	3.56	3.89	4.07	6.43	6.45	7.86	8.43	3.27	32

* All pairs of means not connected by a horizontal line are significantly different, df=30, $p < .05$

Note: MC = mode of criterion, MR = mode of reproduction, DR = direction of reproduction, SR = speed of reproduction, A = active, P = passive, L = left, R = right, S = slow, F = fast.

fast ($\bar{X}$ = 7.16 cm) or passive-fast ($\bar{X}$ = 7.43 cm) movements which were not significantly different from each other.

Analysis of the interaction of mode of criterion by mode of reproduction by speed of reproduction revealed that all the slow components of the interaction were significantly more accurate than all the fast components. Passive-passive-slow ($\bar{X}$ = 2.71 cm) movements were not significantly different from active-passive-slow ($\bar{X}$ = 3.56 cm), but were significantly more accurate than active-active-slow ($\bar{X}$ = 3.89 cm) and passive-active-slow ($\bar{X}$ = 4.07 cm). The latter three components were not different from each other. Passive-passive-fast ($\bar{X}$ = 6.43 cm) movements were not different from active-active-fast ($\bar{X}$ = 6.45 cm), but they were significantly better than both passive-active-fast ($\bar{X}$ = 7.86 cm) and active-passive-fast ($\bar{X}$ = 8.43 cm) movements which were not different from each other.

Constant Error (CE)

Analysis of variance for CE is summarized in Table 5. Main effects for mode of reproduction, $\underline{F}(1,30) = 4.21$, $\underline{p} < .05$, direction of reproduction, $\underline{F}(1,30) = 13.06$, $\underline{p} < .001$, and speed of reproduction, $\underline{F}(1,30) = 79.29$, $\underline{p} < .0001$, were significant. There were no other main effects. Interactions of mode of criterion by mode of reproduction,

Table 5

Analysis of Variance Summary Table for Constant Error

Source	SS	df	MS	F
Between Subjects	2038.84	31		
MC (mode of criterion)	30.40	1	30.40	0.45
Swg (subjects within groups)	2008.44	30	66.94	
Within Subjects	3687.51	224		
MR (mode of reproduction)	26.02	1	26.02	4.21*
MC x MR	74.20	1	74.20	12.00***
MR x Swg	185.45	30	6.18	
DR (direction of reproduction)	136.48	1	136.48	13.06***
MC x DR	4.61	1	4.61	0.44
DR x Swg	313.42	30	10.44	
SR (speed of reproduction)	1609.89	1	1609.89	79.29****
MC x SR	10.63	1	10.63	0.52
SR x Swg	609.11	30	20.30	
MR x DR	48.19	1	48.19	6.59**
MC x MR x DR	6.44	1	6.44	0.88
MR x DR x Swg	219.34	30	7.31	
DR x SR	51.01	1	51.01	21.39****
MC x DR x SR	6.98	1	6.98	2.93
DR x SR x Swg	71.55	30	2.38	
MR x SR	87.45	1	87.45	19.57****
MC x MR x SR	26.18	1	26.18	5.86*
MR x SR x Swg	134.08	30	4.46	
MR x DR x SR	2.01	1	2.01	0.96
MC x MR x DR x SR	1.08	1	1.08	0.51
MR x DR x SR x Swg	63.29	30	2.10	

* $p < .05$

** $p < .01$

*** $p < .001$

**** $p < .0001$

$F(1,30) = 12.00$, $p < .001$, mode of reproduction by direction of reproduction, $F(1,30) = 6.59$, $p < .01$, direction of reproduction by speed of reproduction, $F(1,30) = 21.39$, $p < .0001$, mode by speed of reproduction, $F(1,30) = 19.57$, $p < .0001$, and mode of criterion by mode of reproduction by speed of reproduction, $F(1,30) = 5.86$, $p < .05$, were all significant. No other interactions reached significant levels.

Post hoc comparisons are shown in Table 6. All means indicated that all types of movements tended to be overshot. For the RM, active movements ($\bar{x}$ = 4.69 cm) were overshot to a greater extent than passive movements ($\bar{x}$ = 4.05 cm), movements to the right ($\bar{x}$ = 5.10 cm) were overshot more than movements to the left ($\bar{x}$ = 3.64 cm), and the overshooting of fast movements ($\bar{x}$ = 6.88 cm) exceeded the overshooting of slow movements ($\bar{x}$ = 1.87 cm).

A Duncan's post hoc analysis revealed that in the mode of criterion by mode of reproduction interaction, active-active ($\bar{x}$ = 4.50 cm), passive-active ($\bar{x}$ = 4.89 cm), and passive-passive ($\bar{x}$ = 4.94 cm) movements, while not significantly different from each other, all overshot passive-passive movements ($\bar{x}$ = 3.17 cm).

The mode of reproduction by direction of reproduction interaction indicated that active-left ($\bar{x}$ = 3.53 cm), passive-left ($\bar{x}$ = 3.76 cm), and passive-right ($\bar{x}$ = 4.35 cm) movements,

Table 6

Duncan's Analysis of Significant Effects for Constant Error

Effect	Duncan*								MS error	n
MR	P	A								
	4.05	4.69							6.18	128
DR	L	R								
	3.64	5.10							10.44	128
SR	S	F								
	1.87	6.88							20.30	128
MC x MR	PP	AA	PA	AP						
	3.17	4.50	4.89	4.94					6.18	64
MR x DR	AL	PL	PR	AR						
	3.53	3.76	4.35	5.86					7.31	64
DR x SR	LS	RS	LF	RF						
	1.58	2.15	5.70	8.06					2.38	64
MR x SR	PS	AS	AF	PF						
	0.96	2.77	6.62	7.15					4.46	64
MC x MR x SR	PPS	APS	PAS	AAS	AAF	PPF	PAF	APF		
	0.20	1.73	2.14	3.10	5.90	6.15	7.33	8.15	4.46	32

* All pairs of means not connected by a horizontal line are significantly different, df=30, $p < .05$

Note: MC = mode of criterion, MR = mode of reproduction, DR = direction of reproduction, SR = speed of reproduction, A = active, P = passive, L = left, R = right, S = slow, F = fast.

while not different from each other, were overshot to a lesser extent than active-right movements ($\bar{x}$ = 5.86 cm).

For the direction by speed of reproduction interaction, left-slow movements ($\bar{x}$ = 1.58 cm) were overshot less than right-slow movements ($\bar{x}$ = 2.15 cm) which were overshot less than left-fast movements ($\bar{x}$ = 5.70 cm) which were overshot less than right-fast movements ($\bar{x}$ = 8.06 cm).

Analysis of the mode by speed of reproduction interaction revealed that active-fast ($\bar{x}$ = 6.62 cm) and passive-fast ($\bar{x}$ = 7.15 cm) movements, while not significantly different from each other, both overshot active-slow movements ($\bar{x}$ = 2.77 cm) which, in turn, overshot passive-slow movements ($\bar{x}$ = 0.96 cm) which were also overshot.

Analysis of the mode of criterion by mode of reproduction by speed of reproduction interaction showed that all fast movement components of the interaction were overshot to a greater extent than all slow movement components. Passive-active-fast movements ($\bar{x}$ = 7.33 cm) and active-passive-fast movements ($\bar{x}$ = 8.15 cm) did not differ but did overshoot active-active-fast ($\bar{x}$ = 5.90 cm) and passive-passive-fast ($\bar{x}$ = 6.15 cm) movements which were not different from each other. Passive-passive-slow movements ($\bar{x}$ = 0.20 cm) were overshot less than the other three slow components of the interaction. Active-passive-slow movements ($\bar{x}$ = 1.73 cm) were not overshot as much as active-active-slow movements ($\bar{x}$ = 3.10 cm), and neither differed from passive-active-slow movements ($\bar{x}$ = 2.14 cm).

Variable Error (VE)

Analysis of variance for VE is summarized in Table 7. The main effect of speed of reproduction, $F(1,30) = 6.49$, $p < .01$, was the only main effect to reach significant levels. An interaction of mode of criterion by mode of reproduction, $F(1,30) = 4.53$, $p < .05$, was the only interaction that was significant.

Post hoc comparisons are shown in Table 8. Analysis indicated that for RMs, slow movements ($\bar{x}$ = 9.05 cm) were significantly less variable than fast movements ($\bar{x}$ = 11.55 cm).

A Duncan's post hoc analysis performed on the interaction of mode of criterion by mode of reproduction indicated that the only significant difference was that passive-passive movements ($\bar{x}$ = 8.28 cm) were significantly less variable than passive-active movements ($\bar{x}$ = 12.37 cm). Active-active ($\bar{x}$ = 10.19 cm) and active-passive ($\bar{x}$ = 10.36 cm) movements did not differ from each other or from passive-passive or passive-active movements.

Table 7

Analysis of Variance Summary Table for Variable Error

Source	SS	df	MS	F
Between Subjects	3948.30	31		
MC (mode of criterion)	0.15	1	0.15	0.00
Swg (subjects within groups)	3948.25	30	131.60	
Within Subjects	13564.13	224		
MR (mode of reproduction)	246.61	1	246.61	3.86
MC x MR	289.49	1	289.49	4.53*
MR x Swg	1916.94	30	63.89	
DR (direction of reproduction)	196.89	1	196.89	3.79
MC x DR	1.41	1	1.41	0.03
DR x Swg	1559.62	30	51.98	
SR (speed of reproduction)	397.68	1	397.68	6.49**
MC x SR	21.86	1	21.86	0.36
SR x Swg	1838.29	30	61.27	
MR x DR	61.14	1	61.14	0.92
MC x MR x DR	33.10	1	33.10	0.50
MR x DR x Swg	1985.47	30	66.18	
DR x SR	10.96	1	10.96	0.23
MC x DR x SR	3.22	1	3.22	0.07
DR x SR x Swg	1406.91	30	46.89	
MR x SR	8.61	1	8.61	0.16
MC x MR x SR	15.05	1	15.05	0.29
MR x SR x Swg	1575.70	30	52.52	
MR x DR x Sr	1.88	1	1.88	0.03
MC x MR x DR x SR	38.70	1	38.70	0.59
MR x DR x SR x Swg	1954.35	30	65.14	

* $p < .05$

** $p < .01$

Table 8

Duncan's Analysis of Significant Effects for Variable Error

Effect	Duncan*				MS error	n
SR	S	F				
	9.05	11.55			61.27	128
MC x MR	PP	AA	AP	PA		
	8.28	10.19	10.36	12.37	63.89	64

* All pairs of means not connected by a horizontal line are significantly different, df=30, $p < .05$

Note: MC = mode of criterion, MR = mode of reproduction, DR = direction of reproduction, SR = speed of reproduction, A = active, P = passive, L = left, R = right, S = slow, F = fast.

Percentage Correct Based on Difference Limen (PCDL)

Analysis of variance for PCDL is summarized on Table 9. Main effects for direction of reproduction, $\underline{F}(1,30) = 9.32$, $\underline{p} < .01$, and speed of reproduction, $\underline{F}(1,30) = 61.45$, $\underline{p} < .0001$, were significant with no other main effects reaching significant levels. Interactions of mode of criterion by mode of reproduction, $\underline{F}(1,30) = 10.83$, $\underline{p} < .01$, and mode by speed of reproduction, $\underline{F}(1,30) = 13.24$, $\underline{p} < .001$, were significant. All other interactions failed to reach significant levels.

Post hoc comparisons are shown in Table 10. Analysis of main effects showed that for RMs, those to the left ($\overline{X}$ = 51.95 %) were recalled significantly better than those to the right ($\overline{X}$ = 42.87 %), and those that were slow ($\overline{X}$ = 63.08 %) had significantly better recall than those that were fast ($\overline{X}$ = 31.73 %).

Duncan's analysis of the mode of criterion by mode of reproduction interaction indicated that active-passive ($\overline{X}$ = 48.63 %), passive-passive ($\overline{X}$ = 49.41 %), and active-active ($\overline{X}$ = 54.10 %) movements were not different from each other, but all produced better recall than passive-active movements ($\overline{X}$ = 37.50 %).

Post hoc analysis of the interaction of mode by speed of reproduction showed that passive-fast ($\overline{X}$ = 29.29 %) and active-fast ($\overline{X}$ = 34.17 %) movements did not differ, but both resulted in poorer recall than active-slow movements

Table 9

Analysis of Variance Summary Table for Percentage Correct

Based on Difference Limen

Source	SS	df	MS	F
Between Subjects	101469.10	31		
MC (mode of criterion)	4004.51	1	4004.51	1.23
Swg (subjects within groups)	97464.59	30	3248.81	
Within Subjects	181972.67	224		
MR (mode of reproduction)	664.67	1	664.67	1.49
MC x MR	4834.59	1	4834.59	10.83**
MR x Swg	13387.45	30	446.24	
DR (direction of reproduction)	5278.93	1	5278.93	9.32**
MC x DR	444.94	1	444.94	0.79
DR x Swg	16990.96	30	566.36	
SR (speed of reproduction)	62891.23	1	62891.23	61.45****
MC x SR	1465.45	1	1465.45	1.43
SR x Swg	30701.90	30	1023.39	
MR x DR	664.67	1	664.67	1.83
MC x MR x DR	444.94	1	444.94	1.22
MR x DR x Swg	10902.09	30	363.40	
DR x SR	444.94	1	444.94	1.77
MC x DR x SR	176.39	1	176.39	0.70
DR x SR x Swg	7562.25	30	252.07	
MR x SR	4204.71	1	4204.71	13.24***
MC x MR x SR	0.61	1	0.61	0.00
MR x SR x Swg	9525.14	30	317.50	
MR x Dr x SR	322.87	1	322.87	0.90
MC x MR x DR x SR	322.87	1	322.87	0.90
MR x DR x SR x Swg	10740.96	30	358.03	

** $p < .01$

*** $p < .001$

**** $p < .0001$

Table 10

Duncan's Analysis of Significant Effects for

Percentage Correct Based on Difference Limen

Effect	Duncan*				MS error	n
DR	R	L				
	42.87	51.95			566.36	128
SR	F	S				
	31.73	63.08			1023.40	128
MC x MR	PA	AP	PP	AA		
	37.50	48.63	49.41	54.10	446.24	64
MR x SR	PF	AF	AS	PS		
	29.29	34.17	57.42	68.75	317.40	64

* All pairs of means not connected by a horizontal line are significantly different, df=30, $p < .05$

Note: MC = mode of criterion, MR = mode of reproduction, DR = direction of reproduction, SR = speed of reproduction, A = active, P = passive, L = left, R = right, S = slow, F = fast.

($\overline{x}$ = 57.42 %), which, in turn, produced signficantly poorer recall than passive-slow movements ($\overline{x}$ = 68.75 %).

Three-Cue vs. Zero-Cue Comparisons and Condition Means

A priori comparisons of the three-cue and zero-cue conditions for each group are found in Table 11, with means for all conditions shown in Table 12.

A comparison of the AEs indicated that for the active group the three-cue ALS condition ($\overline{x}$ = 2.91 cm) was significantly more accurate than the cueless PRF condition ($\overline{x}$ = 9.12 cm), with all other conditions falling between these two. For the passive group the AE of the PLS maximum cue condition ($\overline{x}$ = 2.63 cm) indicated that it was significantly more accurate than the zero-cue ARF condition ($\overline{x}$ = 8.94 cm), with all other conditions falling between them.

The PCDLs were compared to show that for the active group the three-cue ALS condition ($\overline{x}$ = 74.21 %) was recalled significantly better than the zero-cue PRF condition ($\overline{x}$ = 30.46 %) with the means of all the other conditions between them. For the passive group, the PCDLs indicated that the maximum-cue PLS condition ($\overline{x}$ = 72.65 %) surpassed the cueless ARF condition ($\overline{x}$ = 22.65 %) in recall, with all other conditions falling between.

All one-cue conditions had lower PCDLs and higher AEs

Table 11

Duncan's Analysis of the AE and PCDL Means for the Zero-Cue vs. Three-Cue Conditions

Dependent Variable	Criterion Group	Duncan* 3 cues 0 cues	MS error	k
AE	ALS	ALS vs. PRF significant	2.10	14
	PLS	PLS vs. ARF significant	2.10	14
PCDL	ALS	ALS vs. PRF significant	358.03	12
	PLS	PLS vs. ARF significant	358.03	14

* df=30, n=16, $p < .01$

Note: AE = absolute error, PCDL = percentage correct based on difference limen, A = active, P = passive, L = left, R = right, S = slow, F = fast.

Table 12

AE and PCDL Means of Reproduction Movement Conditions

for Active and Passive Groups

Dependent Variable	Criterion Group	Means of Reproduction Movement Conditions							
AE	ALS	ALS 2.91	PLS 3.35	PRS 3.77	ARS 4.87	ALF 5.14	PLF 7.74	ARF 7.77	PRF 9.12
	PLS	PLS 2.63	PRS 2.80	ALS 3.57	ARS 4.57	PLF 5.65	ALF 6.79	PRF 7.22	ARF 8.94
PCDL	ALS	ALS 74.21	PLS 71.09	PRS 60.93	ARS 52.34	ALF 51.56	ARF 38.28	PLF 32.03	PRF 30.46
	PLS	PLS 72.65	PRS 70.31	ALS 57.81	ARS 45.31	PLF 32.03	ALF 24.21	PRF 22.65	ARF 22.65

Note: AE = absolute error, PCDL = percentage correct based on difference limen, A = active, P = passive, L = left, R = right, S = slow, F = fast.

than two-cue conditions containing that cue except for in the active group where passive-right-slow RMs (slow cue) were more accurate and recalled more often than active-right-slow RMs (active and slow cues).

Description of the Memory Trace for the Active Group

The requirement that there is a significantly smaller percentage correct for the zero-cue condition ($\overline{X}$ = 30.46 %) than for the three-cue condition ($\overline{X}$ = 74.21 %), with all other conditions between these two, was met. However, the mean percentage recall was better when the slow cue was used alone ($\overline{X}$ = 60.93 %) than when the active and slow cues were used simultaneously ($\overline{X}$ = 52.34 %). This violates the encoding specificity principle assumption that movement using one cue must be poorer than or equal to movement using that cue plus another. Therefore, a memory trace could not be derived from the data.

Description of the Memory Trace for the Passive Group

The corrected probability coefficients are shown in Table 13. The coefficient of the three-cue condition (.50) was considerably higher than the total of the coefficients of the three one-cue conditions (.00 + .01 + .22). The additive effects of all possible combinations of pairs of single-cue conditions were all considerably less than the

Table 13

Corrected Probability Coefficients

for Gross Valences of the Memory Trace

for the Passive Group Based on PCDL

Condition	Retrieval Cue or Gross Valence	Experimental Probability**	Corrected Probability Coefficient***
PRF	P	.23	.00
ALF	L	.24	.01
ARS	S	.45	.22
PLF	P&L	.32	.09
ALS	L&S	.58	.35
PRS	P&S	.70	.47
PLS	P&L&S	.73	.50
ARF	U*	.23	

* U = uncontrolled cues or the portion of the memory trace with unknown relationship

** experimental probability = PCDL / 100 (see Table 12 for PCDL values)

*** corrected probability coefficient = experimental probability - U

Note: PCDL = percentage correct based on difference limen, A = active, P = passive, L = left, R = right, S = slow, F = fast.

effects of the corresponding conditions using the same two cues simultaneously. The encoding specificity principle does not provide for some kind of bonus or catalyst effect when cues are used in combination. Since the formulation of a qualitative description of the memory trace is based on the assumptions of the encoding specificity principle, no such description of the trace could be derived in this case.

CHAPTER IV

DISCUSSION

The present experiment was designed primarily to test the hypothesis that the encoding specificity principle could be graphically demonstrated in motor short-term memory by manipulating multiple cues for retrieval of extent information, and that the resulting data could be used to compose a quantitative description of the memory trace such as that produced by Tulving and Watkins (1975) in the verbal literature.

Information from Traditional Measures of AE, CE, and VE

Using AE as a measure of accuracy, the results of the present study clearly demonstrate that for mode, direction, or speed, the retrieval of extent information is more accurate when output matches input, supporting the encoding specificity principle as it applies to episodic memory. Lee and Hirota's (1980) findings that there is no advantage to active over passive movements as long as mode of retrieval matches mode of encoding were supported. The results of the present study and the Lee and Hirota study for the mode of criterion by mode of reproduction interaction were the same: Passive-passive and active-active movements did not differ but were more accurate than passive-active or active-passive movements which did not themselves differ.

In an effort to extend the encoding specificity principle findings for motor short-term memory by using multiple cues, it was found that for both active and passive groups the three-cue condition at retrieval was significantly more effective than the zero-cue condition, with all other cue conditions falling between. With one exception, all two-cue conditions were more effective at retrieval than either of the single-cue conditions utilizing those cues. These results, although partially flawed, lend support to the contention that the closer the conditions at input and output are matched the more accurate is the retrieval of episodic memory. The fact that for the active group, contrary to the encoding specificity principle, the single cue of slow movement was more effective than the simultaneous use of both active and slow movement cues cannot readily be explained. Possibly the addition of a weak cue to a strong one has such a minimal effect that the two conditions cannot be statistically differentiated. The present experiment should be replicated to clarify whether the result occurred by chance or whether there are certain circumstances when the encoding specificity principle does not apply.

Speed of reproduction interacted with direction of reproduction, with mode of reproduction, and with mode of criterion by mode of reproduction. For each interaction, all the slow movement conditions were more accurate than all the fast movement conditions. Speed was the most powerful cue.

For accuracy, the direction of reproduction interacted only with the speed of reproduction, indicating that the effects of direction were relatively independent. For both slow and fast RMs, those in the same direction as the CMs were superior to those in the opposite direction.

Interactions of mode of reproduction by speed of reproduction indicated that for slow movements, those that were passive were more accurate than those that were active, a finding that is difficult to explain. There were no differences between active and passive fast movements indicating that efforts to coordinate the subjects' "stop" commands and the experimenter's actual stopping of the carriage were successful despite the fast speed.

For the mode of criterion by mode of reproduction by speed of reproduction interaction, with fast movements all four active and passive combinations compared exactly as in the mode of criterion by mode of reproduction interaction. For slow movements the results were not so clear cut. Passive-passive movements were more accurate than both active-active and passive-active movements with no other significant differences. In the present experiment, the encoding specificity principle applied more for mode when the speeds of the RM and CM were different than when they were both slow. This suggests that weak cues are used more efficiently when strong cues are not present, a possibility worth investigating.

In terms of CE, all RMs tended to be overshot, and decreased accuracy was generally accompanied by increased overshooting. A surprising finding, since Lee and Hirota (1980) found that passive RMs overshot active, was that active RMs were overshot more than passive RMs. The difference may be due to the use of 20 cm movements in the present study rather than 30 cm movements used by Lee and Hirota.

In terms of VE, fast movements were more variable than slow movements reflecting a lack of precision for fast movements. The subject must monitor proprioceptive information to gain knowledge of constrained and passive movements (Carlton, 1978). The experimenter attempted to ensure that subjects would have time to make use of proprioceptive feedback by aborting movements which were judged to be too fast. The increased variability for fast movements over slow may have been due to the increased distance travelled for fast movements compared to slow in the reaction time for kinesthetic feedback. Making a stop at the exact spot where sensory information matches the memory of the sensory information produced by the CM would be more difficult in such circumstances. A more sophisticated, automated, electro-mechanical brake system to stop the carriage might have provided less variability in measurement than the experimenter-controlled procedure that was used.

PCDL as a Dependent Measure

The PCDL results were identical to AE in terms of the direction and speed of reproduction and of the mode of reproduction by speed of reproduction interaction. Both dependent variables indicated a mode of criterion by mode of reproduction interaction. Analysis of the PCDL interaction indicated that passive-active movements were significantly inferior in recall than all other criterion and reproduction mode combinations, a finding that does not fit the encoding specificity principle hypothesis as completely as the secondary analysis of the AE results. Unlike AE, there were no direction of reproduction by speed of reproduction or mode of criterion by mode of reproduction by speed of reproduction interactions ($p < .05$). For the most part, the post hoc comparisons of the AE interactions which failed to materialize for PCDL could be adequately explained and added valuable information i.e. the relationship of the cues to each other.

Although PCDL was proposed as a measure for motor short-term memory research to minimize individual differences in recall capabilities, comparison of the PCDL results with the more meaningful results of AE indicated that PCDL is not a very sensitive measure. One way of improving the measure might be to use an extended DL in cases where the range of signed errors used to determine the DL does not encompass zero. In such cases the range used to determine the extended DL could be from zero to the greatest error. It is expected, however, that this refinement in the measure would result in only a marginal increase in sensitivity due to the relative infrequencey of such occurrences.

In view of the inadequate sensitivity of PCDL as a measure of recall, an alternate measure should be sought for use in future studies attempting to quantitatively describe the memory trace. The percentage correct based on AE (PCAE) might be a more sensitive measure and thus more useful. This would be computed by dividing the unsigned error by the CM and multiplying by 100, then subtracting the result from 100. If PCAE had been used in the present experiment, the results (see Appendix C, Tables 14 and 15) would have been identical to the AE results.

Although the present attempts to quantitatively describe the motor memory traces fell short of expectations, the idea seems worth pursuing.

A memory trace for the active group could not be constructed because the experimental findings did not completely support the encoding specificity principle upon which the idea for determining the properties of the trace was based. The experiment should be replicated to investigate whether this was a meaningful or chance finding. Perhaps, in cases where a cue has a minimal effect, its addition to a strong cue would not be statistically discriminable. If such is the case, a modification of the treatment of the data in generating the qualitative description of the memory trace would have to be considered or the idea abandoned.

If PCAE proves to be a sensitive measure in future experiments, it may be the means by which the components of the motor memory trace can be quantitatively described. Indeed, if PCAE had been used as a dependent variable in the present experiment, a quantitative description of the memory trace could have been composed for the passive group (see Appendix C, Table 16 and 17, and Figure 4).

Encoding Specificity Difficulties as Revealed by Other Studies

Tulving (1972) states that episodic memory "receives and stores information about temporally dated episodes or events and relations among those events". Watkins and Tulving (1975) claim that an encounter with an event results in the creation of a unique trace which will be largely governed by, but be retained independently of, knowledge of the event. Tulving and Watkins cautioned that the trace is not necessarily a true, nor even an incomplete or impoverished copy of what has been presented to the memory system.

In the present experiment, the closer the conditions at recall to the conditions at encoding, the better the retrieval. In this case the memory trace appeared to be a fairly good copy of the conditions encountered during the CM. But in cases where the trace is an impoverished or distorted copy of the conditions at encoding, the probe at recall is only effective in as much as it overlaps the actual memory trace rather than the conditions at encoding. Tulving and Watkins' (1975) reduction method, then, is a valuable aid in determining the nature of the memory trace and is a possible way of getting at components that have actually been stored, including cognitive components. However, care must be taken to anticipate subjects' retrieval strategies which might change the nature of the probe or cue to one that was not intended.

Lee and Hirota (1980) commented that their results did not agree with those of Kelso (1977) who found, when both end-location and extent were reliable cues for retrieval of constrained movements, that active-active, passive-active, and passive-passive movements were only marginally different (active-active had the lowest mean and passive-passive the highest).

The Kelso (1977) results can be interpreted in terms of the subjects' retrieval strategies. Since end-locations of all movements were parallel to and in front of the frontal plane of the body, one component of the memory trace may have been a location code associated with the specific reference points on the body. If subjects found this body-referenced location code more reliable and easier to use than kinesthetic cues alone, to the point where active and passive cues were rendered redundant, the mode cues may have been ignored at retrieval in favour of a cognitive strategy of aiming the RM for the same end-location relative to the body as the CM. If such is the case, with practice subjects may not even have attended to or encoded mode or extent cues. Since the elbow was in a splint, another reliable strategy might have been to retrieve, and perhaps even encode, only the degree to which the inner arm touched the bcdy at the armpit. If each CM-RM pair was a test of location code or tactile code or a combination of both, then the different groups would be expected to be invariant with respect to accuracy.

Further evidence for this interpretation can be found in the mixed results of other end-location studies in which conditions at input and output were manipulated.

Larish, Stelmach, and McCracken (1979) found that switched-limb reproduction of end-location was inferior to same-limb reproduction in each of three direction conditions, as would be expected by the encoding specificity principle. In this case the CM and RM were performed on different tracks of a dual-track apparatus, and the movements were conducted in vertically up, vertically down, and near to far directions. Both of these factors would make a retrieval strategy of using a location code associated with specific reference points on the body relatively unreliable. Subjects, then, would have to rely on perceptible properties of inputs, handedness would be both encoded and used at retrieval, and switched-limb production would be expected to be poorer than same-limb reproduction.

Wallace (1977) also manipulated the use of limbs for CMs and RMs for end-location, but with different results. When direction was invariant, switched-limb reproduction was equal to same-limb reproduction. In this case, end-locations were parallel to and in front of the frontal plane as in the case of Kelso (1977), encouraging subjects to ignore kinesthetic handedness cues in favour of location codes associated with the body. Thus there was no effect for handedness. When directions were switched from CM to RM, but the same limb was used, location codes associated with the body were probably still reliable, direction could be ignored, and there was no main effect for direction. Actually, in both cases there probably was a minimal effect, not detected statistically. For all five targets, when handedness was invariant, means were higher when direction was changed than when it was the same. For four of the five targets, when direction was invariant, means were higher for switched-limb conditions than same-limb conditions. The only exception was virtually equal means at the mid-point of the body, where location cues would be the same and joints of both arms would be bent at the same angle.

When both direction and limb were manipulated for the CM and the RM, in keeping with the encoding specificity principle, the closer the match between conditions at retrieval matched the conditions at encoding, the more accurate the retrieval. Wallace speculated that "location code is associated with specific reference points on the body which can be more easily used when reproduction movement is initiated from the same side of the body as the criterion". When the location code can no longer be reliably used, perceptible properties of inputs are encoded and utilized at retrieval.

Because motor movements are prone to cognitive retrieval strategies, experimenters studying the effects of the encoding specificity principle must anticipate and minimize any that might occur. When cues that are manipulated during CM and RM are ineffective in demonstrating the encoding specificity principle, it is possible that cognitive mediation is taking place during retrieval so that the retrieval cue is not the one intended by the experimenter. Thus, the only memory trace component actually retrieved is the one that is part of the subject's retrieval strategy. The experimenter who is seeking to construct a replicate of the memory trace, then, must ensure that retrieval cues are well-controlled pure probes.

Suggestions for Further Research

Replication of the present experiment is suggested using AE and PCAE as dependent measures. As previously suggested, replication would help clarify some minor peculiarities found in the present experiment. Also, the qualitative description of the memory trace for the passive group could be verified or disconfirmed when the conditions are identical.

Another interesting experiment would be to use the same within-subject variables, but to use a group with active fast CMs to the left and another group with active slow CMs to the left. Such an experiment would indicate whether speed is an equally strong cue for fast movements as for slow, and would clarify the relationship between mode and slow and fast speeds.

It is suggested that another experiment be conducted similar to the present experiment, but using only one of the two groups. A second group would be identical except for the fact that it would be provided with a counting strategy. Such an experiment would allow investigation as to whether or not such a retrieval strategy would render kinesthetic cues redundant.

If a method can be found for quantitatively describing memory traces, many new types of research would be possible. The developmental aspect of storage and retrieval of motor information could be investigated as was done for verbal information (Ceci and Howe, 1978; Ceci, Lea, and Howe, 1980). Traces could also be compared between athletes, people who consider themselves to be clumsy, and a control to see if there are differences in coding or recall. Similarily, traces of mild retardates and normals could be compared. The effects of various kinds of interference could be studied by comparing memory traces under different conditions.

<u>Summary</u>

Extending the encoding specificity principle in motor short-term memory by the use of multiple cues indicates that the conditions of retrieval as well as the conditions of encoding should always be taken into consideration. How well the encoding specificity principle applies under special conditions, however, requires further investigation. Such an approach must take into account cognitive retrieval strategies.

Attempts to quantitatively describe the memory trace met with failure in the present experiment, but further attempts using PCAE as a dependent measure might prove to be lucrative and should be pursued.

APPENDIX A

PRESENTATION ORDER OF EXPERIMENTAL CONDITIONS

Subject								
1.	ALS	ALF	ARF	ARS	PRF	PRS	PLS	PLF
2.	ALF	ALS	ARS	ARF	PRS	PRF	PLF	PLS
3.	ARS	ARF	ALF	ALS	PLF	PLS	PRS	PRF
4.	ARF	ARS	ALS	ALF	PLS	PLF	PRF	PRS
5.	PLS	PLF	PRF	PRS	ARF	ARS	ALS	ALF
6.	PLF	PLS	PRS	PRF	ARS	ARF	ALF	ALS
7.	PRS	PRF	PLF	PLS	ALF	ALS	ARS	ARF
8.	PRF	PRS	PLS	PLF	ALS	ALF	ARF	ARS

(time)
→

Note: The sequence repeats for subjects 9 to 16, 17 to 24, 25 to 32.

APPENDIX B

INSTRUCTIONS TO SUBJECTS

Written Preliminary Instructions

The purpose of this experiment is to see how well the distance of arm movements can be repeated under different conditions when you cannot see your arm. The task involves movement of a small carriage between two stops along a straight slide.

During the pretest phase you will be acquainted with the apparatus and the kinds of movement required. There will be two TYPES of movement:

(1) during ACTIVE movement you will grasp the handle of the carriage with your first two fingers and actively move the carriage.

(2) during PASSIVE movement you will lightly place two fingers on the handle, totally relaxing your arm and hand, and the carriage will be moved for you.

There will be two SPEEDS of movement:

(1) SLOW

(2) FAST

There will be two DIRECTIONS of movement:

(1) from right to LEFT

(2) from left to RIGHT

In the test phase, one trial will consist of two movements: a given movement, and an attempt to reproduce the distance of that movement. The first movement will require (an active / a passive) movement starting from your right and moving to your left until a stop is contacted. You will slowly and smoothly place your hand in your lap and immediately reach for the carriage and try to reproduce the distance of the first movement. The second movement will take place under eight different conditions resulting from changing the type, the speed, and the direction of the movement. Each condition will be preceded by a practice session to familiarize you with the procedure that is required.

The entire experiment should take about 80 min., including a 5 min. break after the pretest and another 5 min. break half way through the test phase.

The experimenter will join you in a moment. Please feel free to ask any questions that you might have.

<u>Pretest Adjustments</u>

1. Adjust stool.
2. Adjust chin rest.
3. Adjust shelf.
4. Indicate the green dot on the visual shield.
5. Provide earphones - listen to white noise.

Pretest Instructions

Whenever you make a movement, look in the direction of the green dot and keep your chin secured in the chin rest. All movements go from outside inwards.

First we will practise a passive slow movement. Extend your right hand to your right. I will guide your hand to the carriage. Place the first two fingers lightly around the handle, totally relaxing your arm and hand, and I will move the carriage for you to your left at a slow even pace. Try to remember the speed of a slow movement. Drop your hand at the end of a movement. (3 movements)

Now extend your hand to your left and perform a passive slow movement moving to your right. (3 movements)

Now we will practise an active slow movement. Extend your hand to your right. Grasp the carriage handle between your first two fingers. Actively move the carriage to your left at the same slow steady pace that you moved before. (3 movements)

Now extend your hand to your left and perform an active slow movement to your right. (3 movements)

Now we will practise a passive fast movement. Remember to put your two fingers on the handle and totally relax your arm and hand. Extend your hand to the right and move to the left. Try to remember the speed of a fast movement. (3 movements)

Now extend your hand to the left and perform a passive fast movement to your right. (3 movements)

Now we will practise an active fast movement. Extend your arm to the right and actively move the carriage to your left at the same speed that you moved before. (3 movements)

Now extend your hand to your left and perform an active fast movement to your right. (3 movements)

For each trial there will be a first movement to a stop followed by an attempt to reproduce the distance of that movement. The first movement will always be performed the same way: (actively / passively) move the carriage slowly to your left. Whenever you are moving, look in the direction of the green dot. At the end of the movement slowly and smoothly place your hand in your lap. Try it when you hear the white noise. (2 movements)

Now we will try another first movement followed by an attempt to reproduce the distance of that movement. The second movement will be of the same type, in the same direction, and at the same speed as the first. For each trial, white noise will be a signal for you to begin. After performing the first movement and dropping your hand in your lap, immediately, at the same speed, extend your hand. The carriage will be in a slightly different position, but I will guide your hand to it, and you immediately try to reproduce the distance the carriage moved during the first movement. When you do these movements, I want you to concentrate on the distance you move. Don't pay any attention to the location of the carriage or any other cues that might halp you with the second movement. Just concentrate on the feeling of moving the distance during the first movement, and then try to get the feeling of the same distance when you perform the second movement. (Quickly say "stop" when you have gone far enough.) (2 trials)

Now we will do two more trials with the second movement at the same speed and in the same direction as the first, but of the (active / passive) type. (Quickly say "stop" when you have gone far enough.) (2 movements)

You will run the experiment under eight different conditions with eight trials for each condition. The first movement will always be the same, but the second movement will change type, direction, or speed for each condition. We will have a practice prior to each condition.

(5 min. break)

Test Instructions

For the first half of the experiment, the second movement will always be (active / passive). That is, there will be (an active / a passive) first movement followed by (an active / passive) attempt to reproduce the distance of the first movement. (Remember to say "stop".) Look in the direction of the green dot whenever you are making a movement.

During the (first / next / last) condition, the second movement will be (active / passive, to the left / to the right, slow / fast).

(practise 2 times for each condition)

(Note: subjects were allowed to remove their chins from the chin-rest and shift their positions between conditions)

(5 min. break)

For the last half of the experiment, the second movement will always be (active / passive). That is, there will be (an active / a passive) first movement followed by (an active / a passive) attempt to reproduce the distance of the first movement. (Remember to say "stop".) Look in the direction of the green dot whenever you are making a movement.

During the (first / next / last) condition, the second movement will be (active / passive, to the left / to the right, slow / fast).

practise 2 times for each condition)

(Note: subjects were allowed to remove their chins from the chin-rest and shift their positions between conditions).

APPENDIX C

DATA ANALYSIS BASED ON POST HOC PCAE MEASUREMENT

Table 14

Analysis of Variance Summary Table for Percentage Correct Based on Absolute Error

Source	SS	df	MS	F
Between Subjects	32358.84	31		
MC (mode of criterion)	158.20	1	158.20	0.15
Swg (subjects within groups)	32200.64	30	1073.33	
Within Subjects	61893.26	224		
MR (mode of reproduction)	130.10	1	130.10	
MC x MR	1973.30	1	1973.30	16.45***
MR x Swg	3598.60	30	119.95	
DR (direction of reproduction)	3185.19	1	3185.19	19.32****
MC x DR	56.48	1	56.48	0.34
DR x Swg	4946.96	30	164.89	
SR (speed of reproduction)	22336.23	1	22336.23	47.29****
MC x SR	0.61	1	0.61	0.00
SR x Swg	14171.07	30	472.36	
MR x DR	439.68	1	439.68	3.59
MC x MR x DR	46.62	1	46.62	0.38
MR x DR x Swg	3677.71	30	122.59	
DR x SR	437.07	1	437.07	7.41**
MC x DR x SR	20.95	1	20.95	0.36
DR x SR x Swg	1769.92	30	58.99	
MR x SR	500.64	1	500.64	6.12**
MC x MR x SR	561.83	1	561.83	6.87**
MR x SR x Swg	2454.64	30	81.82	
MR x DR x SR	7.30	1	7.30	0.14
MC x MR x DR x SR	0.03	1	0.03	0.00
MR x DR x SR x Swg	1578.23	30	52.60	

** $p < .01$

*** $p < .001$

**** $p < .0001$

Table 15

Duncan's Analysis of Significant Effects for

Percentage Correct Based on Absolute Error

Effect	Duncan*								MS error	n
DR	R 69.31	L 76.36							164.89	128
SR	F 63.50	S 82.18							472.36	128
MC x MR	AP 69.99	PA 70.13	AA 74.11	PP 77.11					119.95	64
DR x SR	RF 58.66	LF 68.33	RS 79.96	LS 84.40					5.89	64
MR x SR	PF 62.81	AF 64.18	AS 80.07	PS 84.29					81.82	64
MC x MR x SR	APF 57.82	PAF 60.66	AAF 67.70	PPF 67.81	PAS 79.61	AAS 80.53	APS 82.16	PPS 86.42	81.82	32

* All pairs of means not connected by a horizontal line are significantly different, df=30, $p < .05$

Note: MC = mode of criterion, MR = mode of reproduction, DR = direction of reproduction, SR = speed of reproduction, A = active, P = passive, L = left, R = right, S = slow, F = fast.

Table 16

AE Converted to Percentage Correct for the Passive Group

RM	Mean AE (cm)	PCAE
PLS	2.63	86.84
PRS	2.80	86.00
ALS	3.57	82.11
ARS	4.57	77.10
PLF	5.65	71.73
ALF	6.79	66.04
PRF	7.22	63.88
ARF	8.94	55.28

Note: AE = absolute error, RM = reproduction movement, PCAE = percentage correct based on absolute error, A = active, P = passive, L = left, R = right, S = slow, F = fast.

Note: PCAE = 100 - [(AE / 20) x 100].

Table 17

Duncan's Analysis of the PCAE Means

for the Zero-Cue vs. Three-Cue Conditions

Dependent Variable	Criterion Group	Duncan* 3 cues	0 cues	MS error	k
PCAE	ALS	ALS vs. PRF significant		52.60	13
	PLS	PLS vs. ARF significant		52.60	14

* df=30, n=16, $p < .01$

Note: PCAE = percentage correct based on absolute error, A = active, P = passive, L = left, R = right, S = slow, F = fast.

Table 18

PCAE Means of Reproduction Movement Conditions

for Active and Passive Groups

Dependent Variable	Criterion Group	Means of Reproduction Movement Conditions							
PCAE	ALS	PRF	ARF	PLF	ALF	ARS	PRS	PLS	ALS
		54.35	61.13	61.28	74.28	75.63	81.10	83.22	85.42
	PLS	ARF	PRF	ALF	PLF	ARS	ALS	PRS	PLS
		55.30	63.88	66.04	71.73	77.10	82.15	86.00	86.84

Note: PCAE = percentage correct based on absolute error, A = active, P = passive, L = left, R = right, S = slow, F = fast.

Table 19

Corrected Probability Coefficients

for Gross Valences of the Memory Trace

for the Passive Group Based on PCAE

Condition	Retrieval Cue or Gross Valence	Experimental Probability**	Corrected Probability Coefficient***
PRF	P	.64	.09
ALF	L	.66	.11
ARS	S	.77	.22
PLF	P&L	.72	.17
ALS	L&S	.82	.27
PRS	P&S	.86	.31
PLS	P&L&S	.87	.32
ARF	U*	.55	

* U = uncontrolled cues or the portion of the memory trace with unknown relationship

** experimental probability = PCAE / 100 (see Table 18 for PCAE values)

*** corrected probability coefficient = experimental probability - U

Note: PCAE = percentage correct based on absolute error, A = active, P = passive, L = left, R = right, S = slow, F = fast.

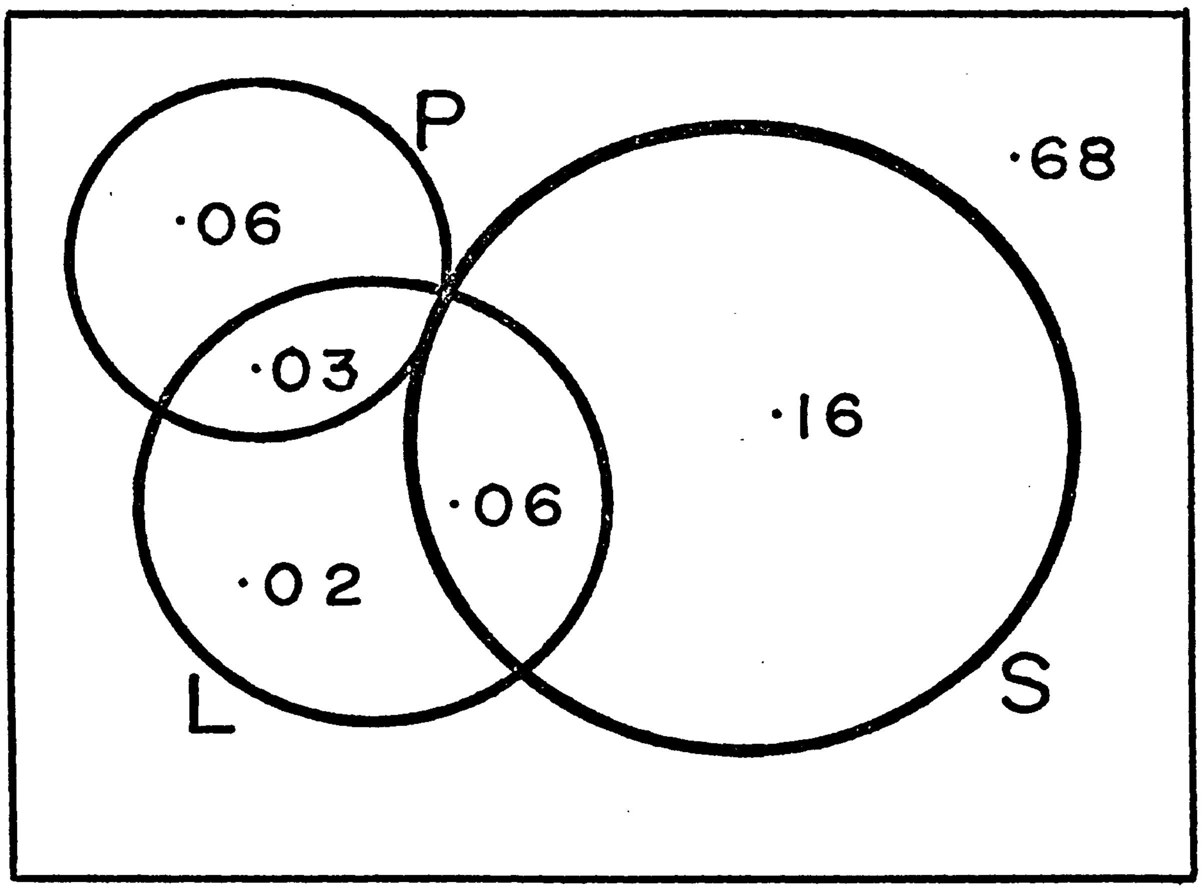

Figure 4. Passive (P), left (L), and slow (S) components of the memory trace for the passive group. Note: Elenents with unknown relatiunship=.55, error=.01. Note: Error = (100 - the sum of the elements of the variables being tested) - (100 - the PCAE for the three-cue condition).

Table 20

Valences of the Memory Trace Based on PCAE for the Passive Group

Valence	Percentage of Trace	Valence	Percentage of Trace
Gross Valence		Reduced Valence	
P&L&S	.32	$P\&S\overline{L}$	.28
P&S	.31	$P\&L\overline{S}$	.11
P&L	.17	$L\&S\overline{P}$	.24
L&S	.27	$P\overline{S}$	.09
P	.09	$P\overline{L}$	.06
L	.11	$P\overline{L}\overline{S}$	.06
S	.22	$S\overline{P}$	.22
Common Valence		$S\overline{L}$	.16
PS	.00	$S\overline{P}\overline{L}$	.16
PL	.03	$L\overline{P}$	.08
LS	.06	$L\overline{S}$	.05
PLS	.00	$L\overline{P}\overline{S}$	.02
Uncontrolled Extent Valence		Additional Trace Valence	
U	.55	$\overline{PLS}$	.68

Note: PCAE = percentage based on absolute error, A = active, P = passive, L = left, R = right, S = slow, F = fast.

Note: P&L&S = the union of P, L, & S

PLS = the intersect of P, L, & S.

APPENDIX D

RAW DATA--SIGNED ERRORS

CODE

VARIABLE	NEMONIC	INTERPRETATION
Observation	OBS	in sequential order
Subject	ID	in sequential order
Mode of Criterion	MC	1 = active, 2 = passive
Mode of Reproduction	MR	1 = active, 2 = passive
Direction of Reproduction	DR	1 = left, 2 = right
Speed of Reproduction	SR	1 = slow, 2 = fast
Condition	CON	in sequential order within subjects
Error 1	E1	signed error (cm), trial 1
Error 2	E2	signed error (cm), trial 2
Error 3	E3	signed error (cm), trial 3
Error 4	E4	signed error (cm), trial 4
Error 5	E5	signed error (cm), trial 5
Error 6	E6	signed error (cm), trial 6
Error 7	E7	signed error (cm), trial 7
Error 8	E8	signed error (cm), trial 8

OBS	IDI	MC	MR	DR	SR	CON.	E1	E2	E3	E4	E5	E6	E7	E8
1	17	2	2	2	2	1	13.3	1.9	11.1	5.7	4.8	8.3	8.0	10.9
2	17	2	2	2	1	2	-1.1	-1.4	5.3	-3.5	2.1	1.2	4.0	-3.1
3	17	2	2	1	1	3	0.1	3.5	0.0	-0.6	0.6	-0.5	4.2	5.0
4	17	2	2	1	2	4	6.2	6.9	4.4	1.4	0.0	2.2	2.3	3.0
5	17	2	1	1	1	5	5.5	-1.4	-1.0	-1.9	5.7	4.4	2.2	1.1
6	17	2	1	1	2	6	5.1	1.4	1.1	4.5	5.3	2.8	4.5	4.1
7	17	2	1	2	2	7	7.8	7.8	8.2	7.6	6.0	11.9	15.8	15.1
8	17	2	1	2	1	8	9.0	10.5	8.1	5.8	8.8	9.3	4.4	6.1
9	18	2	2	2	1	1	7.2	7.1	2.5	-0.3	3.4	5.9	2.1	1.9
10	18	2	2	2	2	2	9.3	2.0	6.6	2.6	2.2	3.4	1.5	4.6
11	18	2	2	1	2	3	-2.6	-2.6	5.4	-1.7	1.8	6.7	3.4	-0.2
12	18	2	2	1	1	4	4.4	-5.7	5.2	1.2	-7.2	-2.6	3.4	1.1
13	18	2	1	1	2	5	6.9	5.6	7.9	-0.2	4.5	11.2	4.4	5.8
14	18	2	1	1	1	6	2.2	6.4	2.0	0.3	5.6	1.4	7.9	5.3
15	18	2	1	2	1	7	7.2	1.7	9.1	1.3	1.9	0.8	1.1	1.8
16	18	2	1	2	2	8	8.9	3.6	4.6	0.4	5.7	-1.4	5.4	5.3
17	19	2	2	1	2	1	2.9	2.4	6.3	-13.0	4.8	10.9	8.4	7.7
18	19	2	2	1	1	2	2.0	0.9	-0.7	-2.9	-1.3	-2.2	-1.8	1.8
19	19	2	2	2	1	3	0.0	-0.3	-1.7	-6.2	-4.7	-1.4	2.3	-1.6
20	19	2	2	2	2	4	3.8	4.6	6.5	0.9	5.0	5.3	0.7	-3.2
21	19	2	1	2	1	5	-1.1	-0.6	1.7	-4.0	-3.5	-2.8	-3.0	-0.8
22	19	2	1	2	2	6	5.5	5.7	0.3	-2.3	4.9	1.8	6.1	2.8
23	19	2	1	1	2	7	4.7	3.5	1.6	4.1	4.9	3.9	2.9	5.6
24	19	2	1	1	1	8	3.3	1.6	2.6	3.6	3.0	2.0	1.2	2.4
25	20	2	2	1	1	1	0.0	2.0	5.6	2.8	6.5	0.7	4.8	5.2
26	20	2	2	1	2	2	15.4	7.0	17.9	10.6	9.2	10.9	18.6	14.7
27	20	2	2	2	2	3	13.1	9.5	2.5	8.5	9.0	7.4	8.7	8.8
28	20	2	2	2	1	4	-3.3	2.5	-3.9	-4.9	-1.6	-0.7	-1.7	3.3
29	20	2	1	2	2	5	7.6	10.5	10.4	7.2	3.6	7.1	7.7	11.6
30	20	2	1	2	1	6	0.4	1.7	-1.1	-0.9	-0.6	-2.7	-0.8	5.4
31	20	2	1	1	1	7	-0.3	-2.7	1.6	8.6	0.0	-0.9	7.4	3.7
32	20	2	1	1	2	8	6.1	7.5	6.8	3.2	5.8	12.0	10.3	6.9
33	21	2	1	2	2	1	9.0	-0.8	5.4	6.3	7.2	6.2	6.8	4.8
34	21	2	1	2	1	2	3.3	5.5	5.6	5.4	4.2	4.8	1.2	4.9
35	21	2	1	1	1	3	0.3	-0.2	5.2	0.1	-0.6	1.7	1.0	1.5
36	21	2	1	1	2	4	12.9	6.1	7.8	6.6	3.5	1.8	4.9	-0.2
37	21	2	2	1	1	5	-4.2	-1.7	-1.9	0.0	-0.9	-1.8	-1.2	-1.3
38	21	2	2	1	2	6	0.9	6.2	4.3	3.1	3.1	3.1	4.9	5.5

OBS	ID	MC	MR	DR	SR	CON	E1	E2	E3	E4	E5	E6	E7	E8
39	21	2	2	2	2	7	3.4	5.9	5.0	8.0	3.4	4.1	7.7	6.7
40	21	2	2	2	1	8	-1.7	-1.8	-0.4	-1.4	0.5	-3.7	0.1	-1.4
41	22	2	1	2	1	1	5.3	5.7	-1.3	-4.0	-3.3	-2.8	-3.7	1.8
42	22	2	1	2	2	2	15.3	9.9	18.0	13.0	1.1	6.7	8.6	13.5
43	22	2	1	1	2	3	1.1	8.1	9.8	10.8	13.5	5.1	14.6	10.4
44	22	2	1	1	1	4	10.6	3.2	4.4	3.7	7.1	2.3	2.3	5.4
45	22	2	2	1	2	5	4.6	7.3	6.9	9.6	7.4	5.2	5.4	7.4
46	22	2	2	1	1	6	3.7	-0.7	3.4	6.8	0.2	0.6	-2.6	0.1
47	22	2	2	2	1	7	-4.6	-0.6	2.9	1.2	-1.5	1.0	-2.0	-2.3
48	22	2	2	2	2	8	5.8	14.5	10.2	5.4	11.4	10.1	7.4	11.0
49	23	2	1	1	2	1	7.7	10.6	10.2	5.8	14.5	10.3	13.5	6.0
50	23	2	1	1	1	2	5.3	3.2	-1.7	-5.0	-1.2	2.1	-2.4	-1.1
51	23	2	1	2	1	3	2.6	4.6	3.4	-0.1	2.6	2.2	1.2	2.2
52	23	2	1	2	2	4	29.4	17.7	2.7	18.6	17.6	12.6	13.0	21.0
53	23	2	2	2	1	5	-2.4	-0.8	-2.7	-0.1	1.8	0.3	3.2	-2.7
54	23	2	2	2	2	6	11.8	15.3	8.4	13.8	8.5	10.6	8.1	7.6
55	23	2	2	1	2	7	2.4	6.7	0.3	4.3	8.5	8.8	7.7	3.9
56	23	2	2	1	1	8	0.5	3.2	2.0	-0.8	-1.3	-2.1	2.4	-0.3
57	24	2	1	1	1	1	-4.5	0.1	2.1	-1.8	5.7	3.5	10.4	1.8
58	24	2	1	1	2	2	0.5	3.7	-0.6	11.8	4.3	11.8	12.8	1.0
59	24	2	1	2	2	3	11.7	2.4	7.5	7.2	11.8	9.3	12.7	13.3
60	24	2	1	2	1	4	11.6	5.1	-3.6	1.8	2.3	2.8	8.1	8.2
61	24	2	2	2	2	5	6.6	6.7	5.8	5.1	9.8	13.0	15.1	13.5
62	24	2	2	2	1	6	3.5	3.8	6.5	0.6	1.2	3.6	1.1	2.2
63	24	2	2	1	1	7	0.3	1.7	7.0	0.8	0.8	2.5	4.8	3.7
64	24	2	2	1	2	8	8.1	7.1	12.2	7.5	8.7	9.0	12.8	9.8
65	25	1	2	2	2	1	6.2	2.3	4.2	1.3	-0.3	1.9	10.5	7.2
66	25	1	2	2	1	2	6.6	-0.1	0.4	-0.3	0.3	2.4	3.4	1.3
67	25	1	2	1	1	3	1.8	0.3	3.4	2.0	-1.4	2.1	-2.7	7.1
68	25	1	2	1	2	4	9.3	9.3	7.3	6.8	4.0	3.7	9.0	8.0
69	25	1	1	1	1	5	3.6	1.4	-3.1	-2.6	-1.4	-2.8	1.1	5.1
70	25	1	1	1	2	6	5.8	1.3	-0.4	-0.4	1.9	2.6	0.6	1.1
71	25	1	1	2	2	7	2.5	4.1	6.0	6.1	4.0	2.4	5.4	0.4
72	25	1	1	2	1	8	3.1	3.3	2.0	0.0	-2.6	3.7	1.9	2.8
73	26	1	2	2	1	1	4.3	0.5	2.7	-2.4	4.2	3.5	4.1	3.7
74	26	1	2	2	2	2	16.9	16.4	13.3	13.4	20.0	19.3	16.1	13.2
75	26	1	2	1	2	3	13.9	13.6	9.9	13.9	27.2	12.6	20.0	16.8

OBS	ID	MC	MR	DR	SR	CON	E1	E2	E3	E4	E5	E6	E7	E8
76	26	1	2	1	1	4	13.5	10.5	7.0	9.3	6.1	7.0	8.2	7.5
77	26	1	1	1	2	5	12.1	8.5	10.6	9.6	13.3	11.4	6.4	10.4
78	26	1	1	1	1	6	7.3	4.6	-0.6	0.1	-2.1	3.8	2.9	1.2
79	26	1	1	2	1	7	8.2	3.5	11.1	13.1	9.4	0.8	0.4	9.8
80	26	1	1	2	2	8	20.8	25.6	26.9	23.9	15.2	22.8	18.7	16.1
81	27	1	2	1	2	1	12.3	10.7	12.1	5.3	8.3	9.3	11.0	4.9
82	27	1	2	1	1	2	0.5	2.4	-2.2	1.4	-2.8	-0.3	-0.4	1.0
83	27	1	2	2	1	3	-1.2	-4.8	-1.5	-3.5	-2.8	-4.7	-5.0	-3.3
84	27	1	2	2	2	4	7.0	8.9	10.0	14.7	14.6	11.9	6.9	7.3
85	27	1	1	2	1	5	-1.3	-2.6	1.7	-1.2	2.8	-4.4	5.8	-4.5
86	27	1	1	2	2	6	0.4	0.6	1.9	-1.5	1.8	2.1	2.4	2.2
87	27	1	1	1	2	7	9.3	2.8	9.1	1.8	8.9	8.1	-1.3	1.9
88	27	1	1	1	1	8	-0.8	4.0	-4.5	-4.6	1.7	-0.7	1.9	3.9
89	28	1	2	1	1	1	-0.9	1.0	1.6	-1.1	4.9	-1.8	2.2	1.9
90	28	1	2	1	2	2	4.2	5.7	5.5	5.2	5.5	13.1	10.4	6.8
91	28	1	2	2	2	3	7.1	6.5	9.0	5.6	2.7	8.3	12.9	7.5
92	28	1	2	2	1	4	1.8	1.9	-1.7	-7.1	4.0	-0.9	-1.8	-1.2
93	28	1	1	2	2	5	2.5	5.7	-0.1	4.9	9.4	7.8	9.9	3.4
94	28	1	1	2	1	6	2.6	5.3	-2.5	-0.4	3.2	2.6	-1.5	0.9
95	28	1	1	1	1	7	4.4	0.6	2.6	2.4	3.9	2.4	-0.3	-2.3
96	28	1	1	1	2	8	5.1	4.3	2.2	5.0	3.0	1.2	5.7	4.2
97	29	1	1	2	2	1	17.1	12.1	14.1	7.0	17.6	23.5	12.7	15.7
98	29	1	1	2	1	2	9.5	6.5	7.9	6.9	2.8	3.6	11.3	7.7
99	29	1	1	1	1	3	0.6	7.1	1.1	1.4	0.1	-0.5	2.2	2.7
100	29	1	1	1	2	4	8.5	11.2	16.2	11.9	17.2	8.6	14.2	7.1
101	29	1	2	1	1	5	6.2	-0.6	8.1	3.0	-2.9	2.6	1.9	-4.7
102	29	1	2	1	2	6	9.6	11.4	12.4	10.8	17.7	14.2	12.8	12.0
103	29	1	2	2	2	7	7.9	23.8	15.6	15.0	13.0	17.7	13.5	12.4
104	29	1	2	2	1	8	10.2	6.8	1.6	1.1	5.0	6.0	8.7	5.8
105	30	1	1	2	1	1	8.8	5.1	11.9	4.5	4.2	5.8	13.8	5.8
106	30	1	1	2	2	2	9.7	8.3	5.7	9.4	8.1	13.0	4.7	11.2
107	30	1	1	1	2	3	3.4	5.6	6.9	1.9	14.4	8.9	12.2	10.8
108	30	1	1	1	1	4	3.1	5.7	2.5	3.7	3.7	3.2	4.3	-1.3
109	30	1	2	1	2	5	5.4	9.9	3.4	4.6	4.0	7.9	8.7	7.4
110	30	1	2	1	1	6	-0.5	-0.9	1.2	3.8	-0.1	1.3	3.4	1.4
111	30	1	2	2	1	7	8.8	4.8	3.3	5.3	5.9	0.5	1.4	1.8
112	30	1	2	2	2	8	9.1	17.9	21.2	26.3	12.7	17.4	12.0	11.6
113	31	1	1	1	2	1	2.1	2.0	4.3	1.7	5.4	7.6	6.4	-0.1

OBS	ID	MC	MR	DR	SR	CON	E1	E2	E3	E4	E5	E6	E7	E8
114	31	1	1	1	1	2	3.8	-2.5	0.1	-0.6	6.4	0.6	0.3	-0.7
115	31	1	1	2	1	3	4.2	7.6	11.1	4.4	6.8	8.6	16.2	21.0
116	31	1	1	2	2	4	8.7	17.5	7.7	25.1	17.5	18.3	6.6	14.9
117	31	1	2	2	1	5	-7.6	-1.0	4.1	5.4	5.6	9.4	6.6	11.2
118	31	1	2	2	2	6	6.2	10.5	14.4	18.1	17.4	12.0	12.9	14.2
119	31	1	2	1	2	7	20.5	8.5	15.4	12.0	7.5	11.1	13.1	9.4
120	31	1	2	1	1	8	7.6	3.2	-2.3	-1.5	-1.0	2.9	16.8	2.5
121	32	1	1	1	1	1	-2.8	3.5	0.8	-3.1	-0.7	4.2	-4.1	0.6
122	32	1	1	1	2	2	-2.5	-1.6	-0.5	3.5	2.6	2.3	-4.1	0.4
123	32	1	1	2	2	3	7.4	2.6	9.5	0.6	9.3	13.3	1.2	4.5
124	32	1	1	2	1	4	2.7	5.5	4.6	-0.3	1.3	1.0	6.3	12.2
125	32	1	2	2	2	5	6.0	4.2	8.6	4.8	2.6	6.2	6.0	5.3
126	32	1	2	2	1	6	-6.7	1.9	-1.7	6.5	5.1	2.9	-6.2	3.2
127	32	1	2	1	1	7	0.9	2.7	4.0	1.0	-5.4	1.9	2.5	-2.4
128	32	1	2	1	2	8	4.0	6.0	-2.3	2.1	2.6	6.6	2.5	1.7
129	33	2	2	2	2	1	0.4	2.1	4.4	-0.4	4.7	5.2	4.2	8.1
130	33	2	2	2	1	2	-3.5	-0.3	-2.2	3.3	-3.2	-6.6	-0.9	-0.7
131	33	2	2	1	1	3	-4.0	-3.5	-2.1	-4.9	-2.9	-1.2	-0.9	-3.6
132	33	2	2	1	2	4	1.2	1.5	0.9	3.4	2.9	1.3	-0.3	4.5
133	33	2	1	1	1	5	1.7	4.4	-1.8	-0.9	-2.6	-1.4	3.7	0.1
134	33	2	1	1	2	6	4.2	1.3	4.3	1.5	5.8	6.2	10.5	8.8
135	33	2	1	2	2	7	1.5	5.5	9.1	5.4	2.2	4.1	8.6	4.0
136	33	2	1	2	1	8	-2.8	0.8	-1.4	1.2	2.0	-4.4	-2.7	-2.0
137	34	2	2	2	1	1	-0.9	-8.1	-5.7	1.6	3.1	-2.6	3.0	-2.4
138	34	2	2	2	2	2	13.5	14.7	13.2	11.7	9.1	7.3	6.6	10.9
139	34	2	2	1	2	3	11.4	9.1	6.7	13.4	7.4	3.5	8.7	6.4
140	34	2	2	1	1	4	0.0	3.3	0.7	0.1	3.9	5.9	1.7	-0.7
141	34	2	1	1	2	5	13.2	10.9	9.3	6.3	15.2	9.2	5.9	4.5
142	34	2	1	1	1	6	14.0	4.9	4.9	4.3	5.5	-2.6	-2.7	-0.1
143	34	2	1	2	1	7	6.3	8.0	1.1	8.4	0.3	11.4	7.0	8.8
144	34	2	1	2	2	8	8.2	16.2	11.3	6.6	8.4	12.6	3.4	2.6
145	35	2	2	1	2	1	1.9	3.9	9.5	0.7	2.2	6.8	-0.4	7.1
146	35	2	2	1	1	2	-5.2	1.5	-2.2	-2.8	1.1	-5.4	-7.1	1.3
147	35	2	2	2	1	3	-4.4	-7.6	-5.6	-1.3	-3.9	1.0	-8.1	-3.9
148	35	2	2	2	2	4	9.3	4.8	4.3	6.4	6.2	9.4	13.2	7.4
149	35	2	1	2	1	5	-1.7	-0.5	-0.0	5.5	7.1	-4.6	9.3	7.7
150	35	2	1	2	2	6	15.7	7.9	10.1	3.7	5.5	13.4	9.9	0.4

OBS	ID	MC	MR	DR	SR	CON	E1	E2	E3	E4	E5	E6	E7	E8
151	35	2	1	1	2	7	9.7	9.6	-4.2	5.9	-1.9	7.1	-0.3	-1.6
152	35	2	1	1	1	8	6.4	6.4	0.6	-1.4	7.8	3.1	-3.8	-4.6
153	36	2	2	1	1	1	-0.9	-6.2	-3.3	1.4	-6.2	-2.2	-4.0	-1.2
154	36	2	2	1	2	2	-2.3	-0.4	-4.0	-0.6	0.4	-1.0	-0.1	4.4
155	36	2	2	2	2	3	6.1	6.5	6.1	6.7	0.6	2.8	2.0	5.0
156	36	2	2	2	1	4	2.5	0.7	-0.1	-5.9	0.7	-6.5	1.1	2.8
157	36	2	1	2	2	5	1.8	2.3	2.4	-1.0	5.5	9.2	-3.8	4.1
158	36	2	1	2	1	6	4.6	-1.1	-7.1	-4.9	-5.7	2.1	0.2	-1.2
159	36	2	1	1	1	7	-2.2	-0.5	-3.6	-4.1	-2.1	3.7	-1.4	-3.8
160	36	2	1	1	2	8	-7.9	0.6	-8.0	-7.3	-3.3	-1.2	-4.8	-4.1
161	37	2	1	2	2	1	4.6	1.4	7.1	8.0	4.3	4.4	0.8	3.3
162	37	2	1	2	1	2	-5.5	4.7	2.1	-1.9	-0.8	2.2	-1.0	3.4
163	37	2	1	1	1	3	0.7	4.0	-1.7	-2.4	2.9	1.5	-2.9	-5.2
164	37	2	1	1	2	4	6.1	5.7	1.8	-0.9	5.8	3.3	-0.1	-4.8
165	37	2	2	1	1	5	-3.8	-0.9	-0.3	-3.2	-0.4	-0.9	-4.2	-0.6
166	37	2	2	1	2	6	1.1	1.8	0.0	4.0	3.3	2.3	3.2	1.9
167	37	2	2	2	2	7	2.3	-0.6	4.2	-0.2	-0.2	0.0	4.4	8.5
168	37	2	2	2	1	8	-4.0	-3.4	3.6	2.9	-1.3	0.2	-5.3	-3.2
169	38	2	1	2	1	1	7.2	9.8	13.8	6.5	13.3	10.5	8.1	5.8
170	38	2	1	2	2	2	16.3	19.3	18.5	17.8	11.0	15.2	15.5	23.2
171	38	2	1	1	2	3	23.6	15.5	18.1	13.7	11.4	13.6	8.9	15.5
172	38	2	1	1	1	4	5.7	5.8	8.2	15.0	4.1	2.6	7.1	8.9
173	38	2	2	1	2	5	2.5	7.9	2.8	6.8	1.9	7.4	11.6	4.5
174	38	2	2	1	1	6	0.6	3.5	9.3	2.8	6.2	3.1	6.4	6.4
175	38	2	2	2	1	7	13.8	4.4	-3.2	6.1	1.4	2.6	0.7	1.6
176	38	2	2	2	2	8	9.7	12.5	11.5	9.6	11.2	0.4	6.7	7.2
177	39	2	1	1	2	1	-4.8	3.7	6.5	6.6	4.7	6.2	-2.2	7.0
178	39	2	1	1	1	2	3.9	-3.6	-4.2	-1.4	4.5	-0.7	1.4	-2.2
179	39	2	1	2	1	3	-0.1	-5.6	-3.1	-2.8	-4.7	-3.9	-2.8	16.4
180	39	2	1	2	2	4	10.7	11.8	4.0	5.8	9.7	17.6	9.1	9.5
181	39	2	2	2	1	5	-3.9	0.1	1.0	-0.1	-0.3	-0.4	-5.0	1.8
182	39	2	2	2	2	6	-2.7	0.6	0.2	2.4	9.6	1.7	10.1	6.6
183	39	2	2	1	2	7	10.4	9.6	3.9	10.2	4.0	8.4	5.1	10.2
184	39	2	2	1	1	8	-1.5	2.7	4.7	0.5	-0.1	0.4	-0.1	-1.0
185	40	2	1	1	1	1	7.2	6.2	6.8	2.9	9.3	2.2	4.7	6.1
186	40	2	1	1	2	2	6.6	6.2	9.6	11.0	6.9	14.7	11.1	10.5
187	40	2	1	2	2	3	10.2	9.6	17.8	20.9	26.2	18.6	14.4	15.7
188	40	2	1	2	1	4	10.0	10.9	11.6	12.6	5.7	6.0	11.5	5.9

OBS	ID	MC	MR	DR	SR	CON	E1	E2	E3	E4	E5	E6	E7	E8
189	40	2	2	2	2	5	9.6	5.8	11.6	22.0	17.3	10.3	15.5	21.8
190	40	2	2	2	1	6	5.7	1.1	2.3	3.3	3.6	6.0	5.6	-0.2
191	40	2	2	1	1	7	4.0	4.2	5.2	-1.6	4.3	4.5	2.6	0.5
192	40	2	2	1	2	8	12.3	6.2	6.6	5.4	7.6	8.2	5.6	4.4
193	41	1	2	2	2	1	2.2	0.3	1.5	1.9	3.2	-0.4	-1.5	1.6
194	41	1	2	2	1	2	-5.3	-2.3	0.9	-3.0	1.9	-5.4	-2.3	1.1
195	41	1	2	1	1	3	3.0	4.3	2.3	1.5	-1.6	1.3	-1.2	2.7
196	41	1	2	1	2	4	2.8	-10.0	5.7	2.2	0.9	4.5	7.9	9.3
197	41	1	1	1	1	5	3.7	6.3	6.3	-2.7	1.3	0.6	2.0	-2.3
198	41	1	1	1	2	6	0.4	-0.1	2.9	3.5	7.1	5.0	2.4	4.6
199	41	1	1	2	2	7	7.5	3.9	10.8	5.7	3.6	9.6	2.1	10.3
200	41	1	1	2	1	8	2.4	8.1	7.1	4.7	5.8	1.7	-0.7	-2.8
201	42	1	2	2	1	1	-4.9	2.0	-0.3	1.6	-1.2	-4.0	-1.3	-3.1
202	42	1	2	2	2	2	8.1	11.4	8.9	12.5	19.3	19.1	20.7	23.1
203	42	1	2	1	2	3	10.3	9.9	17.6	19.7	10.6	16.6	12.2	19.6
204	42	1	2	1	1	4	0.9	1.3	7.4	2.2	5.2	1.7	7.5	5.4
205	42	1	1	1	2	5	7.3	1.5	14.1	11.4	13.1	10.4	9.2	8.7
206	42	1	1	1	1	6	3.9	7.4	8.2	1.7	4.1	1.0	4.5	4.7
207	42	1	1	2	1	7	9.5	8.6	4.1	0.4	3.1	2.9	5.7	7.0
208	42	1	1	2	2	8	6.4	9.5	18.9	19.3	17.7	9.9	15.7	17.6
209	43	1	2	1	2	1	3.3	6.7	12.3	7.9	5.7	9.7	5.0	5.8
210	43	1	2	1	1	2	3.2	6.1	3.5	2.5	1.1	5.4	3.4	3.4
211	43	1	2	2	1	3	7.5	5.6	0.4	2.0	4.1	1.3	5.5	2.2
212	43	1	2	2	2	4	16.1	6.6	11.1	11.2	8.1	8.4	10.5	5.4
213	43	1	1	2	1	5	4.6	4.6	1.5	5.6	0.8	5.2	2.6	0.9
214	43	1	1	2	2	6	3.5	3.5	1.2	5.4	3.5	2.9	3.9	9.7
215	43	1	1	1	2	7	3.4	5.1	3.4	0.2	3.0	0.7	0.8	1.5
216	43	1	1	1	1	8	4.8	3.5	5.0	2.9	1.9	2.9	1.2	1.2
217	44	1	2	1	1	1	0.6	-3.5	-7.8	-10.5	6.1	-5.2	-1.5	-2.4
218	44	1	2	1	2	2	17.5	10.2	15.0	12.2	2.7	0.8	11.4	8.2
219	44	1	2	2	2	3	11.6	15.7	16.1	29.2	25.3	12.0	22.9	17.9
220	44	1	2	2	1	4	5.0	6.4	4.1	11.0	6.7	5.3	10.1	8.4
221	44	1	1	2	2	5	9.4	16.4	5.0	10.8	4.9	8.6	17.5	16.7
222	44	1	1	2	1	6	12.1	7.2	2.0	11.8	5.9	13.2	2.5	10.3
223	44	1	1	1	1	7	0.0	3.6	4.9	11.7	1.0	3.0	3.0	5.6
224	44	1	1	1	2	8	13.6	7.9	4.2	5.0	4.6	11.3	10.6	6.2
225	45	1	1	2	2	1	0.2	0.3	2.0	-0.7	2.5	5.2	2.1	2.0

OBS	ID	MC	MR	DR	SR	CON	E1	E2	E3	E4	E5	E6	E7	E8
226	45	1	1	2	1	2	7.2	4.0	3.7	1.0	5.1	5.1	-0.6	1.3
227	45	1	1	1	1	3	5.5	1.6	13.0	5.4	-0.3	2.7	-2.5	6.5
228	45	1	1	1	2	4	-7.3	-0.1	3.5	7.9	2.8	4.6	1.0	3.5
229	45	1	2	1	1	5	2.3	6.8	5.5	4.4	0.5	0.2	8.8	0.7
230	45	1	2	1	2	6	-1.0	4.9	4.1	4.3	3.8	4.1	4.3	3.3
231	45	1	2	2	2	7	-2.4	-0.1	4.3	-2.8	-0.2	1.8	2.7	-1.2
232	45	1	2	2	1	8	-2.0	2.4	3.6	2.0	-4.7	1.6	2.2	-3.0
233	46	1	1	2	1	1	1.2	0.7	1.8	7.4	1.1	2.1	6.1	3.3
234	46	1	1	2	2	2	-0.4	-3.2	0.8	2.0	-1.2	4.8	2.7	0.3
235	46	1	1	1	2	3	-3.0	-4.4	-3.2	0.0	4.3	-0.2	3.4	6.2
236	46	1	1	1	1	4	0.2	0.6	-0.3	-3.2	1.0	5.0	-2.1	0.3
237	46	1	2	1	2	5	-2.7	-0.4	0.1	0.9	0.3	-1.8	3.4	-1.0
238	46	1	2	1	1	6	-0.9	5.0	-0.5	0.8	5.6	-0.2	-2.6	5.0
239	46	1	2	2	1	7	5.4	4.6	8.8	6.9	3.2	5.8	9.4	6.3
240	46	1	2	2	2	8	1.3	9.1	9.5	8.4	10.9	2.2	5.9	5.2
241	47	1	1	1	2	1	2.3	-1.9	-1.8	4.1	3.2	5.4	-4.4	-2.4
242	47	1	1	1	1	2	-3.7	-5.2	2.9	-4.2	-2.1	0.8	1.7	1.6
243	47	1	1	2	1	3	-0.8	-1.0	6.1	0.6	11.9	-0.3	1.1	-0.1
244	47	1	1	2	2	4	6.7	1.4	3.6	2.0	-10.5	4.9	1.3	6.6
245	47	1	2	2	1	5	-1.1	1.9	-2.6	-3.4	-1.6	-1.4	-1.3	1.2
246	47	1	2	2	2	6	3.9	3.9	0.0	2.6	2.0	7.6	2.1	2.3
247	47	1	2	1	2	7	5.0	1.7	9.0	3.3	3.0	7.8	8.6	3.6
248	47	1	2	1	1	8	0.3	1.8	-1.2	2.9	4.1	7.9	-2.7	-3.9
249	48	1	1	1	1	1	5.9	4.3	-0.1	-0.2	6.4	-1.3	2.2	-0.7
250	48	1	1	1	2	2	-5.5	-0.4	1.1	-1.4	-0.2	0.1	-5.6	1.6
251	48	1	1	2	2	3	-0.4	2.1	-0.7	-2.8	-4.9	2.2	0.0	-2.2
252	48	1	1	2	1	4	-0.2	-0.3	6.9	7.1	3.9	6.4	6.3	4.7
253	48	1	2	2	2	5	0.1	3.7	-0.1	3.0	-2.0	0.3	-4.4	-1.9
254	48	1	2	2	1	6	-2.0	-4.9	-3.5	-1.4	-0.1	-4.7	-1.5	-3.5
255	48	1	2	1	1	7	-1.5	-3.9	1.4	-0.8	1.7	5.3	-3.6	-1.9
256	48	1	2	1	2	8	2.1	2.7	4.8	4.4	1.0	2.5	3.7	0.3

APPENDIX E

RAW DATA--DEPENDENT VARIABLES

CODE

VARIABLE	NEMONIC	INTERPRETATION
Observation	OBS	in sequential order
Subject	ID	in sequential order
Mode of Criterion	MC	1 = active, 2 = passive
Mode of Reproduction	MR	1 = active, 2 = passive
Direction of Reproduction	DR	1 = left, 2 = right
Speed of Reproduction	SR	1 = slow, 2 = fast
Condition	CON	in sequential order within subjects
Absolute Error	AE	average error (cm)
Constant Error	CE	response bias (cm)
Variable Error	VE	within-subject variance (cm)
Percentage Correct using Difference Limen (DL)	PCDL	percentage of trials within DL (%)
Percentage Correct using Absolute Error	PCAE	retrieval accuracy (%)

OBS	ID	MC	MR	DR	SR	CON	AE	CE	VE	PCDL	PCAE
1	17	2	2	2	2	1	8.1000	8.1000	12.4375	12.5	59.5000
2	17	2	2	2	1	2	2.7125	0.4375	9.1798	50.0	86.4375
3	17	2	2	1	1	3	1.8125	1.5375	4.6198	62.5	90.9375
4	17	2	2	1	2	4	3.3000	3.3000	4.9225	50.0	83.5000
5	17	2	1	1	1	5	2.9000	1.8250	8.5094	62.5	85.5000
6	17	2	1	1	2	6	3.6000	3.6000	2.3425	37.5	82.0000
7	17	2	1	2	2	7	10.0250	10.0250	12.2419	0.0	49.8750
8	17	2	1	2	1	8	7.7500	7.7500	3.8125	0.0	61.2500
9	18	2	2	2	1	1	3.8000	3.7250	6.4969	75.0	81.0000
10	18	2	2	2	2	2	4.0250	4.0250	6.3769	75.0	79.8750
11	18	2	2	1	2	3	3.0500	1.2750	11.5369	87.5	84.7500
12	18	2	2	1	1	4	3.8500	-0.0250	18.9619	87.5	80.7500
13	18	2	1	1	2	5	5.8125	5.7625	9.3073	62.5	70.9375
14	18	2	1	1	1	6	3.8875	3.8875	6.6011	75.0	80.5625
15	18	2	1	2	1	7	3.1125	3.1125	8.8036	75.0	84.4375
16	18	2	1	2	2	8	4.4125	4.0625	9.1448	87.5	77.9375
17	19	2	2	1	2	1	7.0500	3.8000	47.3800	12.5	64.7500
18	19	2	2	1	1	2	1.7000	-0.5250	3.0644	87.5	91.5000
19	19	2	2	2	1	3	2.2750	-1.7000	6.2750	75.0	88.6250
20	19	2	2	2	2	4	3.7500	2.9500	9.1075	25.0	81.2500
21	19	2	1	2	1	5	2.1875	-1.7625	3.1673	50.0	89.0625
22	19	2	1	2	2	6	3.6750	3.1000	7.9425	37.5	81.6250
23	19	2	1	1	2	7	3.9000	3.9000	1.3775	12.5	80.5000
24	19	2	1	1	1	8	2.4625	2.4625	0.6073	50.0	87.6875
25	20	2	2	1	1	1	3.4500	3.4500	5.1000	50.0	82.7500
26	20	2	2	1	2	2	13.0375	13.0375	15.5773	0.0	34.8125
27	20	2	2	2	2	3	8.4375	8.4375	7.4648	12.5	57.8125
28	20	2	2	2	1	4	2.7375	-1.2875	7.4911	75.0	86.3125
29	20	2	1	2	2	5	8.0875	8.0875	6.9711	12.5	59.5625
30	20	2	1	2	1	6	1.7000	0.1750	5.2844	87.5	91.5000
31	20	2	1	1	1	7	3.1500	2.1750	14.4144	62.5	84.2500
32	20	2	1	1	2	8	7.3250	7.3250	6.5044	12.5	63.3750
33	21	2	1	2	2	1	5.8125	5.6125	7.2561	12.5	70.9375
34	21	2	1	2	1	2	4.3625	4.3625	1.9423	12.5	78.1875
35	21	2	1	1	1	3	1.3250	1.1250	2.9444	87.5	93.3750
36	21	2	1	1	2	4	5.4750	5.4250	14.0144	25.0	72.6250
37	21	2	2	1	1	5	1.6250	-1.6250	1.2744	87.5	91.8750
38	21	2	2	1	2	6	3.8875	3.8875	2.4911	12.5	80.5625

OBS	ID	MC	MR	DR	SR	CON	AE	CE	VE	PCDL	PCAE
39	21	2	2	2	2	7	5.5250	5.5250	2.9644	0.0	72.3750
40	21	2	2	2	1	8	1.3750	-1.2250	1.5194	87.5	93.1250
41	22	2	1	2	1	1	3.4875	-0.2875	14.1586	75.0	82.5625
42	22	2	1	2	2	2	10.7625	10.7625	25.0948	12.5	46.1875
43	22	2	1	1	2	3	9.1750	9.1750	16.9544	12.5	54.1250
44	22	2	1	1	1	4	4.8750	4.8750	6.9594	62.5	75.6250
45	22	2	2	1	2	5	6.7250	6.7250	2.2669	12.5	66.3750
46	22	2	2	1	1	6	2.2625	1.4375	7.8273	87.5	88.6875
47	22	2	2	2	1	7	2.0125	-0.7375	4.9448	100.0	89.9375
48	22	2	2	2	2	8	9.4750	9.4750	8.3269	0.0	52.6250
49	23	2	1	1	2	1	9.8250	9.8250	8.9594	0.0	50.8750
50	23	2	1	1	1	2	2.7500	-0.1000	9.8700	62.5	86.2500
51	23	2	1	2	1	3	2.3625	2.3375	1.7073	75.0	88.1875
52	23	2	1	2	2	4	16.5750	16.5750	51.4469	12.5	17.1250
53	23	2	2	2	1	5	1.7500	-0.4250	4.1394	87.5	91.2500
54	23	2	2	2	2	6	10.5125	10.5125	7.2761	0.0	47.4375
55	23	2	2	1	2	7	5.3250	5.3250	8.3219	25.0	73.3750
56	23	2	2	1	1	8	1.5750	0.4500	3.1825	87.5	92.1250
57	24	2	1	1	1	1	3.7375	2.1625	18.3298	50.0	81.3125
58	24	2	1	1	2	2	5.8125	5.6625	27.4498	37.5	70.9375
59	24	2	1	2	2	3	9.4875	9.4875	11.8186	12.5	52.5625
60	24	2	1	2	1	4	5.4375	4.5375	19.7548	37.5	72.8125
61	24	2	2	2	2	5	9.4500	9.4500	13.6225	0.0	52.7500
62	24	2	2	2	1	6	2.8125	2.8125	3.3086	50.0	85.9375
63	24	2	2	1	1	7	2.7000	2.7000	4.7400	62.5	86.5000
64	24	2	2	1	2	8	9.4000	9.4000	3.8500	0.0	53.0000
65	25	1	2	2	2	1	4.2375	4.1625	11.2798	50.0	78.8125
66	25	1	2	2	1	2	1.8500	1.7500	4.8025	87.5	90.7500
67	25	1	2	1	1	3	2.6000	1.5750	7.8094	87.5	87.0000
68	25	1	2	1	2	4	7.1750	7.1750	4.4194	25.0	64.1250
69	25	1	1	1	1	5	2.6375	0.1625	8.5123	87.5	86.8125
70	25	1	1	1	2	6	1.7625	1.5625	3.5073	87.5	91.1875
71	25	1	1	2	2	7	4.9625	4.9625	3.4723	37.5	75.1875
72	25	1	1	2	1	8	2.4250	1.7750	3.8994	100.0	87.8750
73	26	1	2	2	1	1	3.1750	2.5750	4.8919	100.0	84.1250
74	26	1	2	2	2	2	15.5750	15.5750	4.7394	0.0	22.1250
75	26	1	2	1	2	3	15.9875	15.9875	25.6786	0.0	20.0625

OBS	ID	MC	MR	DR	SR	CON	AE	CE	VE	PCDL	PCAE
76	26	1	2	1	1	4	8.6375	8.6375	5.1048	0.0	56.8125
77	26	1	1	1	2	5	10.2875	10.2875	4.0611	0.0	48.5625
78	26	1	1	1	1	6	2.8250	2.1500	8.3175	87.5	85.8750
79	26	1	1	2	1	7	7.0375	7.0375	20.4123	37.5	64.8125
80	26	1	1	2	2	8	21.2500	21.2500	16.2625	0.0	-6.2500
81	27	1	2	1	2	1	9.2375	9.2375	7.2523	0.0	53.8125
82	27	1	2	1	1	2	1.3750	-0.0500	2.7350	100.0	93.1250
83	27	1	2	2	1	3	3.3500	-3.3500	1.8775	62.5	83.2500
84	27	1	2	2	2	4	10.1625	10.1625	9.2198	0.0	49.1875
85	27	1	1	2	1	5	3.0375	-0.4625	11.5198	62.5	84.8125
86	27	1	1	2	2	6	1.6125	1.2375	1.5473	100.0	91.9375
87	27	1	1	1	2	7	5.4000	5.0750	15.5569	50.0	73.0000
88	27	1	1	1	1	8	2.7625	0.1125	10.0186	75.0	86.1875
89	28	1	2	1	1	1	1.9250	0.9750	4.2094	87.5	90.3750
90	28	1	2	1	2	2	7.0500	7.0500	8.2575	0.0	64.7500
91	28	1	2	2	2	3	7.4500	7.4500	7.4800	12.5	62.7500
92	28	1	2	2	1	4	2.5500	-0.6250	9.8144	75.0	87.2500
93	28	1	1	2	2	5	5.4625	5.4375	10.6248	37.5	72.6875
94	28	1	1	2	1	6	2.3750	1.2750	6.0394	87.5	88.1250
95	28	1	1	1	1	7	2.3625	1.7125	4.3911	75.0	88.1875
96	28	1	1	1	2	8	3.8375	3.8375	2.1373	37.5	80.8125
97	29	1	1	2	2	1	14.9750	14.9750	20.3019	0.0	25.1250
98	29	1	1	2	1	2	7.0250	7.0250	6.9369	25.0	64.8750
99	29	1	1	1	1	3	1.9625	1.8375	4.9148	87.5	90.1875
100	29	1	1	1	2	4	11.8625	11.8625	12.2298	0.0	40.6875
101	29	1	2	1	1	5	3.7500	1.7000	16.3950	62.5	81.2500
102	29	1	2	1	2	6	12.6125	12.6125	5.3361	0.0	36.9375
103	29	1	2	2	2	7	14.8625	14.8625	18.5448	0.0	25.6875
104	29	1	2	2	1	8	5.6500	5.6500	8.6250	25.0	71.7500
105	30	1	1	2	1	1	7.4875	7.4875	11.5211	0.0	62.5625
106	30	1	1	2	2	2	8.7625	8.7625	6.4648	0.0	56.1875
107	30	1	1	1	2	3	8.0125	8.0125	16.5736	25.0	59.9375
108	30	1	1	1	1	4	3.4375	3.1125	3.5811	50.0	82.8125
109	30	1	2	1	2	5	6.4125	6.4125	4.9736	12.5	67.9375
110	30	1	2	1	1	6	1.5750	1.2000	2.5800	87.5	92.1250
111	30	1	2	2	1	7	3.9750	3.9750	6.6644	50.0	80.1250
112	30	1	2	2	2	8	16.0250	16.0250	29.0694	0.0	19.8750
113	31	1	1	1	2	1	3.7000	3.6750	6.2044	62.5	81.5000

OBS	ID	MC	MR	PR	SR	CON	AE	CE	VE	PCDL	PCAE
114	31	1	1	1	1	2	1.8750	0.9250	7.0144	87.5	90.6250
115	31	1	1	2	1	3	9.9875	9.9875	30.4511	25.0	50.0625
116	31	1	1	2	2	4	14.5375	14.5375	35.9048	0.0	27.3125
117	31	1	2	2	1	5	6.3625	4.2125	31.4361	25.0	68.1875
118	31	1	2	2	2	6	13.2125	13.2125	12.7386	0.0	33.9375
119	31	1	2	1	2	7	12.1875	12.1875	15.6011	0.0	39.0625
120	31	1	2	1	1	8	4.7250	3.5250	34.2544	75.0	76.3750
121	32	1	1	1	1	1	2.4750	-0.2000	8.1650	100.0	87.6250
122	32	1	1	1	2	2	2.1875	0.0125	6.2911	100.0	89.0625
123	32	1	1	2	2	3	6.0500	6.0500	10.0475	37.5	69.7500
124	32	1	1	2	1	4	4.2375	4.1625	13.9248	50.0	78.8125
125	32	1	2	2	2	5	5.4625	5.4625	2.6523	25.0	72.6875
126	32	1	2	2	1	6	4.2750	0.6250	21.7019	50.0	78.6250
127	32	1	2	1	1	7	2.6000	0.6500	8.3125	87.5	87.0000
128	32	1	2	1	2	8	3.4750	2.9000	6.7350	75.0	82.6250
129	33	2	2	2	2	1	3.6875	3.5875	6.6886	50.0	81.5625
130	33	2	2	2	1	2	2.5875	-1.7625	7.2898	87.5	87.0625
131	33	2	2	1	1	3	2.8875	-2.8875	1.6986	87.5	85.5625
132	33	2	2	1	2	4	2.0000	1.9250	2.1069	87.5	90.0000
133	33	2	1	1	1	5	2.0750	0.4000	5.9300	87.5	89.6250
134	33	2	1	1	2	6	5.3250	5.3250	9.1244	50.0	73.3750
135	33	2	1	2	2	7	5.0500	5.0500	6.5075	50.0	74.7500
136	33	2	1	2	1	8	2.1625	-1.1625	4.4648	87.5	89.1875
137	34	2	2	2	1	1	3.4250	-1.5000	14.3250	75.0	82.8750
138	34	2	2	2	2	2	10.8750	10.8750	7.7269	0.0	45.6250
139	34	2	2	1	2	3	8.3250	8.3250	8.3044	0.0	58.3750
140	34	2	2	1	1	4	2.0375	1.8625	4.6298	75.0	89.8125
141	34	2	1	1	2	5	9.3125	9.3125	12.0236	0.0	53.4375
142	34	2	1	1	1	6	4.8750	3.5250	25.9269	37.5	75.6250
143	34	2	1	2	1	7	6.4125	6.4125	12.8736	25.0	67.9375
144	34	2	1	2	2	8	8.6625	8.6625	18.5323	12.5	56.6875
145	35	2	2	1	2	1	4.0625	3.9625	10.6998	62.5	79.6875
146	35	2	2	1	1	2	3.7000	-1.9750	13.6044	87.5	81.5000
147	35	2	2	2	1	3	4.5125	-4.2625	8.3498	75.0	77.4375
148	35	2	2	2	2	4	7.6250	7.6250	7.4569	25.0	61.8750
149	35	2	1	2	1	5	4.6500	2.7500	23.8600	62.5	76.7500
150	35	2	1	2	2	6	8.9750	8.9750	19.2119	25.0	55.1250

OBS	ID	MC	MR	DR	SR	CON	AE	CE	VE	PCDL	PCAE
151	35	2	1	1	2	7	5.0375	3.0375	27.6948	50.0	74.8125
152	35	2	1	1	1	8	4.2625	1.8125	20.5011	62.5	78.6875
153	36	2	2	1	1	1	3.1750	-2.8250	6.1219	62.5	84.1250
154	36	2	2	1	2	2	1.6500	-0.4500	5.0900	75.0	91.7500
155	36	2	2	2	2	3	4.4750	4.4750	4.8194	37.5	77.6250
156	36	2	2	2	1	4	2.5375	-0.5875	11.3236	75.0	87.3125
157	36	2	1	2	2	5	3.7625	2.5625	13.6123	62.5	81.1875
158	36	2	1	2	1	6	3.3625	-1.6375	14.2148	50.0	83.1875
159	36	2	1	1	1	7	2.6750	-1.7500	5.6075	87.5	86.6250
160	36	2	1	1	2	8	4.6500	-4.5000	8.7800	37.5	76.7500
161	37	2	1	2	2	1	4.2375	4.2375	5.4073	25.0	78.8125
162	37	2	1	2	1	2	2.7000	-0.7750	9.1994	37.5	86.5000
163	37	2	1	1	1	3	2.6625	-0.3875	8.7561	37.5	86.6875
164	37	2	1	1	2	4	3.5625	2.1125	13.2036	37.5	82.1875
165	37	2	2	1	1	5	1.7875	-1.7875	2.3736	62.5	91.0625
166	37	2	2	1	2	6	2.2000	2.2000	1.4700	50.0	89.0000
167	37	2	2	2	2	7	2.5500	2.3000	9.0825	50.0	87.2500
168	37	2	2	2	1	8	2.9875	-1.3125	9.4011	25.0	85.0625
169	38	2	1	2	1	1	9.3750	9.3750	7.9794	0.0	53.1250
170	38	2	1	2	2	2	17.1000	17.1000	11.0650	0.0	14.5000
171	38	2	1	1	2	3	15.0625	15.0625	17.1723	0.0	24.6875
172	38	2	1	1	1	4	7.1750	7.1750	12.4644	25.0	64.1250
173	38	2	2	1	2	5	5.6750	5.6750	9.7844	37.5	71.6250
174	38	2	2	1	1	6	4.7875	4.7875	6.6936	50.0	76.0625
175	38	2	2	2	1	7	4.2250	3.4250	21.8969	75.0	78.8750
176	38	2	2	2	2	8	8.6000	8.6000	13.1750	12.5	57.0000
177	39	2	1	1	2	1	5.2125	3.4625	17.6248	12.5	73.9375
178	39	2	1	1	1	2	2.7375	-0.2875	9.3311	50.0	86.3125
179	39	2	1	2	1	3	4.9250	-0.0250	44.6044	50.0	75.3750
180	39	2	1	2	2	4	9.7750	9.7750	14.4844	0.0	51.1250
181	39	2	2	2	1	5	1.5750	-0.0500	4.8675	75.0	92.1250
182	39	2	2	2	2	6	4.2375	3.5625	19.0673	62.5	78.8125
183	39	2	2	1	2	7	7.7250	7.7250	7.3469	0.0	61.3750
184	39	2	2	1	1	8	1.3750	0.7000	3.6425	87.5	93.1250
185	40	2	1	1	1	1	5.6750	5.6750	4.7394	25.0	71.6250
186	40	2	1	1	2	2	9.5750	9.5750	7.3594	0.0	52.1250
187	40	2	1	2	2	3	16.6750	16.6750	26.4569	0.0	16.6250
188	40	2	1	2	1	4	9.2750	9.2750	7.4344	0.0	53.6250

OBS	ID	MC	MR	DR	SR	CON	AE	CE	VE	PCDL	PCAE
189	40	2	2	2	2	5	14.2375	14.2375	30.4473	0.0	28.8125
190	40	2	2	2	1	6	3.4750	3.4250	4.5494	37.5	82.6250
191	40	2	2	1	1	7	3.3625	2.9625	4.8473	37.5	83.1875
192	40	2	2	1	2	8	7.0375	7.0375	5.2448	0.0	64.0125
193	41	1	2	2	2	1	1.5750	1.1000	2.0400	100.0	92.1250
194	41	1	2	2	1	2	2.7750	-1.8000	7.0675	75.0	86.1250
195	41	1	2	1	1	3	2.3375	1.6375	3.9998	100.0	88.3125
196	41	1	2	1	2	4	5.4125	2.9125	30.9086	50.0	72.9375
197	41	1	1	1	1	5	3.1500	1.9000	10.3525	75.0	84.2500
198	41	1	1	1	2	6	3.2500	3.2250	4.9944	62.5	83.7500
199	41	1	1	2	2	7	6.6875	6.6875	9.8036	37.5	66.5625
200	41	1	1	2	1	8	4.1625	3.2875	12.7836	50.0	79.1875
201	42	1	2	2	1	1	2.3000	-1.4000	5.4650	75.0	88.5000
202	42	1	2	2	2	2	15.3875	15.3875	29.5286	0.0	23.0625
203	42	1	2	1	2	3	14.5625	14.5625	15.7923	0.0	27.1875
204	42	1	2	1	1	4	3.9500	3.9500	6.5775	50.0	80.2500
205	42	1	1	1	2	5	9.4625	9.4625	13.5123	12.5	52.6875
206	42	1	1	1	1	6	4.4375	4.4375	5.3398	25.0	77.8125
207	42	1	1	2	1	7	5.1625	5.1625	8.4348	37.5	74.1875
208	42	1	1	2	2	8	14.3750	14.3750	21.9169	0.0	28.1250
209	43	1	2	1	2	1	7.0500	7.0500	7.1350	0.0	64.7500
210	43	1	2	1	1	2	3.5750	3.5750	2.1494	12.5	82.1250
211	43	1	2	2	1	3	3.5750	3.5750	5.3894	25.0	82.1250
212	43	1	2	2	2	4	9.6750	9.6750	9.7694	0.0	51.6250
213	43	1	1	2	1	5	3.2250	3.2250	3.4969	37.5	83.8750
214	43	1	1	2	2	6	4.2000	4.2000	5.4925	12.5	79.0000
215	43	1	1	1	2	7	2.2625	2.2625	2.5748	50.0	88.6875
216	43	1	1	1	1	8	2.9250	2.9250	1.8944	37.5	85.3750
217	44	1	2	1	1	1	4.7000	-3.0250	22.8444	62.5	76.5000
218	44	1	2	1	2	2	9.7500	9.7500	28.5950	25.0	51.2500
219	44	1	2	2	2	3	18.8375	18.8375	35.3748	0.0	5.8125
220	44	1	2	2	1	4	7.1250	7.1250	5.3994	37.5	64.3750
221	44	1	1	2	2	5	11.1625	11.1625	23.1573	25.0	44.1875
222	44	1	1	2	1	6	8.1250	8.1250	16.8444	37.5	59.3750
223	44	1	1	1	1	7	4.1000	4.1000	11.2175	87.5	79.5000
224	44	1	1	1	2	8	8.1750	8.1750	11.3269	37.5	59.1250
225	45	1	1	2	2	1	1.8750	1.6500	3.0675	100.0	90.6250

OBS	ID	MC	MR	DR	SR	CON	AE	CE	VE	PCDL	PCAE
226	45	1	1	2	1	2	3.5000	3.3500	5.8525	100.0	82.5000
227	45	1	1	1	1	3	4.6875	3.9875	19.9561	87.5	76.5625
228	45	1	1	1	2	4	3.8375	1.9875	17.3261	87.5	80.8125
229	45	1	2	1	1	5	3.6500	3.6500	9.0975	87.5	81.7500
230	45	1	2	1	2	6	3.7250	3.4750	3.0419	100.0	81.3750
231	45	1	2	2	2	7	1.9375	0.2625	5.4448	100.0	90.3125
232	45	1	2	2	1	8	2.6875	0.2625	8.0823	100.0	86.5625
233	46	1	1	2	1	1	2.9625	2.9625	5.4298	75.0	85.1875
234	46	1	1	2	2	2	1.9250	0.7250	5.3369	87.5	90.3750
235	46	1	1	1	2	3	3.0875	0.3875	13.2411	62.5	84.5625
236	46	1	1	1	1	4	1.5875	0.1875	5.1106	87.5	92.0625
237	46	1	2	1	2	5	1.3250	-0.1500	2.9975	100.0	93.3750
238	46	1	2	1	1	6	2.6750	1.6250	9.6719	62.5	86.6250
239	46	1	2	2	1	7	6.3000	6.3000	3.7225	12.5	68.5000
240	46	1	2	2	2	8	6.5625	6.5625	10.7848	25.0	67.1875
241	47	1	1	1	2	1	3.1875	0.5625	11.3673	75.0	84.0625
242	47	1	1	1	1	2	2.7750	-1.0250	8.6094	75.0	86.1250
243	47	1	1	2	1	3	2.7375	2.1875	17.9811	75.0	86.3125
244	47	1	1	2	2	4	4.6250	4.6250	9.0244	50.0	76.8750
245	47	1	2	2	1	5	1.8125	-1.0375	2.7723	100.0	90.9375
246	47	1	2	2	2	6	3.0500	3.0500	4.2775	87.5	84.7500
247	47	1	2	1	2	7	5.2500	5.2500	7.0050	50.0	73.7500
248	47	1	2	1	1	8	3.1000	1.1500	13.0400	87.5	84.5000
249	48	1	1	1	1	1	2.6375	2.0625	8.4123	62.5	86.8125
250	48	1	1	1	2	2	1.9875	-1.2875	6.7861	75.0	90.0625
251	48	1	1	2	2	3	1.9125	-0.8375	5.1223	87.5	90.4375
252	48	1	1	2	1	4	4.4750	4.3500	8.0900	37.5	77.6250
253	48	1	2	2	2	5	2.0375	-0.0625	6.8973	87.5	89.8125
254	48	1	2	2	1	6	2.7000	-2.7000	2.5625	75.0	86.5000
255	48	1	2	1	1	7	2.5125	-0.4125	8.2811	87.5	87.4375
256	48	1	2	1	2	8	2.6875	2.6875	2.1686	75.0	86.5625

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