8228845

Johnson, Sandra Kay

TIME-SERIES ANALYSIS OF INDIVIDUAL PERFORMANCES OF OLDER WOMEN ON A SERIAL GROSS MOTOR TASK

The University of North Carolina at Greensboro Ed.D. 1982

University Microfilms International 300 N. Zeeb Road, Ann Arbor, MI 48106

TIME-SERIES ANALYSIS OF INDIVIDUAL PERFORMANCES OF OLDER WOMEN ON A SERIAL GROSS MOTOR TASK

by

Sandra K. Johnson

A Dissertation Submitted to
the Faculty of the Graduate School at
The University of North Carolina at Greensboro
in Partial Fulfillment
of the Requirements for the Degree
Doctor of Education

Greensboro
1982

Approved by

Rosemary McGee

Dissertation Adviser

JOHNSON, SANDRA K. Time-series Analysis of Individual Performances of Older Women on a Serial Gross Motor Task. (1982)
Directed by: Dr. Rosemary McGee. Pp. 295.

The individual performance characteristics of older women on a novel serial gross motor task were described in this study. The task was specifically designed to study memory for movement sequences as well as the relative importance of visual and kinesthetic information for motor performance. Performance requirements for the nine individual, sequentially arranged elements in each of the four major task segments were obtained by reading or manipulating cues. The times required to refer to the cue and perform the requirements were recorded for each element. Accuracy measures (number of errors, cue referrals, and map referrals) were also recorded.

Four right-handed women, ranging in age from 61 to 75 years, served as subjects. Pertinent biographical information as well as scores on tests of field dependence/independence, spatial reasoning, and information processing speed were obtained prior to data collection. Subjects then performed the task once a day for 15 days. Following every fifth trial, an intervention was employed to change either the order of task segments or the order of elements within the segments. Measures of speed and accuracy obtained from these trials were presented graphically and analyzed by a time-series technique, visual inspection, to

determine the performance characteristics before and after the interventions.

The findings appeared to indicate that performance was faster throughout all 15 trials in segments which had a predominance of visual information. Performances of three subjects were more accurate, however, in those segments with a predominance of tactile/kinesthetic information. Limited evidence of the recall of performance aspects was revealed as few serial position effects were apparent in the time measures for all subjects. One subject, however, accurately recalled and performed the first and last elements in a segment which had predominately visual information. Thus, serial position effects were suggested by the accuracy profiles for this subject. Neither the order of segments nor the order of elements appeared to be a factor in the emergence of serial position effects. Rather, faster and more accurate performances were evident as practice with the task requirements continued.

APPROVAL PAGE

This dissertation has been approved by the following committee of the Faculty of the Graduate School at the University of North Carolina at Greensboro.

Dissertation Adviser Rosemary McGee

Committee Members William B Karper

Vira R. Kivett

E. Doris McKinney

Sarah M. Robinson

May 4, 1982
Date of Acceptance by Committee

May 4, 1982
Date of Final Oral Examination

ACKNOWLEDGMENTS

Sincere appreciation is extended to Dr. Rosemary McGee who directed this study with competence and understanding. Her gentle firmness and enthusiasm as an adviser, her dedication to excellence as a professional, and her concern, warmth, and humor as an individual made the writing of this manuscript a rewarding experience. My gratitude also goes to Dr. William Karper, Dr. Vira Kivett, Dr. E. Doris McKinney, and Dr. Sarah Robinson. As committee members, they willingly gave of their time and expertise, and provided invaluable assistance with the design of the study.

Special expressions of thanks go to numerous individuals whose assistance and contributions were vital to the completion of the study:

To Caryl Dix who greatly enhanced the entire process by willingly exchanging ideas and sharing the frustrations and joys of task design, subject selection, and test administration;

To Dr. Jerry Wilkerson and Dr. Betty Haven who assisted in obtaining the necessary equipment for the data collection;

To Mr. Bert Mikesell who provided the technical expertise for the design and construction of the timing apparatus;

To Mr. and Mrs. Frank Clark who assisted with locating and obtaining a space for conducting the Pilot Test;

To the subjects who willingly gave of their time and who made data collection a joyful experience;

To Vicki Simmons who provided invaluable assistance as a test administrator;

To Lynne Gaskin whose assistance made the preparation of figures possible, and whose concern, understanding, and willingness to share made the entire experience meaningful;

To Mrs. Elizabeth Crabtree whose genuine interest, concern for quality, and efficiency in the typing of this manuscript were greatly appreciated; and, especially,

To my family whose support, encouragement, and sensitivity made this endeavor all the more worthwhile.

TABLE OF CONTENTS

CHAPTER Page

CHAPTER | Page

CHAPTER Page

LIST OF TABLES

LIST OF FIGURES

Figure Page

Figure Page

CHAPTER I

INTRODUCTION

Little is known about the memory capacity for movement sequences within a gross motor task. Several studies (Keele & Ells, 1972; Marshall, Jones, & Sheehan, 1977; Marteniuk, 1973; Roy, 1977) focused on short term motor memory. These studies, however, all dealt with limb positioning movements rather than the gross physical movements which characterize performance of most physical sport skills. Miller (1956) suggested that individual memory capacity is limited to approximately seven items at a time. It is possible that larger amounts of information can be handled by organizing single elements of a series into a larger unit.

One means of approaching the study of memory capacity is the utilization of serial tasks. Serial tasks require the performance of the component parts of the task in a particular order. Studies of serial learning in the verbal domain (Jahnke, 1963; Murdock, 1976; Sumby, 1963) consistently revealed a recency-primacy effect. That is, those items at the beginning and end of a series are recalled the best, while those in the middle are recalled the poorest. The recency primacy effect is thus characterized by a bow-shaped curve.

Few studies have been made of the recency-primacy effect in the motor domain. Zaichkowsky (1974) described a primacy effect but no recency effect occurring in a task requiring the pressing of various switches in response to lights. Cratty (1963) and Magill (1976) suggested that motor skill learning occurs in a linear fashion, i.e., that parts of a motor skill are recalled in the order of their presentation, without any bowing effect occurring. More recently, Magill and Dowell (1977) described a recency-primacy effect in the performance of a positioning task involving the recall of six and nine items. Magill and Dowell found that only a linear effect occurred when there were three positions to be recalled. This suggests that the length of motor sequences is a factor in eliciting a recency-primacy effect in motor performance just as it is in the verbal domain.

Relatively little is known about older individuals' memory capacity for movement sequences. Most studies concerned with changes in memory capacity associated with age utilize vocabulary lists, story recall, color recall, or letter recall as the test of memory. Results of these studies indicate that it is the early stages of the memory process which are most adversely affected by aging.

In addition to memory for movement sequences, the rapid and accurate processing of both visual and kinesthetic information is important to the performance of motor tasks

(Whiting, 1972). Studies (Fleishman & Rich, 1963; Stallings, 1968) showed that vision is more important during the initial phases of motor performance, while kinesthetic information predominates later. It may be theorized that the relative predominance of visual or kinesthetic cues determines which segments of a motor task are recalled and performed more easily.

It is not known if visual information or kinesthetic information is more easily processed by the aged individual. Age-related decrements do occur in the sensory processes. In regard to visual perception, older individuals are more "rigid" and have greater difficulty in "extracting information from a complex visual configuration" (Corso, 1971, p. 96). Thompson, Axelrod, and Cohen (1965) suggested that there is "a selective impairment of 'searching behavior' with senescence" (p. 249). The few studies dealing with age differences in kinesthetic ability revealed that little or no decrement occurs (Howell, 1949; Landahl & Birren, 1959).

Statement of the Problem

The purpose of this study was to describe the performance characteristics of older women (60-75 years of age) on a novel serial gross motor task. The task was specifically constructed to study memory capacity for movement sequences. The task also allowed study of the relative importance of visual and kinesthetic information for motor-skill performance.

More specifically, answers to the following questions and subquestions were sought:

1. What effect does varying the relative predominance of visual and kinesthetic information have on performance?

a. What are the original performance profiles of the high visual and low visual segments?

b. What are the performance profiles of the high visual and low visual segments after an intervention in the order of task components has occurred?

c. What are the similarities among profiles of the high visual and low visual segments?

d. What are the differences among profiles of the high visual and low visual segments?

2. What are the serial effects in a task segment in relation to its position in the total task?

a. What are the original performance profiles of early, middle, and late segments?

b. What are the performance profiles of early, middle, and late segments after an intervention in the order of components of the task has occurred?

c. What are the similarities among performance profiles of those segments located in the same relative position, i.e., early, middle, or late within the total task?

d. What are the differences among the performance profiles of those segments located within the same relative position of the total task?

3. What is the pattern of performance recall within each segment of the task?

a. What is the original profile of performance breaks?

b. Do the profiles of performance breaks change before intervention?

c. Do these profiles of performance breaks change after intervention?

d. What is the relationship of the number of performance errors to the number of cue referrals?

4. How does the time utilized for self-pacing intervals affect the performance of various segments of the task?

a. What is the profile of the self-pacing intervals for the three-week period?

b. Does the time utilized in the self-pacing intervals change depending on the location of the segment in the total task?

c. Does the time utilized in the self-pacing intervals change depending on the type of sensory information which predominates in the task segment?

d. Does the time utilized in the self-pacing intervals have any relationship to the number of errors committed in the task segment?

Definition of Terms

Cue Referral. The manipulation of wooden forms or the reading of cards to get information necessary for the performance of the specific elements composing the segments of the serial gross motor task.

Element. A particular performance requirement within a segment. Each of the two low visual segments and two high visual segments contained nine elements.

Field dependence/independence. A dimension of cognitive style which interrelates information about the individual and the visual environmental display. The average of scores across 21 trials obtained from the Rod-and-Frame test represented field dependence/independence.

High Visual Segments. Two major portions of the total task, each of which required the performance of nine different elements. Elements within these segments involved the performance of body part movements and/or the transferral of various colored blocks. One high visual segment (4HV) contained four stations, i.e., cone markers, arranged in a relatively distinguishable geometric pattern. The other high visual segment (9HV) contained nine such stations arranged in an amorphous pattern. Cues and stations for these segments were highly visible.

Information Processing. The organization and classification of items in an environmental display to select a plan of action (Welford, 1968). Information processing in the serial gross motor task was of two types: visual and tactile/kinesthetic.

Information Processing Speed. The ability to quickly search and code items in a visual display. The score on the subtest, Digit Symbol, of the Wechsler Adult Intelligence Scale represented information processing speed (Metarazzo, 1972).

Intervention Strategy. The reordering of specific parts of the serial gross motor task. Two intervention strategies were employed. One was the reordering of the elements within each of the high and low visual segments. The other intervention strategy was the reordering of the high visual and low visual segments within the total task.

Low Visual Segments. Two major portions of the total task, each of which required the performance of nine different elements. Elements within these segments involved the movement of the entire body in specific geometric patterns. One low visual segment (4LV) contained four stations, which were marked by fishing line and arranged in a relatively distinguishable geometric pattern. The other low visual segment (9LV) contained nine stations arranged in an amorphous pattern. Cues and stations in these segments were relatively nonvisual.

Performance Break. An interruption in the sequential completion of any of the segments. An interruption was either the (a) failure to perform any element correctly,

(b) failure to make correct body position adjustments at the obstacles, or (c) reference to either the segment map or element cues.

Performance Profiles. Time-series graphs presented to depict the mean cue referral and element performance times for each segment of the serial gross motor task.

Self-pacing Interval. Period of time elapsing between the completion of one segment and the initiation of a subsequent segment of the serial gross motor task.

Serial Gross Motor Task. A particular arrangement of two low visual, two high visual, and two tossing segments. Each of the low visual and high visual segments contained multiple elements which had to be performed in a particular order.

Spatial Reasoning. The ability to recognize the interrelationships in an environmental display and mentally manage these interrelationships. The score on the subtest, Space Relations, of the Differential Aptitude Test (Bennett, Seashore, & Wesman, 1972) represented spatial reasoning.

Tossing Segments. Two portions of the serial gross motor task which involved the tossing of beanbags to targets located a specific distance from the subject. The short tossing segment, which was always the second segment of the serial gross motor task, contained targets located 4-10 feet from the subject. For the long tossing segment, which was always the fifth segment of the serial gross motor task, targets were located 12-18 feet from the subject.

Assumptions

The following assumptions were acknowledged in this study. These identify ideas upon which the research was based, but which were not tested as an integral part of the study.

1. The Rod-and-Frame test is a valid measure of field dependence/independence.

2. The subtest, Space Relations, of the Differential Aptitude Test, is a valid and reliable measure of spatial reasoning.

3. The subtest, Digit Symbol, of the Wechsler Adult Intelligence Scale, provides a valid and reliable measure of information processing speed.

4. Time to the nearest tenth of a second is a valid assessment of the serial gross motor task performance.

5. The number of elements successfully and sequentially completed without cue reference is a valid and reliable measure of a recalled motor sequence.

Scope of the Study

Subjects for the study were four women, 60-75 years of age. All subjects were right-handed and without any apparent physical limitations. No attempt was made to control the visual acuity of the subjects except to require those who normally wore corrective lenses to use such lenses in their usual pattern.

All data from the performance of the serial gross motor task were collected by the primary investigator between May 4 and May 22, 1981. No attempt was made to control for the subjects' prior motor experience.

Significance

The number of people aged 65 and over in the United States has increased from three million in 1900 to twenty-four million in 1981 (United States Bureau of the Census, 1981). In addition, concern over population growth, better education in family planning, and scientific advances in contraceptive devices have all contributed to a declining birthrate in this country. These facts point to an increase in the proportion of older adults in the total population. It has been estimated that by the year 2000, older adults will account for 20% of the American population (United States Bureau of the Census, 1981).

Yet, physical educators know little about the physical skill learning capabilities of this growing segment of the population. Knowledge about many of the age decrements in abilities which may affect physical skill learning must be inferred from psychological and physiological studies which are not concerned directly with the learning of gross physical skills.

In addition, studies which utilize aggregate data may be particularly irrelevant to an aged population. Age decrements noted in short term memory (Taub, 1966; Taub & Walker, 1970) and information processing time (Botwinick, 1978; Welford, 1972) may have an effect on the performance of physical skills. However, there is a great deal of individual variability among aged people in these abilities. When aggregate data are analyzed, the averaging of subjects' scores tends to mask what may be significant differences in individual performance (Hersen & Barlow, 1976).

The focus of this study was to describe the changes which occur in the individual performances of four older women on a serial gross motor task. The design of the study allowed the examination of these performances to occur over time. Although the size of the population used in this study limits generalization of the results obtained, the study represents a significant starting point. Knowledge from such research is important if physical educators are to understand the effect that the age decrements noted in psychological and physiological studies have on the performance of physical skills. Such knowledge is at the very heart of the successful planning and teaching of physical skills to the aged individual.

CHAPTER II

REVIEW OF LITERATURE

The literature pertaining to information processing and motor skill performance is extensive. The following text is limited to the theoretical constructs of an information processing model and to factors which limit human information processing. The perception and organization of sensory information is one important aspect of this model. Attention is focused on those studies dealing with kinesthetic and visual information processing abilities and their effect on motor performance. A second aspect of the information processing model is memory. Literature from both the verbal and motor domains is reviewed. This review is limited to those studies dealing with serial learning. Research on older adults which is related to sensory information processing and memory also is included.

Limited use of time-series research designs has been made for studying motor skill performance. Types of time-series research designs and strategies for visual analysis of time-series data are reviewed.

The chapter is organized in four major sections: (a) information processing model, (b) visual/kinesthetic abilities and performance, (c) serial position curves, and

(d) time-series research designs. The chapter concludes with a brief summary.

Information Processing Model

Several theoretical models have been used to explain the performance of skilled behavior. Whiting (1975) identified three such models as: (1) communication models, (2) control systems models including cybernetics, and (3) adaptive systems models. Whiting (1975) believes the most fruitful line of inquiry has been provided by the communication model which views man as an information processor.

The early statements of the information processing model (Craik, 1947, 1948) described man as a link in a communication channel. As such, man receives, processes, and transmits information from a display (input) to output. This model was expanded later by Welford (1968) who viewed the "human mechanisms mediating between sensory input and motor output as a communication channel of limited capacity" (p. 16). This capacity depends on the number of "distinct states the brain mechanism concerned can assume at any given instant" (Welford, 1968, p. 21).

Using Welford's model as background, Marteniuk (1976) identified processes limiting the perceptual and decision mechanisms of information processing. The following discussion will briefly review some factors which limit these mechanisms.

Perceptual Mechanism

The perceptual mechanism organizes and classifies information from the environment and passes selected responses on to the decision mechanism. Information available to this mechanism arises from the sensory capabilities of humans, including proprioception. Two factors limiting the perceptual mechanism are memory and the acuteness with which an individual can detect information.

The role of memory in motor skills is "concerned with the capacities of the memory system . . . for retaining information over short time intervals" (Marteniuk, 1976, p. 11). In the information processing model, memory is a limiting factor in that it restricts the amount of information which can be processed over a given period of time. Short-term memory appears to be limited by the number of items which are presented. In the nonmotor domain it appears that the capacity of the short term memory system is about seven to eight items (Miller, 1956). No definitive work is available on this capacity in the motor domain.

The second factor which limits the perceptual mechanism is the individual's ability to detect information. This ability is affected by the degree of stress or arousal under which the individual is performing. Welford (1968) explained this on the basis of the underlying neural firing occurring in the central nervous system. When the individual is under-aroused the central channel is "inert" and information is lost. Conversely, when arousal is too high, there is an increased amount of random "noise" in the central channel due to random firing of the neural mechanisms and information is lost again.

Related to an individual's ability to detect information is his ability to make absolute judgments about information. Miller (1956) found that when an individual is asked to classify a number of stimuli, there is a point beyond which the addition of further stimuli leads only to an increase in the number of errors committed.

Miller (1956) reviewed literature dealing with channel capacity of humans. Channel capacity is defined as "the greatest amount of information a person can give . . . about the stimulus on the basis of an absolute judgment" (Miller, 1956, p. 82). He concluded that channel capacities for a wide range of unidimensional sensory decisions range from three to fifteen items, with the average channel capacity being approximately seven items. In the motor domain, Marteniuk (1971) found the channel capacity for performing up to 16 different movements of a lever to varying distances using kinesthetic information was approximately six movements.

Miller (1956) contended that humans have a variety of ways to increase the channel capacity to process information. Adding variables from which information can be gained is one such way. As more variables are added to the display, the total channel capacity is increased but accuracy diminishes. It appears that it is possible to "make rather crude judgments of several things simultaneously" (Miller, 1956, p. 88). Another powerful way to increase channel capacity is to "recode" the information, i.e., group the stimuli into units or chunks. By recoding information, the channel capacity of approximately seven items is increased because now each item contains several bits of information treated as a single item. Miller (1956) concluded that "by organizing the stimuli . . . successively into a sequence of chunks, we manage to break . . . this information bottleneck" (p. 95) caused by the limited channel and short term memory capacities.

Decision Mechanism

The decision mechanism is involved in the processing of information to select a plan of action. The time involved to reach this plan of action is commonly known as reaction time. Space limits the decision mechanism just as it does the perceptual mechanism (Keele, 1973). Space in this sense refers to the limited processing capacity of the performer. Since information processing places an attention demand on the central nervous system, it adversely affects the operation of other mechanisms (Marteniuk, 1976). There is a linear relationship between the amount of information which must be processed and decision time. That is, slow decision times are related to high amounts of information and fast decision times are associated with low amounts of information (Welford, 1968).

In information processing terms, decision time is "predictable according to how much uncertainty (the amount of information) there is in a situation" (Kay, 1970, p. 141). Kay (1970) suggested that information flow may be reduced by either slowing down the operation or by reducing the number of choices. Finally, information flow may be reduced through learning "the probabilities of events by assessing their past frequencies or rates of occurrence" (Kay, 1970, p. 146). As frequencies or rates of occurrence are learned, serial dependencies among events are identified. The performer can then chunk stimuli to reduce the information flow (Hayes & Marteniuk, 1976).

Summary

Information processing mechanisms are involved with perceiving and organizing information obtained from the environment in order to select a plan of action. The limited channel capacity (space) was found to be a major factor limiting information processing. Recoding information received from the environment helps to stretch the channel capacity. Other factors which influence information processing were identified. These factors included the amount of information contained in the display, degree of arousal, short term memory, and familiarity with the task.

Kinesthetic/Visual Abilities and Performance

Several studies have attempted to demonstrate that, as learning progresses, changes occur in the relative importance of various abilities in motor skill performance. These studies have emanated from Fitts' (1951) belief that it is necessary to examine the relative importance of visual and proprioceptive cues for performance. Fitts suggested that "visual control is very important while an individual is learning, . . . [however] as performance becomes habitual, it is likely that proprioceptive feedback . . . becomes the more important" (1951, pp. 1323-1324).

Dickinson (1974) suggested that three types of experiments would demonstrate that proprioception becomes more important later in performance. These three types of experiments are those which

(1) Assess individual differences in ability and classify them as more sensitive and less sensitive in this ability. Differences in performance between these two groups should indicate differences in the importance of this ability;

(2) Utilize a secondary task. If this task involves visual acuity, it should be less distracting in later performance trials; and

(3) Anaesthetize relevant sensory receptors at different stages of performance. (Dickinson, 1974, pp. 109-110)

Relevant studies which used the first and last type of experimental conditions described by Dickinson are cited in the following text. No studies were found which utilized the second type of experimental condition.

Comparisons of High-Low Ability Groups

Fleishman (1972), in a review of his studies regarding abilities, stated that "particular combinations of abilities contributing to performance . . . change as practice on the task continues" (p. 1024). Fleishman described "ability" as a more general trait of an individual, which develops during childhood and facilitates performance on many different tasks. In their classic study, Fleishman and Rich (1963) assessed individual differences in kinesthetic and spatial abilities and then compared performances of groups high and low in each of these abilities on a two-hand tracking apparatus. Results indicated there was a decline in the correlation between performance and visual ability measures and an increase in correlation between performance and kinesthetic measures as the number of trials on the tracking test increased. Additionally, when performance curves for those high and low on spatial ability were compared, the curves indicated a significant difference ($p = .01$) only in the early trials; the curves converged by the later trials. Conversely, performance curves of individuals high and low in kinesthetic ability diverged by the later trials and were significantly different ($p = .01$) only at the last trial. Fleishman and Rich concluded that there was a shift from spatial to kinesthetic cues as trials progressed.

Stallings (1968) found similar results in relation to visual abilities only. Those subjects scoring high on a visual-spatial measure, card rotation, scored significantly higher ($p = .05$) on a two-hand volleyball speed pass than subjects scoring low on the visual-spatial measure. This difference was demonstrated on the early trials and on the first trial following a two-week break in the practice schedule.

Phillips and Summers (1954) and Dickinson (1969) obtained results conflicting with those described above. Phillips and Summers utilized an arm-positioning task as the measure of proprioceptive sensitivity. Scores obtained on this test by the group of bowlers classified as fast learners were compared with scores obtained by slow learners. Results indicated that proprioceptive sensitivity was more important in the early trials. Dickinson (1969) compared scores achieved by novice adults on a badminton serve test. Those subjects who scored high on a kinesthetic sensitivity test, i.e., sensitivity to differences in weights, formed one group. The other group was composed of subjects who scored low on this measure. Results indicated that kinesthetic ability played a constant and highly important role in badminton serving performance throughout all 20 trials.

Dickinson and Rennie (cited in Dickinson, 1974) replicated the Dickinson (1969) study using children 10-11 years of age. Scores on the serve test correlated higher with kinesthetic sensitivity scores as trials progressed. This result was consistent with that obtained by Fleishman and Rich (1963). However, when the serving scores of an experienced group, those having experience with rackets, were compared to this same groups' kinesthetic sensitivity scores, it appeared that kinesthetic ability played an important part throughout all trials. No consistent relationship was found for the novice group. These results suggested that "Kinesthetic sensitivity is not an important ability when the child has no experience" (Dickinson & Rennie, cited in Dickinson, 1974, p. 116). On the other hand, those children who had some experience with rackets showed the same relationship between kinesthetic sensitivity and scores on serving as the novice adults. Dickinson speculated that there was not enough time for the novice children to gain experience with the service task to allow proprioception to dominate. The novice adults and experienced children had sufficient experience with similar tasks for proprioception to take over earlier.

Temple and Williams (1977) classified 20 sixth-grade children as having either visual information processing preference or proprioceptive information processing preference. Those classified as preferring visual information processing scored in the same category, i.e. high, middle, or low, on three of the five visual screening tests administered.

Similarly, proprioceptive information processing preference was assigned to those students scoring in the same category on four of six proprioceptive screening measures. Subjects then performed two tasks: (1) a Pursuit Rotor test which required equal proprioceptive and visual information processing ability and (2) one of two agility tasks. One agility task primarily required visual information processing and the other required proprioceptive information processing. Those subjects classified high on proprioceptive and high on visual information processing performed better and showed more progress on the Pursuit Rotor test. Differences between groups in both categories of information processing preference were significant ($p = .05-.01$). On both agility tasks, high visual preference children performed at higher levels at the beginning. This difference had disappeared by the end. The group classified as high proprioceptive preference scored significantly better through all five trials than did those classified as low or medium in proprioceptive preference. Temple and Williams (1977) explained these results on the basis of the proprioceptive characteristics of <u>both</u> the learner and the task. When preference for proprioceptive information processing was matched with high proprioceptive demands of the task, performance was better throughout all trials. As in the Fleishman and Rich (1963) study, high visual information processors exhibited a significantly better performance only on the early trials.

Blocking Relevant Sensory Information

Laszlo (1967) investigated the relative roles of kinesthesis and vision in two motor tasks through the direct reduction of these sensory modalities. The two tasks utilized were fast Morse-key tapping, which emphasized kinesthetic feedback, and straight runway tracking, which emphasized visual feedback. Two groups of ten subjects performed these tasks in a normal condition, i.e., with vision and kinesthesis, and with one or both of these modalities blocked. Vision was blocked by shielding the hand from the eyes, while kinesthesis was eliminated by a nerve compression block. Results indicated that the "loss of kinaesthetic information impairs performance in all . . . tasks to a greater extent than the loss of extereoceptive (visual) information" (Laszlo, 1967, p. 364).

In a subsequent study, Laszlo and Baker (1972) required subjects to write letters with their index fingers (novel task) under different conditions of practice. Conditions included: (a) no practice, (b) practice with kinesthetic but without visual cues, +K -V, and (c) practice with kinesthetic and visual cues, +K +V. Subjects then performed six trials of writing four letters. The first trial was performed with vision and subsequent trials were performed without vision, -V. Results indicated that the group with no practice was the only group to show no improvement between the first and second trials. The +K -V group performed significantly better than the +K +V group. These results indicated that practice with a task prior to information loss resulted in a reliance on kinesthetic cues. Even though visual cues were available in the +K +V group, this availability was not sufficient to allow the performance of this group to equalize that of the +K -V group.

Visual/Kinesthetic Information Processing Among Older Adults

Several aspects of visual information processing exhibit changes with age (Fozard, Wolf, Bell, McFarland, & Podolsky, 1977). Of particular interest to this study are the effects of age on extracting information from a complex, static display, and the results from studies dealing with continuous perceptual-motor tasks.

Talland (1966) varied the rate of change of numerals on a circular display. Subjects (N = 280 men, 20-70 years of age) monitored these displays for the occurrence of a particular numeral. Older subjects experienced notable declines in performance when the rate of presentation was fast. Rabbitt (1965) allowed subjects to set their own pace in a card-sorting task. Subjects aged 20-70 years searched cards for particular letters and placed cards containing the target letters in separate piles. The number of other letters on the card was varied. When only two targets (A and B) were used, increasing the number of other letters resulted in a slowing of sorting for the older subjects. Rabbitt (1965) suggested this result was due to age differences in scanning rates. Thompson, Axelrod, and Cohen (1965) found much the same result using an array of geometric forms. As the array increased in complexity, older subjects required more time and committed more errors than did younger subjects. From these studies, it appears that older individuals are adversely affected in extracting information from visual displays when the time available for inspection of the display is fast and when the display contains a large amount of information.

Experiments involving the continuous tracking of moving targets also indicate age differences. Welford (1958) required subjects to keep a pointer aligned with a curving track by moving a wheel. The amount of track which was available for subject monitoring was varied. When the speed was slow all subjects were successful. Older subjects made fewer movements when the speed was fast and when little track was available for monitoring. Even when previewing of the track was possible, older subjects were less accurate in their tracking attempts. Welford (1977) explained these results by an information processing model. The observation of the display and the execution of an accurate response take space in the information processing system. When the pace is quickened the limit is exceeded.

Subjects adjust by decreasing the extent of differentiation in their movement response. When more track is available for processing, the space taken up in the information processing system is decreased and older subjects are more accurate in their response.

Little is known regarding age changes in kinesthetic ability. The only study dealing with an active judgment of movement (touching the nose with the eyes closed) found that until the age of 85 there is little change in the percentage of people who are unsuccessful in this task (Howell, 1949).

Older individuals are only slightly less accurate than younger individuals in their sensitivity to differences in lifted weights (Landahl & Birren, 1959). Small differences in weights were noticed by older subjects with an accuracy equal to that of younger subjects. It was only when rapid decisions were required that older individuals' performances were less accurate, and then the differences were slight.

Studies by Szafran (1951, reported by Welford, 1958) indicated that older subjects were less able to perform perceptual-motor tasks without visual cues than were young subjects. A subsequent study by Szafran (1951) was designed to further test this observation. Industrial workers (20-60 years of age) touched a target with a stylus when a light over the target was illuminated. Two experimental conditions were employed. First, subjects were able to see all aspects of the display. Upon completion of this aspect, the procedures were repeated with the subjects' vision limited to just the electric lights. Older subjects took significantly longer to locate the targets in the second experimental condition, limited vision. All subjects made postural adjustments (movement of the head and body toward the target) when visual reference was available. Older subjects continued to make these adjustments during the limited vision condition even though they could not see the targets. Szafran (1951) speculated that the older subjects required both visual and kinesthetic information to locate the target under the first condition. When one of these sources, vision, was eliminated, they were able to rely on the kinesthetic patterns developed earlier.

Summary

In general, studies indicated that proprioception becomes more important in the later stages of motor skill performance. Although some conflicting evidence (Dickinson, 1969; Phillips & Summers, 1954) was presented, these conflicting results may be explained on the basis of the measure used to assess kinesthetic sensitivity, the amount of experience subjects have with the task, or the amount of practice allowed.

Age differences noted in visual information processing indicated that older subjects were adversely affected by fast-paced tasks and by the amount of information available.

No differences were noted in older subjects' kinesthetic abilities. Limited evidence was shown that older adults were able to rely on kinesthetic information when visual information processing was denied. Again, some experience with the task prior to loss of visual sources of information was necessary.

Serial Position Curves

Verbal Curves

Since the classic studies of Ebbinghaus (1919), the most popular and stable result of serial learning studies in the verbal domain is the serial position curve. This curve is characterized by a bow-shape, indicating a recency-primacy effect, i.e., items at the beginning and end of a list are learned faster than those items in the middle.

Several theories attempt to account for the serial position curve. The earliest of these was the Lepley-Hull theory (Hull, 1935; Lepley, 1934). This theory proposed that learning of the middle items is suppressed due to the inhibitory effects of strong associations formed between items at the two ends of the list. This theory is largely held in doubt today as it cannot, by itself, explain all the conditions which affect the serial position curve. Modern theories regarding the cause of the serial position curve include: (a) a "gap" theory (Deese & Hulse, 1967),

(b) an information processing model (Fiegenbaum & Simon, 1967), and (c) an item-to-position association theory (Murdock, 1976). The gap theory proposes that the separateness of the beginning and end items in a list allows these items to be more easily learned. Because nothing precedes the first item in a list, the beginning of the list is most easily learned. Similarly, due to the fact that nothing follows the last word it is the next most easily learned. Although the last item is perceptually distinct by reason of its location, errors are still likely to occur since the accurate placement of this word depends on learning which word it follows. The information processing model (Fiegenbaum & Simon, 1967) postulates that items in a list are learned in an orderly fashion due to the limitations of man's central processing mechanism. Immediate memory, which has a capacity of approximately five to six symbols, controls what is learned. The ends of a list are perceptually unique and are treated as anchor points from which learning proceeds, thereby limiting the strain placed on immediate memory. Finally, Murdock's (1976) item-to-position theory suggests that both the order of an item and the item itself are important factors in remembering a list. Associations between the item and its order are more easily accomplished at the ends of a list.

Several conditions which affect the serial position curve are indicated in verbal learning studies. These conditions include the length of the list, amount of presentation time, meaningfulness of words in the list, degree of relationship between words, and practice. The following studies deal with the effect these variables have on the serial position curve.

Jahnke (1963) presented lists of either 5, 6, 7, 8, or 9 consonants. Lists were presented once at a rate of one consonant per second to 101 women. Following presentation, subjects were asked to write the consonants in the order they were presented. The serial position curve was obtained for each of the list lengths with the exception of the five-consonant list. As list length increased, the bowing of the curve became more pronounced and there was poorer recall of the middle items than of the initial items.

Murdock (1962) determined that the curves obtained from six groups of men and women, each with a different list length and presentation time, showed a marked recency effect, a flat middle section, and a primacy effect of less magnitude than the recency effect. The six combinations of list length and presentation time used were 10-2, i.e., ten words, presented for two seconds each, 20-1, 15-2, 30-1, 20-2, and 40-1. All curves were characterized by a recency effect which extended over the last eight items, a primacy effect which extended over the first three items, and a flat middle section which spanned the recency and primacy effects. The only difference between groups was that as list length decreased the flat middle section became less obvious.

Murdock (1968) studied the effects of various recall techniques, presentation time, and list length on the serial position curve. Presentation times varied from one word every two seconds to two words every second. List lengths were 5, 8, 10, or 11 words. Following list presentation, one of the following probe techniques was used: (a) sequential (subject responds to a given word with the following word), (b) positional (subject responds to a word with the numerical position it held), and (c) reverse (subject responds to a given numerical position with the word located in that position). In addition, two types of ordered recall were tested; recall of the entire list from beginning to end and recall of the list in order starting from _either_ the beginning or from the last part of the list. All experiments resulted in a serial position curve. Longer lists resulted in a more depressed middle section, but had comparable recency and primacy effects. No differences were found in the amount of information recalled as a result of presentation time. Murdock (1968) concluded:

> List presentation under these experimental conditions clearly overloads the buffer store (short term memory), and performance does break down with overload. However, it deteriorates not by retaining perfect information about a limited number of items but by retaining imperfect information about an unlimited number of items. (p. 4)

When structured material, i.e., prose, is presented, recall of the first part of the series is best. Recall of unstructured verbal material shows that the words at the end of a series are recalled best. Sumby (1963) hypothesized that lists of high frequency words would be recalled in the same manner as structured material. Conversely, lists of low frequency words would be recalled in a manner similar to that of unstructured material. Sumby had ten women recall as many words as possible, i.e., free recall, from lists representing each of four word frequency categories. The word frequency categories were 0-1, 9-11, 90-110, and 900-1100 word occurrences per 4.5 million words. He found that when either of the low frequency (0-1, 9-11) word lists was compared with either of the high frequency lists, the high frequency words were recalled better ($p = .01$). A tendency to recall the second half of the list more often was indicated for the low frequency words. When word lists of 0-1 and 900-1100 word frequencies were recalled in serial order but with free recall allowed, differences were also present. For the low frequency word list, the subjects emitted the last word first and worked backward from there. Subjects emitted the initial words first and then the last words when high frequency lists were presented. Only performance scores on the high frequency word list resulted in the typical serial position curve. Sumby (1963) concluded that the association potential of items in a list is a "major determinant" (p. 450) of the serial position curve.

Saufley (1975) studied the effects of practice with serial lists under different conditions. Lists of words were presented 15 times under four different treatments: (a) 0-1, order of words changed on each trial, (b) 0-3, order of words changed every third trial, (c) N-1, different word list presented each trial, and (d) N-3, different word list presented every third trial. The mean number of words recalled was about the same under treatments 0-1 and N-1, both of which involved learning a new list or a new serial order. Mean number of words recalled was similar under treatments 0-3 and N-3, both of which involved learning a list which stayed the same for three trials. In addition, following the change of list or serial order in the 0-3 and N-3 groups, the mean number of words recalled dropped to a level similar to that obtained with the 0-1 and N-1 groups. It appears "that performance (recall) improves considerably when serial order remains constant" (Saufley, 1975, p. 427) and that a change in the serial location of items is equivalent to a change in the composition of list items.

Murdock (1976) indicated that category similarity has a differential effect on item (word or syllable) and order (numerical position) information. Following a review of pertinent studies, Murdock summarized what is known about the item-to-position association. Recall of items is better when words are in the same category, but placement of these items in the wrong order is also more likely to occur. When order information is lost, it is more likely that item information also will be lost. Finally, errors resulting from order loss show the bow-shaped serial position curve.

Motor Curves

Several studies focus on the serial position curve in fine motor tasks. Zaichkowsky (1974) used a Serial Perceptual-Motor Discriminator (SPMD) to measure the serial perceptual-motor responses of 120 boys and girls aged 5, 7, and 9 years. Subjects were required to recall a random or organized sequence of stimulus lights presented on the SPMD. Subjects responded to the lights as they appeared and, after a short interval, were asked to recall the entire sequence of eight lights in the order in which they occurred. Results indicated a primacy effect occurred on the random presentation of lights. All three age groups recalled the early responses much easier than the middle or late responses. Serial position effects were significant ($p = .01$). No primacy effect occurred when lights were presented in an ordered sequence.

Wrisberg (1975), using a linear positioning task, found a recency-primacy effect. Blindfolded subjects moved a linear slide to predetermined stops (up to five).

Following either a five-second or a 50-second retention interval, subjects replicated these movements with the stop indicators removed. Using percentage of absolute error as the measure of accuracy, Wrisberg obtained a serial position curve for subjects with a five-second retention interval and five positions to be recalled. Although verbal learning studies indicate at least six items are necessary for the serial position curve to result, Wrisberg's study indicated that only five motor responses are necessary to obtain this curve.

Magill (1976) also used a lever positioning task to study the serial position curve. Blindfolded subjects (105 males) were required to learn three positions in serial order with knowledge of results given after each trial of three positions. Using variable error as the performance measure, Magill found no recency-primacy effect. Rather, subjects learned the positions in the order in which they were presented. In a later study, Magill and Dowell (1977) found a recency-primacy effect when the number of positions to be recalled was either six or nine. Subjects (45 males and females) were given nine trials on the positioning task. Three groups were formed: one with three positions to be recalled, one with six positions, and one with nine positions. Using absolute error as the performance measure, Magill and Dowell found only a primacy effect for the three-position group. The six- and nine-position group results showed a bowed serial learning curve (p = .01).

Relatively little is known about serial position effects in gross motor behavior. Cratty (1963) constructed a maze consisting of a continuous irregular pathway. Two groups of blindfolded male subjects (N = 42) were used. Each group began at opposite ends and traversed the maze ten times. Time required to complete the first half of the maze was compared to time required for completion of the second half of the maze. A recency-primacy effect appeared to occur following the fourth trial. Differences between performance times on the first half and the last half of the maze were significant (p = .01). These differences were exhibited regardless of starting point. In an earlier study, Cratty (1962) compared performance of a fine motor task to performance of a gross motor task. Traversal times of the maze described above (gross motor) were compared to traversal times on an identical maze constructed to a much smaller scale (fine motor). Two groups of 30 blindfolded subjects completed one maze 12 times and then performed the other maze 12 times. Each group of 30 men began performance on a different maze. Curves of traversal times for each group on each maze revealed a recency-primacy effect.

Singer (1968) varied the order in which four volleyball skills, e.g., serve, spike, set, and dig, were presented to

91 male students. Presentation orders given to four beginning classes included: (a) serve, set, spike, dig, (b) set, spike, dig, serve, (c) dig, serve, set, spike, and (d) spike, dig, serve, set. One skill was presented during each of the first four days and testing of that skill was conducted at the conclusion of each day. In addition, testing of all four skills was done on the fifth day and again on the twentieth day. Although isolated significant differences were found, no consistent pattern of between-group or within-group differences was demonstrated. Singer (1968) concluded that "skill performance in volleyball is unaffected by the learning sequence" (p. 193).

Memory Characteristics of Older Adults

Memory is of paramount importance in the performance of serial tasks. Early views of memory dichotomized it into short term memory (limited capacity store) and long term memory (unlimited capacity store) (Craik, 1977). More recently, this view has been elaborated and a distinction has been made between primary and secondary memory. In this view, primary memory is defined as a temporary holding and organizational store and is thought to be limited to two to four verbal items (Craik, 1977; Waugh & Norman, 1965). Secondary memory is a larger and more permanent storage aspect of memory. Both primary and secondary memory are involved in the recall of serial tasks.

The recall of serial tasks by elderly individuals usually results in a recency effect, i.e., the last few items are recalled first. Craik (1968) and Raymond (1971) used various lists (English county names, animal names, digits, high frequency words, and unrelated words) with young and old subjects. Recency effects were the same for both groups of subjects. However, the primacy effect was of smaller magnitude for the elderly than for the young.

These and similar results have been interpreted in terms of primary and secondary memory (Watkins, 1974). The recency effect is a result of primary memory, since the last few items are within the capacity of this system. Recall of items at the beginning and middle of a list is beyond primary memory capacity and must depend on secondary memory. The consistent findings of no age differences in the recency effect indicate there are no changes in primary memory processes with age (Craik, 1968). Various experimental conditions, including auditory rather than visual presentation and fast presentation rates (Murdock & Walker, 1969) can increase the length of the recency effect.

The dissimilarity of nonrecency effects between young and old subjects is explained, in part, by age differences in the storage and retrieval of items from the secondary store (Craik, 1977; Eysenck, 1977). Acquisition of material from the secondary memory store depends on such factors as the organization of material and the development of an elaborate encoding system. Older individuals exhibit a deficit in organizational strategies in that no chunking or clustering of items occurs (Denney, 1974).

Practice in organizing material helps the elderly perform better on memory tasks (Taub & Walker, 1970). Murphy, Sanders, Gabriesheski, and Schmitt (1981) determined the memory span for elderly subjects. These subjects were then presented three lists of pictures (the number of pictures equaling the span, subspan, and supraspan) under three experimental conditions. Group 1 was allowed to study until they thought they were ready to begin recall. Group 2 was instructed in techniques of chunking pictures into groups, and Group 3 was given a specified amount of time, which was longer than that taken by Group 1. Groups 2 and 3 scored significantly better than Group 1 on the span and supraspan lists while Group 3 scored better than Group 2 on the supraspan list. It seems that the lack of organizational ability is not due to lack of appropriate strategies for organization but is influenced by the time it takes for an appropriate strategy to be selected and utilized. Elderly subjects apparently underestimate this even in experimental conditions which allow them to set their own pace.

Little is known about nonverbal memory and no studies were located which dealt with serial position effects in the nonverbal domain. Reige and Inman (1981) found that older subjects scored significantly lower than younger subjects on visual, auditory, and tactual memory tasks. However, longitudinal or cross-sequential studies must be conducted before it can be stated that nonverbal memory processing is adversely affected by age.

Summary

The consistency of the serial position curve resulting from verbal studies was discussed. Various factors, including list length, presentation time, and practice, affecting the magnitude of the recency-primacy effect were identified. Serial position effects are found in the motor domain, but the results are not as consistent as they are in the verbal domain.

In verbal studies, elderly subjects exhibit comparable recency effects but less marked primacy effects than the effects found with young subjects. These results were explained in terms of primary and secondary memory. Additionally, preliminary studies indicate that the elderly perform at a lower level than younger subjects in nonverbal memory tasks.

Time-Series Research Designs

Time-series experimental designs involve the study of individuals or groups over time. Generally, periodic measurements are made of a variable before and after some experimental change, or intervention, is introduced (Campbell & Stanley, 1966; Glass, Willson, & Gottman, 1975; Kratochwill, 1978). This design allows description of the results of the intervention which are assessed by the analysis of repeated measures of the variable(s) across time.

Those observations made of a variable before an intervention occurs are referred to as baseline or the A condition; while those made after intervention are referred to as the experimental or B condition. The most basic time-series design is an A-B design, one which has multiple observations in the baseline phase followed by repeated observations of the same variable after an intervention has occurred. Other time-series designs include A-B-A which contain a return to baseline conditions and A-B-C designs which involve multiple interventions (Hersen & Barlow, 1976).

Two techniques are commonly used to assess the significance of the changes occurring as a result of application or withdrawal of an intervention. The most commonly used technique is to plot the data in graph form and visually analyze the data. The second technique combines visual analysis with the use of inferential statistics (Kratochwill, 1978). Preliminary data analysis depends on carefully designed visual displays (Elashoff & Thoresen, 1978). Appropriate statistical models can be applied to the data, but only when some knowledge about the structure of the data and possible intervention effects has been gained (Elashoff & Thoresen, 1978; Parsonson & Baer, 1978). Although the use of inferential statistics is appropriate to time-series analysis, it was not an approach used in this study, which was exploratory in nature. The following discussion focuses solely on techniques for visual analysis of time-séries data, which was the technique used in this study.

Visual Analysis

A basic requirement for the successful use of visual analysis is that the intervention produces large differences between baseline and experimental conditions or phases (Kratochwill, 1978; Parsonson & Baer, 1978). If large differences are not apparent, no claims for a stable change can be made.

Visual analysis of the data is concerned with an assessment of the data both within and between the different phases. Changes in the trend, or direction, and the level of the data between phases are particularly important. Trends are determined by utilizing either a semiaverage or a least squares regression technique. The latter method is appropriate only if visual inspection of the data reveals a straight-line trend. Use of the semiaverage method involves manipulation of the data within each phase. Means and ranges of the two halves of data points obtained during each phase are calculated. Means and the midpoints of each range are then presented in graph form. When there are an uneven number of data points within a phase, the middle data point is omitted (Parsonson & Baer, 1978). After all data have been visually presented in graph form, visual analysis can indicate the significance of intervention effects. Claims of a significant intervention effect may be made when there is (a) an abrupt change in trend between phases, particularly if any trend within a phase has remained constant, (b) little overlap between scores of successive phases, (c) an abrupt change in level between phases, and (d) an overall pattern to the data across all phases (Parsonson & Baer, 1978).

Potential problems can arise when data are visually analyzed. Kratochwill (1978) and Parsonson and Baer (1978) identify such problems and suggest solutions. First, baseline data must indicate stability in the variable under observation has occurred prior to intervention. Should no stability occur prior to intervention, trend lines need to be fit to the data. Or, use of a multiple intervention design (A-B-C) can alleviate this problem. A second problem occurs if the data exhibit great variability within a phase. Such variability indicates more data are needed during each phase. If collecting more data is not possible, averaging data points across consecutive days or using a mean line to represent the data within a phase reduces the variability.

The display of data for visual analysis is crucial. The most commonly used graphs for time-series data are line, bar, and range graphs. Of these, line graphs are the easiest to construct and are widely acceptable (Parsonson & Baer, 1978). Whatever type graph is utilized, it should be clear, simple, and explicit. Finally, labeling should clearly indicate the different phases and identify the nature and purpose of the graph.

Summary

Time-series designs are utilized to assess the effects of an intervention on experimental variables. The analysis of time-series data includes visual inspection of the data and, when appropriate, the application of inferential statistics. The characteristics of the data which are essential for significant effects, including changes in the level and trend of the data, were discussed. Potential problems with visual analysis of time-series data and their solutions were presented.

Summary

Information processing constructs were discussed in the early portion of the chapter. The capacity of humans to process information is limited to approximately seven items at a time (Miller, 1956). This capacity can be extended by reorganizing bits of information into larger chunks (Hayes & Marteniuk, 1976; Kay, 1970; Miller, 1956).

The second portion of the chapter focused on the relative predominance of visual and kinesthetic abilities to performance. In general, support for Fleishman and Rich's (1963) finding that kinesthetic abilities are more important later in performance was demonstrated (Dickinson, 1974; Laszlo, 1967; Laszlo & Baker, 1972; Temple & Williams, 1977). Visual and kinesthetic information processing characteristics of the elderly were discussed. Decline in visual processing characteristics (Rabbitt, 1965; Talland, 1966; Welford, 1958) and stability in kinesthetic abilities (Howell, 1949; Landahl & Birren, 1959) were noted. Elderly subjects performed less well on an aiming task when vision was eliminated but were able to achieve success by relying on kinesthetic cues (Szafron, 1951).

The review of serial position effects in the verbal domain revealed a consistent recency-primacy curve (Jahnke, 1963; Murdock, 1962, 1969; Saufley, 1975; Sumby, 1963). The recency-primacy effect was exhibited in studies of recall in the motor domain (Cratty, 1962, 1963; Magill & Dowell, 1977; Wrisberg, 1975). However, some studies in the motor domain found a primacy effect only (Zaichkowsky, 1974), or no recency-primacy effect (Magill, 1976; Singer, 1968). Elderly subjects show comparable recency effects

(Craik, 1977; Raymond, 1971) on recall tasks in the verbal domain. The primacy effect is less evident, which was explained in terms of difficulties in organizing and encoding information for secondary memory storage experienced by the elderly (Craik, 1968; Denney, 1974; Eysenck, 1977; Murphy et al., 1981). The pattern of recall by elderly subjects in the motor domain is not known.

The final section of the chapter reviewed procedures for time-series research design. The use of time-series research designs has not been employed to determine the changes in motor skill performance over time. Such use would appear to be of value in describing serial position effects as well as the effect of kinesthesis and vision on performance.

CHAPTER III

PROCEDURES

The methods used to investigate the research problem are described in this chapter. The text is organized into four related sections: (a) development of the serial gross motor task, including preliminary and pilot testing, (b) selection and pretesting of subjects for main study, (c) administration of the serial gross motor task, and (d) analysis of data. A rationale for the development of components of the motor task is included in the description.

Development of Motor Task

The development of the serial gross motor task utilized in this investigation centered around two major criteria. First, there must be distinct differences between segments of the task in regard to the mode of information processing. In order to meet this criterion, two of the segments (low visual) required information gathering via the tactile sense and two segments (high visual) were organized to allow visual information processing. In addition, the low visual segments required movement of the body in particular patterns through space, a task which places limited demands on the visual processing mechanism (Whiting, 1969). The high visual segments, on the other hand, placed a heavier demand on the visual processing mechanism due to the need to handle and move objects through space (Whiting, 1969). Secondly, the number of elements within each of the four segments must be of sufficient length to elicit a recency-primacy effect. Following the work of Magill and Dowell (1977), it was known that at least six to nine items (elements) must be included. The initial motor task, therefore, contained two high visual and two low visual segments, each of which included 12 elements.

In addition, a means to vary the position of various parts of the task was necessary in order to study the recency-primacy effect in relation to the relative position of the task segments. Two intervention strategies were utilized to accomplish this. One intervention strategy was to reorder the serial order of the 12 elements within each of the high and low visual segments of the task. The reordering of the high and low visual segments of the task was employed for the second intervention strategy. The latter strategy was employed because it was theorized a recency-primacy effect may be elicited by the order of segments as well as by the order of elements within the segments. By varying the sequential location of the segments, the performance of the elements within each of the task segments could be studied in relation to the relative position of these segments. Thus one sequence of high visual, low visual, low visual, high visual segments, and one of low visual, high visual, high visual, low visual segments were adopted.

The low visual and high visual segments all involved the processing of many pieces of information prior to the performance of the component parts of these segments. Two other segments, different in nature from the low visual and high visual segments, were adopted. These segments were added to the sequential order of the serial gross motor task in order to provide a contrast to, and allow a break between, the performance of the low visual and high visual segments. Criteria for these different segments included that they (a) be stationary in nature, (b) allow an accumulation of scores which could be recorded, and (c) be variable in a simple, systematic manner. Beanbag tossing to targets set at varying lengths met these criteria and was adopted. These tossing segments were placed in the sequence of the serial gross motor task so that they were always performed second and fifth. Thus, the two sequences finally adopted were (a) high visual, beanbag tossing, low visual, low visual, beanbag tossing, high visual segments, and (b) low visual, beanbag tossing, high visual, high visual, beanbag tossing, low visual segments.

Preliminary Pilot Testing

A preliminary pilot test was conducted in December, 1980 to (a) pretest the length and structure of the motor task, (b) pretest the instructions for the task, and (c) test the efficiency of the measuring devices. Nineteen women subjects were used in this phase of the study. Eight subjects ranged from 50-60 years of age and the rest of the subjects were 20-50 years of age. All were volunteers obtained from the faculty, staff, and student body of the School of Health, Physical Education, Recreation, and Dance, University of North Carolina at Greensboro. Consent forms were obtained (see Appendix A, p. 241) and subjects were interviewed upon completion of testing each day.

Testing was conducted over a four-day period. Pretesting of the three types of segments of the motor task--beanbag tossing, high visual segments, and low visual segments--was done separately on each of the first three days. Administration of the entire task was conducted on the fourth day. All testing was done in Coleman and Rosenthal Gymnasia, University of North Carolina at Greensboro. The following procedures were utilized during this phase of the study.

Day 1: Tossing Segments

Two tossing segments, a long one and a short one, were administered to five subjects. Each segment involved the tossing of beanbags to a series of targets, each of which was 18 inches square. Three such targets were marked with white tape on two strips of green felt. For the long tossing segment, the nearest target was located 12 feet and the most distant target was 18 feet from the subject. Each target was separated by 12 inches. For the short tossing segment, the three targets were located 4 to 10 feet from the subject.

Each subject performed both tossing segments twice. Each time, the subject performed the short tossing segment first. Initially, subjects were required to toss beanbags at a specified sequence of targets. The first beanbag was tossed to the closest target, the second to the middle target, and the next to the most distant target. This sequence of close, middle, and distant targets was repeated until all 20 beanbags were tossed. One point was recorded for each beanbag landing wholly within the boundaries of the correct target. One-half point was awarded for those beanbags landing partially within a correct target. On the second trial of both tossing segments, subjects were directed to achieve the highest score possible. Again, 20 beanbags were tossed, but no specific sequence was designated. The closest target scored one, middle target scored two, and the most distant target scored three points. Any beanbag landing wholly within a target scored full value, while any beanbag landing partially within a target scored half value. The total score achieved was reported to the subject following each trial.

At the conclusion of this day, the following decisions were made:

1. The second set of directions, maximum score

possible, was adopted. This decision was judged appropriate because:

a. Individual strategies were employed under these task directions. It was concluded that greater variability in scores would accrue.
b. Subjects consented that under this set of directions they had to focus more closely on the task. Thus, the performance of beanbag tossing truly represented an interruption between the high and low visual segments of the task.

2. The numerical value of each of the targets was changed to simplify scoring procedures. Rather than targets of one, two, and three points, the nearest target now scored two, the middle target scored four, and the most distant target scored six points. Beanbags landing partially within a target could be scored in whole numbers, i.e., one, two, or three respectively, rather than in fractions.

3. Scores achieved on the short tossing segment (Range = 53-81; Mean = 76) and the long tossing segment (Range = 16-46; Mean = 36) were markedly different from one another. It was concluded that the variation between the two segments was sufficient.

Day 2: High Visual Segments

The administration of the two high visual segments occurred on the second day. Each segment consisted of 12 different elements. For each of these 12 elements, the subject was required to (a) move to a particular station, (b) move the hand/arm in various patterns, and/or carry and stack various colored blocks at the station. In addition, it was necessary for the subject to step over or duck under any obstacles in the pathway to and from any of these stations.

Two areas, measuring 20 feet square, were demarcated for the high visual segments. One high visual segment, 4HV, contained four brightly colored, 12-inch-high cone markers arranged in an easily recognizable pattern (see Figure 1). The other high visual segment, 9HV, contained nine such cone markers arranged in an amorphous pattern. Each segment contained three obstacles, 12-foot lengths of dowel rods placed on standards of varying heights. The obstacles were set at heights of 5 feet, 1.75 inches, and 3 inches. White, orange, and blue wooden blocks, used for stacking, were located adjacent to each of the segment areas. Specific placements of these cones, obstacles, and blocks are indicated in Appendix A, p. 243. Cue cards and an element key were placed on a table within each segment area. Two element keys and a pressure mat, located in an area central to both segments, were wired into an Esterline Angus Servo Recorder for timing purposes.

Six subjects served to pretest the requirements of these segments. All subjects performed the requirements of the 9HV segment first. General directions were given which included the sequence of key contacts, the location of the stations, and a description/example of the information contained on the cue cards. In addition, the directions

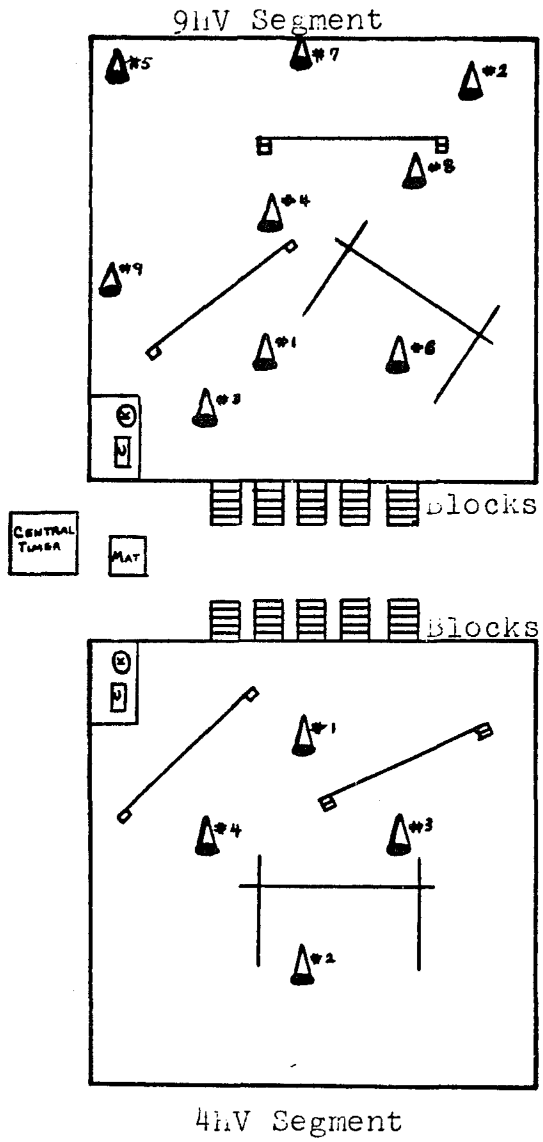


Figure 1. 9HV and 4HV segments (Preliminary Pilot Testing)

= cone station markers

= high obstacles

= low obstacles

emphasized that speed and accuracy both were being recorded. A map designating the locations of the stations was shown to the subjects, and it was indicated that the subject could refer to it if necessary (see Appendix A, p. 242).

Specific requirements for each of the 12 elements in the 4HV and 9HV segments were located on sequentially stacked cue cards, measuring 5 x 8 inches. A sample card is shown in Figure 2. The subject obtained the following information from the card: (a) the number 3 indicated the station to which she should go, (b) the number of blocks to pick up, carry, and stack at the designated station, and (c) the type and number of hand movements to make. The order of these 12 cards was randomly determined for the 4HV and 9HV segments.

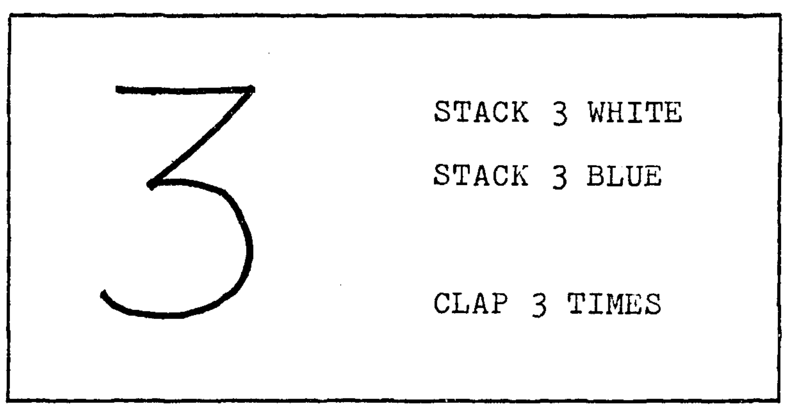


Figure 2. Sample cue card used for high visual segments

When the subject was ready to begin, she stepped on the pressure mat and then depressed the element key. After reading and understanding the information on the first cue card, she turned it over on a separate pile, and went to the specified station to perform the element delineated. If the route from the cue card location to the specified station contained an obstacle, the subject ducked under or stepped over it. Upon completion of the first element requirements, the subject returned to the table where the cue cards were located, stepping over or ducking under any obstacle in her pathway. The subject contacted the element key again to signal completion of that element. This procedure--(a) key contact, (b) cue referral, (c) performance of element requirements, and (d) key contact--was repeated for the remaining 11 elements in the segment. After contacting the key following the requirements of the last (12th) element, the subject stepped on the pressure mat to signal completion of the 9HV segment. Identical procedures were followed for the 4HV segment following a short rest period (10-15 minutes).

At the conclusion of this day of preliminary testing, the following observations and decisions were made:

1. A new sequence of contacting the element key was adopted. The sequence of element key contact, performance, element key contact, element key contact to begin the next element performance resulted in two rapid contacts which could not be distinguished on the graph output from the Servo Recorder. In addition, this sequence did not result

in a separation of cue referral time from performance time. The new sequence adopted required element key contact, cue referral, element key contact, performance, element key contact.

2. The subjects did not perceive the bars as obstacles. The height of the low bars, previously set at 1.75 and 3.5 inches, was raised to 11.75 inches. The height of the high bar was changed from 5 feet to 4 feet 6 inches.

3. The investigator noted a slowing in performance near the end of the segments. Subjects reported that the segments were "too tedious." No decision about altering the segment length was made until after the low visual segments were administered.

Day 3: Low Visual Segments

Two low visual segments were pretested on the third day. These segments consisted of 12 different elements. For each of these 12 elements, the subject was required to move to a particular station, and duplicate particular geometric figures by walking in that pattern a specified number of times. In addition, it was necessary for the subject to step over or duck under any obstacles in the pathway to and from the station.

Two areas, measuring 20 feet square, were demarcated for the low visual segments. One low visual segment, 4LV, contained strips of 12-gauge fishing line suspended from an overhead grid to mark four stations. These stations were arranged in an easily recognizable geometric pattern (see Figure 3). The other low visual segment, 9LV, contained nine such strips marking stations arranged in an amorphous pattern. Three photoelectric cells were arranged in each segment so their beams served as obstacles. The height of these cells was 11.75 inches for the low obstacles and 4 feet 6 inches for the high obstacle. The fishing lines and photoelectric cells were adapted to present a contrast to the high visual segments. The suspended lines, parallel in purpose to the brightly colored cones in the high visual segments, were barely visible. The photoelectric cells themselves presented a marked contrast to the bars used as obstacles in the high visual segments. Specific placements of the lines and photoelectric cells are indicated in Appendix A, p. 244. An element key and a box containing the wooden cues were located on a table situated in the area. The photoelectric cells, element keys, and the pressure mat, located in an area central to both segments, were wired into the Servo Recorder. Nine subjects pretested the requirements of these segments. All subjects performed the 4LV requirements first. General directions were given which included the sequence of key contact, the location of the stations, and a description/example of the information contained on the wooden cues. In addition, the directions emphasized that speed and accuracy both were being recorded. A map

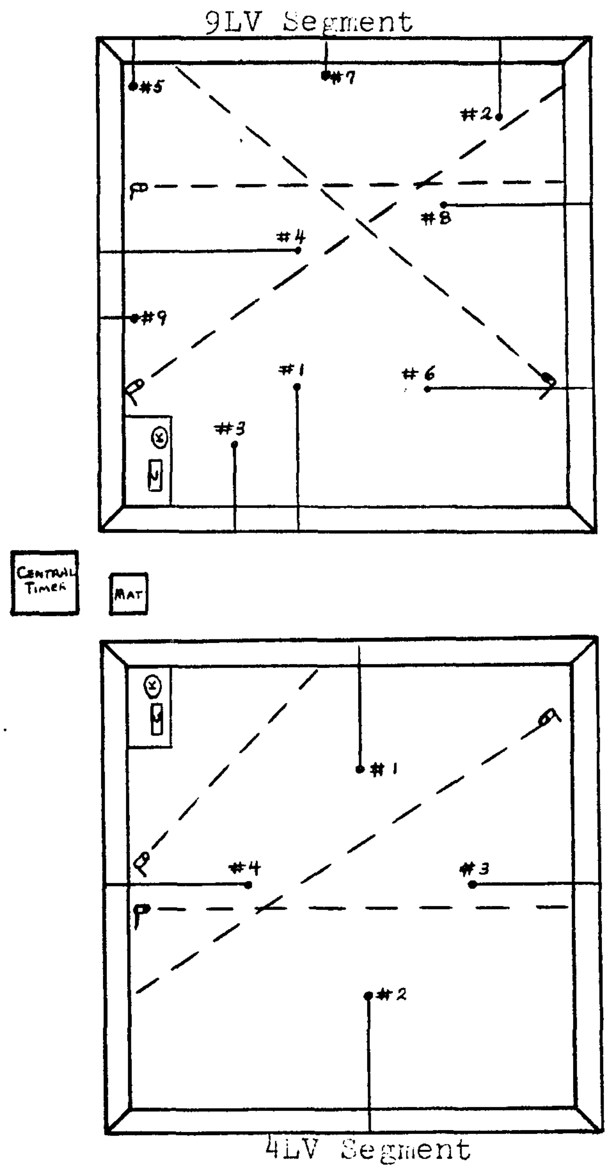


Figure 3. 9LV and 4LV segments (Preliminary Pilot Test)

——• = fishing line station markers

P = photoelectric cells

designating the locations of the stations was shown to the subject, and it was indicated that she could refer to the map if necessary.

Specific requirements for each of the 12 elements in the 4LV and 9LV segments were located on geometric forms inside a box (see Appendix A, p. 248). The forms, shown in Figure 4, were cut from one-foot square wooden blocks. The shape of the form, e.g., circle, square, etc., indicated the pattern to replicate. The notches on the side of the form indicated the number of repetitions to perform, and the holes in the center of the form indicated the station at which to perform the pattern. One random order of these 12 forms was presented for each segment.

When the subject was ready to begin, she stepped on the pressure mat and then depressed the element key. She reached into the box and, without removing the top wooden form from the box, manipulated it until all the information on it was understood. The form was placed in a separate pile within the box by the subject when she was finished with it. The subject then contacted the element key and went to the station indicated to perform the element. For example, if the first form the subject manipulated was a triangle with one notch and three holes, she went to Station 3 and walked in a triangular pattern one time. If the route to the station contained an

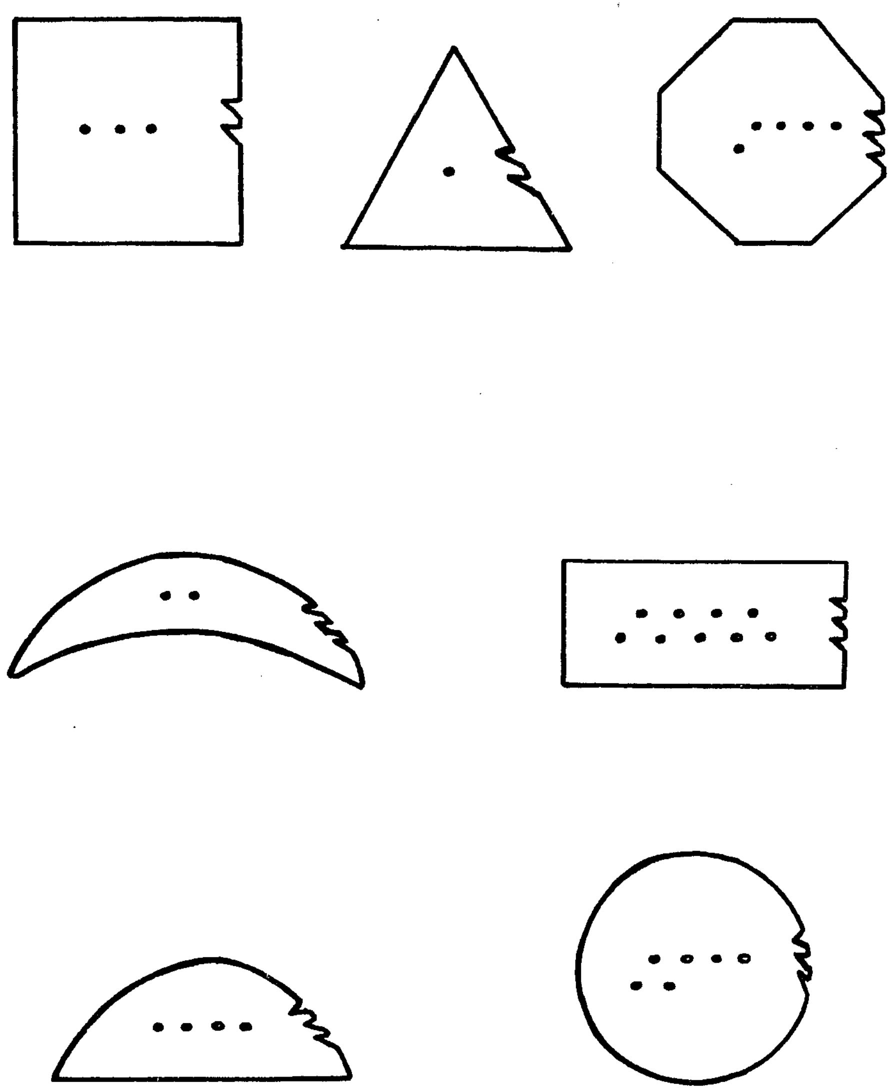


Figure 4. Wooden shapes used as cues in 4LV and 9LV segments. Size = 9" before shaping. Figures used for Preliminary Pilot Test were 12" before shaping.

obstacle (photoelectric cell beam), the subject ducked under or stepped over it. After completing the first element, the subject returned to the cue box, ducking under or stepping over any obstacles, and contacted the element key. This sequence of key contact, cue referral, key contact, performance was repeated for the remaining elements. After contacting the key following the requirements of the last (12th) element, the subject stepped on the pressure mat to signal completion of the 4LV segment. Identical procedures were followed for the 9LV segment following a short rest period.

Upon completion of each segment, the subject was informed of the time required to perform the segment as well as the number of cue referrals and errors. Time was recorded on a manual stopwatch operated by the investigator. The stopwatch was started when the subject contacted the pressure mat to begin the segment and stopped with the second pressure mat contact.

At the conclusion of this day, the following decisions were made:

1. Both low visual (4LV and 9LV) and both high visual (4HV and 9HV) segments were reduced from 12 to 9 elements.

It was noted again that subjects were slowing down toward the end of a segment. They expressed feelings that the segments were "too long" and "too tedious." These expressions were borne out by the fact that the times required to complete the 4LV segment ranged from 7.25 minutes to 15 minutes. Completion times for the 9LV segment ranged from 9.50 minutes to 16 minutes.

2. The wooden cues were reduced to 9-inch squares before shaping. This change was made because subjects reported difficulty with tactile manipulation of the wooden shapes due to their size.

3. Placement of the photoelectric cells was changed so that all beams were parallel across the space. When the cells were arranged at an angle, two beams often caused multiple obstacles within the same limited space. To keep the high visual segments parallel in their physical arrangement, identical changes were made in the placement of obstacles in these segments.

Day 4: Serial Gross Motor Task

The final day of the preliminary pilot test was used to pretest the entire serial gross motor task. Spatially, the entire task was organized as shown in Figure 5. The photoelectric cells, all element keys, and two pressure mats were wired to the Servo Recorder by means of a junction box (see Appendix A, p. 246).

The task consisted of the two tossing segments, two high visual segments, and two low visual segments pretested on the previous days. This combination of segments was performed as a whole. Two different sequences of these

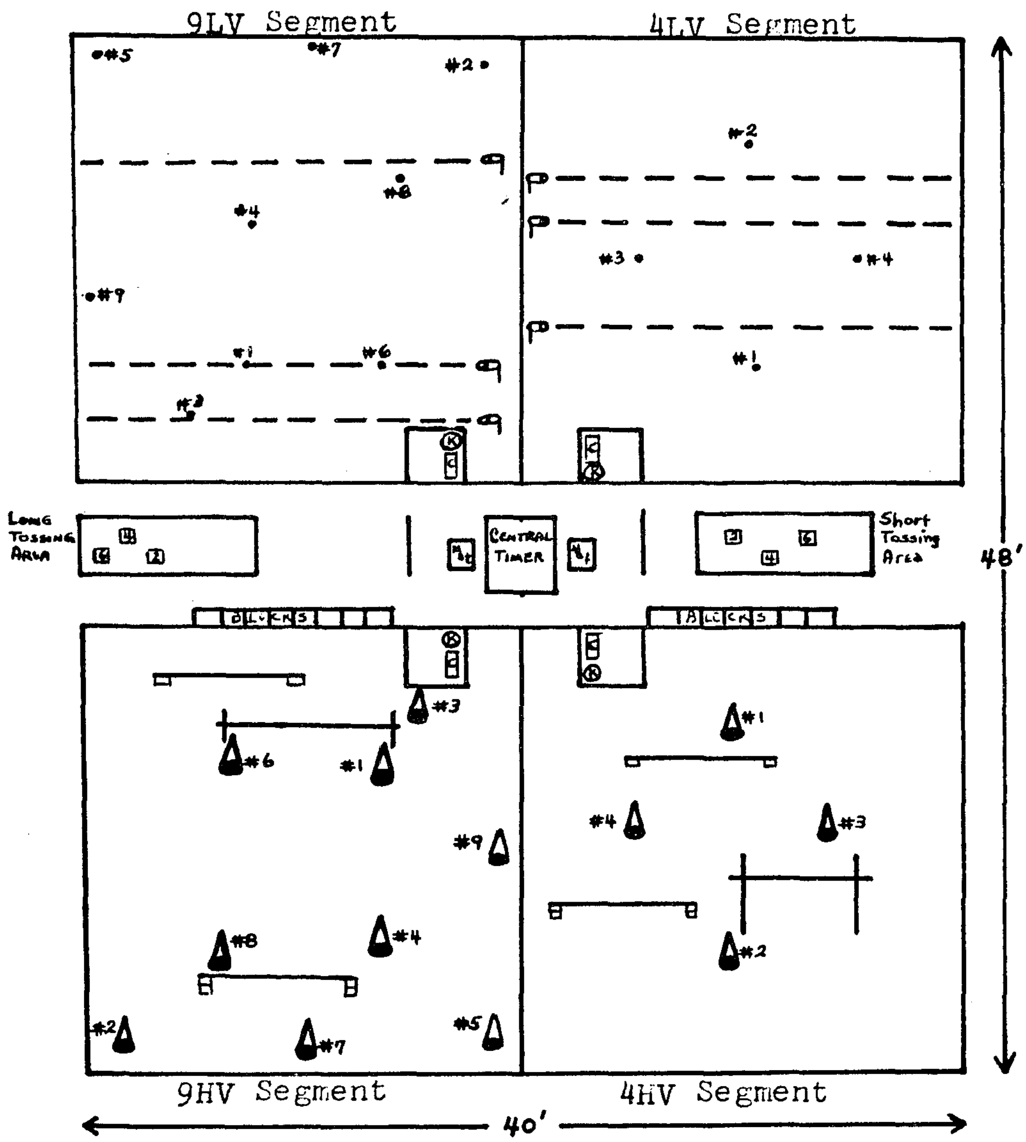


Figure 5. Spatial organization of the serial gross motor task (Preliminary Pilot Test)

segments were administered to nine subjects. The two different sequences of the task were:

Task 1-A	Task 1-B
9HV	4LV
Short Tossing	Short Tossing
4LV	9HV
9LV	4HV
Long Tossing	Long Tossing
4HV	9LV

Five subjects were pretested on Task 1-A and four subjects on Task 1B.

Directions for the entire task were given segment-by-segment. As the directions were given for each segment, the subject was shown the area itself as well as any special cues which were available in the area. Questions were answered before proceeding to the next segment. Once directions for all segments were understood, the subject began the task by stepping on a pressure mat. She then contacted the element key, referred to the first cue, and performed the first element of the first segment. Upon completion of that element, she contacted the key again. This sequence of key contact, cue referral, key contact, performance, key contact was followed for all elements in the first segment. After the last (9th) element in the segment was performed, the subject stepped on a pressure mat to signal the end of the segment. When she was ready to begin the next segment, the same procedure was followed, i.e., key contact, cue referral, key contact, performance, for each of the elements in that segment. This procedure was repeated until all six segments were completed. The order of elements performed within the 4HV, 9HV, 4LV, and 9LV segments was randomly determined.

Upon completion of the entire task, the subject was notified of the time required to perform the total task, the number of errors, and the number of cue referrals. Time was recorded on a manual stopwatch operated by the investigator. The stopwatch was started when the subject contacted the pressure mat initially and stopped with the pressure mat contact following the completion of the sixth segment.

At the conclusion of this day, the following decisions were made:

1. One and a half hours would be scheduled per subject for the first day of pilot testing. One subject required 44 minutes, 38 seconds to complete the entire task. It was felt that an hour and a half would be sufficient time for instruction and performance. Subsequent trials would be scheduled at one-hour intervals.

2. Subjects concurred that the instructions were clear.

3. Reducing the high and low visual segments from 12 to 9 elements was sufficient. Subjects reported the task was "fair," "interesting," and, from those who had participated in the 12-element segments, "much shorter." In addition, the range of performance times on the 4LV and 9LV segments decreased one to two minutes.

4. The efficiency of the measuring devices was affirmed. The only alteration of equipment was in the use of the photoelectric cells. These cells were extremely sensitive to changes in illumination of the room. To diminish this sensitivity, a solid white background, opposite the photoelectric cells, was added.

5. Subjects indicated they perceived the low visual segments as actually being low visual. This perception may be borne out by a comparison of the times required to complete the different segments as shown in Table 1.

Table 1

Time Required to Complete the High and Low Visual Segments (Preliminary Pilot Testing)

Type of Segment	Average Time N=9	Range
9LV	10 minutes 23 seconds	6:43-12:15
9HV	4 minutes 22 seconds	3:32- 6:38
4LV	7 minutes 57 seconds	5:35-13:06
4HV	3 minutes 46 seconds	3:02- 6:15

Pilot Test

Pilot testing was conducted in March, 1981 to (a) train observers for error recording, (b) further refine the gross motor task, and (c) reaffirm previous changes made in the structure of the serial gross motor task. Two right-handed women, 60 and 67 years of age, were used in this phase of the study. Both were volunteers obtained from the city of Greensboro, North Carolina. The purpose of the test was explained and consent forms were obtained (see Appendix B, p. 248). Both were informed that payment of $10.00 would be made at the completion of testing. Both subjects refused payment when it was offered. Following the completion of testing on the final day, subjects were debriefed.

Testing was conducted over a three-day period at the Congregational United Church of Christ Fellowship Hall, Greensboro, North Carolina. The following procedures were used in this phase of the study.

Spatially, the motor task was organized as it was for the final day of Preliminary Pilot Testing (see Figure 5). The photoelectric cells, element keys, and pressure mats were wired into the Servo Recorder. Contact with the mats or keys, as well as breaking the beam of the photoelectric cells resulted in markings on the graph output from the Recorder. An observer was seated at the Recorder and coded the markings which were placed on the chart output. Marks were coded to indicate key contact, mat contact, and error marks when the beam from a photoelectric cell was broken. Times required for the entire task and for the individual elements of the task were available from the chart output.

Also, two observers were given practice trials for error recording. Code sheets (see Appendix B, p. 249) were used for this recording purpose.

A particular sequential order of the task segments was assigned to each subject. Subject 1 completed Task 1-A which included the following order of segments: 9HV, short tossing, 4LV, 9LV, long tossing, and 4HV segments. The ordering for Subject 2 was that of Task 1-B which included, in order, 4LV, short tossing, 9HV, 4HV, long tossing, and 9LV segments.

Prior to beginning her trial on the first day, each subject was given directions for the entire task. Directions were given segment by segment in the sequential order assigned to each subject. Sample cues for the high and low visual segments were shown. Station locations were identified, and a map indicating these locations was available to subjects for reference. Any questions were answered. Subjects were allowed to study the maps for as long as they desired prior to beginning their performance.

When the subject was ready to begin, she stepped on a pressure mat, and moved to the first segment location. She performed all nine elements in this segment, depressing an element key before cue referral, before performance, and after performance of the element requirements. After the key had been contacted following performance of the last of the nine elements, the subject stepped on a pressure mat to signal completion of that segment. When she was ready to initiate the next segment of the task, she stepped on a mat, referred to the cues, performed the element requirements and key contacts, and stepped on a mat upon completion of the segment. This procedure was repeated for the remaining segments.

On subsequent days, subjects performed the same sequential order of the task as they had on the first day. Prior to beginning the task each day, subjects were shown their Individual Performance Summary form. No directions were administered, but any questions subjects had were answered. It was emphasized each day that subjects should try to remember as much information as possible. Subjects were permitted to study any cue materials as long as necessary before performance began. When a subject was ready to begin, she stepped on a pressure mat, performed the cue referral and element requirements, and stepped on a pressure mat at the completion of the first segment. This procedure was followed for the remaining five segments, just as it was during the first day.

Upon completion of the serial gross motor task each day, the subject was notified of the time required for the entire task, number of cue and map referrals, number of errors, and scores achieved on the two tossing segments. The time required to complete the serial gross motor task was recorded on a stopwatch operated by the investigator. The watch was started with the first mat contact and stopped with the mat contact signaling the end of the last (sixth) segment. The number of cue referrals, map referrals, and errors was obtained from the Code Sheets used by the observers. The observers also tallied the tossing scores and verbally informed subjects when errors in performance occurred. All times and scores were recorded on an Individual Performance Summary form (see Appendix B, p. 250). The following observations and decisions were made at the conclusion of Pilot Testing:

1. One low obstacle was removed from both low visual segments and both high visual segments. The placement of the third obstacle was such that it was a factor in very few of the element requirements. It was felt that two obstacles in all four of the low and high visual segments was sufficient.

2. The height of the low obstacle in both low visual and both high visual segments was lowered from 11.75 inches to 8 inches. The majority of errors occurring at the low obstacle in the low visual segments was caused by just the trailing foot failing to clear the photoelectric cell beam. Thus, this reduction in height was thought to be sufficient. No difficulties were noted in clearing the low obstacle in the high visual segments. The low obstacle in these segments was reduced in height to keep the

requirements of the low visual and high visual segments parallel.

3. The directions to the subjects were changed so there was more emphasis on the fact that subjects should try to remember as much as possible. Subjects continued to use the cues for information each time they performed a segment element. When asked during the debriefing process if they could remember any of these element requirements, they were unable to do so. They were able to remember the location of the stations and portions of some of the element requirements, but not in their sequential order.

4. The order of key contacts was changed. It was noted that the sequence of key contact, cue referral, key contact, performance, key contact would result in two rapid key contacts should the subject be able to perform the element requirements without cue referral. A new sequence of cue referral, key contact, performance, key contact was adopted.

5. The Code Sheet was efficient for error recording. Since both observers did not record the same segments, no comparisons of number of errors, map referrals, or cue referrals recorded could be made. Both observers found the Code Sheet easy to use.

6. Subjects concurred that the requirements of the task segments were different. Both subjects recognized that the cues, obstacles, and station markers (cones) in

the high visual segments were "easily seen," while those in the low visual segments were not. The subjects' difficulty in perceiving the station markers (fishing lines) for the low visual segments was apparent from the first day. The subjects also indicated that the long tossing segment was more difficult than the short tossing segment.

Selection and Testing of Subjects for Main Study

This study was designed to describe the changes in the individual performances of older women on the serial gross motor task described previously. Subjects for this study were four right-handed women, 60-75 years of age. All were residents of Guilford County, North Carolina. Potential subjects were telephoned by the investigator. The purpose of the study and the length of time involved for the study were explained. Subjects were notified they would be paid for their participation. The subjects who were without physical impairments and judged themselves to be in good physical health were invited to participate in the study.

Three preliminary tests were administered to the four subjects during individual sessions. Measures of field dependence/independence, spatial reasoning, and information processing speed were taken. Tests used to measure these abilities were the Rod-and-Frame test (Witkin, Moore,

Goodenough, & Cox, 1977), Space Relations subtest of the Differential Aptitude Test, Form T (Bennett, Seashore, & Wesman, 1972), and the Digit Symbol subtest of the Wechsler Adult Intelligence Test (Wechsler, 1972). Scores obtained on these measures were recorded. These scores served as a basis for subject description and discussion of relevant aspects of performance on the serial gross motor task.
All testing was done on two separate days in the Human Performance Laboratory of Rosenthal Gymnasium at the University of North Carolina at Greensboro. The specific procedures followed on each day of testing are described below.

The first day of pretesting was used to obtain consent forms from the subjects as well as to obtain measures of field dependence/independence and spatial reasoning. At the beginning of the session the subject was asked to complete an Informed Consent Form and a Subject Information Sheet (see Appendix C, pp. 252-253).

Subjects were informed that measures obtained during the pretesting period would not influence their ability to participate in the study. Measures were obtained solely for descriptive purposes. The measure of field dependence/independence was administered first, followed by the measure of spatial reasoning.

Measures

Field dependence/independence. Field dependence/independence was measured by the Portable Rod-and-Frame device, Stoelting Company Model #12009 (Witkin et al., 1977). The subject was instructed to seat herself at a table in front of the Rod-and-Frame device. The following directions were given:

> The apparatus in front of you is called the Rod-and-Frame device. The object of this task is to move the rod (by turning this knob) until it appears to you to be vertical. You will be given 21 trials. As you finish positioning the rod on each trial, say "Ready" and then close your eyes while I make adjustments to the device. When I say "Go," open your eyes and readjust the rod. Do you have any questions?

When any questions had been answered, the room was darkened. The subject was allowed five minutes to practice adjusting the rod with the knob and to adjust to the darkened room.

For each of the 21 trials, the rod and frame were set at specified positions relative to each other. One random but constant order of presentation of rod and frame relations was used for all subjects (see Appendix C, p. 254). The recorded score for each trial was the difference between vertical (0°) and the degree location at which the subject positioned the rod. The mean deviation of the 21 trials was used as the measure of field dependence/ independence.

Spatial Reasoning. The Space Relations subtest of the Differential Aptitude Test, Form T (Bennett et al., 1972) was used to measure spatial reasoning. This test was administered immediately following the field dependence/ independence measure described above.

The subject was seated at a table in a room which had constant illumination. She was provided with an answer sheet and a test booklet for the subtest, Space Relations. She was given time to study the directions and sample questions before proceeding. The directions included:

> This test consists of 60 patterns which can be folded into figures. To the right of each pattern there are four figures. You are to decide which one of these figures can be made from the pattern shown. The pattern always shows the outside of the figure (2 examples given).
>
> Remember: The surface you see in the pattern must always be the outside surface of the completed figure. Study the pattern carefully and decide which figure can be made from it. Only one of the four figures following the pattern is correct.
>
> Show your choice on the answer sheet by circling the letter which is the same as that of the figure you have chosen. You will have 25 minutes for this test. Work as rapidly and accurately as you can. If you are not sure of an answer, mark the choice which is your best guess. (Bennett et al., 1972, p. 3)

The number of correct responses was recorded as the score on spatial reasoning. A maximum of 60 was possible. When the subject completed this test, any questions about the tests were answered. A second day of testing was arranged for the information processing speed measure.

Information processing speed. The Digit Symbol subtest of the Wechsler Adult Intelligence Scale was used to measure information processing speed (Metarazzo, 1972). The test was administered in a room with constant illumination. The time limit for the test was 90 seconds.

The test form was placed before the subject and the following directions from the test manual were given:

> (Pointing to the key) . . . Look at these boxes. Notice that each has a number in the upper part and a mark in the lower part. Every number has a different mark. Now look here (pointing to samples) where the upper boxes have numbers but the squares beneath have no marks. You are to put in each of these squares the mark that should go there, like this (point to key, then to samples). Here is a 2, so you would put in this mark. Here is a 1, so you put in this mark. Here is a 3, so you put in this mark.
> (The first three items were written in as demonstration. Subject was then given a pencil and completed the remaining seven items in the sample. If she understood the task, she was told:) Now, when I tell you to begin, start here and fill in as many squares as you can without skipping any. Ready, begin. (Wechsler, 1972, p. 44)

The score recorded for the Digit Symbol test was the number of squares filled in correctly, with a maximum score of 90. One-half credit was given for any reversed symbols. Upon completion of the test, a time was arranged with the subject for the first day of serial gross motor task performance.

Administration of Serial Gross Motor Task

Data were collected for 15 days over the three-week period, May 4-May 22, 1981. Testing was conducted Monday through Friday of each week. Data included the number of errors committed and the number of cue and map referrals made during performance of the serial gross motor task. In addition, measures of the time required for (a) element performance, (b) cue referral, and (c) self-pacing intervals were obtained from the graph output of the Servo Recorder.

The serial gross motor task was arranged in an area measuring 40 feet by 48 feet and organized as shown in Figures 6 and 7. The contrast between the low visual and high visual segments is depicted in these figures. Figure 6 indicates the placement of the obstacles and cone station markers in the 4HV segment. The background of this figure shows the overhead grid (A) from which the fishing line station markers were suspended. The individual lines are not visible in this figure. The two photoelectric cells used for high obstacles in the 9LV and 4LV segments (B) are visible. Other items are depicted, including the timing apparatus (C), the blocks used for stacking in the 4HV segment (D), and the cue boxes (E) for the low visual segments. Figure 7 shows the station markers and obstacles in the 9HV segment as well as the organization of the short tossing segment. Dimensions for each of the areas and a listing of equipment needed for the performance of the task are located in Appendix D, pp. 256-257).

Each subject performed the serial gross motor task 15 times. This number of trials was consistent with the available literature on serial position effects in gross motor task performance (Cratty, 1962, 1963; Singer, 1968). In these studies 10-20 trials were administered.

Following the first and second block of five trials, i.e., after the fifth and tenth trials, a two-day interval occurred. When the subject returned to perform each

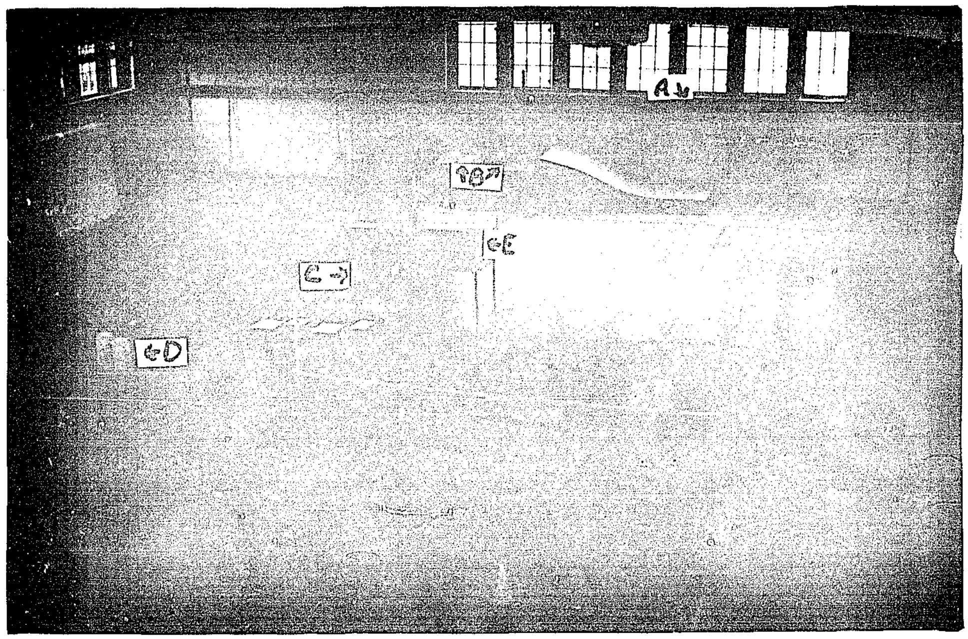


Figure 6. Serial gross motor task arrangement (4HV, 4LV, and 9LV segments)

A = Overhead grid from which fishing line station markers were suspended

B = Photoelectric cells

C = Timing apparatus

D = Blocks for stacking

E = Cue boxes for low visual segments

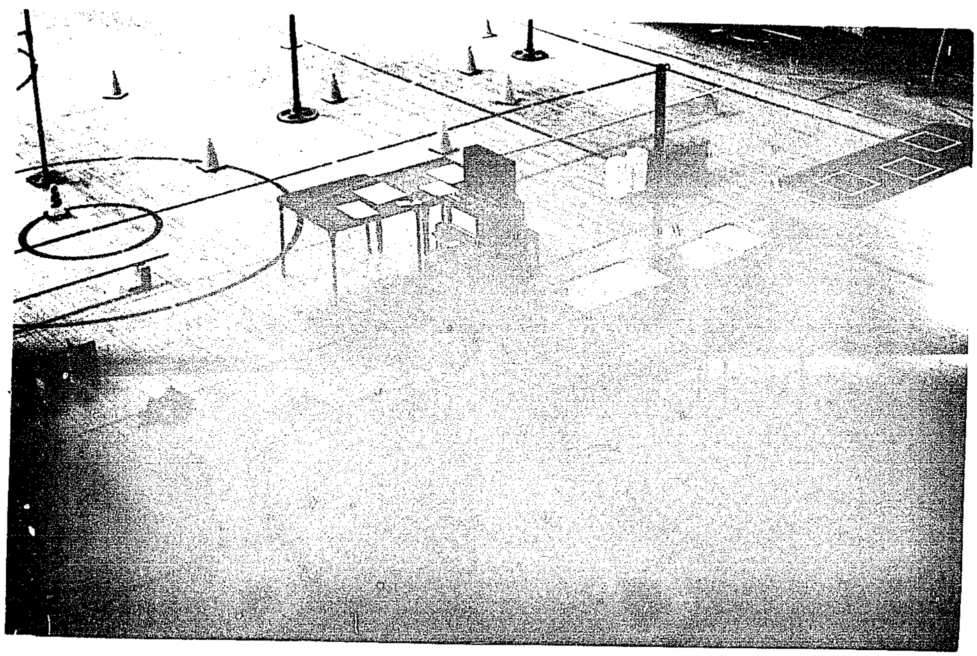


Figure 7. Serial gross motor task arrangement (9HV, 9LV, and short tossing segments)

subsequent block of five trials, an intervention strategy had been employed. The intervention strategy was either a reordering of the sequence of elements within the low visual and high visual segments or a reordering of the sequence of task segments. After the first two-day interval, the sequence of elements was reordered for two subjects, and the order of segments was changed for the other two subjects. Thus, the block of trials prior to intervention was of an equal number with each of the two blocks of trials following intervention. The sequencing of the task and intervention strategies are shown in Tables 2, 3, and 4.

Procedures followed for performance of the serial gross motor task, with the exception of the order of key contacts, were identical to those described in the Pilot Test section. Directions for the entire task (see Appendix D, p. 258) were given segment-by-segment to the subject on the first day only. On all subsequent trials, any questions the subjects had were answered and from the second day on, the importance of trying to remember as much as possible was emphasized. Subjects were allowed to study the maps of the areas prior to beginning. On the first day following an intervention, i.e., Days 5 and 11, the particular intervention strategy employed was identified for each subject. From the sixth day on, procedures to be used if the subject would remember a cue without using a cue card or a wooden cue were given. This procedure involved moving the cue to a

Table 2

Order of Task Sequence and Intervention Strategies

# of Days	Subject #1 Sequence	Subject #2 Sequence	Subject #3 Sequence	Subject #4 Sequence
5	9HV Short Toss 4LV 9LV Long Toss 4HV	9HV Short Toss 4LV 9LV Long Toss 4HV	4LV Short Toss 9HV 4HV Long Toss 9LV	4LV Short Toss 9HV 4HV Long Toss 9LV
2	INTERVAL	INTERVAL	INTERVAL	INTERVAL
5	Intervention Reorder Segments 4LV Short Toss 9HV 4HV Long Toss 9LV	Intervention Reorder Elements* Segments Remain as Above	Intervention Reorder Segments 9HV Short Toss 4 LV 9LV Long Toss 4HV	Intervention Reorder Elements* Segments Remain as Above
2	INTERVAL	INTERVAL	INTERVAL	INTERVAL
5	Intervention Reorder Elements* Segments Remain as Above	Intervention Reorder Segments 4LV Short Toss 9HV 4HV Long Toss 9LV	Intervention Reorder Elements* Segments Remain as Above	Intervention Reorder Segments 9HV Short Toss 4LV 9LV Long Toss 4HV

*See Tables 3 and 4 for this Intervention Strategy.

Table 3

Element Reordering Intervention Strategy

for High Visual Segments

Original Order of Elements		After Intervention	
	9HV		
1.	Stack 2 White, 2 Blue; Clap 1 time at 5	1.	Original #7
2.	Stack 5 White; Wave 2 times at 9	2.	Original #1
3.	Stack 1 White, 1 Blue; Clap 1 time at 5	3.	Original #5
4.	Stack 5 Blue; Wave 2 times at 4	4.	Original #8
5.	Stack 3 Blue; 3 White; Salute 3 times at 7	5.	Original #4
6.	Stack 2 White, 3 Orange at 8	6.	Original #3
7.	Stack 4 Orange; Wave 2 times at 7	7.	Original #2
8.	Stack 1 Blue, 1 Orange; Clap 1 time at 7	8.	Original #9
9.	Stack 2 Orange; Salute 1 time, Wave 1 time at 5	9.	Original #6
	4HV		
1.	Stack 3 White, 3 Blue; Clap 3 times at 3	1.	Original #4
2.	Stack 3 Orange, 2 White at 2	2.	Original #1
3.	Stack 3 Blue, 3 Orange; Salute 3 times at 3	3.	Original #8
4.	Stack 3 Blue, 2 White at 1	4.	Original #9
5.	Stack 3 White; Wave 1 time at 2	5.	Original #3
6.	Stack 2 Orange, 2 Blue; Salute 3 times at 3	6.	Original #6
7.	Stack 4 Blue; Clap 1 time at 1	7.	Original #7
8.	Stack 4 Orange; Wave 3 times, Clap 1 time at 4	8.	Original #5
9.	Stack 5 Blue; Wave 2 times at 1	9.	Original #2

Table 4

Element Reordering Intervention Strategy

for Low Visual Segments

Original Order of Elements	After Intervention
9LV	
1. Make an octagon 3 times at 5	1. Original #7
2. Make a rectangle 3 times at 9	2. Original #1
3. Make an octagon 2 times at 5	3. Original #5
4. Make a triangle 1 time at 4	4. Original #8
5. Make a rectangle 3 times at 9	5. Original #4
6. Make a half-circle 2 times at 6	6. Original #3
7. Make a crescent 3 times at 3	7. Original #2
8. Make a triangle 1 time at 1	8. Original #9
9. Make a crescent 1 time at 4	9. Original #6
4LV	
1. Make a triangle 3 times at 1	1. Original #4
2. Make a rectangle 2 times at 2	2. Original #1
3. Make a circle 3 times at 4	3. Original #8
4. Make a half-circle 3 times at 4	4. Original #9
5. Make a crescent 2 times at 2	5. Original #3
6. Make a rectangle 3 times at 4	6. Original #6
7. Make an octagon 1 time at 2	7. Original #7
8. Make a circle 1 time at 4	8. Original #5
9. Make a square 2 times at 3	9. Original #2

separate pile without looking at it, contacting the element key, and then performing the element requirements.

When the subject was ready to begin any trial, she stepped on a pressure mat. She then performed all nine elements in her first segment, referring to a cue, contacting an element key before and after performing each of the elements. When the subject had completed the last element in this segment, she pressed the element key and stepped on a pressure mat. Contact with the pressure mat signaled completion of this segment. This procedure was followed for all the high and low visual segments when they occurred in the task. For the two tossing segments, the subject stepped on a map when she was ready to begin. She then tossed all 20 beanbags and stepped on a mat again when she was finished.

Two observers recorded errors, cue and map referrals for each subject on each trial. One observer recorded these measures on the 9LV and 9HV segments. The other observer recorded the same information on the 4LV and 4HV segments. These observers also tallied scores achieved on the tossing segments.

Upon completion of each trial, the subject was shown her Individual Performance Summary form. Measures recorded on this form included the (a) time required to complete the entire task, (b) scores achieved on the two tossing segments, (c) number of errors committed, and (d) number of cue and map referrals. All the above data, with the exception of time required to complete the task, were obtained from the Code Sheet utilized by the two observers. The time measure was obtained from a manually operated stopwatch kept by the investigator. The stopwatch was started when the subject first stepped on a pressure mat and stopped when she stepped on a pressure mat following completion of the last (6th) segment.

Data for the time-series analysis were obtained from the chart output of the Servo Recorder. Chart speed was set at 7.5 inches per minute. Each contact with an element key or a pressure mat resulted in a marking on the chart. These markings were coded by an observer seated at the Servo Recorder. The coding symbols used were (a) K-Cue for element key contact at end of cue referral, (b) K-Perf for element key contact at end of element performance, and (c) M for mat contact at the beginning and end of each segment. Time intervals for each of the nine elements in all low visual and high visual segments were obtained by measuring the distance between K-Perf and K-Cue marks. Performance times were measured from K-Cue to K-Perf marks (see Appendix D, p. 262). In addition, the number of errors, cue referrals, and map referrals were obtained from the Individual Performance Summary form.

Upon completion of the last (15th) trial, each subject was debriefed. Questions pertaining to any aspect of the study were answered. Each subject was given an opportunity to rearrange cues used in the low visual and high visual segments into the order in which they had appeared during the last block of five trials. Following debriefing, subjects were paid $50.00 for their participation in the study. They also could request an abstract of the study upon completion of the investigation.

Analysis of Data

A time-series analysis technique was utilized to analyze data obtained. Measures of time required for (a) element performance, (b) cue referral, and (c) self-pacing intervals were submitted to visual time-series analysis. A separate analysis was done on these measures for each of the four major segments of the serial gross motor task. In addition, a record of the number of errors, cue referrals, and map referrals was kept and visually analyzed.

A summary of subject characteristics relevant to this study was presented. This summary included age, educational level, the use of corrective lenses, as well as the scores obtained on the measures of field dependence/independence, spatial reasoning, and information processing speed. Where appropriate, this descriptive information was discussed in relation to the performance data from the serial gross motor task.

Four questions were formulated to guide this investigation. Specific questions and methods of answering each question are described below.

Question 1: What effect does varying the relative predominance of visual and kinesthetic information have on performance? This question focused on the comparison of times used for cue referral and element performance in the high visual segments with these times in the low visual segments. Originally, the actual times used for these performance aspects were to be used. Data presentation in this fashion was not clear. Therefore, actual times used for all nine elements per trial were summed. Then, mean cue referral and element performance times were calculated. These mean times were plotted on graphs. Three data paths, each of which connected the mean times for the five trials within a block, were formed for each of the four major task segments. The data paths prior to intervention (Block 1) were visually inspected and described. Comparisons of these data paths to those resulting after the first and second interventions (Blocks 2 and 3) were made. Any similarities and differences in the patterns of mean times for the high visual and low visual segments were noted. These procedures were followed for each of the four subjects.

Question 2: What are the serial effects in a task segment in relation to its position in the total task?

The times used for cue referral and element performance also were used to answer this question. For Question 2, however, the times used for <u>each</u> of the nine elements was important. This contrasted to Question 1, when the times used for <u>all</u> nine elements were analyzed.

Actual cue referral and element performance times were to be used to answer Question 2, but presentation of the data in this fashion was not clear. Actual times used for each element over the five trials in each of the three blocks were summed. For example, the times required to refer to the cue for the first element within a particular segment on the five trials within Block 1 were totaled. Then, the mean was calculated and plotted on a graph. These mean times for each element were also plotted for the five trials in Blocks 2 and 3. The same procedures were followed for mean element performance times. Separate graphs were made to present the mean times in each of the segments which occupied the early, middle, and late positions in the total task during Block 1. The data paths in Block 1 were visually inspected to determine whether or not serial position effects resulted in any of the four segment positions of the serial gross motor task. Serial position effects, primacy and recency, were noted if the first and/or last elements were performed faster than the middle elements. Comparisons of the patterns emerging in Block 1 were made to patterns emerging after an intervention had occurred (Blocks 2 and 3). Any similarities and differences in the serial position effects noted in segments which occupied the same position in the total task were noted. Identical procedures were followed for each of the four subjects.

Question 3: What is the pattern of performance recall within each segment of the task? The focus of Question 3 was the frequency of map referral, cue referral, and errors in the performance of each of the four segments of the serial gross motor task. Reference to the map and cue, as well as the number of errors occurring were considered performance breaks. Any changes in the frequency of such performance breaks enabled the investigator to make inferences regarding the recall of aspects of the total task. Failure to avoid the obstacles, failure to contact the element key either before or after performance, and incorrect performance of the element requirements (wrong station, wrong number of repetitions, wrong number or color of blocks, etc.) were all included as errors. The number of cue referrals, map referrals, and the type of errors occurring on each trial were presented in table form. Any patterns emerging in each of the three blocks of trials were described. Error frequencies, of all types, noted during the performance of all nine elements in each of the high visual and low visual segments were totaled and plotted on a graph. The total errors occurring on the five trials within each of the three blocks were plotted to form a data path. The error frequencies depicted in the data paths for Block 1 were described to give the original profiles of error occurrence and to indicate if any changes in the data paths resulted prior to intervention. The pattern of the data paths in Block 1 was compared with the patterns of the data paths in Blocks 2 and 3 to describe the profiles of error occurrence following each of the two interventions. Finally, any relationships between the number of cue referrals and the number of errors in the four segments were noted. These same procedures were followed for all four subjects.

Question 4: How does the time utilized for self-pacing intervals affect the performance of various segments of the task? The relevant measure for this question was the time elapsing between the completion of one segment and the initiation of the subsequent segment (self-pacing interval). The actual time used for the self-pacing interval preceding each of the low visual and high visual segments was plotted on a graph. The points representing these times during each of the five days in Block 1 were connected to indicate the data path for the self-pacing intervals. Identical procedures were followed for Block 2 and Block 3. The pattern of these data paths for each segment in Block 1 was to be described to indicate the original profile of time used for the self-pacing intervals.

Comparisons between the data paths in Block 1 and these paths in Blocks 2 and 3 were to be made. However, data for the segments (9HV and 4LV) located in the early position were missing. Therefore, no attempt was made to answer this question.

CHAPTER IV

PRESENTATION AND DISCUSSION OF FINDINGS

The purpose of this study was to describe the individual performance characteristics of four elderly women. Selected aspects of the subjects' serial gross motor task performances were submitted to a time series analysis. Performance aspects analyzed included the (a) time used for cue referral, (b) time used for element performance, (c) number of cue and map referrals, (d) number of errors, and (e) time used for the self-pacing intervals. These measures were collected for all four of the major segments of the serial gross motor task. These included the 4HV, 9HV, 4LV, and 9LV segments.

Subjects for the study were four right-handed women ranging from 61 to 75 years of age. Tests of field dependence/independence, spatial reasoning, and information processing speed were administered to them prior to their performance of the serial gross motor task. Selected biographical information was also obtained from the four subjects prior to data collection. Subjects then performed the serial gross motor task for 15 days. One trial per day was administered for the first five days. Following a two-day interval, at the end of the fifth day and at the end of the tenth day, subjects again performed the serial gross motor task five times. For the five trials following each of the two intervals, however, either the order of the segments (segment reordering intervention) or the order of elements within the segments (element reordering intervention) had been changed. The amount of time used by each subject for cue referral, for actual performance of each element, and for the self-pacing interval between segments was obtained from the Servo Recorder for all 15 trials. Other performance aspects, including the number of cue and map referrals as well as the number of errors committed in each segment, were obtained from the observers' Code Sheets.

Data obtained from the performances of the serial gross motor task are presented in this chapter. The data obtained prior to an intervention were compared to data obtained following each of the two interventions. A time-series analysis technique, visual inspection, was used for this purpose. Discussion of the findings follows the presentation of the data. The chapter is organized in five major sections. Characteristics of the subjects are presented in the first section. Data for each of the research questions formulated for this study are presented and discussed in each of the four remaining sections.

Subject Characteristics

Prior to the administration of the serial gross motor task, subjects completed an Information Sheet and took three preliminary tests. Measures of field dependence/independence, spatial reasoning, and information processing speed were taken. The Rod-and-Frame test was used to measure field dependence/independence. Subtests of the Differential Aptitude Test (Space Relations) and the Wechsler Adult Intelligence Scale (Digit Symbol) were used to measure spatial reasoning and information processing speed, respectively. Table 5 summarizes all relevant subject characteristics.

As may be noted from Table 5, Subjects 1 and 2 were the oldest. These two subjects also had achieved the highest level of education. Subject 3 was the youngest (61 years of age). Subject 4 was the only one who had no high school education. She graduated, however, from a School of Cosmetology. All subjects required, and wore, corrective lenses.

The Rod-and-Frame test was used to measure field dependence/independence (Witkin et al., 1977). For this test, subjects were required to adjust a rod until it appeared to be vertical. The frame in which the rod was located was set at different positions. The score recorded was the average difference between vertical and the degree location at which the subject positioned the rod on her 21 trials. Scores at the higher end of the continuum indicated that perception of the verticality of the rod was influenced by the surrounding frame (field dependency). At the other end

Table 5

Subject Characteristics and Scores

Achieved on Preliminary Tests

Sub-ject	Age	Corrective Lenses	Educational Level	Preliminary Test Scores					
				Rod-and-Frame Score	Space Relations Score	%ile*	Digit Symbol Score	Scaled Score**	
1	75	Yes Bifocals	4 Years College	3.7°	18	20th	44	16	(8)
2	74	Yes Near-sighted	Master's Degree	5.5°	13	5th	47	17	(9)
3	61	Yes Far-sighted	High School Graduate	5.3°	15	10th	57	15	(10)
4	66	Yes Far-sighted	No H.School Education Graduate: School of Cosmetology	7.0°	4	1st	50	17	(9)

* Based on norms for 11th Grade girls.

** Number indicates scaled score based on norms for people in the same age group as the subjects in this study.
Number in parentheses indicates scaled score based on norms of 20-34-year-old referance group.

of the continuum, scores indicated that perception was relatively independent of the surrounding field (field independency).

As may be seen in Table 5, there was only a 3.3° range of scores on the Rod-and-Frame test. The limited number and the small range of scores precluded a definite assignment of field dependency or independency to the subjects. It may be said, however, that the score for Subject 4 indicated that she tended to be field dependent. Similarly, the score for Subject 1 indicated that she tended to be field independent. Field dependent and field independent individuals have been found to have distinctive cognitive styles. Cognitive style refers to the process by which individuals solve problems and learn information (Witkin et al., 1977). Field dependent individuals solved problems more easily when all cues were salient to the solution and when the organization of the field was structured. Field independent people, on the other hand, used cues out of context and reorganized the perceptual field for problem solving.

The Space Relations Subtest (Form T) of the differential Aptitude Test was used to measure Spatial Reasoning (Bennett et al., 1972). This test required subjects to mentally create solid figures from flat forms. The score recorded was the number of correct responses given in a 25-minute time limit. A score of 60 was possible. As noted in Table

5, scores ranged from 4 to 18. Based on norms for 11th grade girls, these scores were all relatively low. Subject 4 apparently was least able to recognize and mentally manage the interrelationships in the display. All other subjects' scores on this test were relatively close. Subject 1, however, appeared to be most adept at spatial reasoning.

The Digit Symbol subtest of the Wechsler Adult Intelligence Scale was used to measure information processing speed (Metarazzo, 1972; Wechsler, 1972). The test required fast and accurate association of certain symbols with particular numbers. Subjects were given 90 seconds in which to reproduce the symbols associated with the numbers, as indicated on the key included with the test. Digit Symbol test performance declines earlier and more rapidly with age than does performance on any other intelligence test. Yet, scores achieved on this test correlate highly with Full Scale (WAIS) scores. These facts have indicated that older individuals are both slower in motor speed and "slowed down" in regard to their mental operations (Metarazzo, 1972).

The scaled scores in Table 5 indicate how the raw score achieved by each subject compared with scores of other people in the four comparable age brackets. All subjects scored relatively high in comparison with their own age group. These scaled scores, 15, 16, 17, were based on scales that ranged from 0 to 19 and had a mean of 10. In addition, the scaled scores in parentheses allowed comparison of the raw scores to scores of a 20-34 reference group. The respective scaled scores of the four subjects when compared with norms from the same reference group were also very similar. Thus, the speed with which the subjects were able to process information appeared to be relatively close for all subjects.

Question 1: What effect does varying the relative predominance of visual and kinesthetic information have on performance?

The serial gross motor task used in this investigation was composed of four major segments. Two of these segments had a predominance of tactile/kinesthetic cues (low visual segments). The other two segments (high visual) had a predominance of visual cues. One high visual and one low visual segment had nine stations (9HV and 9LV). The other two segments (4HV and 4LV) had four stations. The following specific questions were formulated to guide the description of the patterns of cue referral and element performance in these different types of segments.

a. What are the original performance profiles of the high visual and low visual segments?

b. What are the performance profiles of the high visual and low visual segments after intervention?

c. What are the similarities among profiles of the high visual and low visual segments?

d. What are the differences among profiles of the high visual and low visual segments?

The actual times taken for cue referral and element performance in each of the four major segments were to have been used to answer this question. Preliminary graphs were made in this fashion but the range of times was so great that the graphic presentations were not clear. Therefore, the mean times for cue referral and element performance were calculated. These average cue referral and element performance times were calculated from the actual times used for all nine elements each day. The graphs used to present the data for Question 1 will show the mean times for each day within the three five-day blocks of trials. Any patterns established in Block 1 will be discussed. Then comparisons will be made between any pattern established in Block 1 to patterns in Block 2, and, subsequently, to patterns emerging in Block 3. Finally, any differences and similarities among the patterns in the high visual segments and low visual segments will be discussed. The design of the graph lines representing mean cue referral times is consistent for each segment. The design of the graph line representing mean cue referral times in the 9HV segment, for example, is the same for all four subjects. A different design of the graph line represents mean element performance times in this segment. This design remains the same for all subjects' mean element performance times in this segment.

Subject 1

Cue Referral

Mean cue referral times for Subject 1 are presented in Figure 8. Although average times were used, cue referral

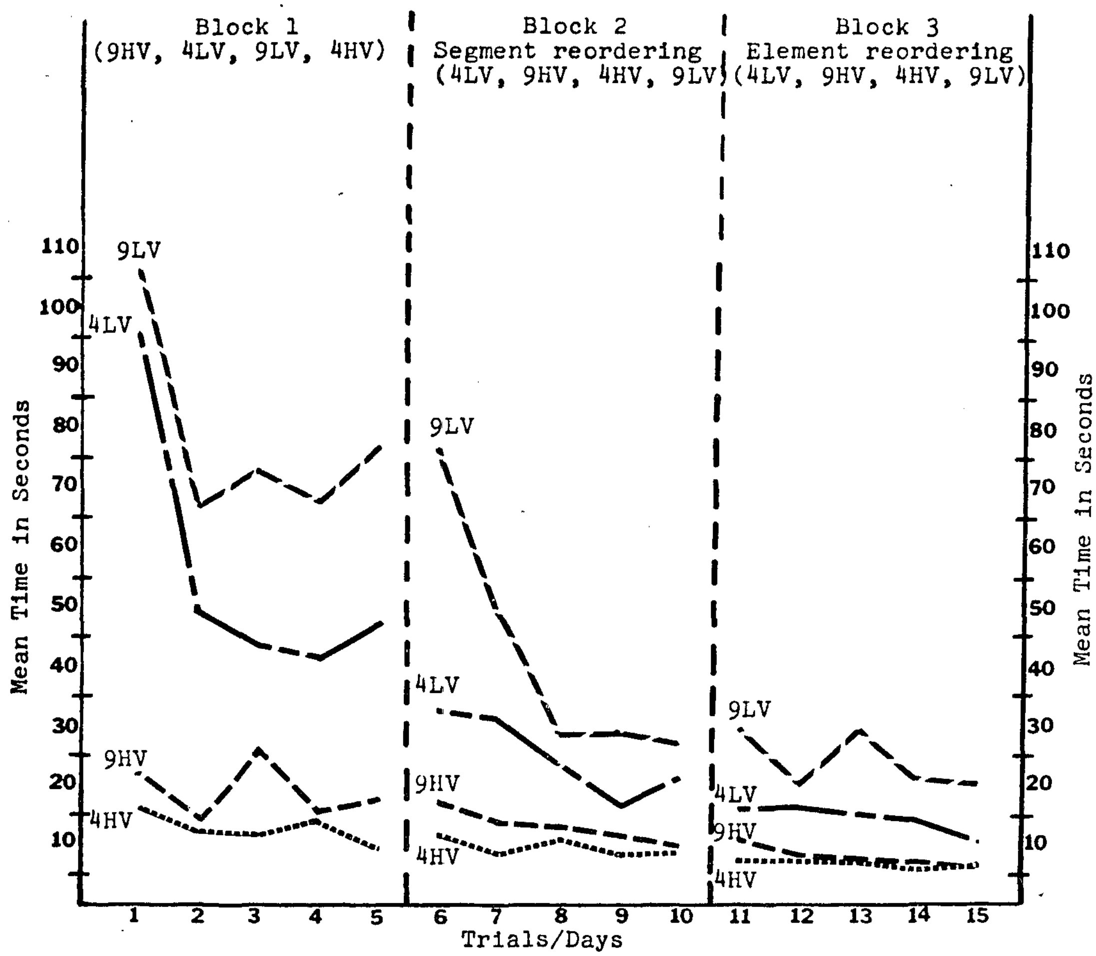


Figure 8. Mean cue referral times for subject 1.

in the 9LV segment took over a minute for each of the five trials in Block 1. In the 4LV segment, mean cue referral times were less than a minute for all trials except the first one. These times were still more than the mean cue referral times in both high visual segments. The pattern of cue referral times in the 9HV and 9LV segments (Block 1) was similar, with changes in trend occurring every day. Mean cue referral times in the 4LV and 4HV segments exhibited a downward trend during the first three (4HV) to four (4LV) days. The downward trend evident in the 4LV segment was greater for all five days than it was in the 4HV segment. The differences for mean cue referral times between the 4LV segment and the 4HV segment decreased 54 seconds during Block 1. The difference in mean time for cue referral in the 9LV segment and 9HV segment was 59 seconds on Day 5, a decrease of 26 seconds from Day 1. Even with these changes, mean cue referral times were more similar for the two high visual segments than the times for the 9HV and 9LV segments or the 4LV and 4HV segments. On Days 3, 4, and 5, the differences between mean cue referral times in the 9HV and 4LV segments were less than the differences between the two low visual segments.

The first intervention strategy was employed prior to the sixth trial. This intervention resulted in Subject 1 performing the segments in a different order for the trials in Block 2 (see Table 2). In this block of trials, the difference in mean cue referral times for the low visual segments and for the high visual segments was much less. The difference between mean cue referral times in the 4HV segment and 4LV segments ranged from 22 seconds (Days 6-7) to 9-12 seconds (Days 8-10). The difference between mean cue referral times in the 9HV and 9LV segments ranged from 55 seconds (Day 6) to 17 seconds (Day 10). A sharp decreasé was evident in the mean cue referral times in the 9LV segment from Day 6 to Day 8. Following Day 8, times in this segment were relatively stable. Mean cue referral times in the 4LV segment also decreased more sharply than did times in either of the two high visual segments. Mean cue referral times in both low visual segments decreased more, therefore, than times in the high visual segments during Block 2. This resulted in times for all segments being much closer by the end of this block of trials.

The second intervention strategy was utilized prior to Day 11. For all five trials in Block 3, Subject 1 performed the nine elements within each segment in a different order (see Tables 3 and 4). This intervention was different from the first one which resulted in a reordering of segments within the total task. Cue referral profiles in the two high visual segments during Block 3 revealed a nearly level trend from Day 12 through Day 15. There was little or no difference between the cue referral times needed to perform the elements within these segments. Although cue referral took longer in the low visual segments, a general downward trend continued. The differences between the mean times required for the low visual segments and the respective high visual segments were less in all trials of Block 3 than in any previous block of trials. On Days 11, 13, 14, and 15, the mean cue referral times in the 4LV segments were closer to times in the two high visual segments than to times in the 9LV segment.

Element Performance

Mean times that Subject 1 had for element performance are shown in Figure 9. These times are the average time required to complete all nine elements in a segment on a particular day/trial. Following Day 1, the mean time required for element performance was greater for both low visual segments than for the high visual segments. However, performance times in the 4LV segment were more similar to times in both high visual segments than to times in the other low visual segment.

In Block 2, following the segment reordering intervention, mean element performance times in the 9LV segment increased on Days 7 and 8 before dropping appreciably on the last two trials. Mean times taken for element performance in the 4LV segment remained relatively stable in Block 2. A slight increase in mean times was noted for the last two trials (9 and 10). Mean element performance times for the 9HV segment decreased approximately 15 seconds over the

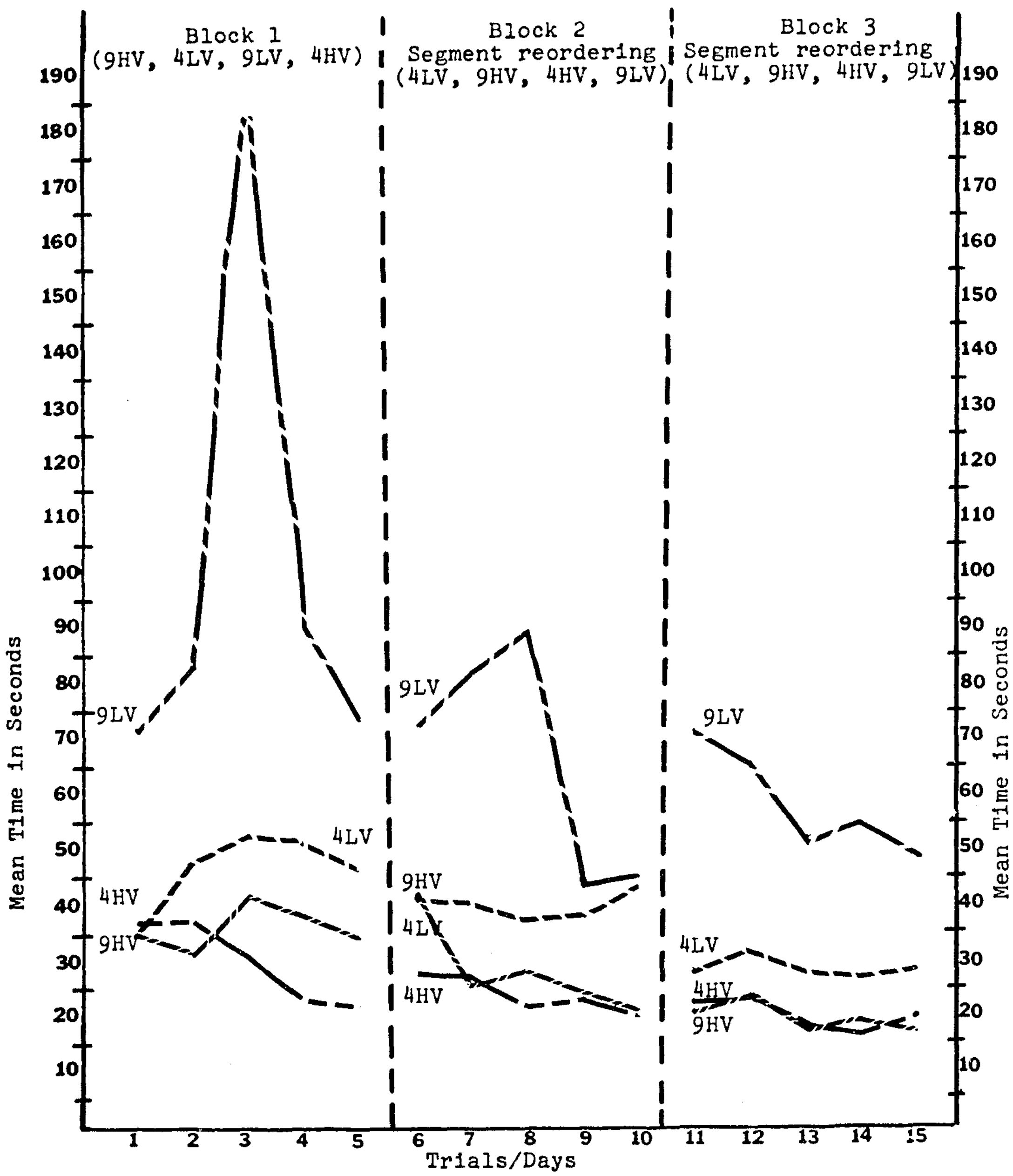


Figure 9. Mean element performance times for subject 1.

trials in Block 2. Times in the 4HV segment were more stable, but still decreased slightly. On Days 9 and 10, there was a distinct separation between the times in the two low visual segments and the times in the two high visual segments. Differences between the two high visual segments or the two low visual segments were less than any comparison of a high visual segment with a low visual segment.

In Block 3, following the element reordering intervention, the pattern of mean element performance times for all segments was more like the pattern in Block 1 than in Block 2. Differences between the high visual segments were less for all trials in Block 3. However, the mean time required for element performance in the 4LV segment was again more similar to the times taken for performance in the high visual segments. This can be explained by the drop in mean performance times for the 4LV segment in Block 3 as compared to Block 2. There was less variability in the time taken for element performance in the 9LV segment for the trials in Block 3. All these times were longer, however, than the times required for element performance for this segment on the last two days of Block 2. Because of this, the differences between the 9HV segment and the 9LV segment were greater than the differences between these segments on the last two days in Block 2.

Summary of Profiles for Subject 1

Mean time needed by Subject 1 for cue referral revealed a general decreasing trend over the 15 trials. The most cue referral time was used for the 9LV segment and the least for the 4HV segment. The relative position of these segments and the decrease in times required for cue referral in all segments were evident throughout all three blocks of trials. These two patterns remained evident in all three blocks of trials in spite of the segment reordering and element reordering interventions. A third pattern emerged in Block 3. Mean cue referral times in the 4LV segment were closer to times in the two high visual segments than to times in the 9LV segment. This pattern was evident on four of the five trials in Block 3.

It was also evident that Subject 1's mean element performance times for the 4LV segment were more similar to both high visual segments than to the other low visual segment. The only exceptions to this general pattern were the last two trials of Block 2, following segment reordering. For these two trials, the mean element performance times in the 4LV segment were closer to times in the 9LV segment than to times in either high visual segment.

Subject 2

Cue Referral

Mean times used for cue referral by Subject 2 are shown in Figure 10. Cue referral took longer in the 9HV segment than in the 4HV segment for the first three trials in Block 1. Very little difference was noted in cue referral times for the two high visual segments on the last two days. Average cue referral times in the 9LV segment were more than

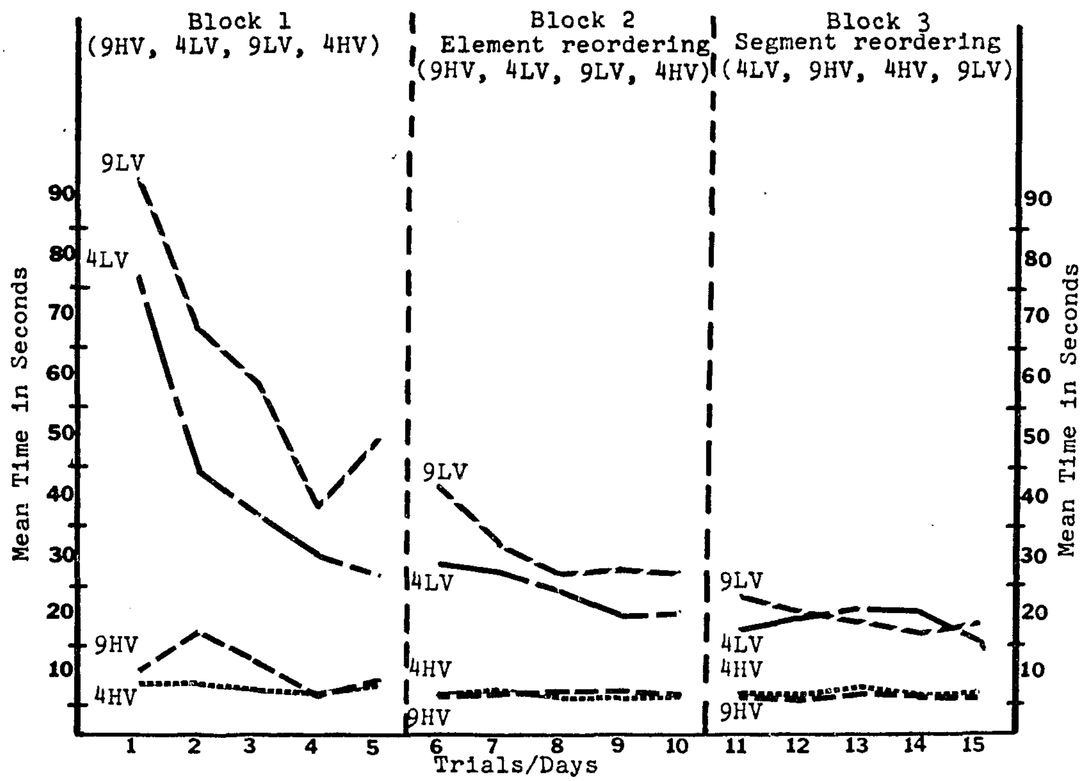


Figure 10. Mean cue referral times for subject 2.

a minute on the first two days. Cue referral for the elements in the 4LV segment required more than a minute only on Day 1. Cue referral times in the two low visual segments were more nearly the same than any comparisons between the 4LV and 4HV segments or between the 9LV and 9HV segments. The differences between the 4HV-4LV segments and the 9HV-9LV segments generally decreased, however, across the five trials in Block 1. This was attributable to less time being taken for cue referral in the low visual segments as trials progressed.

In Block 2, following the element reordering intervention, cue referral times in the two high visual segments remained fairly constant and similar throughout all five trials. Mean time in the 4LV segment decreased steadily from Day 6 to Day 9, and then increased only slightly. A steady decrease in mean cue referral times was exhibited in the 9LV segment also. An exception was a slight increase on Day 9. As in Block 1, the differences between the two low visual segments were less than between either of the low visual segments and its high visual counterpart. This was true in spite of the decreases in cue referral times in the low visual segments noted previously.

In Block 3, following the segment reordering intervention, mean cue referral times in the high visual segments continued to remain fairly constant. Average times for cue referral in these segments ranged from five to seven seconds. Mean times in the 9LV segment continued to decrease throughout the first four trials of this block, and then increased slightly on the final day. Cue referral in the 4LV segment, on the other hand, took longer on Days 12, 13, and 14 than it did on either Day 11 or Day 15. Because of these differences in the trend of the two low visual segments, mean cue referral times in the 9LV segment were lower on two trials (Days 13 and 14) than times in the 4LV segments on these days. Differences in mean cue referral times among all four segments were less in Block 3 than in any other block. A definite separation between the mean times used for cue referral in the high visual segments and low visual segments was evident. Subject 2 required 15-20 seconds more for cue referral in the low visual segments than in the high visual segments.

Element Performance

Mean times used for element performance by Subject 2 are presented in Figure 11. The pattern of mean element performance times demonstrated a downward trend in the 9LV segment over the first three days in Block 1. This trend was similar to that in the 9HV segment, but at a higher level. However, mean times increased and then decreased in the 9LV segment on the last two days. In the 9HV segment, the mean times increased on Days 4 and 5. Subject 2 exhibited an opposite pattern of mean element performance times in the 4LV segment and 4HV segment. When times increased in

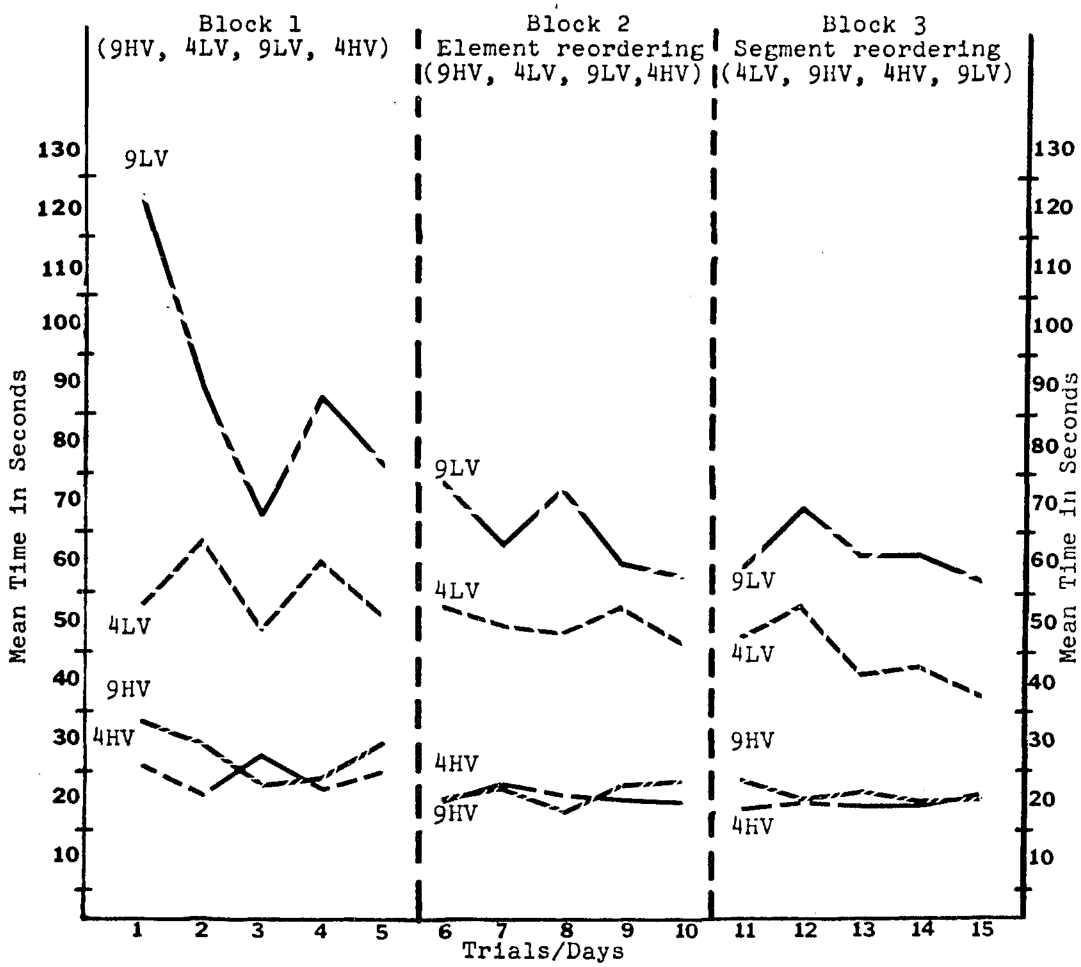


Figure 11. Mean element performance times for subject 2.

one segment, times in the other segment decreased. Following Day 2, there was not much difference between the mean times for element performance in the two high visual segments (three to five seconds). This difference was less than that between the low visual segments (9LV and 4LV), the 4LV-4HV segments, or the 9LV-9HV segments.

Following the element reordering intervention (Block 2), Subject 2 took almost the same amount of time, on the average, for performance of the elements in both high visual segments. The greatest difference between element performance times in the two high visual segments was only three seconds on Day 10. On three trials (6, 7, and 8), this subject had faster element performance times in the 9HV segment than in the 4HV segment. Mean times in the 4LV segment steadily decreased on the first three trials, then increased on Day 9, and decreased again on Day 10. Overall, the times for element performance in the 9LV segment decreased during Block 2. As in Block 1, there was still a definite separation between the mean times required for element performance in the high visual segments and the low visual segments.

Following segment intervention (Block 3), element performance in the 9HV segment took slightly longer for most trials than in the 4HV segment. Element performance also continued to take longer in the 9LV segment than in the 4LV segment. The difference between these two segments was greater than the difference between the two high visual segments. On Days 11-14, the differences between the mean performance times in the 4LV segment and both high visual segments were greater than the differences between the 4LV and 9LV segments. On Day 15, however, there was slightly less separation between mean element performance times in the 4LV segmant and the two high visual segments (17 seconds) than between the 4LV and 9LV segments (20 seconds).

Summary of Profiles for Subject 2

Mean cue referral times for all segments generally decreased throughout the first ten trials. The mean cue referral times in the 9LV segment and 9HV segment continued to decrease for the remaining five trials. Subject 2 had the longest mean cue referral times in the 9LV segment throughout the first 11 trials. On the last four trials, cue referral times were longest in one or the other of the low visual segments. The fastest times were evident in one of the two high visual segments for all 15 trials. Thus, the pattern of cue referral times for Subject 2 revealed a definite separation between the low visual segments and the high visual segments. This pattern was evident throughout all 15 trials, regardless of the intervention strategy used. This pattern was slightly different from that for Subject 1. For Subject 1, mean cue referral times in the 4LV segments were closer to the times for both high visual segments than to the 9LV segment for at least some of the later trials.

The pattern of mean element performance times for Subject 2 also revealed a definite separation between the low visual segments and the high visual segments. This pattern was evident for nearly all trials. Only on the 15th trial were element performance times for the 4LV segment closer to the high visual segments than to the 9LV segment. In contrast, Subject 1 had mean element performance times for the 4LV segment which clustered more closely with times for the two high visual segments throughout most of her 15 trials.

<u>Subject 3</u>

<u>Cue Referral</u>

Mean times, depicting cue referral, for Subject 3 are presented in Figure 13. Subject 3 took longer for both the low visual segments than she did for cue referral in the high visual segments in Block 1. In both the 9LV segment and the 9HV segment, these times decreased steadily after Day 2. The decrease was slightly greater (15 seconds) for the 9LV segment than it was for the 9HV segment (12 seconds). This was due to the greater decrease in mean cue referral times for the 9LV segment between Day 4 and Day 5. Mean cue referral times increased fairly steadily in the 4LV segment through Day 4. In the 4HV segment, on the other hand, these times decreased following Day 2 and then increased on Days 3, 4, and 5. The times for cue referral were closer in the 4LV, 4HV, and 9HV segments on Days 1, 2, and 5 than the times of any of these segments were to the 9LV segment. On Days

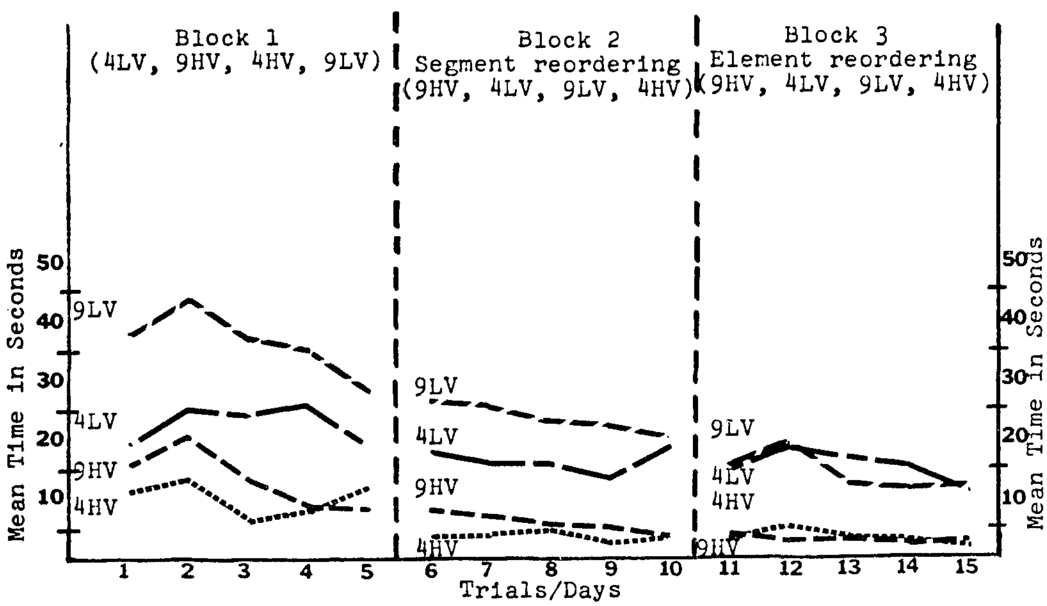


Figure 12. Mean cue referral times for subject 3.

3 and 4, however, mean times were closer for the two low visual segments than any comparison between a low visual segment and its high visual counterpart.

The downward trend in mean times continued for the 9HV and 9LV segments during Block 2 (after segment reordering). Again, the decrease in cue referral times across trials in the 9LV segment was slightly greater (seven seconds) than it was in the 9HV segment (four seconds). Differences between the 4LV segment and the 4HV segment were greater throughout all trials in Block 2 than the difference between these times at Day 5. This seemed to be due to the more noticeable drop in the level of mean cue referral times for the 4HV segment.

In Block 3, following the element reordering intervention, mean cue referral times in the 9LV segment were less than times in the 4LV segment on Days 13 and 14. Except for Day 12, times in the 9HV and 4HV segments were practically identical. As can be seen in Figure 12, there was a definite separation of the mean times required for cue referral in the high visual segments and these times in the low visual segments. Subject 3 took approximately 10-15 seconds longer for cue referrals in the low visual segments than she took in the high visual segments.

<u>Element Performance</u>

Mean element performance times for Subject 3 are shown in Figure 13. Subject 3 required less mean time for element

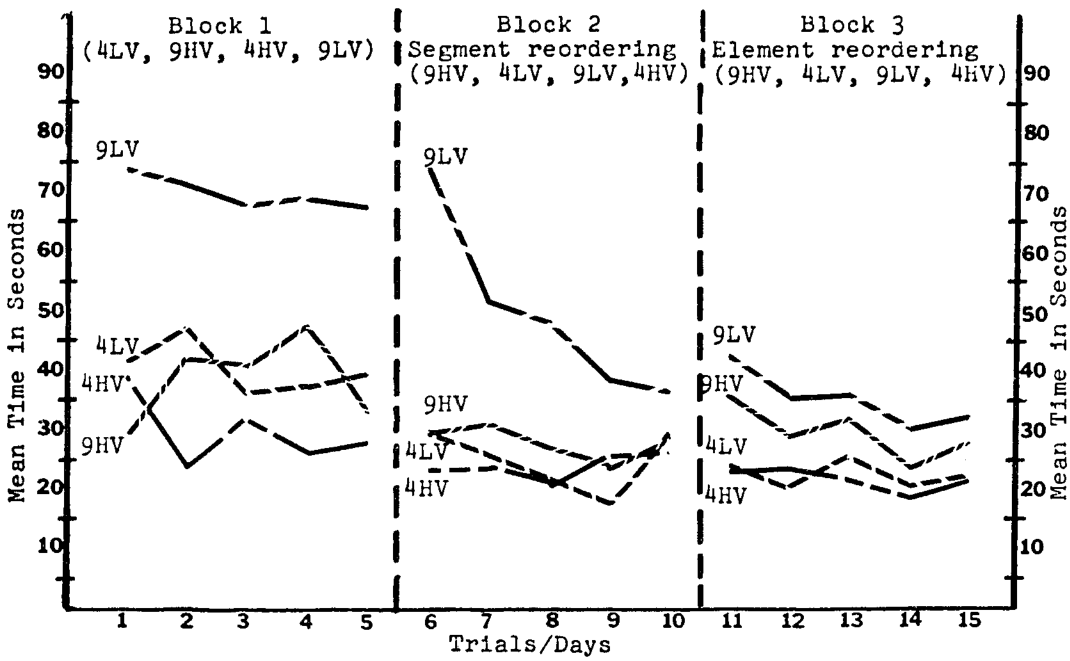


Figure 13. Mean element performance times for subject 3.

performance in the 4LV segment than in the 9HV segment on Days 3 and 4. Element performance in the 9LV segment required approximately the same amount of time throughout all the trials in Block 1, and consistently required more time than any other segment. The patterns of mean element performance times were variable in the other three segments. Element performance times in the 4LV segment were closer to times in the two high visual segments than to the 9LV segment throughout all trials in Block 1.

The biggest change in mean times for the trials in Block 2, following the segment reordering intervention, was in the time required for element performance in the 9LV segment. This time decreased steadily from 74 seconds on Day 6 to approximately 36 seconds on Day 10. Element performance times in the 4LV segment and 4HV segment decreased steadily until Day 9, and then increased on Day 10 to the highest level in Block 2. The mean element performance times in the 9HV segment were more variable, but also increased to the highest level in Block 2 on the last two days. Mean times for element performance in the 4LV segment were closer to times in the two high visual segments than to times in the 9LV segment throughout the trials in Block 2.

In Block 3, which followed the element reordering intervention, performance times were closer among all segments than in Block 1 or Block 2. In fact, only 4-6 seconds separated the times in the two segments with nine stations (9LV and 9HV). The smaller difference between these two segments was due mainly to the rise in the level of mean element performance times in the 9HV segment. The pattern of element performance times in the two four-station segments (4LV and 4HV) was also very similar during Block 3.

Summary of Profiles for Subject 3

The data for Subject 3 revealed that cue referrals in the low visual segments consistently took the longest time. Following Day 3, there was a definite separation between the times required in the low visual segments. This pattern also was evident for Subject 2.

The profile of mean element performance times for Subject 3 revealed a similarity between the two segments which had four stations (4LV and 4HV). Similar times were also evident for the two segments which had nine stations (9LV and 9HV). This pattern was evident only during trials in Block 3, which followed the element reordering intervention. In this block, the number of stations seemed to have more of an effect than the visual or kinesthetic nature of the segment. This pattern was different than that for either Subject 1 or Subject 2. In Blocks 1 and 2, however, Subject 3's mean element performance times in the 4LV segment were closer to times in the two high visual segments than to the 9LV segment. This pattern was similar to that of Subject 1 throughout most of her 15 trials.

Subject 4

Cue Referral

Mean cue referral times for Subject 4 are shown in Figure 14. Cue referral took longest for the 9LV segment, followed by the 4LV segment, during Block 1. Mean cue referral times in the 9HV segment were faster than in the 4HV segment during Day 1, but were longer in subsequent trials in Block 1. By the last trial (Day 5), however, there was virtually no difference in cue referral times for the two high visual segments. The difference between mean times for cue referral in the low visual segments was approximately 11 seconds on the last trial in Block 1. The times Subject 4 took for cue referral in the 4LV segment were more similar to times in the two high visual segments than to times in the 9LV segment. The only exception to this pattern was on Day 3.

The trials in Block 2 followed the element reordering intervention. Cue referral times in the low visual segments continued to decrease. Times for the high visual segments remained at approximately the same level as they were during Block 1. The differences between the 4LV and 4HV segments remained approximately the same during the first two trials in Block 2 as at the end of Block 1. Following Day 7, this difference decreased continuously until only two seconds separated these times on Day 10. The mean cue referral

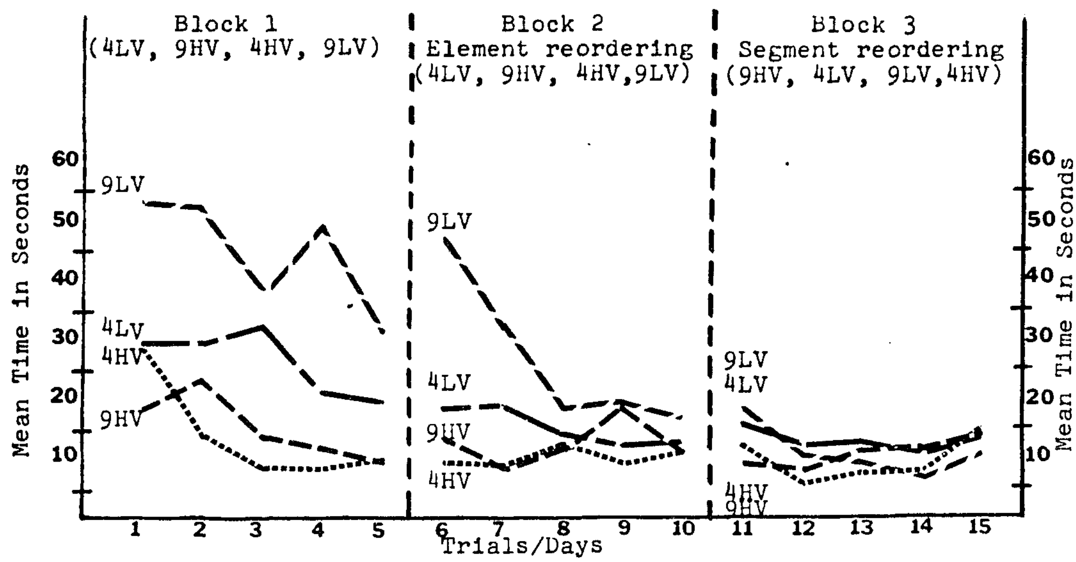


Figure 14. Mean cue referral times for subject 4.

times in the 9LV and 9HV segments exhibited greater differences in the early trials of Block 2 than was exhibited at the conclusion of Block 1. The difference between these two segments decreased to only six seconds on the last trial in this block, however. Cue referral times in the 4LV, 4HV, and 9HV segments were closer than the times in any of these segments were to the 9LV segment on all trials in Block 2, except Day 9.

During Block 3, following segment reordering, Subject 4 required similar times for cue referral in all segments. The largest changes in these times were in the 9LV and 9HV segments. There was a constant decrease in the time required for the 9LV segment and a constant increase in the mean cue referral times for the 9HV segment. There was virtually no difference between cue referral times in the 4HV and 4LV segments by the last day, and only a three-second difference between the 9LV and 9HV segments. Both low visual segments required slightly less cue referral times on the last day than was required for the high visual segments.

Element Performance

Mean element performance times for Subject 4 are presented in Figure 15. Performance times were greater for the low visual segments on all trials but one (Day 5) during Block 1. The time required for the low visual segments steadily decreased as trials in this block progressed.

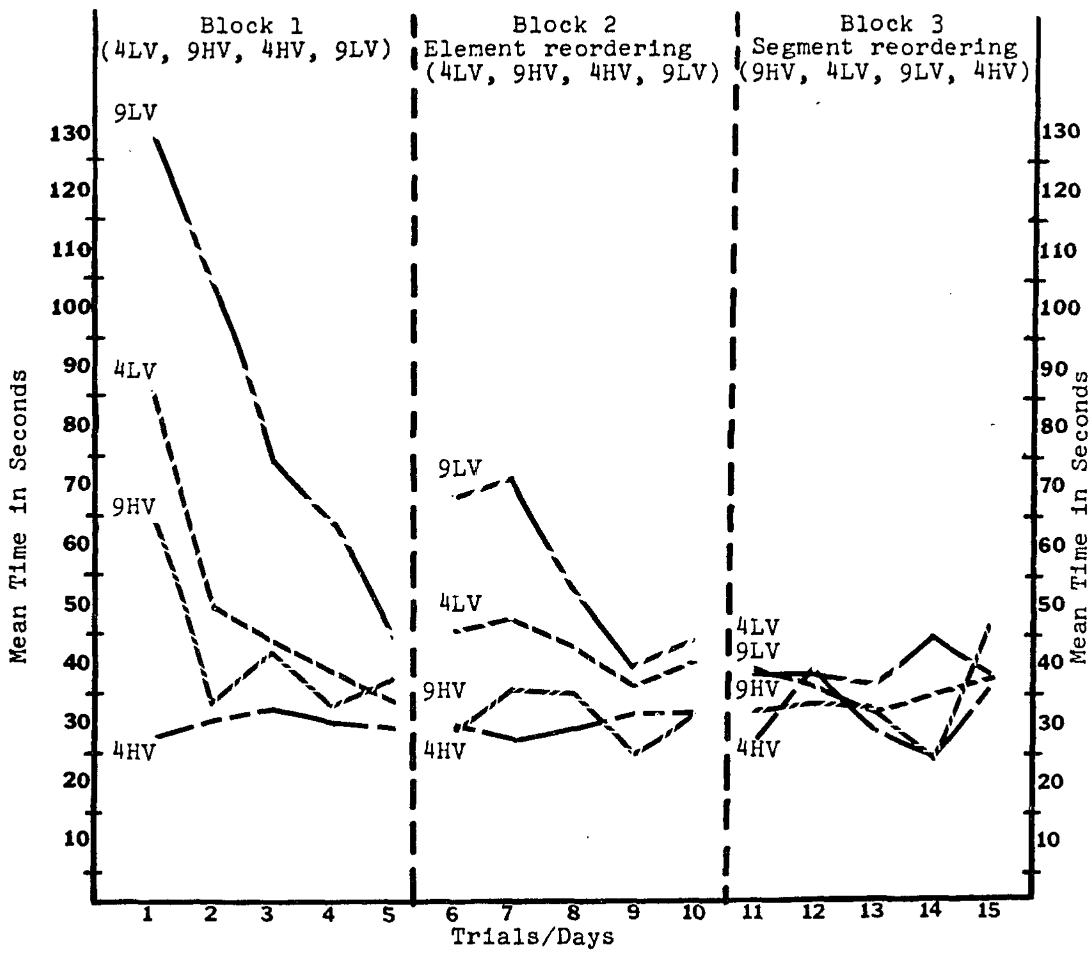


Figure 15. Mean element performance times for subject 4.

Times in the 9HV segment were variable. Times in the 4HV segment increased slightly (Days 1-3) and then decreased slightly on the last two days in Block 1. Mean element performance times in the 4LV segment were closer to times in both high visual segments than to times in the 9LV segment on Days 2-5.

During Block 2, which followed the element reordering intervention, mean element performance times in the 4HV segment showed a steady increase following Day 7. Element performance times in the 9HV segment were more variable. By the end of Block 2, however, there was no difference between mean times for the high visual segments. Mean element performance times in the 4LV segment were higher on Days 6 and 7 than on the last two trials in Block 1. The pattern for element performance in the 9LV segment was almost parallel to that in the 4LV segment throughout all trials in Block 2, although at a higher level. By the end of Block 2, there was only a slight difference (four seconds) between the mean times for the low visual segments. As can be noted on the graph, there was a separation between the mean performance times in the high visual segments and the times in the low visual segments. This was different from Block 1 when the mean times in the 4LV segment were more similar to times in the two high visual segments than to the 9LV segment.

Differences among mean performance times were less apparent in Block 3. Element performance continued to take more time generally in the 9HV segment than in the 4HV segment. Mean performance times were more variable in Block 3 than in Block 2 for the 4HV segment. Average times for element performance in the 9HV segment did not differ much between Block 2 and Block 3 except for the large increase on Day 15 in Block 3. The differences between the high visual segments and the low visual segments were not great for any trial in Block 3. The greatest difference was between the 9HV and 4LV segments on Day 14 (20 seconds).

Summary of Profiles for Subject 4

The overall picture for Subject 4 was different from that of any other subject. Times for cue referral in the 4LV, 4HV, and 9HV segments were more similar than any of these times were to the 9LV segment throughout the first seven trials. For the next three trials, times in the two low visual and in the two high visual segments were closer than any comparison of a low visual and a high visual segment. In Block 3, Subject 4's mean cue referral times for all four segments merged into a very tight cluster. During this block of trials, the nature of the segment seemed to have little effect on the amount of time taken for cue referral by Subject 4.

Mean element performance times of Subject 4 in Block 1 were more similar for the 4LV, 4HV, and 9HV segments than for the 4LV and 9LV segments. In Block 2, however, a definite separation of times in the low visual segments from times in the high visual segments was evident. In Block 3, there were very small differences among any of the four segments. The longer times for element performances in the two high visual segments on the last day were probably due to the fact that Subject 4 attempted to perform several elements in these segments without first referring to the cues.

Discussion of Findings

Several studies (Fleishman & Rich, 1963; Stallings, 1968) indicated that visual abilities were more important in early trials of performance, but that kinesthetic abilities were more important in later trials. Other studies (Dickinson, 1969; Dickinson & Rennie [cited in Dickinson, 1974]; Phillips & Summers, 1954) found results which conflicted with those mentioned above. Phillips and Summers (1954) found that kinesthetic abilities were more important in the early trials. Dickinson (1969) found that kinesthetic abilities were more important for performance throughout both the early and late trials. On the other hand, Dickinson and Rennie (cited in Dickinson, 1974) found that visual abilities were more important throughout all trials, particularly when the task was novel. Older subjects tended to take longer to perform an aiming task when only limited visual cues were available (Szafran, 1951). These subjects were able to complete the task, but having to rely more completely on kinesthetic cues resulted in longer performance times.

In the present study, a predominance of visual cues appeared to be more important, at least for the time measures, throughout all 15 trials. On at least four of the five trials in Block 1, mean cue referral times for all subjects were faster in the high visual segments than in the low visual segments. Cue referral times for the high visual segments were also faster during Blocks 2 and 3 for three subjects (1, 2, and 3). Trials in these blocks followed either the segment reordering intervention or the element reordering intervention. Neither intervention resulted in faster cue referral times for the low visual segments than for the high visual segments. Rather, cue referrals in the low visual segments continued to take longer in the high visual segments.

In addition, mean cue referral times in the high visual segments exhibited an earlier, more stable pattern than did times in the low visual segments. For Subjects 1 and 2, cue referrals in the high visual segments took approximately the same time on all trials in Block 2. During this same block of trials, cue referral times in both low visual segments continued to decrease. In Block 3, cue referral times in the high visual segments were more stable than in the low visual segments. Subject 3 exhibited a slightly different pattern. Fluctuations in mean cue referral times were basically the same for the high visual and low visual segments until Block 3. In Block 3, less variability in the high visual segments was evident.

Subject 4 also had faster cue referral times in the high visual segments than in the low visual segments throughout the first eight trials. On the remaining trials, cue referrals for one or the other of the low visual segments were performed faster than cue referrals for at least one of the high visual segments. There was little difference among the mean cue referral times of all segments for the last seven trials, however. During the trials in Block 3, Subject 4 attempted to perform several elements in the high visual segments without first referring to a cue. Observation of these attempts revealed that she spent more time, on the average, trying to remember what the cue was than she had taken for the actual reading of the cues. This was reflected by the increased mean cue referral times for these segments, particularly on Day 15. For Subject 4, there also was no indication of any intervention effects. The changes in pattern of her referral times were due either to a continual decrease in these times for the low visual segments, or to her attempts to perform without cue referral in the high visual segments.

For all subjects, mean element performance times were the fastest in the high visual segments for most trials in Block 1. In addition, mean element performance times for the 4LV segment in this block were more similar to times in the high visual segments than to times in the other low visual segment (9LV). This pattern was evident for Subjects 1, 3, and 4. Mean element performance times of Subject 2 revealed a definite separation between the times in the low visual and high visual segments for 14 of the 15 trials. Element performance times were faster for all 15 trials in the high visual segments than in the low visual segments.

Mean element performance times were different in Blocks 2 and 3 for each of the other three subjects. Subject 1 had similar element performance times in the 4LV, 4HV, and 9HV segments in both Blocks 1 and 3. This pattern was also true for the first three trials in Block 2. On the last two trials in Block 2, times in the low visual segments were more alike than any comparison between a high visual segment and a low visual segment. This different pattern was possibly due to the fact that little fluctuation was evident for the times in the high visual segments on the last two days in Block 2. Element performance times in the low visual segments, on the other hand, exhibited a steady increase on these two days. For Subject 3, the clustering of times in the 4LV segment with times in the high visual segments was evident in both Blocks 1 and 2. In Block 3, times in segments which had an equal number of stations were more alike (Figure 13). This was possibly due to the increased times for element performance in the 9HV segment in Block 3 as compared to times in Block 2. Subject 4's element performance times indicated a definite separation between low visual and high visual segments only at the end of Block 2. This was different from her pattern in Block 1, when the times in the 4LV segment were more like times in the high visual segments. In Block 3, there was little difference among the element performance times of all segments. On Day 15, however, element performance was faster for both low visual segments than it was for the high visual segments. As noted previously, Subject 4 attempted to perform several elements without cue referral on this day. More errors resulted (as noted by the observers) which would account for the longer element performance times in the high visual segments.

In general, therefore, both cue referral and element performance times were faster in segments which had a predominance of visual cues than in segments which had a predominance of kinesthetic cues. This pattern was evident throughout all 15 trials for most subjects. This finding may be explained by the information processing model. More complex displays require more decision time, according to statements of the information processing model (Kay, 1970; Welford, 1968). It may be theorized that both the cues and the spatial arrangement for the low visual segments were more complex than for the high visual segments. All information from the cues in the low visual segments had to be obtained from tactile manipulation rather than from the more commonly used visual sense. Cue referral (decision) times reflected this, particularly so for the 9LV segment. In addition, the actual location of the stations in the low visual segments was more difficult to determine once the information from the cues had been obtained. There was no discernible pattern to the location of stations in the 9LV segment or the 9HV segment. Since the station markers in the 9LV segment were more difficult to see, element performance times were most affected for this segment. Subject 2, in particular, spent a great deal of her performance times in the 9LV segment searching for the station marker (fishing line).

The amount of information contained on the cues may also have been a factor in the time profiles of various segments. When cues for all segments were designed, an attempt was made to equate the individual bits of information contained on all cues. It was thought that three bits of information were present on the low visual cues: (a) station number, (b) number of repetitions, and (c) shape. It was thought that the same number of information bits were present on the high visual cues: (a) station number, (b) information regarding the blocks, and (c) information regarding the hand movements. Observation of cue referral by the subjects in the low visual segments indicated that the number of bits of information on the cues was much greater than three. Each of the holes and notches on these cues was treated as a separate piece of information by the subjects, at least on the early trials. Because of this, there were as many as 15, and as few as three, bits of information to process from the cues in the 9LV segment. The cues in the 4LV segment contained four to eight different pieces of information. The manner in which subjects treated the information in the high visual segments could not be determined by observation. Questioning of the subjects at the completion of the study indicated that the following separate pieces of information were included on the cues in the high visual segments: (a) station number, (b) number of blocks, (c) color of blocks, (d) number of hand movements, and (e) type of hand movements. The high visual cues with the least amount of information included the station number, one color and number of blocks, and one type of hand motion to make a certain number of times. Five pieces of information were available, therefore, on these cues. Other cues ("stack 2 orange, salute 1 time, wave 1 time at 4") contained seven pieces of information. Thus, the amount of information present on the cues in three of the segments, 4HV, 9HV, and 4LV, was similar. Much more information needed to be processed in the 9LV segment.

The profiles of mean cue referral times supported the above observation that the information load was different for various segments. For the first 10-15 trials, subjects required more time for cue referral in the 9LV segment than in the other three segments. In addition, there was some indication that mean cue referral times in the 4LV segment were more like those in the high visual segments than to times in the 9LV segment. This was true for Subjects 1 and 4 during at least some of the trials. Subjects 2 and 3, however, had cue referral times which indicated a definite separation between the high visual and low visual segments. The separation was less as trials progressed, due mostly to the continual decrease in element performance times in the low visual segments. The fact that the most time was required for cue referral in the 9LV segment may be accounted for by the extra time it took for counting (feeling) the greater number of holes in the center of the wooden cue. This fact may also be accounted for by the greater amount of information contained on these cues. The number of items may have been beyond the memory span (Miller, 1956). That times decreased as much as they did indicated that clustering or chunking of the material was occurring. Observation of subjects revealed that, by the trials in Block 2, the cues for the low visual segments were manipulated less than these had been in Block 1. The shape would be determined, and the hand would just be brushed over the holes rather than actually feeling each hole. The notches, which indicated the number of repetitions to make, were treated this way also. Subjects then verbalized the requirements ("make a triangle 3 times at 1") as they left the cue to begin performance. This would seem to indicate that the individual bits of information on the cues had begun to be treated as a whole.

Element performance times for all subjects also indicated that elements in the 9LV segment took longer to perform for all subjects throughout most of the trials. Additionally, the time taken for element performance in the 4LV segments was more like the amount of time taken in the 9LV segments. This was true for all subjects except Subject 2 until at least the midway point in Block 2. As noted previously, this was possibly due to the fact that the stations in the 4LV, 9HV, and 4HV segments were more easily located than were the stations in the 9LV segment.

A different explanation of the fact that cue referral and element performance times were faster in the high visual segments may be that the requirements in the low visual segments were novel. Dickinson and Rennie (cited in Dickinson, 1974) found that subjects who had no experience with rackets relied more on visual abilities throughout the trials of a badminton serving test. Perhaps there were not enough trials of the low visual segments to give subjects sufficient experience with handling the available kinesthetic-tactile information on the low visual cues. This possibility was supported by the fact that times for cue referral in the low visual segments continued to fluctuate over the 15 trials. Cue referral times in the high visual segments, on the other hand, plateaued in Block 2, and did not change much thereafter. If additional trials had been allowed, a different pattern of these times in the low visual and high visual segments may have emerged.

In summary, profiles in Block 1 indicated that the shortest mean cue referral and element performance times were in the high visual segments. This was generally true for all subjects. While different patterns of cue referral and element performance emerged for each subject following interventions, high visual segments generally continued to be performed in shorter times. Subjects 3 and 4, however, had some mean cue referral and element performance times in the low visual segments which were faster than times in the high visual segments. This pattern for Subject 4 was explained on the basis of her attempts to perform without first referring to the cues during some of the trials in Block 3. For Subject 3, the times in the 9HV segment became more like times in the 9LV segment, but were still faster. This pattern was also true of her times in the 4LV and 4HV segments. Mean cue referral times in the 4LV segment were closer to times in the high visual segments for some subjects on some trials. Thus, the answer to

Question 1 appears to be that cue referral and element performance were slower, throughout all trials, in segments with a predominance of tactile/kinesthetic information. This finding supports that of Dickinson and Rennie (cited in Dickinson, 1974) and Szafran (1951). Since little evidence of stability in mean cue referral and element performance times was demonstrated for the low visual segments, a different pattern may have emerged if more trials had been given.

Question 2: What are the serial effects in a task segment in relation to its position in the total task?

This question focused on the times used for individual elements within each of the four major task segments. In particular, the question was formulated to determine whether any pattern emerged for the occurrence of serial position (recency or primacy) effects. Primacy effects were noted if the times for cue referral or element performance were faster for those elements at the beginning of a segment than for elements in the middle. Recency effects occurred if the times for the last elements were faster than for the middle elements. Although the times for cue referral and element performance were used to answer both Questions 1 and 2, these times were presented and discussed in different ways. Presentation and discussion of Question 1 focused on the times for all elements within a trial. Comparisons were made between these times in the high visual segments and times in the low visual segments. In Question 2, cue referral and element performance times for each element were of concern. The location of the segment within the total task was of more interest than whether this segment was a high visual or a low visual one.

Interventions in the order of aspects of the task were made. The order of the nine sequentially arranged elements in each segment was changed after the first five trials (2 subjects) or after the first ten trials (2 subjects). Thus, over the 15 trials of the serial gross motor task, each subject had ten trials in which the sequential order of elements was the same. The order of segments in the task also remained the same for ten trials for each subject. Two subjects performed the same segment order for the first 10 trials (Blocks 1 and 2). The other two subjects performed the same sequential order of segments for the last 10 trials (Blocks 2 and 3). Comparisons of the timed data for each of the elements before and after these interventions allowed the study of serial position effects in relation to the segment order and to the element order.

To answer Question 2, the following specific questions were formulated.

a. What are the original performance profiles of early, middle, and late segments?

b. What are the performance profiles of early, middle, and late segments after intervention?

c. What are the similarities among performance profiles of those segments located in the same relative position, i.e., early, middle, or late within the total task?

d. What are the differences among performance profiles of those segments located in the same relative position within the total task?

Answers to these questions were to be provided by the actual times taken for cue referral and element performance by each subject. However, the range of times for the same element across trials made presentation of the data in this fashion unwieldy. Therefore, <u>mean times</u> for cue referral and element performance for each of the nine elements across the five trials in each block were calculated and presented graphically. For example, the times required for performance of the first element on Days 1, 2, 3, 4, and 5 were summed, and an average time for this element in Block 1 was calculated. Identical procedures were followed for each of the elements for all three blocks of trials. This procedure may have masked some effects which were actually present or made serial position effects appear to occur which, in fact, did not. This risk was assumed to be necessary if the data were to be presented clearly.

Graphs will be presented to depict the mean times each subject used for cue referral and element performance in segments which occupied the early (first), middle (third and fourth), and late (sixth) positions in the total task. The pattern of element times in the segment occupying the early position for the trials in Block 1 will be visually inspected to determine whether or not serial position effects occurred. Serial position effects will be demonstrated if the times required for the first few elements (primacy effect) and/or the last few elements (recency effect) are faster than times required for elements in the middle. The observed patterns for Block 1 will be compared to patterns observed in Blocks 2 and 3. In Blocks 2 and 3, either the <u>elements</u> within the segment were performed in a different order from that in Block 1, <u>or</u> a different <u>segment</u> order was performed. Any similarities and differences between the serial position effects in segments located in the same relative position in the total task will be noted. Identical procedures will be followed for mean cue referral and element performance times in segments which originally were located in the middle and late positions. The design of graph lines in the following graphs is identical to that used for particular segments in Block 1. For example, the design of the lines depicting cue referral times in the 9HV segment is the same as that depicting cue referral times in this segment for Question 1.

Subject 1

Early Position

9HV Segment

Subject 1 performed the 9HV segment in the early position for the first block of trials. This segment was performed in a middle position for Blocks 2 and 3. In Block 3, the order of elements within this segment was different from the order in Blocks 1 and 2. Mean cue referral and element performance times in the 9HV segment for Subject 1 are presented in Figure 16.

No serial position effects were noted in mean cue referral times in any of the three blocks of trials. After the order of segments was changed (Block 2), a primacy effect would have occurred if the time for the first element had not been so high. Cue referral times for two of the first three elements were 2-3 seconds faster than times for the middle elements (4-6). The longer time required for Element 1 may be due to the fact that time used for movement to the cue (from the mat) was included. This time was originally separated from cue referral time, but when the sequence of key contacts was changed (Pilot Test), this separation was lost inadvertently. Cue referral times for all elements except one decreased across the three blocks of trials. In Block 3, Element 7 was moved to the first position. This change in element order may have accounted for the increased time required for Element 7, due to the reasons stated above.

Recency and primacy effects were noted in the mean element performance times during Blocks 1 and 2. During Block 1, when the 9HV segment was in the early position, a recency effect occurred. The last two elements were performed 2-35 seconds faster than the middle three elements in this block of trials. A primacy effect was nearly

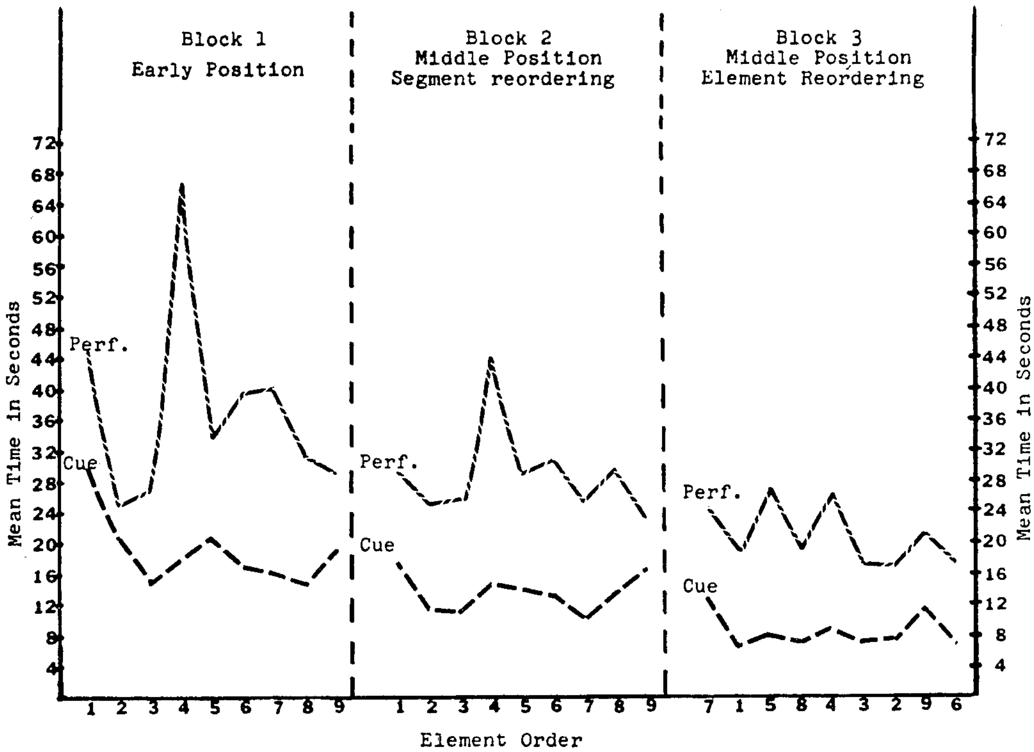


Figure 16. Mean cue referral and element performance times for the 9HV segment (early and middle) for subject 1.

evident, but the mean time for Element 1 was longer than times for all other elements, except Element 4. In Block 2, Subject 1 performed the 9HV segment in a middle position of the serial gross motor task. A recency-primacy effect was noted. The recency effect spanned the last five elements. Times for these elements exhibited a more fluctuating pattern than in Block 1, but still were 13-21 seconds faster than the time for Element 4. The first three elements comprised the primacy effect. These elements were performed 15-19 seconds faster than Element 4. After the elements had been reordered (Block 3), no serial position effects were evident.

Middle Positions

4LV Segment

Subject 1 performed the two low visual segments in the middle of the serial gross motor task during Block 1. Mean cue referral and element performance times for the 4LV segment are presented in Figure 17. As can be noted from this figure the 4LV segment was performed in the early position during Block 2 and Block 3. In Block 3, the order of elements (element reordering intervention) was changed.

No serial position effects were evident in mean cue referral times for either Block 1 or Block 2. Subject 1, therefore, had no serial position effects in the 4LV segment regardless of the order in which she performed this segment. In Block 3, cue referral times for three of the last four elements (6, 7, 5) were faster than times for all other

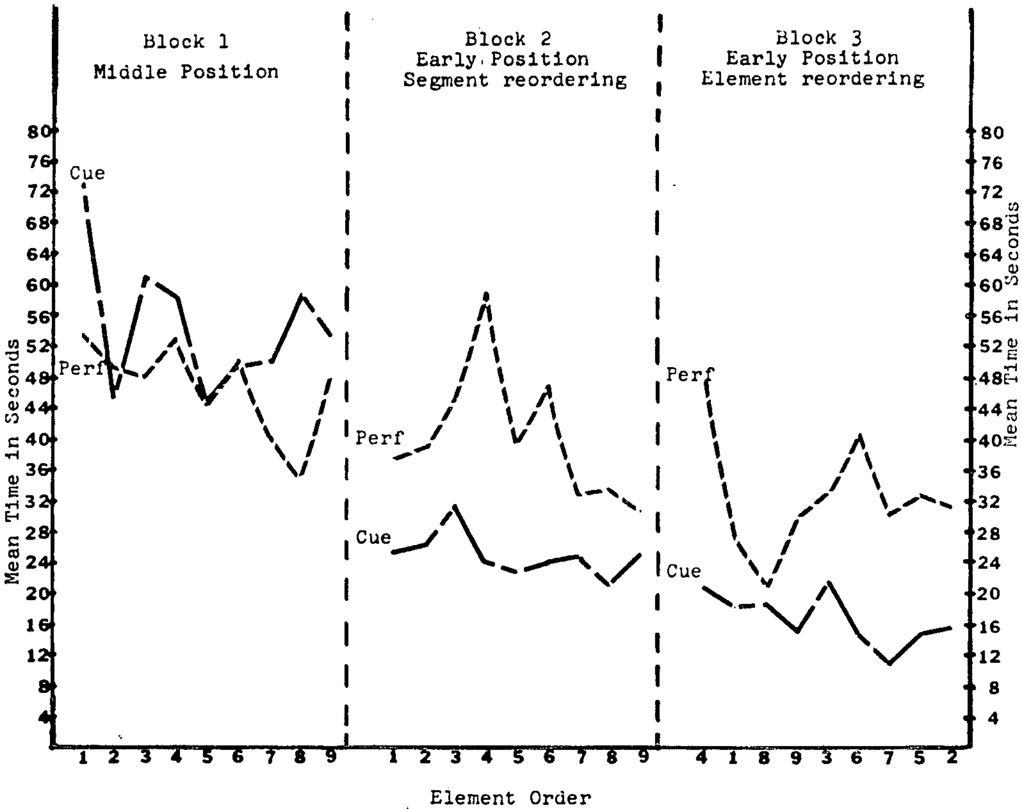


Figure 17. Mean cue referral and element performance times for the 4LV segment (middle and early) for subject 1.

elements. No recency effect occurred, however, since the time for Element 2 was slightly slower (1 second) than the time for Element 9.

The profile of mean element performance times in Block 1 revealed no serial position effects. A recency-primacy effect was apparent in Block 2, after segment reordering had occurred. The first two elements were performed .6-20 seconds faster than the middle elements (primacy). The recency effect spanned the last three elements. These three elements were performed 6-26 seconds faster than the middle elements. No serial position effects were apparent in the profile of element performance times in Block 3. A primacy effect may have occurred if the time for the first element (4) had been purely cue referral time.

9LV Segment

Mean cue referral and element performance times in the other middle segment (9LV) for Subject 1 are presented in Figure 18. Even with averaging the cue referral times for each element over the trials in Block 1, a great deal of fluctuation was evident in these times. Times for the last two elements in Block 1, however, were relatively similar. Times for these two elements were also the fastest in Block 1 and indicated a recency effect had occurred. No serial position effects were noted in cue referral times in either Block 2 or Block 3.

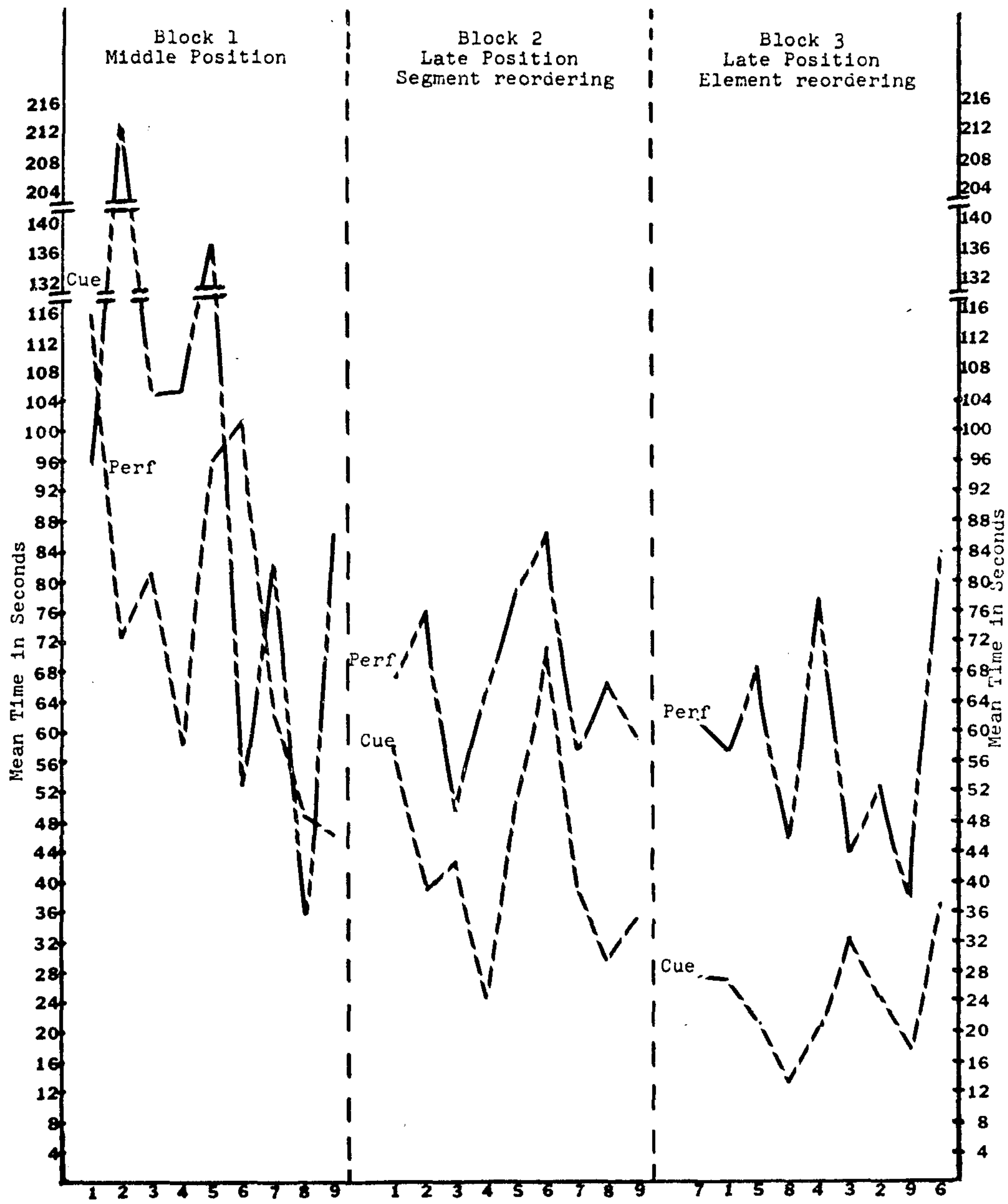


Figure 18. Mean cue referral and element performance times for the 9LV segment (middle and late) for subject 1.

As noted in Figure 18, mean times for performance of Elements 2 and 5 were much longer than for any other elements in Block 1. Both of these element requirements involved making a rectangle three times at Station 9. Performance times for all elements demonstrated little stability, and no serial position effect was noted in Block 1. In Block 2, a recency-primacy effect was evident in element performance times. The recency effect spanned the last three elements, which were performed 12-29 seconds faster than the two middle elements. The primacy effect spanned the first four elements. In Block 3, following element reordering, no recency or primacy effects were noted.

Late Position

4HV Segment

The 4HV segment was performed initially by Subject 1 in the late position. Mean cue referral and element performance times for this segment during all three blocks of trials are presented in Figure 19. Mean cue referral times in Block 1 and Block 2 demonstrated no serial position effects. Subject 1, therefore, had no serial position effects in the mean cue referral times for the 4HV segment, regardless of the order in which she performed this segment. After element reordering (Block 3), a recency effect was demonstrated in the profile of mean cue referral times. Times for the last three elements were 3-6 seconds faster than times for the other elements. As may be noted in

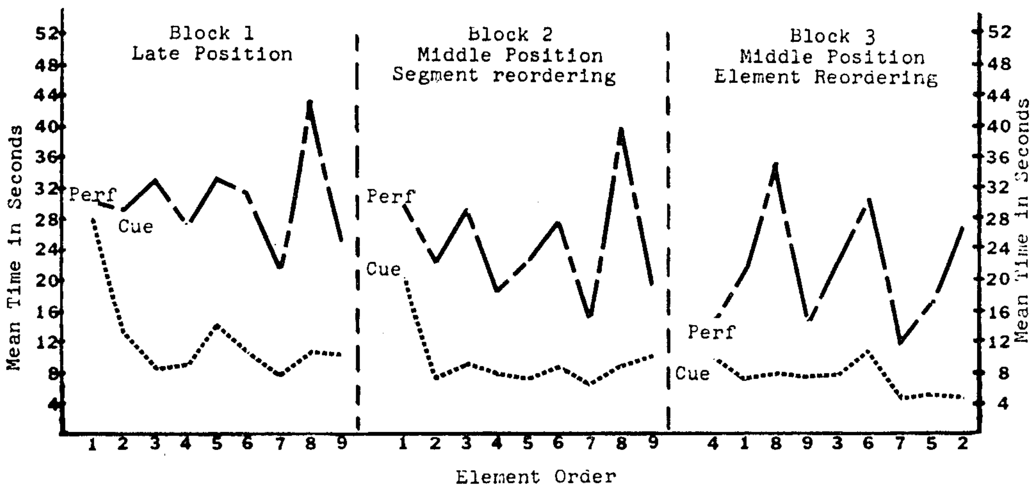


Figure 19. Mean cue referral and element performance times for the 4HV segment (late and middle) for subject 1.

Figure 19, times for cue referral of the first five elements were generally the same. Only times for Elements 4 and 6 were noticeably different. No serial position effects were evident in mean element performance times. Times for performance fluctuated element-by-element in all three blocks of trials.

Summary of Serial Position Effects for Subject 1

Table 6 summarizes the recency and primacy effects evident in the profiles of cue referral and element performance times for Subject 1. A total of 12 recency and 12 primacy effects was possible over the three blocks of trials. No primacy effects were evident in any of the profiles of mean cue referral times for Subject 1. Only two recency effects were noted. Both recency effects were evident in the 4HV or 9LV segments which were located in the same middle position for at least one block of trials.

Four serial position effects in mean element performance times were noted in either Block 1 or Block 2. In these blocks of trials, the order of elements remained the same, but the order of segments did not. In Block 2, recency-primacy effects were noted in element performance times of the 4LV (early), 9HV (middle), and 9LV (late) segments. No similarities in the emergence of serial position effects were noted when the segment order was changed. Performance times in the segments located in the early position (9HV and 4LV) indicated a recency effect in Block 1 (9HV)

Table 6

Serial Position Effects Noted in Profiles of Mean Times of Segments Located in the Early, Middle, and Late Positions:

Subject 1

Block of Trials	Early Position		Middle Position		Middle Position		Late Position	
			Cue Referral Times					
1	9HV:	None	4LV:	None	9LV:	Recency	4HV:	None
2	4LV:	None	9HV:	None	4HV:	None	9LV:	None
3	4LV:	None	9HV:	None	4HV:	Recency	9LV:	None
			Element Performance Times					
1	9HV:	Recency	4LV:	None	9LV:	None	4HV:	None
2	4LV:	Recency-Primacy	9HV:	Recency-Primacy	4HV:	None	9LV:	Recency-Primacy
3	4LV:	None	9HV:	None	4HV:	None	9LV:	None

and a recency-primacy effect in Block 2 (4LV). The recency-primacy effects noted in element performance times for the other segments in Block 2 (9HV and 9LV) were the only ones which occurred in segments located in one of the middle and the late positions. No serial position effects were evident in element performance times following the element reordering intervention (Block 3).

Subject 2

Early Position

9HV Segment

Subject 2 performed the 9HV segment in the early position during Block 1 and Block 2. During Block 3, this segment was performed in the middle position. Mean cue referral and element performance times are presented in Figure 20.

No serial position effects were noted for mean cue referral times in any block of trials. Cue referral times for all elements were very similar in Blocks 2 and 3. Serial position effects were evident for mean element performance times in all blocks. In Block 1, mean element performance took less time for the first three (primacy) and last four elements (recency) than for the middle two elements. The primacy effect was shorter in Blocks 2 and 3. In these blocks, only the first two elements were performed faster than the middle elements. The recency effect, however, continued to span the last four elements. This

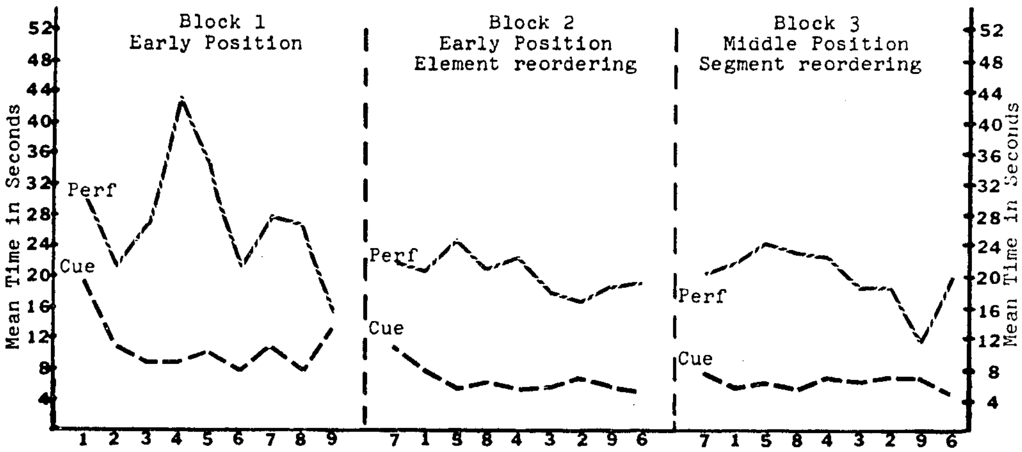


Figure 20. Mean cue referral and element performance times for the 9HV segment (early and middle) for subject 2.

was true even though this segment was in a different position in the total task during Block 2. The recency-primacy effect was also evident during Block 3, even though element order had been changed.

Middle Positions

4LV Segment

Subject 2 performed the two low visual segments in the middle of the serial gross motor task during the first two blocks of trials. In Block 3, this segment was located in the early position. Mean cue referral and element performance times for the 4LV segment are presented in Figure 21.

No serial position effects were noted for mean cue referral times in Block 1. With the exception of the time for the element performed first (Element 4) in Block 2, a primacy effect would have emerged. A recency effect was evident in Block 2, with the last two elements (5 and 2) having cue referral times which were 5-7 seconds faster than times for the middle elements. In Block 3, no serial position effects were evident.

No serial position effects were evident for the mean element performance times during Block 1. In both Block 2 and Block 3, recency-primacy effects were noted. These effects were especially evident in Block 3. In this block of trials, the first four elements and the last three elements were all performed faster than the two middle

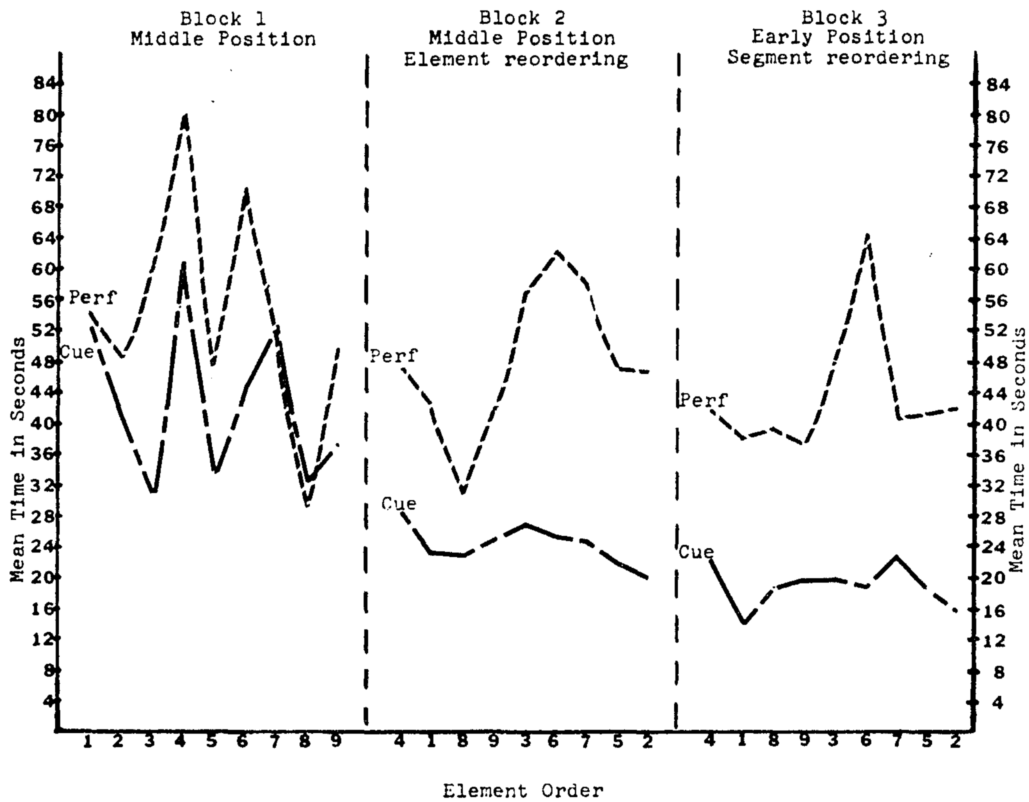


Figure 21. Mean cue referral and element performance times for the 4LV segment (middle and early) for subject 2.

elements (3 and 6). This same pattern was evident in Block 2, but there was more fluctuation among the times for the first four elements in this block. In addition, the recency effect in Block 2 spanned only the last two elements.

9LV Segment

Subject 2 performed the 9LV segment in the fourth (middle) position during Block 1 and Block 2. This segment was in the late position during Block 3. Figure 22 shows the mean cue referral and element performance times for this segment. Note the time axis was broken to accommodate the average times for Elements 2 and 5. Mean cue referral and element performance times generally decreased for all elements across the three blocks of trials. No serial position effects were evident in any of the profiles.

Late Position

4HV Segment

Subject 2 performed the 4HV segment in the late position during Blocks 1 and 2. This segment was in a middle position during Block 3. Mean cue referral and element performance times for the 4HV segment are shown in Figure 23. The cue referral times for each element did not change much over the three blocks of trials. Mean element performance times also did not change much once the element order had been rearranged. No serial position effects were noted in either the mean cue referral or element performance times in any block of trials.

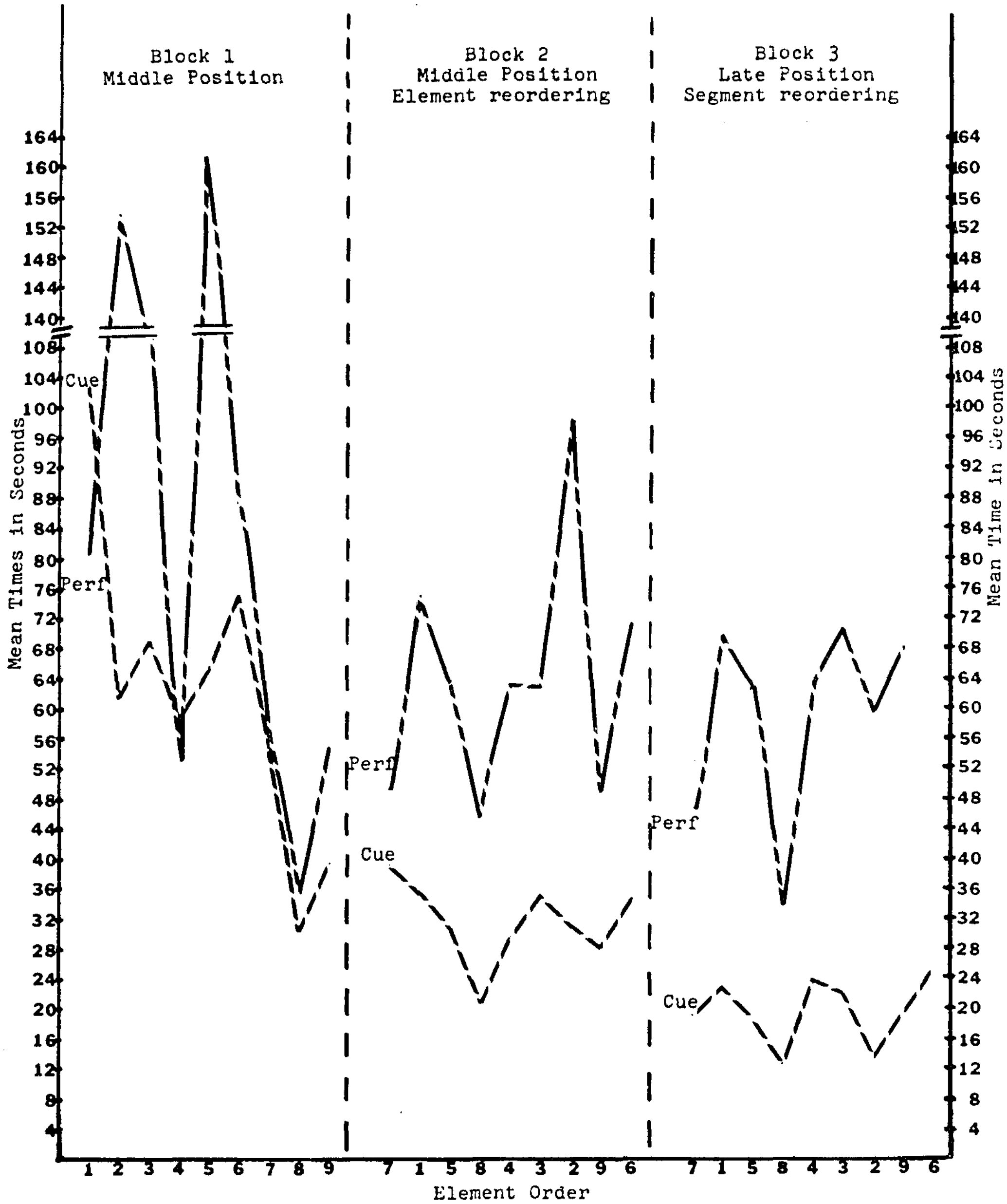


Figure 22. Mean cue referral and element performance times for the 9LV segment (middle and late) for subject 2.

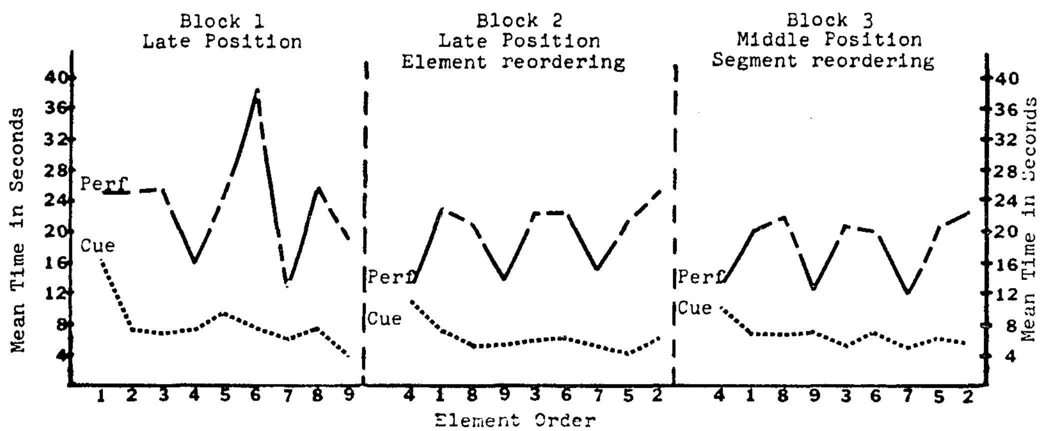


Figure 23. Mean cue referral and element performance times for the 4HV segment (late and middle) for subject 2.

Summary of Serial Position Effects for Subject 2

As noted in Table 7, only one recency effect, of a possible 12, was noted in the mean cue referral times for Subject 2. This effect was noted in the 4LV segment during Block 2, following element reordering. During Block 2, this segment continued to occupy one of the middle positions, as it did in Block 1. No serial position effects were noted in the segment which occupied this position (9HV) during Block 3. No primacy effects were noted in the cue referral profiles for any segment.

Five profiles of mean element performance times exhibited recency-primacy effects. These effects were apparent only for segments which were located in the early and the first of the two middle positions. Recency-primacy effects were demonstrated in the times for the 9HV segment on all three blocks of trials. The primacy effect in Block 1 spanned the first three elements. In Blocks 2 and 3, this effect spanned only the first two elements. The recency effect spanned the last four elements in all blocks of trials. Recency-primacy effects emerged in the element performance profile for the 4LV segment following element reordering (Block 2). These effects remained evident in Block 3, when this segment was performed first. The recency effect spanned the last two elements in Block 2 and the last three elements in Block 3. The primacy effect spanned the first four elements in both blocks of trials.

Table 7

Serial Position Effects Noted in Profiles of Mean Times of Segments Located in the Early, Middle, and Late Positions: Subject 2

Block of Trials	Early Position	Middle Position	Middle Position	Late Position
		Cue Referral Times		
1	9HV: None	4LV: None	9LV: None	4HV: None
2	9HV: None	4LV: Recency	9LV: None	4HV: None
3	4LV: None	9HV: None	4HV: None	9LV: None
		Element Performance Times		
1	9HV: Recency-Primacy	4LV: None	9LV: None	4HV: None
2	9HV: Recency-Primacy	4LV: Recency-Primacy	9LV: None	4HV: None
3	4LV: Recency-Primacy	9HV: Recency-Primacy	4HV: None	4HV: None

Recency-primacy effects were evident, therefore, in both segments which were located in the early position in all three blocks of trials. Serial position effects were evident only in Blocks 2 and 3 for the segments which were located in the first of the two middle positions.

Subject 3

Early Position

4LV Segment

Subject 3 performed the low visual segments in the early and late positions during Block 1. This order was changed in Block 2, so that the high visual segments were in the early and late positions. Element reordering had occurred prior to the last block of trials. Mean cue referral and element performance times for the 4LV segment, which was performed in the early position in Block 1, are presented in Figure 24.

The only serial position effect noted in mean cue referral times was in Block 3. A recency effect, spanning the last two elements, was noted. If the time for Element 4 (now in the first position) had been purely cue referral time, a primacy effect also would have occurred. Mean element performance times in Block 1 exhibited a primacy effect. The times for the first five elements demonstrated less fluctuation and also were faster than the times for the remaining elements. No other serial position effects were evident in the mean element performance times in any segment for the remaining blocks of trials.

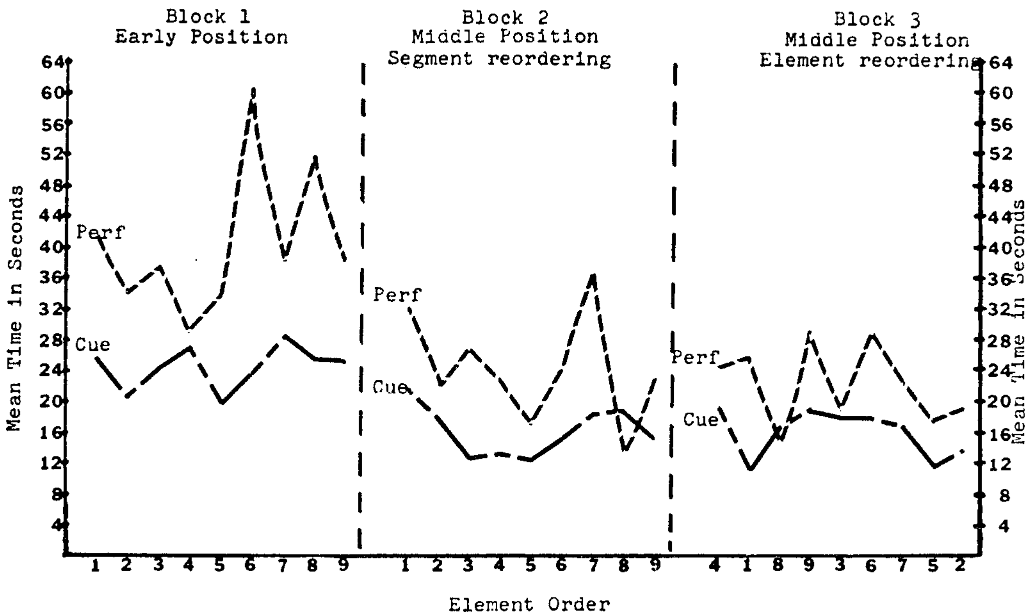


Figure 24. Mean cue referral and element performance times for the 4LV segment (early and middle) for subject 3.

Middle Positions

9HV Segment

The 9HV segment was performed in the middle of the serial gross motor task during Block 1. Figure 25 shows the mean cue referral and element performance times for this segment across the three blocks of trials. No serial position effects were evident in mean cue referral times in Block 1. The middle elements (4-7) had longer cue referral times than the second, third, or eighth element. However, cue referral for the first and last elements took the longest. In Block 2, following the segment reordering, a recency effect was evident in cue referral times. The times for the last three elements were slightly faster than times for the middle elements. No serial position effects were evident in Block 3. A primacy effect, spanning the first four elements, would have occurred if the time for the first element were not inflated.

No serial position effects were evident in the mean element performance times in any of the three blocks of trials. Serial position effects would have emerged in Block 3 except for the fast performance time for Element 3. Times for the first four elements and the last two elements demonstrated the least fluctuation. None of the times for these elements was faster than the time for Element 3, however.

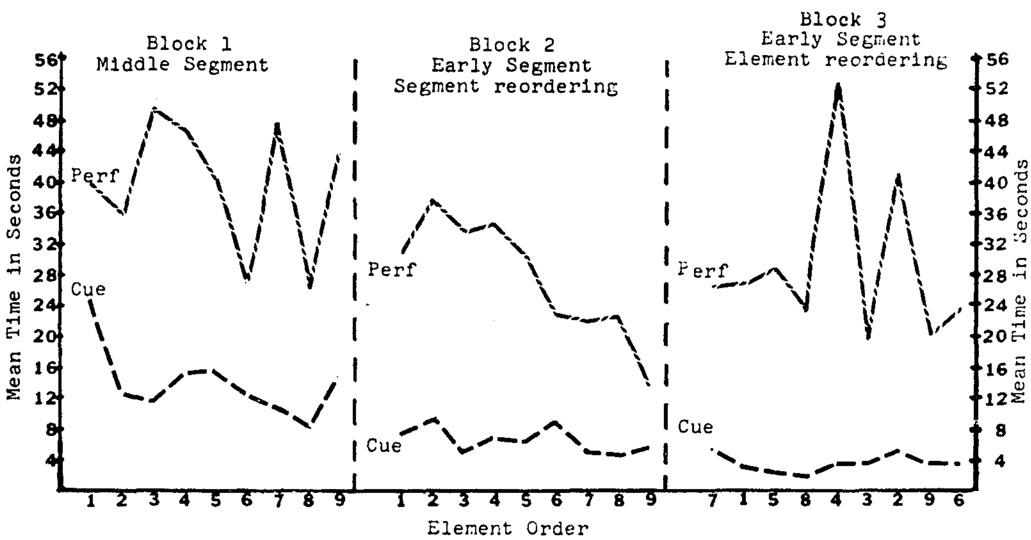


Figure 25. Mean cue referral and element performance times for the 9HV segment (middle and early) for subject 3.

4HV Segment

Mean cue referral and element performance times for the other high visual segment originally located in the middle position are presented in Figure 26. No serial position effects were noted for mean cue referral times in any of the blocks of trials.

Profiles of mean element performance times indicated that no serial position effects occurred in Block 1 or Block 2. In Block 3, following the element reordering, a recency-primacy effect was noted. The first two (primacy) and last four (recency) elements were performed 1-5 seconds faster than the middle three elements.

Late Position

9LV Segment

The 9LV segment was initially performed in the late position by Subject 3. Mean cue referral and element performance times for this segment are presented in Figure 27. Cue referral times followed a similar pattern among elements in Blocks 1 and 2. In Block 1, a primacy effect would have been evident if the time for the first element had not been so long. In Blocks 1 and 2, recency effects were evident. Times for the last three elements were 5-13 seconds faster (Block 1) and 3-6 seconds faster (Block 2) than times for the middle elements. No serial position effects were evident in cue referral times following element reordering (Block 3).

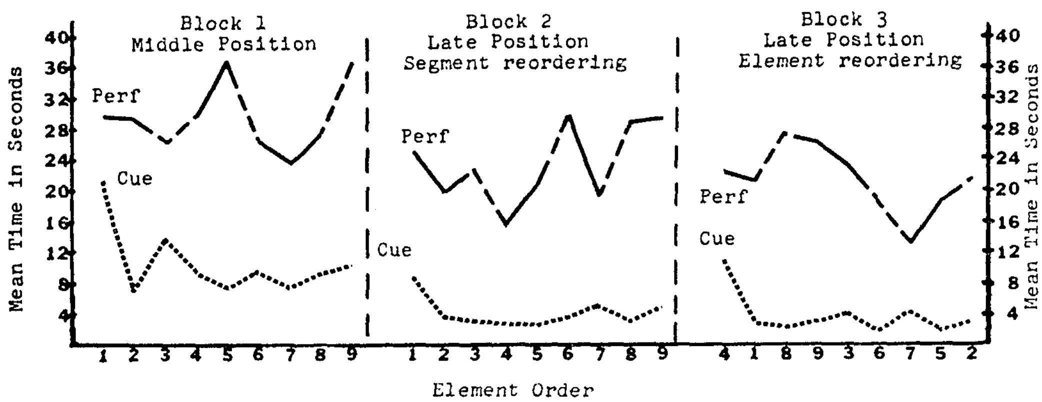


Figure 26. Mean cue referral and element performance times for the 4HV segment (middle and late) for subject 3.

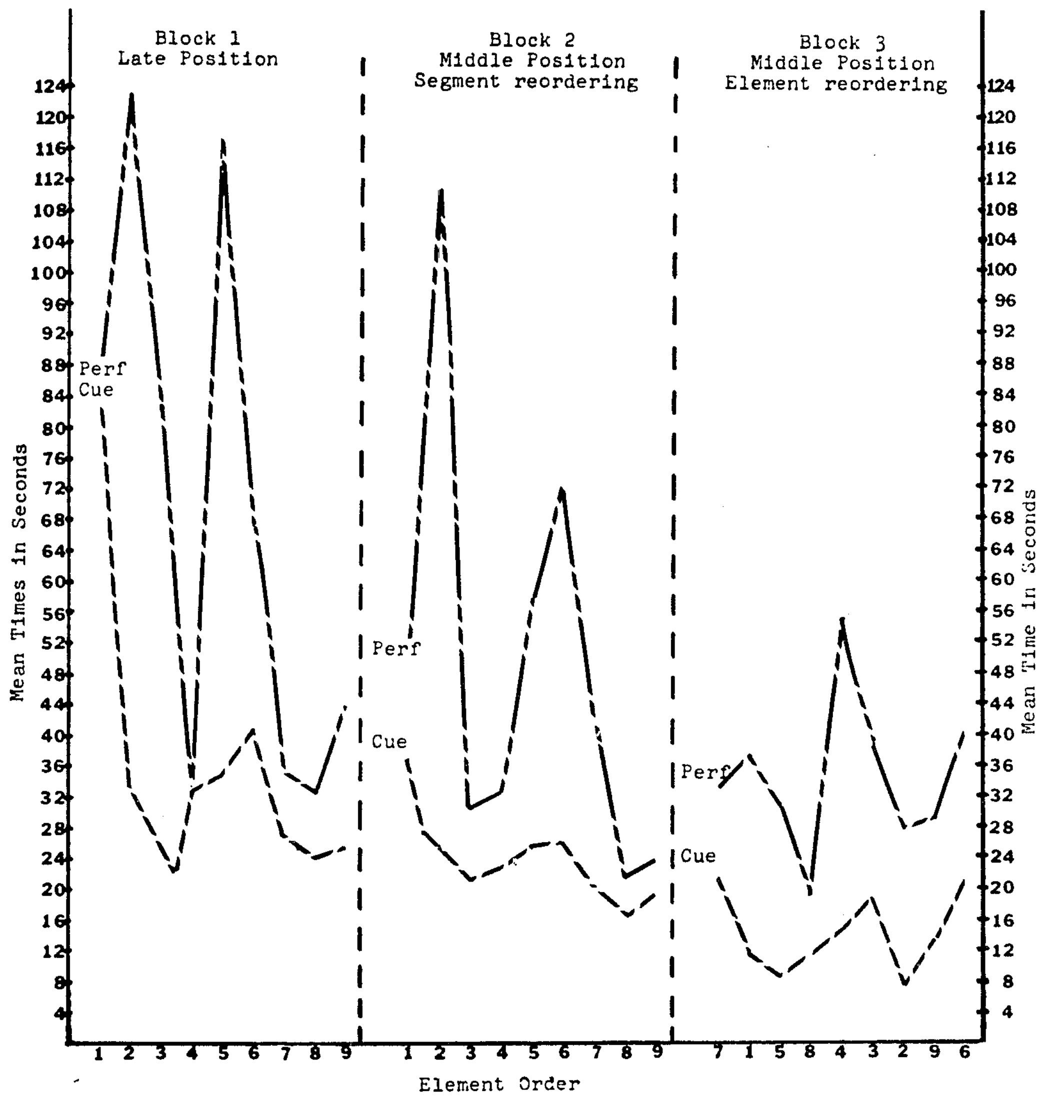


Figure 27. Mean cue referral and element performance times for the 9LV segment (late and middle) for subject 3.

Times for mean element performance in Block 1 revealed no serial position effects. Elements 2 and 5 took the longest times to perform in this block. A recency effect, spanning the last two elements, was evident in Block 2. Times for these elements were 7-87 seconds faster than times for any other element in Block 2. In Block 3, following the element reordering, a recency-primacy effect was noted. Each of these effects spanned four elements. Only Element 4 took a relatively long time to perform during Block 3.

Summary of Serial Position Effects for Subject 3

Serial position effects for Subject 3 are summarized in Table 8. Four, of a possible 12, recency effects were noted in the mean cue referral times for Subject 3. The four effects noted were divided among the 9HV segment (one), the 9LV segment (two) and 4LV segment (one). Mean cue referral times in the 9LV segment exhibited a recency effect when this segment occupied a middle position (Block 2) and the late position (Block 1). The recency effect noted in the 9HV segment was in Block 2, when this segment was in the early position. The recency effect in the 4LV segment was demonstrated when this segment occupied a middle position (Block 3). No primacy effects were evident in the cue referral times for any segment.

Two recency-primacy effects, one recency effect, and one primacy effect were noted in mean element performance times for Subject 3. Three of these effects occurred in segments

Table 8

Serial Position Effects Noted in Profiles of Mean Times of Segments Located in the Early, Middle, and Late Positions: Subject 3

Block of Trials	Early Position	Middle Position	Middle Position	Late Position
		Cue Referral Times		
1	4LV: None	9HV: None	4HV: None	9LV: Recency
2	9HV: Recency	4LV: None	9LV: Recency	4HV: None
3	9HV: None	4LV: Recency	9LV: None	4HV: None
		Element Performance Times		
1	4LV: Primacy	9HV: None	4HV: None	9LV: None
2	9HV: None	4LV: None	9LV: Recency	4HV: None
3	9HV: None	4LV: None	9LV: Recency-Primacy	4HV: Recency-Primacy

which occupied the last of the middle positions and the late position (9LV and 4HV segments). No serial position effects were noted in Block 1 for either of the segments occupying these positions. In Block 2, a recency effect was noted in the 9LV segment when it was located in the last of the two middle positions. The 9LV segment remained in this position for Block 3, and a recency- primacy effect was noted in the element performance profile. The recency-primacy effect evident in the mean element performance times of the 4HV segment was the only serial position effect to occur in either this segment or in the 9LV segment when these segments occupied the late position. The only other serial position effect to occur in mean element performance times for Subject 3 was for the 4LV segment in Block 1. The primacy effect in this block was the only serial position effect which occurred in segments occupying the early position.

Subject 4

Early Position

4LV Segment

Subject 4 performed the low visual segments in the early and late positions during Block 1 and Block 2. Prior to the trials in Block 3, these segments were moved to the middle positions. Mean cue referral and element performance times for the 4LV segment are presented in Figure 28.

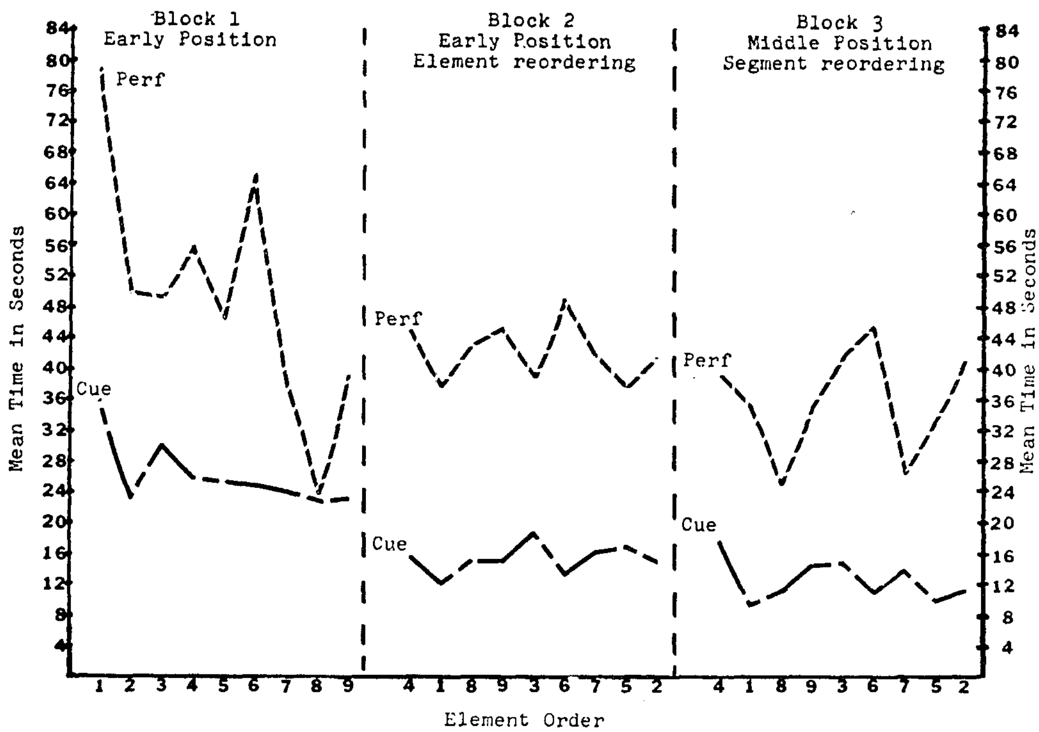


Figure 28. Mean cue referral and element performance times for the 4LV segment (early and middle positions) for subject 4.

No serial position effects were evident for the mean cue referral times in any block of trials. The profile of mean element performance times in Block 1 indicated a recency effect. The last three elements were performed 7-38 seconds faster than the middle elements. Following the element reordering (Block 2) and the segment reordering (Block 3), no serial position effects were evident. In Block 3, a recency-primacy effect was nearly evident. Only the longer times taken for performance of the first and last elements (4 and 2, respectively) prevented this effect from being demonstrated.

Middle Positions

9HV Segment

Subject 4 performed the high visual segments in the middle of the total task during Blocks 1 and 2. Mean cue referral and element performance times for the 9HV segment are presented in Figure 29. No serial position effects were evident in the profiles of mean cue referral or element performance times for any block of trials.

4HV Segment

Mean cue referral and element performance times in the 4HV segment, which occupied the other middle position, are presented in Figure 30. The profile of mean cue referral times in Block 1 and 2 revealed a recency effect. This effect spanned the last two elements in Block 1, and the last three elements in Block 2. A primacy effect, spanning the

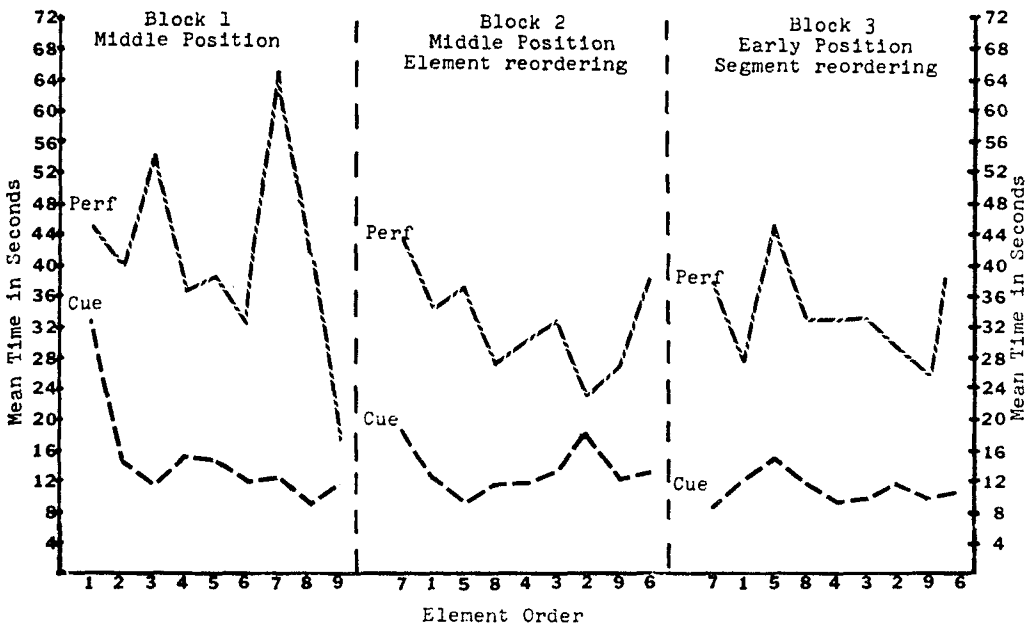


Figure 29. Mean cue referral and element performance times for the 9HV segment (middle and early positions) for subject 4.

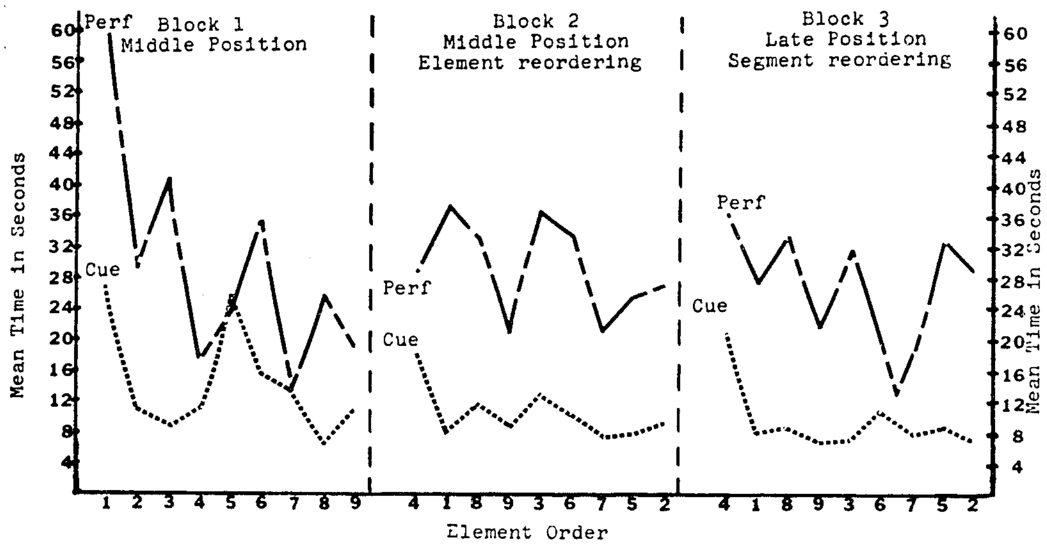


Figure 30. Mean cue referral and element performance times for the 4HV segment (middle and late) for subject 4.

first four elements, would have been evident in Block 1 if cue referral time for the first element had not been so long. No serial position effects were noted for cue referral times in Block 3. No serial position effects were noted for mean element performance times in any of the blocks of trials. The profiles for mean element performance times in Block 1 and Block 3 were very similar. This was true even though the order of elements was different in these two blocks of trials.

Late Position

9LV Segment

The 9LV segment was performed by Subject 4 in the late position during Blocks 1 and 2. In Block 3, this segment was performed in a middle position. Mean cue referral and element performance times in the 9LV segment are presented in Figure 31. No serial position effects were evident in the profiles for mean cue referral times in any of the three blocks of trials.

Mean element performance times were longest for Elements 2 and 5. Note the time axis was broken to accommodate the performance times for these two elements. A recency effect was evident in these times in Block 1. The last four elements were performed 30-118 seconds faster than were the other elements. No recency effect was evident in Block 2, following the element reordering. A primacy effect was evident, however, which spanned the first four elements. Two of these

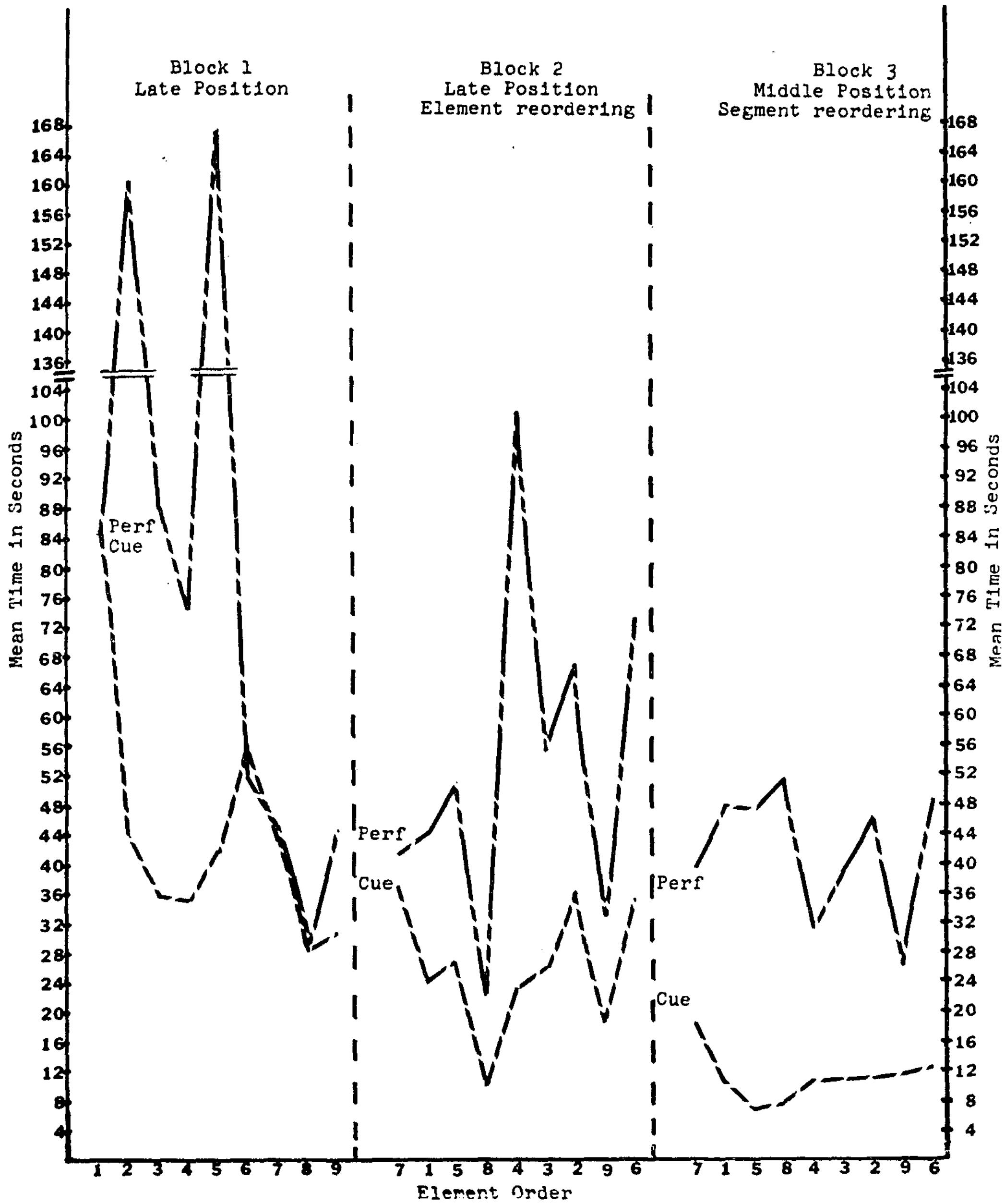


Figure 31. Mean cue referral and element performance times for the 4LV segment (late and middle) for subject 4.

elements (7 and 8) were ones which were located in the last positions during Block 1. In Block 3, no serial position effects were evident.

Summary of Serial Position Effects for Subject 4

As noted in Table 9, only two, of a possible 12, recency effects were noted in the mean cue referral times for Subject 4. Both recency effects were noted in the cue referral times of the 4HV segment when it was located in a middle position of the serial gross motor task. These effects were evident regardless of the order in which the elements within this segment were performed (Blocks 1 and 2). No serial position effects were noted in the 9LV segment when it occupied this middle position during the trials of Block 3. No primacy effects were evident in cue referral times for any segment.

The two recency effects noted in the mean element performance times of Subject 4 occurred in the low visual segments when these segments were performed early or late. In Block 1, a recency effect was noted in the profile of element performance times of the 4LV segment. No further serial position effects were noted for segments which occupied the early position. In Block 1, a recency effect also was noted in the 9LV segment when it occupied the late position. Following element reordering (Block 2), only a primacy effect was noted in this segment. Finally, no serial position effects were noted in the 4HV segment when

Table 9

Serial Position Effects Noted in Profiles of Mean Times of Segments Located in the Early, Middle, and Late Positions:

Subject 4

Block of Trials	Early Position	Middle Position	Middle Position	Late Position
		Cue Referral Times		
1	4LV: None	9HV: None	4HV: Recency	9LV: None
2	4LV: None	9HV: None	4HV: Recency	9LV: None
3	9HV: None	4LV: None	9LV: None	4HV: None
		Element Performance Times		
1	4LV: Recency	9HV: None	4HV: None	9LV: Recency
2	4LV: None	9HV: None	4HV: None	9LV: Primacy
3	9HV: None	4LV: None	9LV: None	4HV: None

it occupied the late position (Block 3). For those segments which were located in the middle positions, no recency or primacy effects were noted in mean element performance times during any of the three blocks of trials.

Discussion of Findings

The most popular and stable finding in verbal serial learning studies is that of a serial position curve (Ebbinghaus, 1919; Jahnke, 1963; Murdock, 1962, 1968, 1976; Saufley, 1975; Sumby, 1963). This curve is characterized by a bow shape, which indicates that the first and last items are recalled better. This curve also is evidenced in fine motor tasks (Magill & Dowell, 1977; Wrisberg, 1975; Zaichkowsky, 1974). Only limited study of serial position effects in gross motor tasks has been done (Cratty, 1962, 1963; Singer, 1968).

Serial position effects occur when the first (primacy) and/or last items (recency) in a series are performed faster than items in the middle. Question 2 was formulated to determine whether serial position effects would appear in the cue referral and element performance times of segments in a serial gross motor task. All four subjects had ten trials in which the sequential order of the nine elements in all segments was the same. In addition, the order in which task segments were performed stayed the same for ten of the 15 trials. Interventions in the order of task segments or elements occurred at different times for the subjects. These interventions permitted the occurrence of any serial position effects to be discussed in relation to the order of the task segment. Based on the literature, it was expected that more serial position effects would occur in segments located in the early and late positions. In addition, more serial position effects should be evident in segments when these segments were performed in an early or late position than when performed in the middle positions.

Ninety-six serial position effects were possible for the cue referral profiles of the four subjects. Relatively few serial position effects (9) were noted in the profiles of subjects' cue referral times. The most recency effects (4) were noted in the profiles for Subject 3. These recency effects were evident in segments located in each of the four positions (early, middle, middle, and late) of the total task. Two recency effects were evident in the cue referral profiles of both Subject 1 and Subject 4. These recency effects were apparent in the segments (4HV and 9LV) located in the last of the middle positions. The only recency effect evident for Subject 2 was in the 4LV segment when it occupied the first of the middle positions. For all subjects, then, the most serial position effects (7) were evident in cue referral profiles of segments located in the middle positions. Only two recency effects were noted in the segments located in an early or late position.

Slightly more (16 of 96) serial position effects were evident in the profiles of mean element performance times. Four serial position effects were apparent in the element performance times for Subject 1. Most of these effects (two recency-primacy effects and one recency effect) occurred in segments located in the early or late positions. The 9HV segment, in which a recency effect was evident in Block 1, was moved to a middle position in Block 3. During this block, a recency-primacy effect occurred. Only one recency-primacy effect was noted in a segment (4LV) located in the early position. Five recency-primacy effects were noted in the element performance times for Subject 2. All these effects were evident in the 9HV and 4LV segments. These segments always were located in either the early or the first of the middle positions. Four serial position effects were also noted in the element performance profiles for Subject 3. Three of these effects were in either the 4HV or 9LV segments which always were located in the last of the middle or the late position of the total task. One primacy effect was noted in a segment (4LV) which was located in the early position. Three serial position effects (two recency effects and one primacy effect) were noted in the profiles of element performance times for Subject 4. All of these effects were noted in segments which were located in the early or late positions. For all four subjects, therefore, the most serial position effects (7) were evident in the element performance profiles of segments in the early position. Slightly more were evident in segments located in middle positions (5) than in the late position (4).

The above data indicated that the anticipated pattern of serial position effects did not emerge. It was thought that more serial position effects would be evident in segments located in the early and late positions. Profiles of cue referral times for all subjects indicated that the opposite pattern was evident. More serial position effects were evident in segments located in the middle of the total task. This pattern was also evident for the element performance profiles for Subject 3. For all other subjects, more serial position effects were evident in the element performance profiles of segments located in the early position than in the middle segments. Subject 4 had slightly more serial position effects for segments located in the late position. These patterns of element performance times would seem to indicate that segment order was a factor in the emergence of serial position effects. Further support for this position would have been provided, however, if serial position effects became more prevalent in segments which were moved from a middle position to either the early or late position. This pattern was not evident for any subject. It appeared, therefore, that segment order was not an important factor for the emergence of serial position effects in the profiles of mean cue referral or element performance times.

There was some indication that serial position effects were more characteristic of low visual segments than of high visual segments. Profiles of mean cue referral times for Subject 2 and Subject 3 revealed more serial position effects for low visual segments (4) than for high visual segments (2). Profiles of mean element performance times for Subjects 3 and 4 also indicated that more serial position effects occurred in low visual segments (6) than in high visual segments (1). This pattern may be related to the finding that material in the same category is recalled better than material in different categories (Murdock, 1976). The information on the cues and the performance of the elements in the low visual segments were both related to the shape of the cue (station at which to make the shape, number of repetitions of the shape to make). In the high visual segments, on the other hand, two or three discrete items were included on the cue cards (location at which to perform, information regarding the blocks, and information regarding the hand movements). These characteristics of the two types of cues would seem to indicate that the performance profiles of the high visual segments would be like those resulting when different categories of information were presented. Conversely, the low visual performance profiles would be more like those resulting when material in the same category was presented. The results for Subjects 2, 3, and 4 indicated that this happened to some extent.

It was anticipated that the number of trials during which element order was the same also would be a factor in the emergence of serial position effects. Studies in the verbal domain indicated that the amount of practice on a list was a factor in eliciting serial position effects. Saufley (1975) found that when the serial order of a list remained constant for three trials, recall was better than when either the order of the list or the composition of the list was changed on every trial. In addition, when serial order of a list was changed after three trials, recall dropped to a level equal to that when a new list was presented on every trial. Saufley (1975) concluded that "Performance (recall) improves considerably when serial order remains constant" (page 427). For this study, therefore, it was thought that more serial position effects would emerge in profiles of times in the two blocks of trials for which serial order of the elements remained constant. Very limited support was evident for this position. The element performance profiles for Subject 1 were the only ones to demonstrate the expected pattern. All four serial position effects evident in her profiles occurred in Block 1 or Block 2. During these blocks of trials, the serial order of elements was the same. When serial order was changed (Block 3), no serial position effects were evident. The number of trials for which element order remained constant apparently was not a factor in eliciting serial position effects for the other three subjects.

Studies of memory in older adults indicated that the last items (recency) were recalled first (Craik, 1968; Raymond, 1971. The four subjects in this study also had more recency (13) than primacy effects (2). Ten recency-primacy effects were evident in profiles of element performance times for Subjects 1, 2, and 3. In general, the recency effects spanned more elements than did the primacy effects. The only profiles which were different from this were for the 9LV segments of Subjects 1 and 3. Recency and primacy effects in this segment spanned an equal number of elements for Subject 3. More elements comprised the primacy effect (4) than the recency effect (3) as indicated in the element performance times for Subject 1. In addition, upon completion of the 15th trial, subjects were given an opportunity to see all the cues and arrange them in the order in which they were last performed. More last items (15) than first items (12) were arranged correctly. This relationship of recency to primacy effects was true for all subjects.

In summary, very few serial position effects were evident in the profiles of mean cue referral or element performance times for any subject. Two subjects (3 and 4) had more serial position effects in the profiles of element performance for early and late segments than for the middle segments. All other profiles for both element performance and cue referral indicated that more serial position effects occurred in the middle segments. When segment order was changed, the expected serial position effects did not emerge. That is, there was no indication that movement of a segment from the middle to either the early or late positions resulted in more serial position effects.

Only the element performance profiles for Subject 1 indicated that the order of elements was a factor in the emergence of serial position effects. This subject's profiles indicated that all serial position effects occurred during the two blocks of trials when serial order of elements was the same. No effects were noted when element order was changed. No consistent results were indicated in the profiles of the other subjects before and after the element reordering intervention.

In response to Question 2, therefore, neither the segment order nor the element order was consistently a factor in the emergence of serial position effects. This may have been due to the limited number of serial position effects which were evident.

There was some indication, however, that serial position effects were more evident in profiles of the low visual segments than of the high visual segments. This may have been due to the fact that cue referral and element performance in the low visual segments was similar to the recall (performance) of a list of items in the same category.

Question 3: What is the pattern of performance recall within each segment of the task?

For each element in a segment, the subject referred to a cue, contacted an element key, performed the element requirements, and contacted the element key again. As she went to and from the station indicated on the cue, she was to avoid any obstacles in her pathway. A map of the segment area was available for subject reference if it was needed to find the location of a particular station. Thus, there were several distinct items which had to be remembered. These included the (a) performance requirements from the cue, (b) location of each of the stations, (c) location of the obstacles, and (d) sequence of key contacts. In addition, subjects were to try to remember what the element requirements were so that cue referral would not be necessary on every trial. To assist in determining the pattern of recall of these items, the following more specific questions were formulated:

a. What is the original profile of performance breaks?

b. Do these profiles of performance breaks change before intervention?

c. Do these profiles of performance breaks change after intervention?

d. What is the relationship of the number of performance breaks to the number of cue referrals?

Performance breaks included the number of cue and map referrals as well as the errors which occurred. Errors included (a) incorrect performance of the element requirements, (b) failure to avoid the obstacles, and (c) failure to contact the element key either before or after performance. The subjects were notified of any performance errors by the observers. If they were unable to correct the performance without assistance, they were required to make additional cue or map referrals to get the correct information. Thus, the data to answer this question included (a) the number of errors, including failure to avoid the obstacles or make contact with an element key, (b) the number of cue referrals, both before and during performance, and (c) the number of map referrals, both before and during performance.

Only one subject successfully performed element requirements without first referring to a cue. This subject did not successfully perform without cue referral until the last block of trials. Therefore, only one sequence of complete performance recall (number of elements successfully performed without cue referral) occurred. The data for each subject, however, will be presented and described to determine whether or not any pattern evolved in subjects' attempts to organize all the necessary information for correct performance. The number of cue referrals, map referrals, and each type of errors occurring on each trial will be presented in table form. The total frequencies of errors occurring on each trial will be presented in graph form. These graphs will depict the sum total of all performance, key contact, and obstacle errors occurring on each of the five days in a block of trials. The design of the graph lines depicting error occurrences for a particular segment is the same for all subjects. For example, the line depicting error frequencies in the 9HV segment for Subject 1 will be used to depict errors in this segment for all subjects. The design of these graph lines for each segment is different from the design used for presenting data for these segments for the preceding two questions.

The error data for each of the three blocks will be presented first for Subject 1. These data will be described to determine the pattern of error occurrences in all segments within each block of trials. The map and cue referral data will then be presented and discussed to determine the pattern of recall within each block of trials. These same procedures will be followed for the remaining three subjects.

Subject 1

Errors

The total number of errors Subject 1 committed during each of the fifteen trials is presented in Figure 32. On four of the five trials in Block 1, more errors were committed in the 9LV segment than in any other segment. Note that the error axis had to be broken to accommodate the total in this segment on Day 3, and the total for the 4LV segment on Day 1. Following Day 1, errors generally decreased in the 4LV segment until only four errors were noted on Days 4 and 5. While the figure depicts the total number of errors, an accompanying table indicates the breakdown of the type of error: performance, key contact, or obstacle. As noted in Table 10, obstacle errors accounted for the largest portion of the total errors in the 4LV and 9LV segments. Even without these errors, however, more errors occurred in the 9LV segments than in any other segments on three days in Block 1 (Days 2, 3, and 4). Element performance in the 9HV segment was less accurate on the last three days in Block 1 than on the first two days. The fewest total errors were committed, in general, in the 4HV segment during Block 1. If only performance errors were considered, however, the number of errors occurring in the 4HV segment (14) and the 4LV segment (13) were very similar (Table 10).

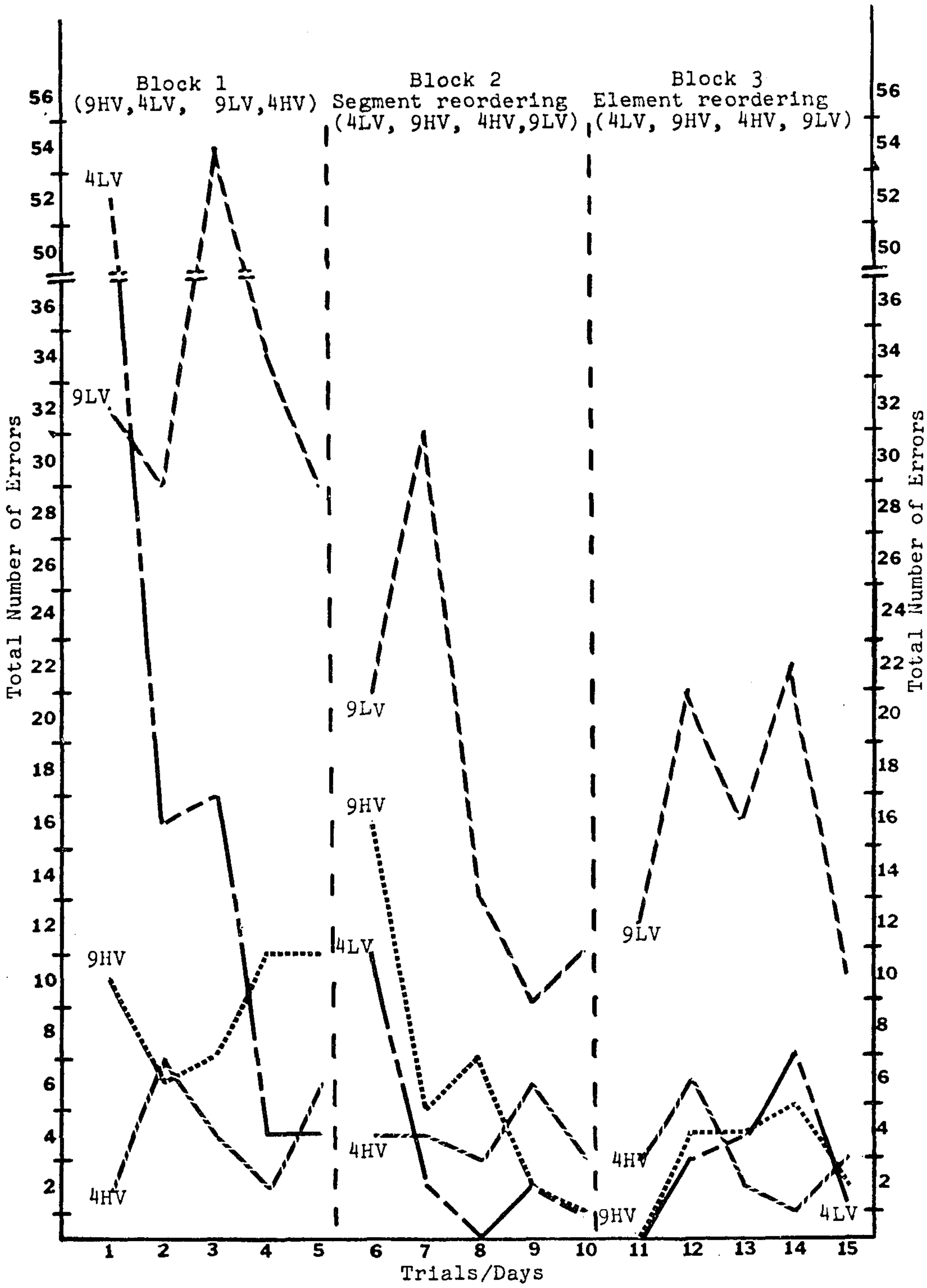


Figure 32. Error occurrences in each of the four segments for subject 1.

The pattern of error occurrence in the 4HV segment was fairly stable in Block 2. Three or four errors were all that Subject 1 committed in this segment except for Day 9 (6 errors). Element performance was generally more accurate in the 9HV segment as trials in Block 2 progressed. On Days 9 and 10, only one or two errors occurred in this segment. For the 4LV segment, more errors occurred on the first day in Block 2 than on the last two days in Block 1. Most of these (9) were obstacle errors (Table 10). The total errors depicted in Figure 32 for the last four days in this segment were all obstacle errors. This segment, therefore, had the fewest actual performance errors (2) during Block 2. Again, Subject 1 committed the most errors in the 9LV segment. All types of errors decreased, however, from the number committed in Block 1. The most errors in this segment were still obstacle errors (5-21) on all days except Day 8.

In Block 3, more errors were committed in the 9LV segment than for all other segments. More performance errors were committed in this segment during Block 3 (37) than were committed in Block 2 (33). On the first four trials in Block 3, performance was less accurate than it had been on the last two trials in Block 2. The total number of errors in all other segments stayed approximately within the same range (0-7). In the 9HV segment and 4LV segment, however, errors increased on three of the first

Table 10

Number of Cue Referrals, Map Referrals, and Errors per Trial:

Subject 1

Segment	9HV Segment						4LV Segment						9LV Segment						4HV Segment					
Trials	1	2	3	4	5	Tot.	1	2	3	4	5	Tot.	1	2	3	4	5	Tot.	1	2	3	4	5	Tot.
Cue Referrals																								
Before Perform.	9	9	9	9	9	45	9	9	9	9	9	45	10	9	9	9	9	46	9	9	9	9	9	45
During Perform.	0	2	2	1	0	5	1	1	1	2	1	6	1	2	7	3	2	15	2	3	3	1	0	9
Map Referrals																								
Before Perform.	10	8	1	0	0	19	8	2	1	1	0	12	9	7	2	1	1	20	1	1	0	1	0	3
During Perform	1	3	3	2	1	10	1	0	0	0	0	1	1	3	6	4	1	15	0	0	0	0	0	0
Errors																								
Performance	4	4	6	10	8	32	7	0	3	2	1	13	4	16	15	5	9	49	2	5	4	1	2	14
Key Contact	6	2	1	1	3	13	0	0	0	0	0	0	2	1	1	1	1	6	0	2	0	1	4	7
Obstacle	0	0	0	0	0	0	45	16	14	2	3	80	26	12	38	28	19	123	0	0	0	0	0	0
						45						93						178						21

Segment	9HV Segment						4LV Segment						9LV Segment						4HV Segment					
Trials	6	7	8	9	10	Tot.	6	7	8	9	10	Tot.	6	7	8	9	10	Tot.	6	7	8	9	10	Tot.
Cue Referrals																								
Before Perform.	9	9	9	9	9	45	9	9	9	9	9	45	9	9	9	9	9	45	9	9	9	9	9	45
During Perform.	0	0	0	0	0	0	1	0	0	0	0	1	1	2	3	0	0	6	3	2	2	1	3	11
Map Referrals																								
Before Perform.	2	0	0	0	0	2	0	0	0	0	0	0	3	3	0	0	0	6	0	0	0	0	0	0
During Perform.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	3	0	0	0	0	0	0
Errors																								
Performance	11	5	6	2	1	25	2	0	0	0	0	2	10	10	8	4	1	33	4	4	2	5	3	18
Key Contact	5	0	1	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	2
Obstacle	0	0	0	0	0	0	9	2	0	2	1	14	11	21	5	5	10	52	0	0	0	0	0	0
						31						16						85						20

Segment	9HV Segment						4LV Segment						9LV Segment						4HV Segment					
Trials	11	12	13	14	15	Tot.	11	12	13	14	15	Tot.	11	12	13	14	15	Tot.	11	12	13	14	15	Tot.
Cue Referrals																								
Before Perform.	9	9	9	9	9	45	9	9	9	9	9	45	9	9	9	9	9	45	9	9	9	9	9	45
During Perform.	0	1	1	0	0	2	0	0	0	0	1	1	1	1	2	0	0	4	2	3	1	0	0	6
Map Referrals																								
Before Perform.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
During Perform.	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	1	0	5	0	0	0	0	0	0
Errors																								
Performance	0	3	1	3	2	9	0	1	0	6	0	7	8	9	7	8	5	37	3	6	2	1	3	15
Key Contact	0	1	3	2	0	6	0	0	0	1	0	1	0	2	0	1	0	3	0	0	0	0	0	0
Obstacle	0	0	0	0	0	0	0	2	4	0	1	7	4	10	9	13	5	41	0	0	0	0	0	0
						15						15						81						15

four days. In the 4LV segment, this increase was due primarily to an increase in the number of performance errors (from 2 in Block 2 to 7 in Block 3). All of the errors depicted in Figure 32 for the 4HV segment were performance errors. During Block 3, the fewest performance errors were committed in the 4LV (7) and 9HV segment (9).

Cue and Map Referrals

As noted in Table 10, Subject 1 referred to each cue in a segment on all 15 trials. On the first trial, she checked one cue twice in the 9LV segment before beginning performance. Subject 1 had 35 additional cue referrals (during performance) for the trials in Block 1. Most of these were for the 9LV segment (15) and the 4HV segment (9). This pattern was also true in Block 2, although more cue referrals were necessary during performance for the 4HV segment (11) than for the 9LV segment (6). In Block 3, only 13 cue referrals were made during performance. Nearly half of these (6) were made in the 4HV segment.

Subject 1 referred to the maps most often for the two segments with nine stations (9HV and 9LV segments) during Block 1. This pattern was also true for the number of map referrals during performance. In Block 2, she only referred to the maps for the 9HV and 9LV segments. In Block 3, map referrals were made only for the 9LV segment. Questioning of this subject following the 15th trial revealed that she never realized that the maps for these two segments were mirror images of one another.

Summary of Performance Breaks for Subject 1

Subject 1 made no attempts to perform element requirements in any segment without first referring to a cue. The number of cue referrals during performance, however, decreased throughout the 15 trials, regardless of the intervention strategy. Two segments (9LV and 4HV) accounted for most of these cue referrals. In Blocks 2 and 3, more were made for the 4HV segment than for the 9LV segment.

Station locations in the two segments with four stations (4LV and 4HV) were apparently easier for Subject 1 to remember. Occasional map reference was necessary for the two segments with nine stations (9LV and 9HV) throughout all three blocks of trials. On Day 12, Subject 1 commented that the stations located on the edges of the segment area (5, 7, 9, and 2) were easy for her to remember. The ones "in the middle" gave her the "most difficulty."

More errors occurred in the low visual segments than in the high visual segments throughout all 15 trials. Most errors in the low visual segments, however, were obstacle errors. If only performance errors were considered, the fewest errors occurred in the 4LV segment during all three blocks of trials. The most such errors occurred in the 9LV segment during Blocks 1, 2, and 3.

Subject 2

Errors

The total number of errors committed by Subject 2 in each segment is presented in Figure 33. In Block 1, there were three distinct patterns of error occurrence. Total errors fluctuated day-by-day in the 9LV segment and were greatest in this segment. The fewest errors were committed in the 4HV segment. Although the profile for the 9HV segment was more stable, approximately the same number of errors were committed in this segment and the 4LV segment. Only on Day 2 was there a large difference between the number of errors in these two segments. As noted in Table 11, the most actual performance errors occurred in the 9HV segment (25). If it had not been for the great number of obstacle errors in the 9LV segment (97), the profile for this segment would have been more like those of the 9HV and 4LV segments.

In Block 2, very few errors (0-3) were committed in the 4HV segment. Only one of these errors was an actual performance error; all others were key contact errors. Element performance of the 9HV segment was more accurate than in Block 1, even though errors increased on Days 9 and 10. The large increase in the number of errors in the 4LV segment from Day 5 to Day 6 was largely due to the number of obstacle errors on Day 6 (13). Following Day 6, the number of errors in this segment stayed relatively stable (2-6). Of the total errors

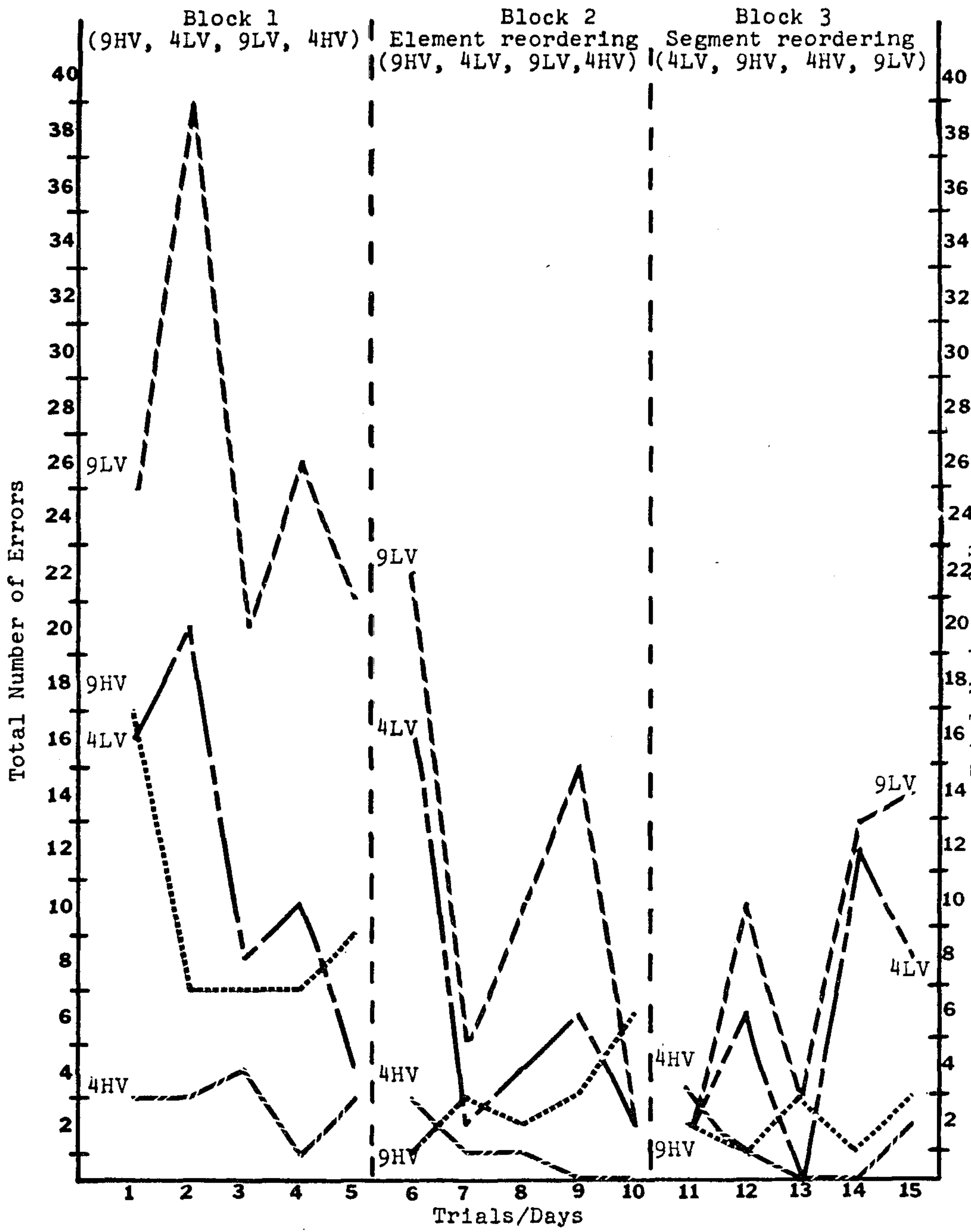


Figure 33. Error occurrences in each of the four segments for subject 2.

Table 11
Number of Cue Referrals, Map Referrals and Errors per Trial:
Subject 2

Segment	9HV Segment						4LV Segment						9LV Segment						4HV Segment					
Trials	1	2	3	4	5	Tot.	1	2	3	4	5	Tot.	1	2	3	4	5	Tot.	1	2	3	4	5	Tot.
Cue Referrals																								
Before Perform.	9	9	9	9	9	45	9	9	9	9	9	45	9	9	9	9	9	45	9	9	9	9	9	45
During Perform.	10	5	5	4	2	26	8	2	0	2	2	14	3	4	0	3	3	13	3	0	4	0	1	8
Map Referrals																								
Before Perform	8	8	4	0	0	20	10	1	0	0	0	11	10	9	2	0	0	21	2	0	0	0	0	2
During Perform	5	3	1	0	0	9	5	1	0	0	0	6	5	4	1	0	0	10	0	0	0	0	0	0
Errors																								
Performance	9	4	3	3	6	25	8	3	1	3	2	17	5	5	4	4	3	21	3	2	1	1	1	8
Key Contact	8	3	4	4	3	22	1	1	1	0	0	3	8	2	2	1	0	13	0	1	3	0	2	6
Obstacle	0	0	0	0	0	0	7	16	6	7	2	38	12	32	14	21	18	97	0	0	0	0	0	0
						47						58						131						14

Segment	9HV Segment						4LV Segment						9LV Segment						4HV Segment					
Trials	6	7	8	9	10	Tot.	6	7	8	9	10	Tot.	6	7	8	9	10	Tot.	6	7	8	9	10	Tot.
Cue Referrals																								
Before Perform.	9	9	9	9	9	45	9	9	9	9	9	45	9	9	9	9	9	45	9	9	9	9	9	45
During Perform.	4	1	0	1	1	7	2	1	0	3	1	7	1	0	2	1	0	4	0	0	0	0	0	0
Map Referrals																								
Before Perform.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
During Perform.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Errors																								
Performance	1	2	0	2	4	9	2	2	3	3	1	11	2	1	1	0	0	4	1	0	0	0	0	1
Key Contact	0	1	2	1	2	6	1	0	1	0	1	3	0	0	1	0	0	1	2	1	1	0	0	4
Obstacle	0	0	0	0	0	0	13	0	0	3	0	16	20	4	8	14	2	48	0	0	0	0	0	0
						15						30						53						5

Segment	9HV Segment						4LV Segment						9LV Segment						4HV Segment					
Trials	11	12	13	14	15	Tot.	11	12	13	14	15	Tot.	11	12	13	14	15	Tot.	11	12	13	14	15	Tot.
Cue Referrals																								
Before Perform.	9	9	9	9	9	45	9	9	9	9	9	45	9	9	9	9	9	45	9	9	9	9	9	45
During Perform.	0	0	1	0	0	1	1	2	0	1	0	4	1	2	1	0	1	5	0	0	0	0	1	1
Map Referrals																								
Before Perform.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
During Perform.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Errors																								
Performance	2	1	1	1	2	7	2	2	0	1	1	6	1	3	2	0	1	7	3	1	0	0	2	6
Key Contact	0	0	2	0	1	3	9	0	0	1	0	1	0	0	0	1	0	1	0	0	0	0	0	0
Obstacle	0	0	0	0	0	0	0	4	0	10	7	21	1	7	1	12	13	34	0	0	0	0	0	0
						10						28						42						6

occurring in the 9LV segment, only 4 were actual performance errors. In fact, the fewest actual performance errors occurred in this segment and the 4HV segment (1).

In Block 3, element performance in the two high visual segments was very accurate. The maximum number occurring in either high visual segment was three. No errors occurred in the 4HV segment on two trials (13 and 14) or in the 4LV segment on one trial (13). The number of errors in both low visual segments rose sharply on the 14th trial. On this day, failure to avoid obstacles accounted for the majority of errors occurring in the 9LV (12) and 4LV (10) segments. The total number of actual performance errors occurring in Block 3 was identical for both of the four-station segments and for both of the nine-station segments. Six performance errors occurred in the 4LV and 4HV segments, while seven occurred in the 9LV and 9HV segments.

Cue and Map Referrals

As shown in Table 11, Subject 2 referred to each cue before performance of every element on all 15 trials. Sixty-one additional cue referrals were necessary in Block 1. Most of these were made while performing the 9HV segment (26) Frequencies of cue referral during performance decreased in Blocks 2 and 3. Most of these were made for the 9HV (7) and 4LV (7) segments in Block 2, and for the 4LV segment (4) and 9LV segment (5) in Block 3.

In Block 1, Subject 2 made approximately the same number of map referrals for the 9HV segment (29), 4LV segment (20), and 9LV segment (31). Only two were made during performance of the 4HV segment, both on Day 1. Prior to beginning her trials on Day 3, Subject 2 asked if she could make a copy of the maps for the 9LV and 9HV segments to study overnight. When she began her performance of the 9LV segment, however, she suddenly realized that these two maps were the "same." Subsequently, she made no map referrals in any segment.

Summary of Performance Breaks for Subject 2

Subject 2 did not attempt to perform any elements without first referring to the cues. The most referrals made during performance were in the 9HV segment in Block 1. In Block 2, more were necessary for both high visual segments, and in Block 3, most cue referrals during performance were for the 9HV and 4LV segments. Referral to maps ended following Day 3. The most map referrals on these three days were for the segments with nine stations (9LV and 9HV).

Performance was generally least accurate in the low visual segments throughout all 15 trials. Failure to avoid the obstacles in these segments accounted for the majority of the total errors in Blocks 1 and 2, and on some trials in Block 3. When only performance errors were considered, fewer errors were committed in both low visual segments than in the 9HV segment during Block 1. In Block 2, the fewest performance errors were committed in the 9LV and 4HV segments. During Block 3, these errors were approximately the same in all four segments.

Subject 3

Errors

Figure 34 shows the total number of errors in each segment for the 15 trials. Note that the error axis was broken to accommodate the number of errors in the 9LV segment during Blocks 1 and 2. On three trials in Block 1 (1, 3, and 5), more errors were committed in the 9LV segment than in any other segment. No consistency was demonstrated in this segment, as a change in the trend was noted every day. For the 9HV segment, the number of errors increased for the first four days and then decreased sharply on Day 5 (from 36 to 16). In the 4LV segment, on the other hand, errors generally decreased throughout the trials in Block 1. Fewer errors were committed in this segment than in the 9HV segment on Days 3, 4, and 5. The number of errors in the 4HV segment remained approximately the same (6-8) for the last four days in Block 1. Table 12 gives a more detailed summary of the types or errors which occurred in each segment. As noted in this table, the fewest actual performance errors were committed in the 4LV segment in Block 1. More performance errors occurred in the 9HV segment than in the 9LV segment. The profile

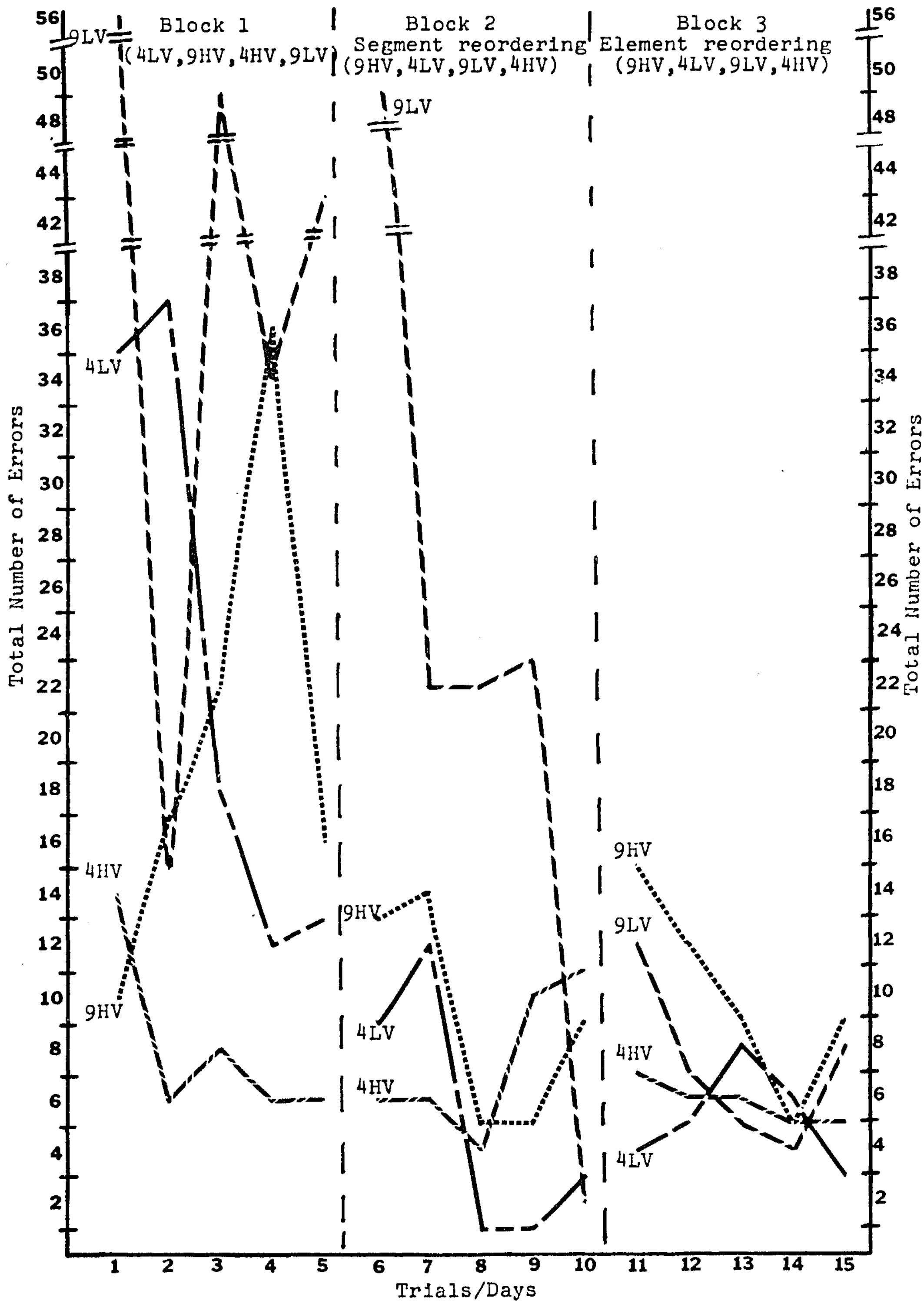


Figure 34. Error occurrences in each of the four segments for subject 3.

Table 12
Number of Cue Referrals, Map Referrals and Errors per Trial:
Subject 5

Segment	4LV Segment						9HV Segment						4HV Segment						9LV Segment					
Trials	1	2	3	4	5	Tot.	1	2	3	4	5	Tot.	1	2	3	4	5	Tot.	1	2	3	4	5	Tot.
Cue Referrals																								
Before Perform.	9	9	9	9	9	45	9	9	10	9	9	46	9	9	9	9	9	45	9	9	9	9	9	45
During Perform.	4	4	2	1	3	14	0	0	2	1	3	6	3	3	2	0	2	10	5	6	3	7	4	25
Map Referrals																								
Before Perform.	1	0	0	0	0	1	6	8	4	1	3	22	0	1	0	1	1	3	4	8	7	6	7	32
During Perform.	3	0	0	0	0	3	2	4	2	1	0	9	0	0	0	0	0	0	9	6	4	2	0	21
Errors																								
Perform.	6	7	5	4	3	25	3	13	17	25	11	69	14	3	8	6	6	37	9	10	11	11	10	51
Key Contact	7	0	0	0	0	7	7	4	5	11	5	32	0	3	0	0	0	3	3	0	1	0	0	4
Obstacle	22	30	13	8	10	83	0	0	0	0	0	0	0	0	0	0	0	0	44	5	39	23	33	144
						115						101						40						199

	4LV Segment						9HV Segment						4HV Segment						9LV Segment					
Trials	6	7	8	9	10	Tot.	6	7	8	9	10	Tot.	6	7	8	9	10	Tot.	6	7	8	9	10	Tot.
Cue Referrals																								
Before Perform.	9	9	9	9	9	45	9	9	9	9	9	45	9	9	9	9	9	45	9	9	9	9	9	45
During Perform.	1	1	1	0	1	4	1	1	2	0	0	4	0	2	1	3	6	12	6	3	2	4	0	15
Map Referrals																								
Before Perform.	0	0	0	0	0	0	1	2	0	0	0	3	0	0	0	0	0	0	5	2	1	0	0	8
During Perform.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	1	0	0	4
Errors																								
Performance	2	2	1	1	3	9	9	12	4	4	7	36	5	4	3	9	11	32	13	9	9	8	2	41
Key Contact	0	0	0	0	0	0	4	2	1	1	2	10	1	2	1	1	0	5	0	0	0	0	0	0
Obstacle	7	10	0	0	0	17	0	0	0	0	0	0	0	0	0	0	0	0	37	13	13	15	0	78
						26						46						37						119

	4LV Segment						9HV Segment						4HV Segment						9LV Segment					
Trials	11	12	13	14	15	Tot.	11	12	13	14	15	Tot.	11	12	13	14	15	Tot.	11	12	13	14	15	Tot.
Cue Referrals																								
Before Perform.	9	9	9	9	8*	44	9	9	9	9	9	45	9	9	9	9	9	45	9	9	9	9	9	45
During Perform.	1	1	1	0	1	4	0	0	3	0	2	5	3	5	3	1	1	13	2	1	4	1	1	9
Map Referrals																								
Before Perform.	0	0	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
During Perform.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Errors																								
Performance	3	2	2	1	2	10	10	8	6	3	9	36	3	5	3	1	3	15	7	3	5	1	5	21
Key Contact	0	0	0	0	0	0	5	4	3	2	0	14	4	1	3	4	2	14	0	0	0	0	1	1
Obstacle	1	3	6	5	1	16	0	0	0	0	0	0	0	0	0	0	0	0	5	4	0	3	3	15
						26						50						29						37

*Subject attempted to perform without cue referral.

for the 9LV segment would have been different if so many obstacle errors (5-44) had not been committed.

For the first four trials in Block 2, the number of errors in the 9LV segment was still greater than in any other segment. Again, most of these errors were obstacle errors (13-77). Subject 3 performed the elements in both the 4LV and 9HV segments more accurately in Block 2 than in Block 1. On the last three days in Block 2, fewer errors were committed in the 4LV segment than in either of the high visual segments. The least number of performance errors also occurred in the 4LV segment during Block 2.

In Block 3, a fairly stable profile of error occurrence was evident for the 4HV segment. Errors decreased in the 9HV and 9LV segments for the first four days in Block 3, and then increased by four errors on Day 15. Errors in the 4LV segment, on the other hand, increased for the first three trials in Block 3, and then decreased on the last two trials. For the first three trials in Block 3, the most errors occurred in the 9HV segment. This was different from most trials in Block 1 and Block 2 when the most errors were noted in the 9LV segment. Actual performance errors were less in the 4HV and 4LV segments in Block 3. This pattern was consistent throughout all three blocks of trials.

Cue and Map Referrals

As noted in Table 12, Subject 3 made one cue referral per element before contacting the element key on all days except two (3 and 15). On Day 15, she attempted to perform the first element in the 4LV segment without first referring to the cue. She was unable to perform this element correctly, however, and had to return to the cue. Subject 3 checked the cues 55 times during performance in Block 1. Most of the total number of extra cue referrals were in the 9LV segment (25) and the 4LV segment (14). In Block 2, more of the additional cue referrals were made for the 9LV segment (15) than for the 4HV segment (12). This pattern was reversed in Block 3, when more occurred in the 4HV segment (13) than in the 9LV segment (9).

Subject 3 made more map referrals for the 9LV (32) and 9HV (22) segments than for the 4LV and 4HV segments during Block 1. No map referrals were made for these segments following Day 7 (9HV) and Day 8 (9LV). Map referral virtually ended in the 4LV and 4HV segments following Block 1. One map referral was made in each of these two segments, however, on Day 13.

Summary of Performance Breaks for Subject 3

Subject 3 attempted to perform one element in the 4LV segment without cue referral in Block 3. This attempt was unsuccessful. During Blocks 2 and 3, more additional cue referrals were necessary for the 9LV and 4HV segments. In Block 2, most of these were for the 9LV segment and in Block 3 most occurred in the 4HV segment. Map referrals in the 4HV and 4LV segments generally ended after Block 1, although one map referral was made in each of these segments in Block 3. Map referrals in the 9LV and 9HV segments ended on the ninth or tenth trial.

Performance was least accurate in the 9LV segment in Block 1 and part of Block 2. Many of the errors in this segment were accounted for by failure to avoid obstacles. For the first three trials in Block 3, however, more errors occurred in the 9HV segment than in either of the low visual segments. The least performance errors occurred in the 4LV and 4HV segments throughout the three blocks of trials.

Subject 4

Errors

Figure 35 shows the total number of errors committed by Subject 4 in each segment for the 15 trials. During Block 1, more errors generally were made in the 9LV segment than in any other segment. An exception to this pattern was on Day 1 when more errors were committed in the 4LV segment. Error occurrence dropped fairly consistently for the two low visual segments during Block 1. This decrease occurred sooner in the 4LV segment (Day 2) than in the 9LV segment. On Day 5, the fewest errors were committed in the 4LV segment. Subject 4 committed more errors in the 9HV segment than in the 4HV segment throughout all five trials in Block 1. As noted in Table 13, fewer actual performance errors occurred in the 4LV segment (18) than in the 4HV segment (29). This same pattern was true for the 9LV segment (36) and the 9HV segment (49).

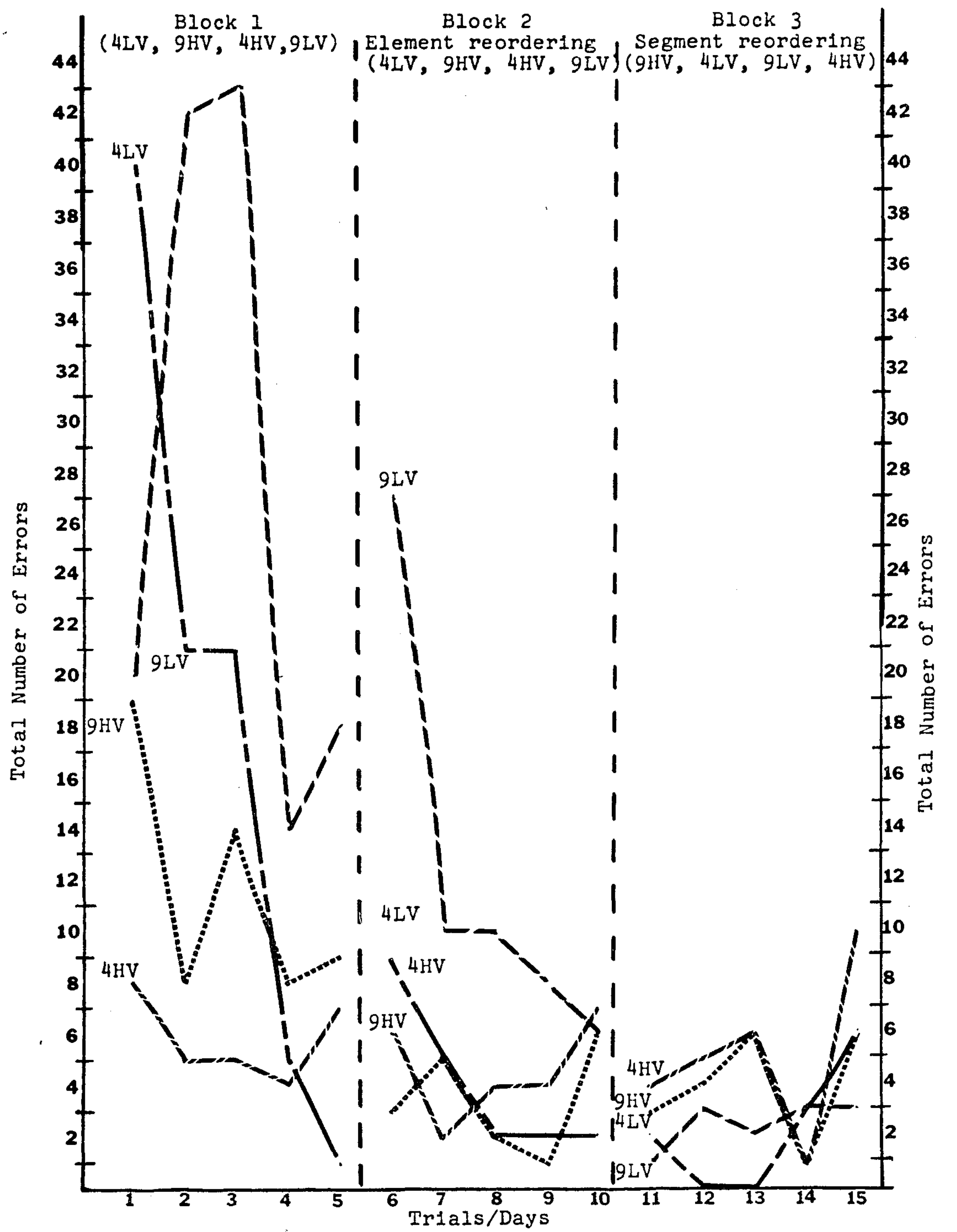


Figure 35. Error occurrences in each of the four segments for subject 4.

Table 13
Number of Cue Referrals, Map Referrals, and Errors per Trial:
Subject 4

Segment	4LV Segment						9HV Segment						4HV Segment						9LV Segment					
Trials	1	2	3	4	5	Tot.	1	2	3	4	5	Tot.	1	2	3	4	5	Tot.	1	2	3	4	5	Tot.
Cue Referrals																								
Before Perform.	9	9	9	9	9	45	9	9	9	9	9	45	9	9	9	9	9	45	9	9	9	9	9	45
During Perform.	4	1	0	0	0	5	5	4	1	3	1	14	3	1	3	4	1	12	6	7	3	3	1	20
Map Referrals																								
Before Perform.	0	1	1	0	0	2	0	1	0	1	0	2	1	1	0	0	0	2	0	0	0	0	0	0
During Perform.	0	0	0	0	0	0	6	0	0	0	0	6	1	1	0	0	0	2	3	2	2	0	0	7
Errors																								
Performance	10	4	2	1	1	18	15	6	13	6	9	49	6	4	5	4	6	25	17	7	6	5	1	36
Key Contact	3	0	0	0	0	3	4	2	1	2	0	9	2	1	0	0	1	4	0	0	0	0	0	0
Obstacle	27	17	19	4	0	67	0	0	0	0	0	0	0	0	0	0	0	0	3	35	37	9	17	101
						88						58						29						137

	4LV Segment						9HV Segment						4HV Segment						9LV Segment					
Trials	6	7	8	9	10	Tot.	6	7	8	9	10	Tot.	6	7	8	9	10	Tot.	6	7	8	9	10	Tot.
Cue Referrals																								
Before Perform.	9	9	9	9	9	45	9	9	8*	8*	8*	42	9	9	9	9	9	45	9	9	9	9	9	45
During Perform.	1	0	1	0	1	3	0	5	4	2	3	14	4	2	5	4	4	19	2	2	3	3	2	12
Map Referrals																								
Before Perform.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
During Perform.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Errors																								
Performance	1	3	2	0	1	7	3	4	2	1	5	15	5	2	4	4	6	21	7	8	6	4	5	30
Key Contact	0	0	0	0	0	0	0	1	0	0	1	2	1	0	0	0	1	2	0	0	0	0	0	0
Obstacle	8	2	0	2	1	13	0	0	0	0	0	0	0	0	0	0	0	0	20	2	4	4	1	31
						20						17						23						61

	4LV Segment						9HV Segment						4HV Segment						9LV Segment					
Trials	11	12	13	14	15	Tot.	11	12	13	14	15	Tot.	11	12	13	14	15	Tot.	11	12	13	14	15	Tot.
Cue Referrals																								
Before Perform.	9	9	9	9	9	45	9	8*	7*	9	3*	36	9	8*	9	9	7*	42	9	9	9	9	9	45
During Perform.	1	0	0	0	1	2	2	3	1	0	3	9	4	4	2	1	0	11	0	0	0	1	0	1
Map Referrals																								
Before Perform.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
During Perform.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Errors																								
Performance	1	0	0	0	1	2	3	4	6	1	6	20	3	5	6	1	10	25	1	1	0	2	0	4
Key Contact	0	0	0	0	2	2	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
Obstacle	0	0	0	3	7	10	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	1	3	8
						14						20						26						12

*Subject attempted to perform without cue referral.

In Block 2, more errors occurred in the 9LV segment on the first four days than in any other segment. On Day 6, more errors occurred in this segment than had occurred on the last two trials in Block 1. On subsequent days, however, fewer errors were committed in this segment than on any of the trials in Block 1. More errors also occurred in the 4LV segment on the first day of Block 2 than on the last two days of Block 1. Performance of the 9HV segment was more accurate in Block 2 than in Block 1. In the 4HV segment, the error profile remained at approximately the same level in Blocks 1 and 2. Only on Day 7 was performance more accurate than in Block 1. As noted in Table 13, the least actual performance errors occurred in the 4LV (7) and 9HV (15) segments during Block 2.

For the first three trials in Block 3, fewer total errors were committed in the two low visual segments than in the high visual segments. In fact, on Days 12 and 13, no errors were made in the 4LV segment. The number of errors in the high visual segments remained at approximately the same level as in Block 2. Only the number of errors noted in the 4HV segment on Day 15 was greater than on any other trial. The fewest actual performance errors in Block 3 occurred in the 4LV segment (1) and 9LV segment (3).

Cue and Map Referrals

As noted in Table 13, Subject 4 referred to each cue in the low visual segments throughout all 15 trials. During Block 2, she obviously was attempting to remember the performance requirements in the 9HV segment without using a cue. On Days 8-10, she attempted either the first or last element without referring to a cue. She was not successful, however, and had to refer to the cues after errors were made. On Days 12 and 13, she unsuccessfully attempted the first element in the 9HV segment. On Day 13, however, she did perform the last element in this segment successfully. On Day 15, she attempted to perform all but three elements (3, 6, and 7) without cue referral. She was only successful for the first element. For all the other elements, errors occurred or additional cue referrals were necessary.

No attempts were made to perform without cue referral in the 4HV segment during Blocks 1 and 2. For two trials in Block 3, she attempted to perform elements in this segment without cue referral. She attempted to perform the first element on Day 12 and the first and eighth elements on Day 15 without cue referral. She was not successful in these attempts. At the end of her trial on Day 15, she commented that "she had not learned much in this [4HV] segment."

Subject 4 generally was able to perform without map referral following Block 1. In Block 1, the most map referrals were for the two segments with nine stations. In Block 2, she referred to the map only once (during performance) for any segment. This referral was in the 9LV segment.

Summary of Performance Breaks for Subject 4

Subject 4 successfully performed two elements in the 9HV segment without cue referral in Block 3. She also attempted to perform two elements without first referring to cues in the 4HV segment in this block. However, errors resulted in these two attempts. All but one attempt to perform without cue referral were on either the first or last element. Cues in the low visual segments were used before performance on all trials. Cue referrals made after performance had begun, however, were more prevalent in the high visual segments in Blocks 2 and 3. Map reference was needed most often for the 9LV and 9HV segments in Block 1. Subject 4 referred to a map only one more time in the remaining two blocks of trials.

When all performance aspects were considered, the most errors occurred in the 9LV segment during Blocks 1 and 2. Most of these errors were due to failure to avoid the obstacles. In Block 3, fewer errors were made in the low visual segments on the first three days than in the high visual segments. A possible intervention effect was noted in Block 2, following the element reordering. More errors occurred in the first four trials of Block 2 than had occurred on the last two days in Block 1. This pattern was true for the low visual segments. The total number of actual performance errors was less in the 9LV and 4LV segments during Blocks 1 and 3. The fewest performance errors in Block 2 were in the 4LV and 9HV segments.

Discussion of Findings

Many different aspects had to be organized before accurate performance could occur. On the first day, subjects were confronted with a task with which, as a whole, they were not familiar. They had to organize, in some way, all the information in a rather lengthy set of instructions so that they could perform even a correct sequence of segments. The recall of specific elements within these segments involved remembering the requirements from the cues and performing these requirements without any errors or references to the maps and cues.

Only two subjects attempted to perform without cue referral. Subjects 3 and 4 each had at least one trial in which such an attempt was made. Subjects 3 and 4 were also the two younger subjects, 61 and 66 years of age respectively. Studies (Denney, 1974; Murphy et al., 1981; Taub & Walker, 1972) found that older individuals had difficulty organizing material for recall. Murphy et al. (1981) found that even in experimental conditions which allowed self-pacing, older subjects took longer to select and use an organizational strategy. The fact that only the two younger subjects in the present study attempted recall seems to indicate that they selected and used such a strategy quicker than the other two subjects. Subject 3 attempted to perform without cue referral only on the last trial. On Day 15, she was unsuccessful in her attempt to perform the first element in a low visual segment (4LV) without cue referral. No other attempts were made in any segment. Subject 4, therefore, was the only one who demonstrated a recalled motor sequence.

Subject 4 was able to perform one element accurately in the 9HV segment without any cue or map referrals. These accurate performances were on Days 13 and 15 in Block 3. The particular elements completed without cue referral were the last one on Day 13 and the first one of Day 15. On several other trials, Subject 4 attempted to perform without cue referral in either the 9HV segment or the 4HV segment. In general, only the first or last few elements were attempted on these trials (Days 8, 9, 10, and 12). Although these attempts were not accurate, the fact that only the first or last elements were attempted indicated that serial position effects occurred. In contrast, the time data used for Question 2 indicated that no serial position effects occurred in either high visual segment during Block 3. In Block 2, only a recency effect was noted in the cue referral profile for the 4HV segment. As indicated by the accuracy measures for this question, Subject 4 apparently was remembering at least some of the items on the first or last cues. The conflicting results obtained for this question and Question 2 may have been due to the averaging of the time measures across the five trials in a block. The raw data for Subject 4 (Appendix E, pp. 288-295) however, did not indicate this. Only the time data for Day 15 gave any indication of serial effects in element performance or cue referral times. It appeared, therefore, that for this subject, the accuracy measures were more efficient in eliciting serial position effects than the time measures.

In other studies of serial position effects in gross motor tasks (Cratty, 1962; 1963; Singer, 1968), either speed <u>or</u> accuracy was the performance measure. No consistent results were obtained in these studies. Studies of fine motor performance recall (Magill & Dowell, 1977; Wrisberg, 1975; Zaichkowsky, 1974), on the other hand, consistently revealed a recency-primacy effect when an accuracy measure (absolute error) was used. In the present study, only isolated recency-primacy effects occurred in the time measures for all subjects (Question 2). Since Subject 4 was the only one to perform without cue referral, the relative efficacy of a speed measure or an accuracy measure cannot be determined. It appeared, however, that for this subject, the accuracy measure was the more sensitive one.

It is interesting to note that Subject 4 was able to perform without cue referral only in the high visual segments. Her score on the Rod-and-Frame test also indicated that she tended toward field dependency. Field dependent individuals tend to learn faster in those situations in which cues are salient (Witken et al., 1977). Although cues in both the low visual and high visual segments were pertinent to the element performances, information from the cues in the high visual segments was obtained from the more predominately used visual modality. In addition, the segment areas (field) were more structured for the high visual segments than for the low visual segments. It appeared that the cues and the structure of the visual field were more suitable to the preferred learning style of Subject 4.

For the other three subjects, the total amount of information was apparently beyond the memory span (Miller, 1956). These subjects generally used the cue prior to element performance on each trial. The data indicated that all subjects attempted to learn the station locations first. Following Day 3, no map referrals were made in any segments by Subject 2. This subject ended map referral in the 4LV and 4HV segments earlier than in the 9LV and 9HV segments. Subjects 1, 3, and 4 continued to use the maps in Block 2, but only for the 9LV and 9HV segments. Station locations in these segments were identical, but were in mirror image to each other (see Appendix A, p. 242). No readily discernible pattern was evident in the positioning of these stations. Subject 2 was the first to realize that the two nine-station segments were the same. Subject 1 apparently had the most difficulty with these stations as she continued to use the map for the 9LV segment through the trials in Block 3. Based on scores achieved on the Space Relations test, these findings were surprising. It was thought that subjects who scored high on this test would have less difficulty in learning the information from the maps. This was not the case, as Subject 1 used the maps the longest but had the highest score on the Space Relations test (18). Subject 4, who had the lowest score on the test (4) had no more difficulty with this aspect of performance than Subjects 2 and 3. Perhaps the amount of time allowed for aspects of the serial gross motor task and for the Space Relations test resulted in these differences. Subjects set their own pace for completion of all aspects of the serial gross motor task. Only 25 minutes were allowed for completion of the 60 items on the Space Relations test. It was possible, therefore, that the time constraints under which the Space Relations test was completed resulted in scores which were not representative of what could be accomplished under different task conditions.

No other consistent patterns of recall of performance aspects (key contacts, obstacle errors, performance errors, cue referrals) emerged. Errors in element performance indicated that performance was the least accurate in the nine-station segments during the early trials. Subjects 1, 2, and 3 had the most errors in the 9LV and 9HV segments during the first block of five trials. This pattern was also true for Subjects 1 and 3 for the trials in Blocks 2 and 3. The least performance errors for these two subjects on all trials were in the 4LV segment. No consistent pattern emerged for the performance errors of Subject 2 for the trials in Blocks 2 and 3. Subject 2 had the most errors in the 4LV segment during Block 2 and the least in the 4HV segment. During Block 3, errors in all segments were approximately equal. Both nine-station segments, however, had one more error (7) than the four-station segments (6).

The above data for Subjects 1 and 3 also indicated that actual performance of the elements was more accurate in the 4LV segment than in the high visual segments. These data indicated a different pattern from that found for the time data in Question 1. Cue referral and element performance times generally remained faster in the high visual segments throughout all trials. The error data, on the other hand, indicated the performances of Subjects 1 and 3 were the most accurate in the 4LV segment for all 15 trials. Thus, these data would seem to indicate that performance was more accurate in one segment which had a predominance of tactile/ kinesthetic cues. As was discussed in Question 2, this finding was possibly related to the type of information contained on the cues in the two different types of segments. Cues in the low visual segments contained information related to a single category (shape). Two or three separate categories of information were contained on the high visual cues. Thus, performance was more accurate in those segments with the same category cues than in those segments with different category cues (Murdock, 1976).

In summary, only one subject was able to accurately recall a motor sequence. Subject 4 correctly performed only the first or last elements in a sequence. In addition, she unsuccessfully attempted the first or last elements on other trials. These facts indicated, contrary to what the results for Question 2 demonstrated, that serial position effects occurred in the high visual segments. No attempts were made by this subject to recall information in the low visual segments. Data for the other subjects indicated that they learned the station locations first, particularly for the four-station segments. No other consistent patterns for the recall of performance aspects were evident for these subjects. Changes which occurred in the performance breaks data were possibly due to practice effects and were not influenced by the interventions.

The answer to Question 3, therefore, could only be determined in regard to the data for Subject 4. It appeared that serial position effects emerged in the recall of a motor sequence in the high visual segments. Recall was attempted only during the last half of the 15 trials and was successful only on two of the last three days. This fact, again, appears to have indicated that practice of performance was necessary before recall was demonstrated. Since Subject 4 attempted recall following both intervention strategies (element reordering and segment reordering), no apparent intervention effects were noted. Although errors increased on some of the trials in which recall was attempted, no consistent relationship of error occurrence and recall was evident. Therefore, no attempt was made to answer Question 3-d.

Question 4: How does the time utilized for self-pacing intervals affect the performance of various segments of the task?

The time between the completion of one segment and the beginning of the subsequent segment was termed the self-pacing interval. During the self-pacing interval, the subjects could use as much time as they needed to study the maps, review the requirements of the segment, and generally get ready for the performance of the segment. It was thought that the time used for the self-pacing interval preceding the different types of segments would be different. In addition, changes in the self-pacing interval times across the 15 trials and some relationships between these times and other performance aspects were expected. Thus, the following more specific questions were formulated to answer Question 4:

a. What is the profile of the self-pacing intervals for the three-week period?

b. Does the time utilized in the self-pacing intervals change depending on the location of the segment in the total task?

c. Does the time utilized in the self-pacing intervals change depending on the type of sensory information which predominates in the task segment?

d. Does the time utilized in the self-pacing intervals have any relationship to the number of errors committed in the task segment?

To answer these questions the actual time utilized by Subject 1 for the self-pacing interval preceding each of the four major segments of the serial gross motor task was plotted in graph form. The self-pacing interval was measured by the time elapsing between mat contacts. For example, the time from mat contact signaling the end of the first segment and the mat contact signaling the beginning of the next segment represented the self-pacing interval for the second segment. These times were plotted for each of the five days in the three blocks of trials. Comparisons were to be made among the patterns established for the first block of trials and the patterns for the second and third blocks of trials. Comparisons were also to be made between the patterns of times utilized for the self-pacing intervals preceding the high visual segments and the patterns of the self-pacing intervals preceding the low visual segments. Finally, any relationships between the time used for the self-pacing interval prior to a particular segment and the number of errors which occurred in that segment were to be noted. Identical procedures were to be followed for each of the subjects.

Figure 36 shows the profiles of self-pacing intervals for Subject 1. As may be seen in this figure, five data

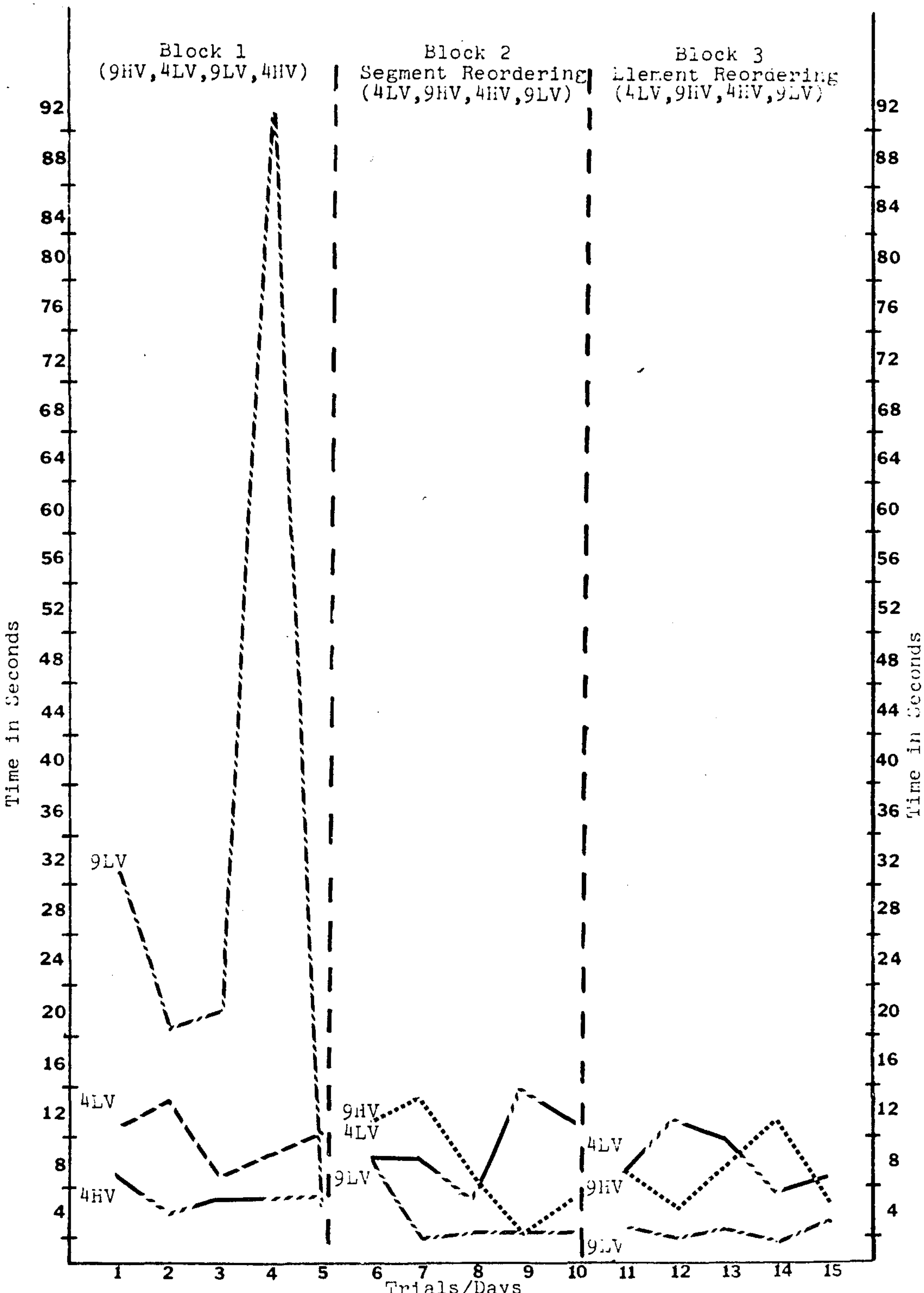


Figure 36. Time utilized for self-pacing intervals prior to each of the four major segments by Subject 1.

points are missing from the 9HV segment in Block 1. In addition, ten data points for the 4LV segment (Blocks 2 and 3) also are missing for Subject 1. A similar pattern was evident for the remaining three subjects. The missing times all preceded the first segment of the serial gross motor task. These data points were missing due to the fact that subjects used as much time as they needed <u>before</u> stepping on the mat to signal the beginning of each trial. Contact with the mat resulted in the first marking on the graph output from the Servo Recorder. The manually operated stopwatch also was started with the first mat contact. Therefore, no record of the time subjects spent prior to the first segment performance was available.

Because of the placement of the segment reordering intervention, five data points were missing from each of the three blocks of trials. These missing times prevented a complete data profile for two of the four major segments of the serial gross motor task. Thus, only limited comparisons could be made of profiles of these two segments when they occupied different positions in the serial gross motor task. In addition, subjects always performed either the 9HV segment or the 4LV segment first. Data points were lacking, therefore, for both types of segments (high visual and low visual). Since the missing data were from a nine-station high visual segment and a four-station low visual segment, meaningful comparisons of the self-pacing intervals preceding the two types of segments would have been impossible. The missing data also would have resulted in an incomplete discussion of the relationships, if any, between the time utilized for the self-pacing interval preceding these two segments and the number of errors which occurred in these segments. Even if these times were available, meaningful analysis of the times may have been difficult. Subjects were observed to use their time preceding the first segment for map study of <u>all</u> segments. Thus, the time for the self-pacing interval preceding the first segment would have included time spent on other segments as well. Therefore, no attempt was made to answer Question 4.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this study was to describe the characteristics of performances on a serial gross motor task. Four right-handed women, ranging in age from 61 to 75 years, served as subjects. The serial gross motor task was specifically constructed to study the memory capabilities of these women for movement sequences. In addition, the task was constructed to study the performance profiles in segments having a predominance of visual information and in those having a predominance of tactile/kinesthetic information.

The total task consisted of four major segments. Two of these segments involved processing of predominately visual information. The other two segments involved predominately tactile/kinesthetic information processing. The two high visual segments involved reading information from cue cards, carrying blocks to stack at particular stations, making hand movements at the stations, and avoiding obstacles. The low visual segments involved tactile manipulation of wooden cues, making varying numbers of replications of the particular geometric shape (determined from the cue) by moving in a pattern representing that shape at particular stations, and avoiding obstacles. The station locations and obstacles in the high visual segments were readily visible, while in the low visual segments, these obstacles and stations were not. Both types of segments also involved contacting a pressure mat and an element key to signal completion of specific portions of the segment. Each segment was composed of nine individual, sequentially arranged element requirements, each of which was available from a cue. The time taken to complete cue referral and performance of each of these nine element requirements was recorded. In addition, a record of the number of errors, cue referrals, and map referrals in each of the segments was kept.

Two preliminary tests were administered to measure attributes related to the performance of gross motor tasks. Field dependence/independence was represented by the average error on 21 trials of the Rod-and-Frame test. Spatial reasoning was measured by the scores achieved on the Space Relations subtest (Form T) of the Differential Aptitude Tests. In addition, a measure of the intellectual capabilities of the subjects was assessed by the Digit Symbol subtest of the Wechsler Adult Intelligence Scale. The score achieved on this test represented information processing speed of the subjects.

Data were collected over a three-week period. Subjects performed the serial gross motor task once a day for fifteen days. After every fifth trial (Day 5 and Day 10), a two-day interval occurred. Subjects then performed the task for a second and third block of five trials. For these trials, however, an intervention strategy had been employed to change either the order of task segments or the order of the nine elements in each of the segments. Two subjects performed Task 1-A for the first five trials. This task was arranged so that the high visual segments were at the beginning and end, and the low visual segments were in the middle of the serial gross motor task. The other two subjects performed Task 1-B for the first five trials. Task 1-B was arranged so that the low visual segments were at the beginning and end, and the high visual segments were in the middle of the total task. One subject who performed Task 1-A and one subject who performed Task 1-B continued to perform the same order of segments for the second block of five trials. Element order within the segments was changed for this series of trials. These two subjects, therefore, performed the same sequential arrangement of task segments on the first ten trials (Days 1-10), and the same sequential order of elements on the last ten trials (Days 6-15). The other two subjects performed the same sequential arrangement of elements on the first ten trials (Days 1-10), and the same sequential order of task segments on the last ten trials (Days 6-15).

For each trial, the average times used for cue referral and performance of all nine elements in each segment were plotted on graphs and visually analyzed. Comparisons were made of the profiles of these data for each of the three blocks of trials. Profiles of the high visual segments were compared to profiles of the low visual segments. Average times used for cue referral and performance of <u>each</u> of the nine elements across five trials were calculated and plotted on graphs. The resulting profiles were visually inspected. Profiles in each of the three blocks of trials were described to determine if serial position effects occurred. Comparisons were made of profiles for segments located in the same relative position of the serial gross motor task. Frequencies of map referral, cue referral, and error occurrences on each trial were summed. These sums were presented in table or graph form. The resulting profiles for each of the three blocks of trials were described to determine the pattern of recall for movement sequences.

Research Conclusions

The problems and subproblems stated for this study were answered by a time-series analysis technique. Profiles of speed (time required for cue referral and element performance) and accuracy (number of errors, cue referrals, and map referrals) were visually analyzed. Based upon the results of these analyses, the following conclusions are warranted:

Question 1: What effect does varying the relative predominance of visual and kinesthetic information have on performance? The time data revealed that cue referral and element performance for the subjects were fastest in the high visual segments for all 15 trials.

a. What are the original performance profiles of the high visual and low visual segments? Times for both cue referral and element performance were faster for the high visual segments than for the low visual segments.

b. What are the performance profiles of the high visual and low visual segments after intervention? Generally, stability was achieved in the times for cue referral and element performance in the high visual segments following the first intervention. These times in the low visual segments generally decreased, but slight fluctuations were evident. Times were faster for the high visual segments than for the low visual segments after both interventions for most subjects.

c. What are the similarities among profiles of the high visual and low visual segments? The times taken by the subjects for cue referral and element performance in the 4LV segments were very similar to times taken for both high visual segments. This pattern was especially evident for two subjects.

d. What are the differences among profiles of the high visual and low visual segments? Times for cue referral and element performance were longer for the low visual segments. Only one subject had any times in the low visual segments which were faster than times in the high visual segments. Times in the high visual segments remained more consistent from trial to trial.

Question 2. What are the serial effects in a task segment in relation to its position in the total task? Relatively few serial position effects emerged in the time data from the four subjects. The relative position of task segments or the order of elements within segments was not a factor in the emergence of serial position effects.

a. What are the original profiles of early, middle, and late segments? The most serial position effects (2) were evident in the cue referral times for the middle segments. The most serial position effects were evident in the profiles of element performance times for segments in the early (4 effects) and late (10 effects) positions.

b. What are the performance profiles of early, middle, and late segments after intervention? The most serial position effects evident in the profiles of cue referral times were for the middle segments. Serial position effects in the profiles of element performance times also were more evident in segments located in the middle of the serial gross motor task following each of the two interventions.

c. What are the similarities among performance profiles of those segments located in the same relative position, i.e., early, middle, or late within the total task. Due to the sparseness of serial position effects, no meaningful comparisons of these effects in segments occupying similar positions could be made. It appeared, however, that regardless of the relative position of the segment, more (or longer) recency effects occurred than primacy effects.

d. What are the differences among profiles of those segments located in the same relative position within the total task? Due to the limited number of serial position effects which occurred, no meaningful comparisons of these effects in segments occupying similar positions could be made. It appeared, however, that serial position effects were most prevalent in the low visual segments regardless of the order of these segments.

Question 3. What is the pattern of performance recall within each segment of the task? Visual inspection of the accuracy measures for each subject revealed that only one subject correctly recalled the requirements for any element. This subject recalled one performance requirement on two separate days in the last block of trials. Either the first or last element in the 9HV segment was correctly performed without cue referral on these days. Other attempts were made at performance recall in the 9HV and 4HV segments for trials in Block 2 and Block 3, but these attempts were not successful. No indication of performance recall was evident for this subject for the low visual segments.

a. What is the original profile of performance breaks? Reference to the cues and maps was made by all subjects for the first three days of Block 1. Cue and map referrals during performance generally decreased as trials in this block progressed. The most errors of all types occurred in the low visual segments. Actual performance errors were least prevalent in the four-station segments (4LV and 4HV segments) for three subjects. The other subject committed the least number of actual performance errors in the two low visual segments during this block of trials.

b. Do these profiles of performance breaks change before intervention? Other than a general decrease in the frequency of error occurrence, map reference, and cue reference there was no change in the patterns for three subjects prior to intervention. One subject ended map referral for all segments prior to the first intervention.

c. Do these profiles of performance breaks change after intervention? One subject attempted to perform elements without cue referral in both blocks of trials following interventions. These attempts were made only in the high visual segments, and were successful only for the first or last element during the last block of trials.

Another subject attempted to perform the first element in the 9LV segment during Block 3, but was not successful. Cue and map referrals in the four-station segments decreased sooner than for the nine-station segments. Errors generally decreased throughout the ten trials following an intervention. Fewer actual performance errors occurred in the low visual segments for three subjects.

d. What is the relationship of the number of performance breaks to the number of cue referrals? Due to the limited number of elements for which recall was attempted, this question was not answered.

Question 4. How does the time utilized for self-pacing intervals affect the performance of various segments of the task? Self-pacing intervals were measured by the time elapsing from the mat contact following completion of one segment and the mat contact signaling initiation of the subsequent segment. Because subjects were allowed to use as much time as they needed prior to stepping on a mat to signal initiation of the first segment, times for the self-pacing intervals preceding the first segment were missing for all subjects. Since the first segment was either a high visual nine-station (9HV) segment or a low visual four-station segment (4LV), no meaningful analyses of self-pacing intervals could be done. Therefore, no attempt was made to answer this question.

Based on the data from these four subjects, it appeared that performance was faster in the high visual segments than in the low visual segments throughout all 15 trials. Three subjects' performances of elements, however, were more accurate in the low visual segments throughout these trials. Only a limited number of serial position effects was evident in the performance profiles of the subjects. Recall of element requirements was accomplished only by one subject. This recall was evident in the high visual segments. In general, the intervention strategies employed in this investigation did not result in the expected changes in motor task performance. Rather, it appeared that practice with the task requirements resulted in faster times and more accurate performance.

Recommendations for Future Research

The older age group in the total population will continue to increase in number for the next several years. This segment of our population deserves attention from educators. Knowledge about their abilities to perform gross motor skills will greatly enhance the planning and development of programs for this group by physical educators. The following suggestions for future research in gross motor task performance derive from this study.

1. Continue to explore, over time, the changes in the performance characteristics of older adults on gross motor tasks.

2. Determine the relationships between the serial gross motor task performance and abilities which are theoretically important to skill acquisition.

3. Develop methods of assessing changes in information processing characteristics <u>during</u> the performance of gross motor tasks.

4. Consider the following factors when designing research projects dealing with the recall of gross motor sequences: (a) preferred movement speed of the subjects, (b) the nature of the task, (c) individual differences in the abilities related to task demands, and (d) the placement (timing) of the intervention strategies.

5. Determine the relative efficacy of speed or accuracy as a measure of the recall of movement sequences in gross motor tasks.

BIBLIOGRAPHY

Bennett, G. K., Seashore, H. G., & Wesman, A. G. Differential aptitude tests (Form T). New York: The Psychological Corporation, 1972.

Birren, J. E. The psychology of aging. Englewood Cliffs, N. J.: Prentice-Hall, 1964.

Botwinick, J. Aging and behavior: A comprehensive integration of research findings (2nd ed.). New York: Springer Publishing Co., 1978.

Campbell, D. T., & Stanley, J. C. Experimental and quasi-experimental designs for research. Chicago: Rand McNally, 1966.

Corso, J. F. Sensory processes and age effects in normal adults. Journal of Gerontology, 1971, 26(1), 90-105.

Craik, F. I. M. Two components in free recall. Journal of Verbal Learning and Verbal Behavior, 1968, 7, 996-1004.

Craik, F. I. M. Age differences in human memory. In J. E. Birren & K. W. Schaie (Eds.), Handbook of the psychology of aging. New York: Van Nostrand Reinhold Co., 1977.

Craik, K. J. W. Theory of the human operator in control systems I: The operator as an engineering system. British Journal of Psychology, 1947, 38(2), 56-61.

Craik, K. J. W. Theory of the human operator in control systems II: Man as an element in a control system. British Journal of Psychology, 1948, 38(3), 142-148.

Cratty, B. J. Comparisons of learning a fine motor task with learning a similar gross motor task, using kinesthetic cues. Research Quarterly, 1962, 33(2), 212-221.

Cratty, B. J. Recency versus primacy in a complex gross motor task. Research Quarterly, 1963, 34(1), 3-8.

Deese, J., & Hulse, S. H. The psychology of learning (3rd ed.). New York: McGraw Hill Book Co., 1967.

Denney, N. W. Clustering in middle and old age. Developmental Psychology, 1974, 10, 471-475.

Dickinson, J. The role of two factors in a gross motor aiming task. British Journal of Psychology, 1969, 60, 465-470.

Dickinson, J. Proprioceptive control of human movement. London: Lepus Books, 1974.

Ebbinghaus, H. [Memory: A contribution to experimental psychology] (H. A. Ruger & C. E. Bussenius, trans.). New York: Dover, 1964. (Originally published 1919)

Elashoff, J. D., & Thoresen, C. E. Choosing a statistical method for analysis of an intensive experiment. In T. R. Kratochwill (Ed.), Single subject research: Strategies for evaluating change. New York: Academic Press, 1978.

Eysenck, M. W. Human memory: Theory, research and individual differences. New York: Pergamon Press, 1977.

Fiegenbaum, E. A., & Simon, H. A. A theory of the serial position effect. In N. J. Slamecka (Ed.), Human learning and memory. New York: Oxford University Press, 1967.

Fitts, P. M. Engineering psychology and equipment design. In S. S. Stevens (Ed.), Handbook of experimental psychology. New York: Wiley, 1951.

Fleishman, E. A. On the relation between abilities, learning, and human performance. American Psychologist, 1972, 27(Nov.), 1017-1032.

Fleishman, E. A., & Rich, S. Role of kinesthetic and spatial-visual abilities in perceptual-motor learning. Journal of Experimental Psychology, 1963, 66, 6-11.

Fozard, J. L., Wolf, E., Bell, B., McFarland, R., & Podolsky, S. Visual perception and communication. In J. E. Birren & K. W. Schaie (Eds.), Handbook of the psychology of aging. New York: Van Nostrand Reinhold Co., 1977.

Glass, G. V., Willson, V. L., & Gottman, J. M. Design and analysis of time-series experiments. Boulder: University of Colorado Press, 1975.

Gottman, J. M. N-of-one and N-of-two research in psychotherapy. Psychological Bulletin, 1973, 80(2), 93-105.

Gottman, J. M., McFall, R. M., & Barnett, J. T. Design and analysis of research using time series. Psychological Bulletin, 1969, 72(4), 299-306.

Hayes, K. C., & Marteniuk, R. G. Dimensions of motor task complexity. In G. E. Stelmach (Ed.), Motor control issues and trends. New York: Academic Press, 1976.

Hersen, M., & Barlow, D. H. Single case experimental designs. New York: Pergamon Press, 1976.

Howell, T. H. Senile deterioration of the central nervous system; clinical study. British Journal of Medicine, 1949, 1, 56-58.

Hull, C. L. The conflicting psychologies of learning--a way out. The Psychological Review, 1935, 42(6), 491-516.

Jahnke, J. C. Serial position effects in immediate memory. Journal of Verbal Learning, 1963, 2, 284-287.

Kay, H. Analyzing motor skill performance. In K. Connolly (Ed.), Mechanism of motor skill development. New York: Academic Press, Inc., 1970.

Keele, S. W. Attention and human performance. Pacific Palisades, California: Goodyear, 1973.

Keele, S. W., & Ells, J. C. Memory characteristics of kinesthetic information. Journal of Motor Behavior, 1972, 4(3), 127-134.

Kratochwill, T. R. Foundations of time-series research. In T. R. Kratochwill (Ed.), Single subject research: Strategies for evaluating change. New York: Academic Press, 1978.

Landahl, H. D., & Birren, J. E. Effects of age on the discrimination of lifted weights. Journal of Gerontology, 1959, 14, 48-55.

Laszlo, J. L. Kinaesthetic and exteroceptive information in the performance of motor skills. Physiology and Behavior, 1967, 2, 359-365.

Laszlo, J. L., & Baker, J. E. The role of visual cues in movement control and motor memory. Journal of Motor Behavior, 1972, 4, 71-77.

Lepley, W. H. Serial reactions considered as conditioned reactions. Psychological Monographs, 1934, 46(1, Whole No. 205).

Magill, R. A. Order of acquisition of the parts of a serial-motor task. Research Quarterly, 1976, 47, 134-139.

Magill, R. A., & Dowell, M. N. Serial-position effects in motor short-term memory. Journal of Motor Behavior, 1977, 9(4), 319-323.

Marshall, P. H., Jones, M. T., & Sheehan, E. M. The spacing effect in short-term motor memory: The differential attention hypothesis. Journal of Motor Behavior, 1977, 9(2), 119-126.

Marteniuk, R. G. An informational analysis of active kinesthesis as measured by amplitude of movement. Journal of Motor Behavior, 1971, 3 (1), 69-77.

Marteniuk, R. G. Retention characteristics of motor short-term memory cues. Journal of Motor Behavior, 1973, 5(4), 249-259.

Marteniuk, R. G. Information processing in motor skills. New York: Holt, Rinehart & Winston, 1976.

Metarazzo, J. D. Wechsler's measurement and appraisal of adult intelligence (5th ed.). Baltimore: Williams & Wilkins, 1972.

Miller, G. A. The magical number seven, plus or minus two: Some limits on our capacity for processing information. The Psychological Review, 1956, 63(2), 81-97.

Murdock, B. B. The serial position effect of free recall. Journal of Experimental Psychology, 1962, 64(5), 482-488.

Murdock, B. B. Serial order effects in short term memory. Journal of Experimental Psychology, 1968, 76(4), 1-15.

Murdock, B. B. Item and order information in short-term serial memory. Journal of Experimental Psychology, 1976, 105(2), 191-216.

Murdock, B. B., & Walker, K. D. Modality effects in free recall. Journal of Verbal Learning and Verbal Behavior, 1969, 8, 665-676.

Murphy, M. D., Sanders, R. E., Gabriesheski, A. S., & Schmitt, F. A. Metamemory in the aged. Journal of Gerontology, 1981, 36(2), 185-193.

Parsonson, B. S., & Baer, D. M. The analysis and presentation of graphic data. In T. R. Kratochwill (Ed.), Single subject research: Strategies for evaluating change. New York: Academic Press, 1978.

Phillips, M., & Summers, D. Relation of kinesthetic perception to motor learning. Research Quarterly, 1954, 25, 456-469.

Rabbitt, P. M. A. An age-decrement in the ability to ignore irrelevant information. Journal of Gerontology, 1965, 20(2), 233-238.

Raymond, B. J. Free recall among the aged. Psychological Reports, 1971, 29, 1179-1182.

Riege, W. H., & Inman, V. Age differences in nonverbal memory tasks. Journal of Gerontology, 1981, 36(1), 51-58.

Roy, E. A. Spatial cues in memory for movement. Journal of Motor Behavior, 1977, 9(2), 151-156.

Saufley, W. H. Memory for serial position. Journal of Verbal Learning and Verbal Behavior, 1975, 14, 418-429.

Singer, R. N. Sequential skill learning and retention effects in volleyball. Research Quarterly, 1968, 39(1), 185-194.

Stallings, L. M. The role of visual-spatial abilities in the performance of certain motor skills. Research Quarterly, 1968, 39(3), 708-713.

Sumby, W. H. Word frequency and serial position effects. Journal of Verbal Learning and Verbal Behavior, 1963, 1, 443-450.

Szafran, J. Changes with age and with exclusion of vision in performance at an aiming task. Quarterly Journal of Experimental Psychology, 1951, 3, 111-118.

Talland, G. A. Visual signal detection, as a function of age, input rate, and signal frequency. Journal of Gerontology, 1966, 63, 105-115.

Taub, H. A. Visual short-term memory as a function of age, rate of presentation, and schedule of presentation. Journal of Gerontology, 1966, 21(3), 388-391.

Taub, H. A., & Long, M. K. The effects of practice on short-term memory of young and old subjects. Journal of Gerontology, 1970, 25(3), 177-183.

Taub, H. A., & Walker, J. B. Short-term memory as a function of age and response interference. Journal of Gerontology, 1970, 25(3), 177-183.

Temple, I. G., & Williams, H. G. Rate and level of learning as functions of information-processing characteristics of the learner and the task. Journal of Motor Behavior, 1977, 9(3), 179-192.

Thompson, L. W., Axelrod, S., & Cohen, L. D. Senescence and visual identification of tactual-kinesthetic forms. Journal of Gerontology, 1965, 20(2), 244-249.

United States Bureau of the Census, 1981 (Telephone conversation, August, 1981).

Watkins, M. J. Concept and measurement of primary memory. Psychological Bulletin, 1974, 81(10), 695-711.

Waugh, N. C., & Norman, D. A. Primary memory. Psychological Review, 1965, 72, 89-104.

Wechsler, D. Manual for the Wechsler adult intelligence scale. New York: Psychological Corporation, 1972.

Welford, A. T. Ageing and human skill. London: Oxford University Press, 1958.

Welford, A. T. Fundamentals of skill. London: Methuen & Co. Ltd., 1968.

Welford, A. T. The obtaining and processing of information: Some basic issues relating to analyzing inputs and making decisions. Research Quarterly, 1972, 43(3), 295-311.

Welford, A. T. Motor performance. In J. E. Birren & K. W. Schaie (Eds.), Handbook of the psychology of aging. New York: Van Nostrand Reinhold Co., 1977.

Whiting, H. T. A. Acquiring ball skill. Philadelphia: Lea & Febiger, 1969.

Whiting, H. T. A. Theoretical frameworks for an understanding of the acquisition of perceptual-motor skills. Quest, 1972, 17, 24-34.

Whiting, H. T. A. Concepts in skill learning. London: Lepus Books, 1975.

Witkin, H. A., Moore, C. A., Goodenough, D. R., & Cox, P. W. Field-dependent and field-independent cognitive styles and their educational implications. Review of of Educational Research, 1977, 47(1), 1-64.

Wrisberg, C. A. The serial-position effect in short-term motor retention. Journal of Motor Behavior, 1975, 7(4), 289-295.

Zaichkowsky, L. D. The development of perceptual motor sequencing ability. Journal of Motor Behavior, 1974, 6(4), 255-261.

APPENDIX A

PRELIMINARY PILOT TEST MATERIALS

THE UNIVERSITY OF NORTH CAROLINA AT GREENSBORO
SCHOOL OF HEALTH, PHYSICAL EDUCATION, RECREATION & DANCE

INFORMED CONSENT FORM
(Preliminary Pilot Test)

I understand that the purpose of this phase of the study was:

1. To pre-test the instructions to the subjects for the motor task

2. To test the efficiency of the mechanical measuring devices

3. To pre-test the length and structure of the motor task.

I confirm that my participation was entirely voluntary. No coercion of any kind was used to obtain my cooperation.

I understood that I might withdraw my consent and terminate my participation at any time during the study.

I was informed of the procedures that were to be used in the study and understood what would be required of me as a subject.

I understood that all of my responses, oral and task, were to be used only in relation to task development and were not recorded for individual performance analyses. I understood that my oral and task performances would remain completely anonymous.

I understand that a summary of the results of the study will be made available to me at the completion of the study if I so request.

I wish to confirm that I gave my verbal consent prior to my participation in the pre-pilot and my voluntary cooperation as a participant.

____
Signature

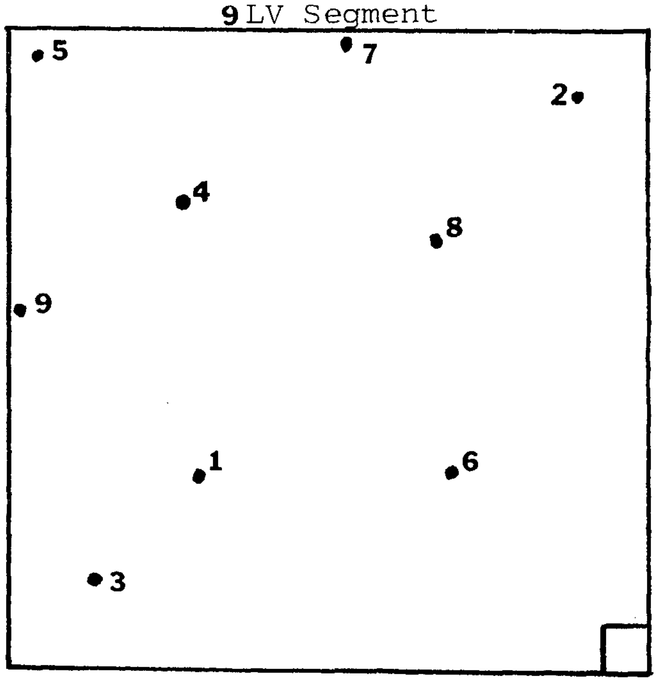
____
Address

____

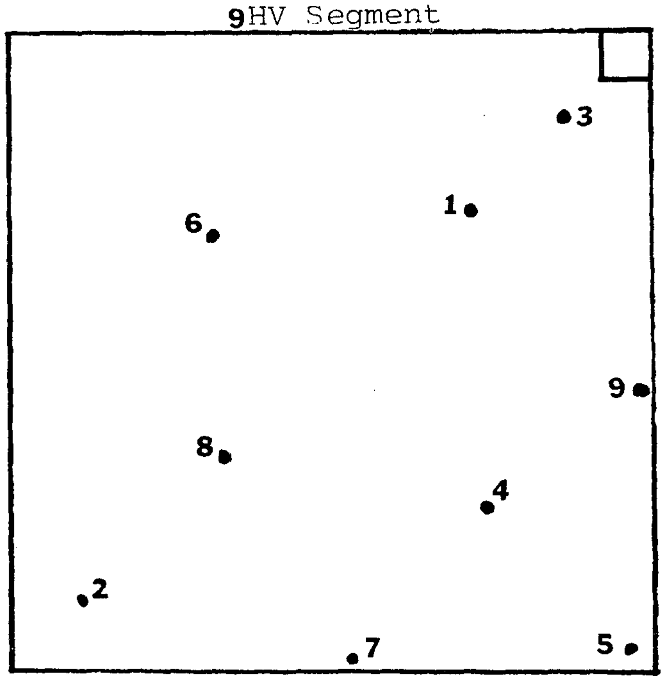
____
Date

Sample Map Available for Subject Reference

9LV Segment

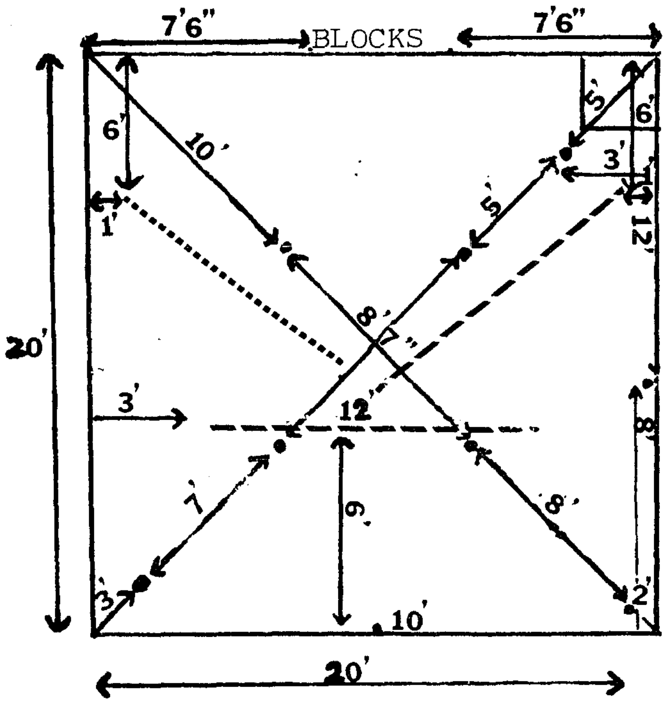


9HV Segment

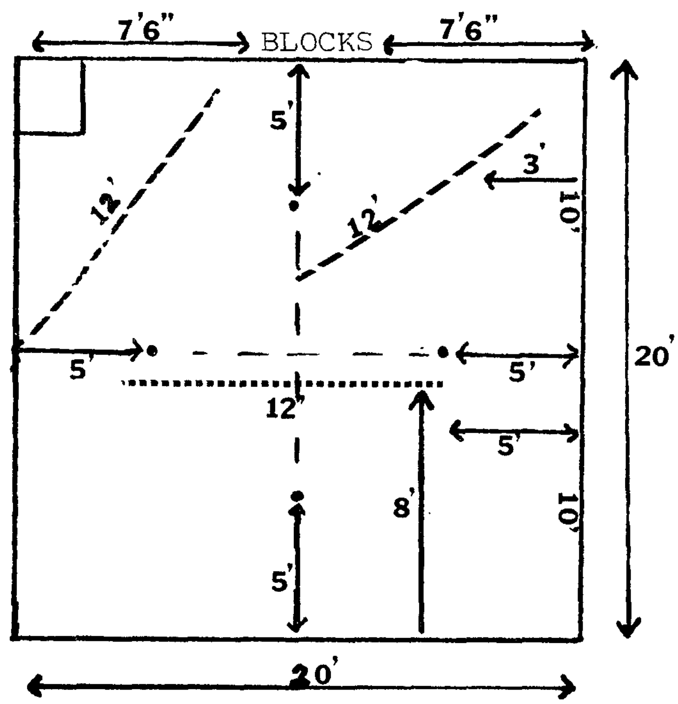


Schematic of the

High Visual Segments



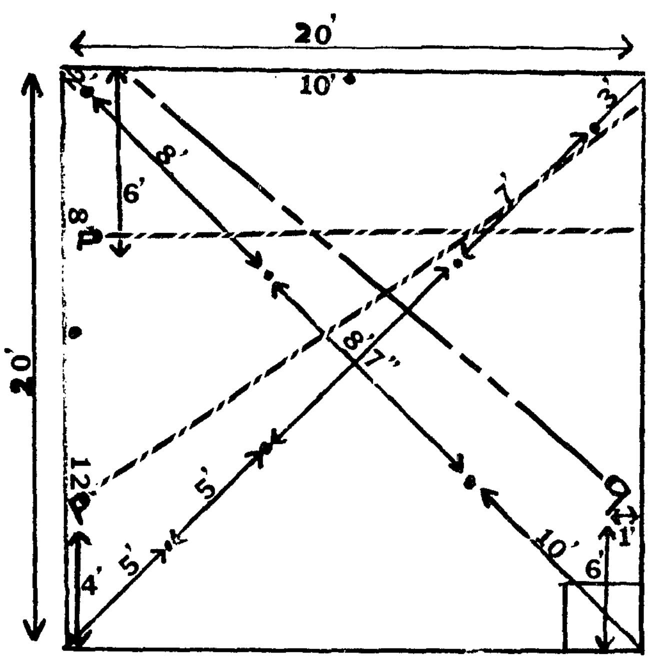
(9HV Segment



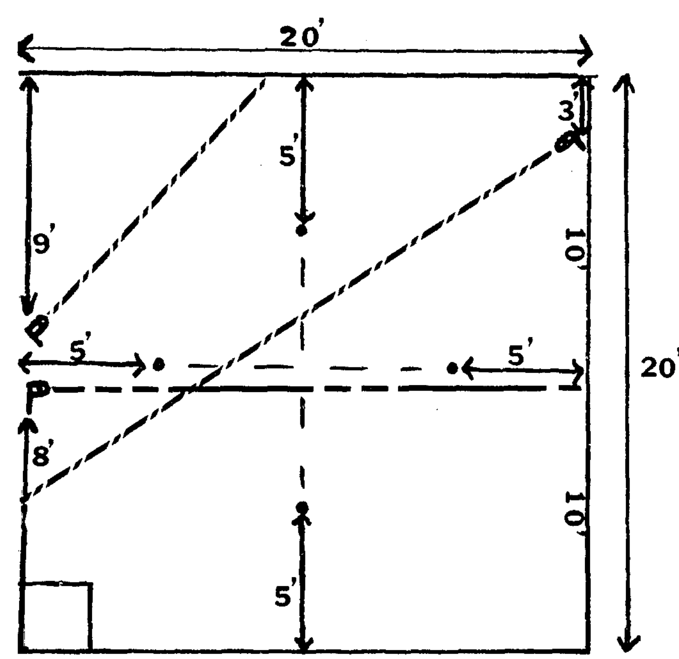
4HV Segment

Schematic of the

Low Visual Segments



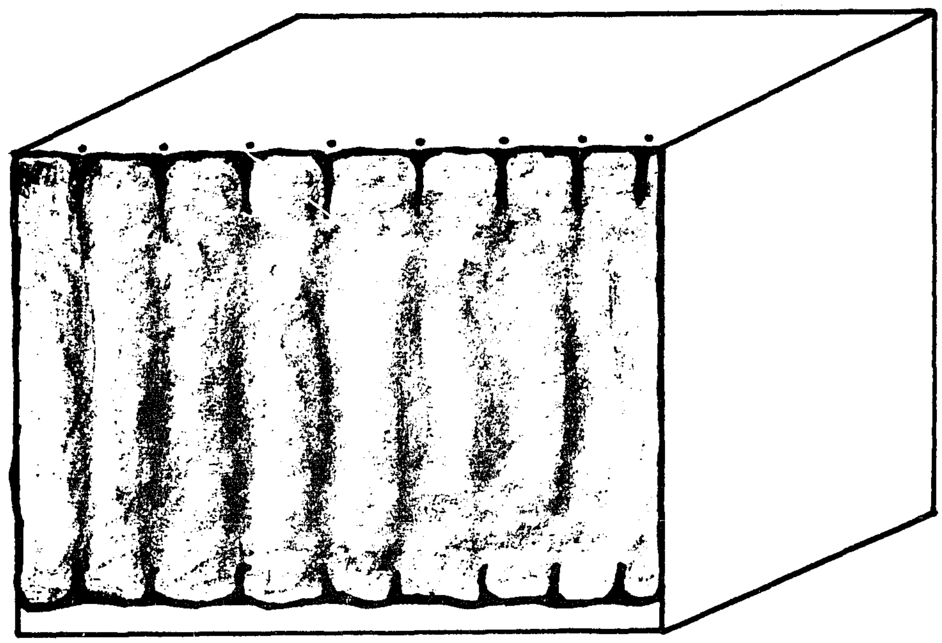
9LV Segment



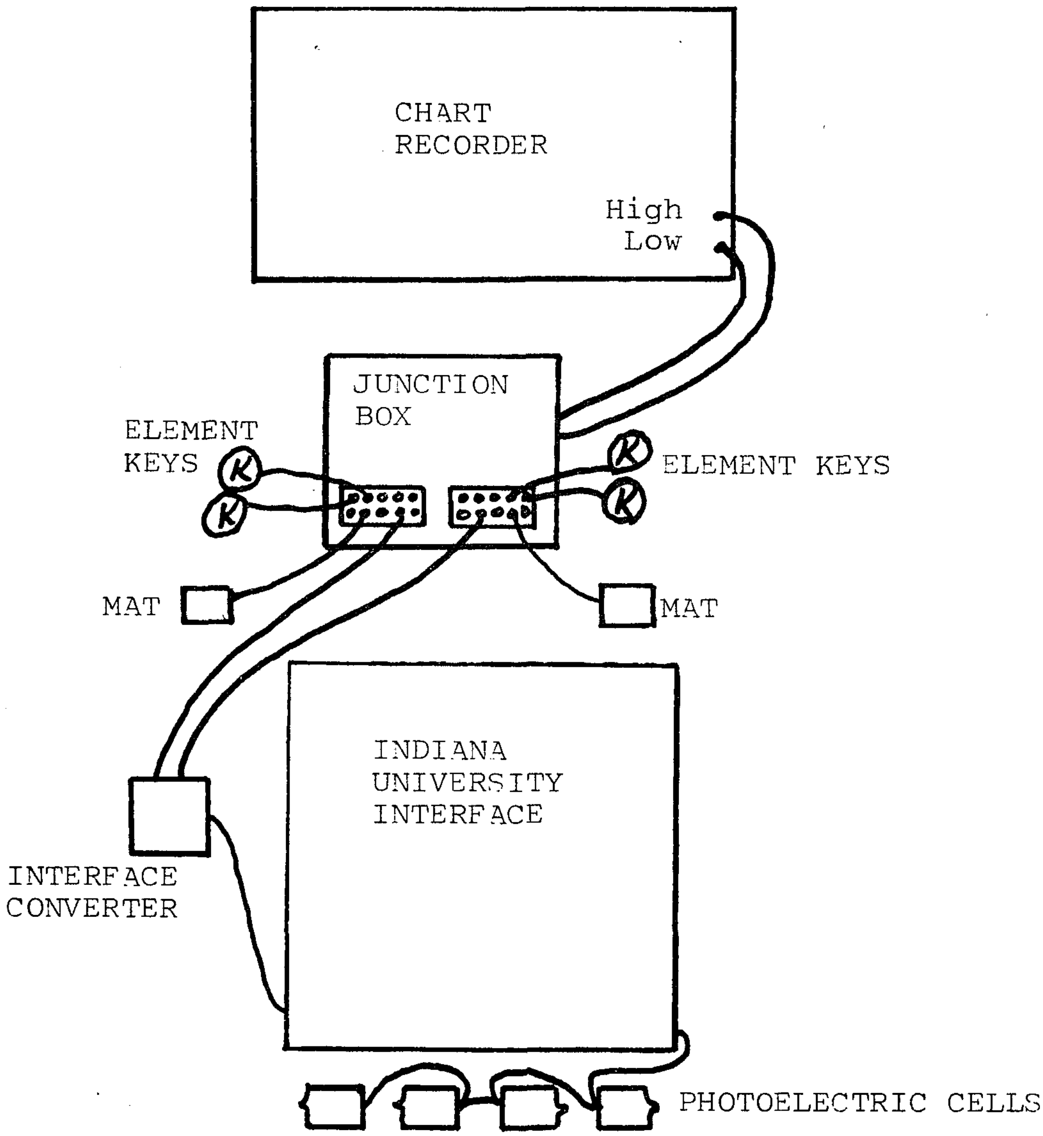
4LV Segment

Schematic of Cue Box Used for

Low Visual Segments



Schematic of the Timing Apparatus



APPENDIX B

PILOT TEST MATERIALS

THE UNIVERSITY OF NORTH CAROLINA AT GREENSBORO
SCHOOL OF HEALTH, PHYSICAL EDUCATION & RECREATION

SCHOOL REVIEW COMMITTEE

INFORMED CONSENT FORM *
Pilot Test

I understand that the purpose of this study/project is

(a) to examine individual performances on a sequential (serial) motor (physical) task, and

(b) to train observers to record error occurrence in the task.

I confirm that my participation is entirely voluntary. No coercion of any kind has been used to obtain my cooperation.

I understand that I may withdraw my consent and terminate my participation at any time during the project.

I have been informed of the procedures that will be used in the project and understand what will be required of me as a subject.

I understand that all of my responses, written/oral/task, will remain completely anonymous.

I understand that a summary of the results of the project will be made available to me at the completion of the study if I so request.

I wish to give my voluntary cooperation as a participant.

____
Signature

____
Address

____

____
Date

*Adopted from L. F. Locke and W. W. Spirduso. *Proposals that work*. New York: Teachers College, Columbia University, 1976, p. 237.

Sample Code Sheet

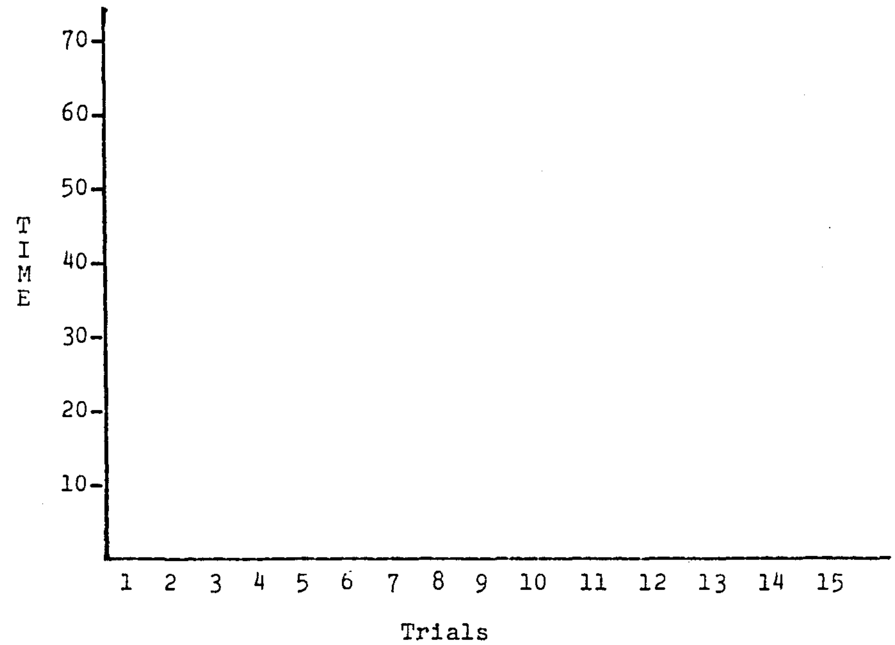
4HV

Subject # _____ Position in Task _____ Date _________

Trial # _______

ELEMENT DESCRIPTION	CUE REFERRAL S.P. INT.	CUE REFERRAL PER W/O E	CUE REFERRAL PER A.E.	MAP REFERRAL S.P. INT.	MAP REFERRAL PER W/O E	MAP REFERRAL PER A.E.	ERRORS DES.	ERRORS OBS.	ERRORS PER.	ERRORS OTHER
1. Stack 3 Wh. Stack 3 Bl. Clap 3x										
2. Stack 3 Or Stack 2 Wh.										
3. Stack 3 Bl. Stack 3 Or. Salute 3x										
4. Stack 3 Bl. Stack 2 Wh.										
5. Stack 1 Wh. Stack 2 Wh. Wave 1x										
6. Stack 1 Wh. Stack 2 Bl. Salute 3x										
7. Stack 1 Bl. Stack 3 Bl. Clap 1x										
8. Stack 4 Or. Wave 3x Clap 1x										
9. Stack 3 Bl. Stack 2 Bl. Wave 2x										

Sample Individual Performance Summary Form



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Cues Used															
Errors															
Tossing Scores															

Subject Code _____ Date of First Trial ________

Phase _____

APPENDIX C

SELECTION AND TESTING OF SUBJECTS FOR MAIN STUDY

THE UNIVERSITY OF NORTH CAROLINA AT GREENSBORO
SCHOOL OF HEALTH, PHYSICAL EDUCATION & RECREATION

SCHOOL REVIEW COMMITTEE

INFORMED CONSENT FORM *
(with adaptation)

Main Study

I understand that the purpose of this study/project is

to examine individual performances on a sequential (serial) motor (physical) task

I confirm that my participation is entirely voluntary. No coercion of any kind has been used to obtain my cooperation.

I understand that I may withdraw my consent and terminate my participation at any time during the project.

I have been informed of the procedures that will be used in the project and understand what will be required of me as a subject.

I understand that all my responses, both on the preliminary tests and on the motor tests, will remain completely anonymous.

I understand that a summary of the results of the project will be made available to me at the completion of the study if I so request.

I wish to give my voluntary cooperation as a participant.

____
Signature

____

____
Address

____
Date

*Adopted from L. F. Locke and W. W. Spirduso. Proposals that work. New York: Teachers College, Columbia University, 1976, p. 237.

Approved 3/78

SUBJECT INFORMATION SHEET

Please complete the following background information. It will remain confidential and will be used without personal identification within the study.

Name ____________________________ Date of Birth__________

Address ______________________________ Phone __________

Do you consider yourself to be naturally right-handed?

Do you wear glasses? _______ Contact Lenses _______
If yes, for what condition (nearsighted, farsighted, etc.)

Would you consider yourself more active than the average woman your age?

Are you a high school graduate?
If yes, indicate class standing ____ out of ____.
If no, highest grade completed ______
Did you attend college? How many years?

To be completed at end of study:

I acknowledge receipt of $________ for my participation in the __________ phase of the study.

____
Signed

____
Date

SUBJECT CODE: __________

Randomly Determined Rod-and-Frame

Presentation Order

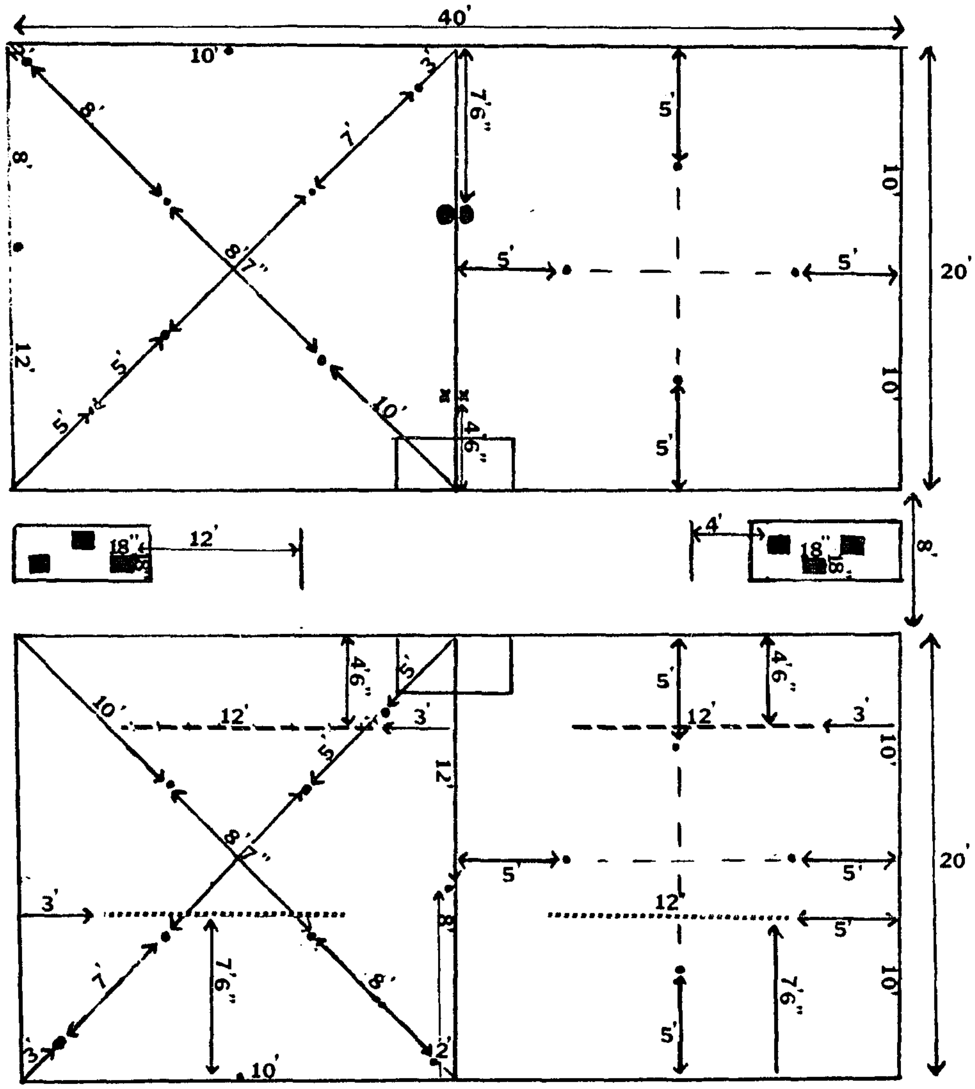
Trial Number	Frame Position	Rod Position
1	10°	20°
2	0°	15°
3	0°	345°
4	10°	10°
5	0°	20°
6	350°	345°
7	0°	5°
8	0°	10°
9	10°	350°
10	0°	350°
11	350°	350°
12	10°	355°
13	10°	15°
14	350°	10°
15	10°	5°
16	0°	355°
17	350°	5°
18	350°	20°
19	10°	345°
20	350°	345°
21	350°	15°

APPENDIX D

MATERIALS FOR THE SERIAL GROSS MOTOR TASK

(MAIN STUDY)

Schematic of the Serial Gross Motor Task



Equipment Needed for Administration of the Serial Gross Motor Task

Tossing Segments

2 strips (7.5 feet long) with 3 targets each
(target size = 18 inches X 18 inches)
(12 inches between each target)
40 beanbags

High Visual Segments

4 dowel rods (12 feet long)
4 standards (4 feet 6 inches high for obstacles)
4 standards (8 inches high for obstacles)
13 cone markers
18 cue cards
80 colored blocks (5.25 inches X 5.25 inches X 1.5 inches)
23 orange
24 white
33 blue

Low Visual Segments

4 photoelectric cells
(2 set at 4 feet 6 inches)
(2 set at 8 inches)
1 overhead grid with 9 fishing line markers suspended
1 overhead grid with 4 fishing line markers suspended
2 cue boxes (29 1/4" x 16 1/2" x 16 1/2")
18 wooden cues (9 inches square before shaping)

General

2 pressure mats
4 element (telegraph) keys
1 Servo recorder (with interface and junction boxes)
4 card tables (35.5 inches X 34.5 inches)
4 maps
1 stopwatch

Directions for the Serial Gross Motor Task

(as Adapted for the Main Study)

1. 9HV

In this segment you duck under or step over obstacles, stack blocks and/or make different hand movements. You want to complete this segment with as few errors and as quickly as you can. Since you will also be doing this for the rest of the week, you want to remember as much information as you can.

You begin here by stepping firmly on this mat. This contact starts the timing device. You then move to the table and read the first card in the stack. These cards look like this (SHOW SAMPLE) and give you the following information:

STATION NUMBER
STACK (NUMBER AND COLOR OF BLOCKS)
WAVE--SALUTE--CLAP

In this segment there are 9 stations marked by cones. I will show you which cone indicates each of these 9 stations. There is a map showing these locations which may be found beside the cards. If you cannot remember where a station is located, you may refer to this map at any time. Whenever you come to an obstacle, you must step completely over the low bar, and duck cleanly under the high bar.

To review: You step on the mat, move to the table, and read the first card. When you can remember what the card indicates, turn it over in a separate stack. Then push the key again and do what the card indicated, moving under or over any obstacles in your path.

When you have finished these requirements, return to the table and push the key again. Then read the next card, try to remember the items on it, turn it over on a separate pile, push the key and perform the items listed on it. Remember to push the key <u>before</u> you begin your performance and <u>after</u> you finish.

You will be told when you make an error. If you go to the wrong station, stack an incorrect number or color of blocks, or make the wrong arm movement, you must return to the table to get the correct information from the cards. Then begin your performance again.

When you push the key after completing the items on the last card, you move to the center and step on a mat.

2. Short Tossing

In this segment, you toss 20 beanbags. Try to get the highest score you can. The closest square scores 2, middle square scores 4, farthest square scores 6 points. If a toss lands on a line, it scores 1/2 the value of the square, i.e., 1, 2, 3.

Remember: Step on a mat before beginning.
Step on a mat when finished.

3. 4LV

In this segment you must move around various stations in a particular pattern a certain number of times. Also, you must step over or duck under any obstacles which are in your path. You want to complete this segment with as few errors and as quickly as you can. Since you will also be doing this for the rest of the week, you want to remember as much information as you can.

Wooden forms which have these shapes (SHOW SAMPLE SHEET OF FORM SHAPES) are located in this box. You reach into this box and feel these forms WITHOUT REMOVING THEM FROM THE BOX. The forms contain this information (SHOW SAMPLE FORM):

SHAPE = indicates the pattern you make at the station.
HOLES = indicate station's number.
NOTCHES = indicates the number of repetitions.

(Let them manipulate sample and make sure they know what all the information means.)

This segment has 4 stations. I will show you the location of each of these stations. There is a map showing these locations which may be found on top of the cue box. If you cannot remember where a station is located, you may refer to this map at any time. Whenever you come to an obstacle (SHOW PHOTOELECTRIC CELLS), you must step completely over the low one, and duck completely under the high one.

When you are ready to begin, move to a mat and step firmly on it. Then go to the table, reach into the box and feel the top form. As you are feeling it, move it to the other side of the box. As soon as you understand all the information on the form, push the key and do the pattern, stepping over or ducking under any obstacles in your path. When you are through, return to the table and push the key again. Then reach in the box, feel and move the next form, push the key when you understand all the information on it, and do what the form indicated. Remember to push the key <u>before</u> you begin your performance and <u>after</u> you finish it.

You will be told when you make an error. If you go to the wrong station, make the wrong pattern, or the wrong number of patterns you must return to the table to get the correct information from the cues. Then begin again.

After the information contained on the last form has been completed and you have pushed the key, move to a mat and step on it.

4. 9LV

This segment requires you to do the same steps as you did in that one (9LV). In this segment, however, there are 9 stations. There is a map showing these locations located on top of this box. You may refer to the map any time you cannot remember where a station is located. Again you must duck under or step over any obstacles that are in your path.

The forms in the box are the same types as were used in the last segment. The only difference is there may be up to 9 holes in the center of the form (SHOW SAMPLE AND EXPLAIN ARRANGEMENT OF THE HOLES).

When you are ready to begin, step on a mat. Then move to the table, reach into the box, feel the top form and move it to a separate pile as you are manipulating it. When you understand the information on it, push the key and perform the requirements. Then return to the table and push the key. Continue this order--manipulate form, perform, push key--until all forms have been completed.

You will be told when you make an error. If you go to the wrong station, make an incorrect pattern, or the wrong number of patterns you must return to the table to get the correct information from the wooden cues. Then begin again.

When the last form has been completed and you have pushed the key, move to the center and step on a mat. Again, try to do the segment as quickly and as accurately as you can.

5. Long Tossing

This segment is the same as that (SHORT TOSSING) except the targets are farther away from you. Remember, the nearest target scores 2, the middle one 4, and the farthest one 6 points. If a toss lands on a line it scores 1/2 value. You toss all 20 beanbags and you want to try to get the highest score you can.

Remember: Step on a mat before beginning.
Step on a mat when finished.

6. 4HV

This segment requires you to do the same steps as you did in that one (POINT TO 9HV). Here, however, there are only 4 stations. I will show you which cone indicates each of these 4 stations. There is a map showing these locations which may be found beside the cards. If you cannot remember where a station is located, you may refer to this map at any time. Again, you must duck under or step over any obstacles that are in your path.

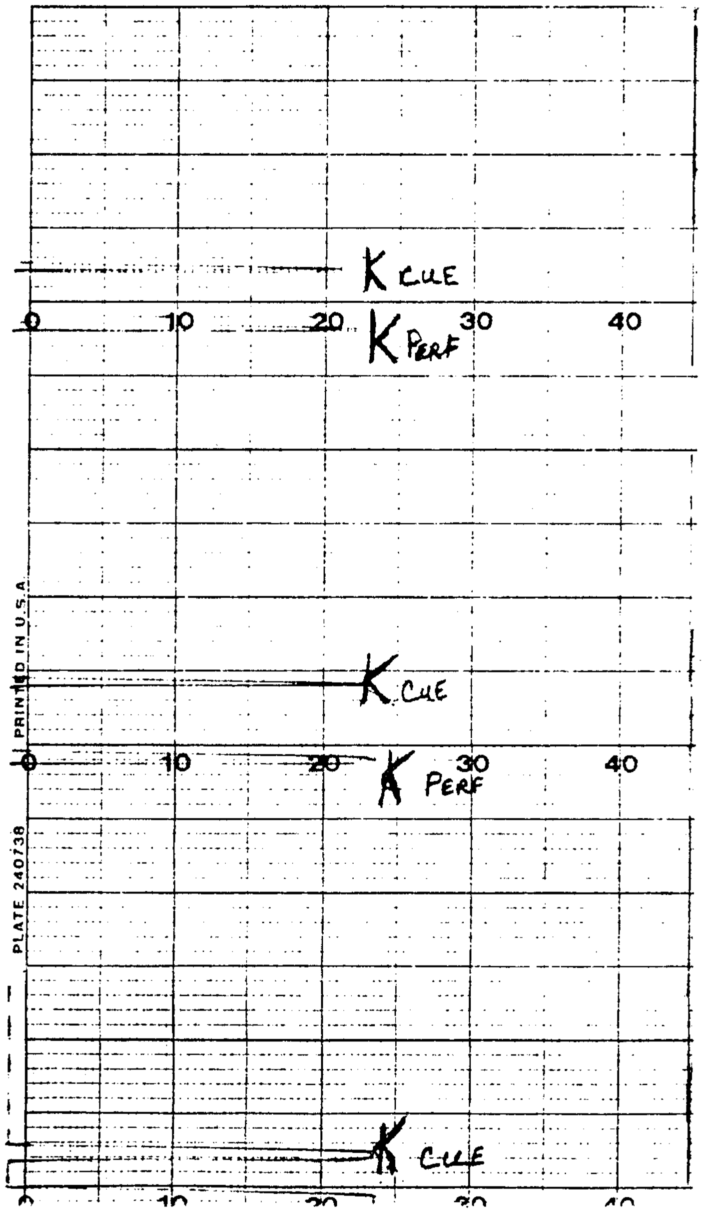
When you are ready to begin this segment, step on a mat. Then move to the table, read the first card, move it to a separate pile, push the key and do what the card indicates. When you have finished performing all items listed on the card, return to the table and push the key. Continue this order of events--read card, move it to a separate pile, push key, perform, push key--until all the cards have been completed.

You will be told when you make an error. If you go to the wrong station, stack an incorrect number or color of blocks, or make a wrong arm movement, you must return to the table to get the correct information from the cards. Then begin again.

When the last card has been completed and you have pushed the key, move to the center and step on the mat. **

**Directions are in the order they would be for Task 1-A. For Task 1-B, the order is #3, #2, #1, #6, #5, #4.

Sample Chart Output Used for Time Scores



APPENDIX E

ACTUAL TIMED DATA FOR THE FOUR SUBJECTS

Table A

Actual Cue Referral Times in Seconds for Subject 1

9HV Segment

	Trials				
Element	1	2	3	4	5
1	40.0	18.4	56.0	21.2	15.6
2	13.6	19.2	45.6	13.6	11.2
3	16.8	12.8	24.0	9.6	12.0
4	20.0	12.8	13.6	20.0	21.6
5	17.6	12.8	33.6	16.0	24.0
6	23.2	12.0	15.2	20.0	16.0
7	20.0	18.4	16.0	12.0	14.4
8	16.8	14.4	11.2	12.8	18.4
9	27.2	12.0	16.8	13.6	26.8
Element	6	7	8	9	10
1	23.2	18.8	14.0	17.4	15.2
2	19.2	13.6	3.6	9.6	12.0
3	14.4	9.6	13.0	11.2	8.0
4	21.6	10.0	13.6	17.6	10.4
5	16.8	16.0	15.6	12.0	9.6
6	14.4	12.0	17.2	13.2	8.8
7	10.4	12.0	14.0	6.6	7.4
8	20.0	13.6	16.6	9.6	7.6
9	20.0	24.0	17.0	10.4	11.2
Element	11	12	13	14	15
7	20.8	15.0	12.2	9.6	6.0
1	6.6	8.0	4.4	6.0	7.2
5	7.0	9.2	8.0	6.8	9.2
8	8.0	6.0	7.2	9.6	5.6
4	13.2	9.2	8.4	8.4	5.2
3	7.6	8.0	4.4	8.0	7.6
2	10.0	6.8	9.2	6.0	5.6
9	16.4	10.0	9.6	8.4	9.6
6	6.4	7.0	6.2	4.8	7.2

Table A (continued)

4LV Segment

	Trials				
Element	1	2	3	4	5
1	133.6	41.6	67.0	53.6	71.2
2	57.6	49.6	47.2	28.8	44.8
3	109.6	39.2	51.6	48.8	56.0
4	102.4	56.0	40.0	43.2	50.4
5	63.2	35.2	50.4	35.2	40.4
6	60.8	86.4	18.4	32.0	51.2
7	85.6	51.2	39.2	45.6	28.8
8	144.8	44.0	40.8	38.4	24.8
9	101.6	37.6	32.8	42.8	52.8
Element	6	7	8	9	10
1	28.0	36.0	28.4	17.0	18.0
2	34.4	39.2	29.2	13.0	15.0
3	48.8	36.8	24.8	24.6	24.6
4	23.2	34.0	23.4	24.0	16.8
5	30.4	30.4	16.8	13.2	23.4
6	28.0	24.8	21.4	15.6	31.4
7	33.6	28.0	28.0	16.4	19.2
8	29.6	19.6	15.0	16.4	16.0
9	36.0	26.0	25.8	16.2	22.4
Element	11	12	13	14	15
4	27.0	18.0	20.4	26.4	12.0
1	20.4	15.6	19.4	15.6	10.2
8	19.6	14.6	14.6	16.8	18.0
9	11.6	23.0	13.6	16.8	12.0
3	29.0	27.6	20.6	20.8	10.8
6	15.6	21.4	12.0	15.2	8.0
7	11.4	10.0	16.0	8.8	8.8
5	13.6	16.4	18.8	14.0	12.0
2	15.6	12.6	29.8	10.8	10.4

Table A (continued)

9LV Segment

	Trials				
Element	1	2	3	4	5
1	82.4	79.2	160.0	100.8	156.8
2	116.0	64.8	66.4	57.6	58.4
3	128.0	112.0	69.6	89.6	108.0
4	89.6	57.6	44.8	55.6	44.8
5	224.0	87.2	60.8	72.0	37.6
6	118.4	62.4	104.0	79.2	144.8
7	84.8	55.2	76.0	37.6	56.2
8	56.0	36.8	35.2	74.4	40.8
9	54.4	49.6	40.0	47.2	39.2
Element	6	7	8	9	10
1	96.0	52.8	41.6	56.0	44.0
2	65.6	35.2	33.6	29.6	30.0
3	71.2	61.6	35.0	24.0	20.0
4	36.8	38.8	16.4	16.0	12.8
5	72.8	48.0	40.0	51.2	39.0
6	171.2	74.4	30.6	44.4	33.2
7	44.0	42.0	47.0	46.4	16.4
8	45.2	36.8	33.6	19.2	12.0
9	46.4	44.8	30.4	20.8	31.6
Element	11	12	13	14	15
7	21.4	33.0	29.2	26.2	25.0
1	33.6	17.8	22.6	26.8	31.8
5	12.4	14.0	31.0	20.0	27.2
8	15.2	13.4	14.0	12.0	9.6
4	27.2	20.0	24.8	18.4	10.4
3	44.8	25.2	44.0	20.8	25.6
2	26.4	11.2	42.0	18.4	23.2
9	17.6	23.4	16.8	17.0	12.0
6	70.8	22.4	44.0	28.0	18.8

Table A (continued)

4HV Segment

Element	Trials				
	1	2	3	4	4
1	36.8	30.4	19.2	31.2	22.4
2	25.6	19.2	6.4	7.6	7.2
3	9.6	10.4	5.6	8.0	8.8
4	16.4	9.6	4.8	10.4	4.8
5	11.2	12.0	8.0	31.2	8.8
6	12.8	5.6	10.4	11.6	12.0
7	10.4	7.2	7.2	8.0	5.6
8	10.0	8.0	8.8	14.4	11.2
9	3.2	2.4	28.8	8.8	7.2

Element	6	7	8	9	10
1	23.2	21.2	21.4	18.2	16.8
2	8.4	7.2	8.4	4.6	7.4
3	9.6	8.4	10.0	8.8	8.0
4	6.4	6.4	7.2	7.2	12.0
5	8.8	7.2	7.4	8.0	6.6
6	10.4	8.8	9.2	9.6	6.0
7	7.2	8.8	4.8	4.4	5.6
8	11.6	7.2	9.6	9.6	6.4
9	11.2	5.6	14.2	8.0	11.2

Element	11	12	13	14	15
4	12.0	9.6	10.6	6.8	10.0
1	9.6	5.4	5.6	5.6	8.4
8	12.0	8.0	6.0	6.8	6.0
9	12.0	8.0	4.6	4.4	6.8
3	7.6	7.2	7.2	5.6	9.2
6	8.0	16.0	13.0	7.2	8.4
7	4.6	5.4	3.0	4.4	5.0
5	5.4	4.0	4.0	3.6	5.6
2	6.0	4.0	3.2	4.0	5.6

Table B

Actual Element Performance Times in Seconds

for Subject 1

9HV Segment

	Trials				
Element	1	2	3	4	5
1	75.2	31.2	61.6	27.2	29.6
2	27.2	23.2	23.2	24.8	27.2
3	26.4	26.4	24.8	28.4	28.0
4	52.0	42.4	63.2	96.0	80.0
5	38.4	28.8	44.0	29.6	28.0
6	45.6	55.2	24.8	36.8	30.4
7	29.6	26.4	62.4	48.0	34.4
8	27.2	28.0	33.6	43.2	26.4
9	12.8	27.2	44.0	21.6	40.4

Element	6	7	8	9	10
1	50.4	24.8	25.8	24.0	22.0
2	23.2	28.0	29.4	28.4	16.8
3	33.6	21.2	30.0	22.2	22.4
4	99.2	33.6	43.0	24.0	20.4
5	30.4	25.6	34.4	27.0	26.0
6	32.8	29.6	30.6	34.4	27.0
7	27.2	25.6	28.8	23.2	21.6
8	44.8	28.8	30.4	25.0	20.0
9	42.4	24.8	14.2	18.4	12.8

Element	11	12	13	14	15
7	32.0	25.2	25.4	23.2	16.0
1	21.0	19.2	17.6	18.0	18.4
5	26.0	36.6	25.6	22.0	23.6
8	20.0	25.0	16.6	15.2	18.8
4	21.0	21.0	20.8	37.6	30.8
3	17.8	19.4	16.6	16.4	16.0
2	18.0	16.0	15.0	18.4	17.6
9	20.4	38.6	20.0	12.8	16.0
6	19.4	20.0	16.0	16.4	14.4

Table B (continued)

4LV Segment

	Trials				
Element	1	2	3	4	5
1	42.4	24.0	83.9	67.6	51.2
2	37.6	63.2	54.4	45.6	47.2
3	28.8	83.2	49.6	37.6	41.6
4	42.4	45.6	40.0	55.2	83.2
5	40.0	44.8	43.2	48.0	46.0
6	42.4	68.0	44.4	53.6	42.4
7	30.4	49.6	39.6	43.2	38.4
8	19.2	28.8	23.6	74.4	28.0
9	32.8	32.8	98.4	37.2	40.0
Element	6	7	8	9	10
1	39.2	40.8	33.4	41.2	34.0
2	39.2	44.0	39.4	34.6	37.0
3	44.0	46.8	42.6	55.0	40.6
4	67.2	49.2	45.6	44.6	89.4
5	44.0	43.2	42.6	30.4	37.0
6	52.0	45.6	44.0	45.4	49.0
7	38.4	35.6	30.8	30.0	28.4
8	26.4	28.8	30.6	24.0	58.4
9	28.8	33.2	27.6	39.0	24.0
Element	11	12	13	14	15
4	44.6	58.6	44.4	45.0	45.6
1	25.6	31.6	22.0	25.6	31.0
8	20.4	22.4	19.4	18.8	24.0
9	28.0	34.4	25.4	29.2	32.8
3	39.0	34.4	26.4	32.8	33.2
6	38.6	36.4	55.4	36.0	36.0
7	31.2	29.2	29.0	29.6	31.2
5	37.0	34.0	34.0	32.0	27.2
2	37.4	35.0	29.6	28.8	27.6

Table B (continued)

9LV Segment

	Trials				
Element	1	2	3	4	5
1	92.0	92.8	160.0	68.0	64.0
2	79.2	288.0	574.4	67.2	57.6
3	61.6	66.4	182.4	155.2	59.2
4	35.2	117.6	199.2	90.0	85.6
5	67.2	49.6	284.0	108.4	174.4
6	80.8	33.6	45.6	43.2	60.8
7	79.2	81.6	79.2	111.2	61.4
8	41.6	32.8	32.0	36.0	36.0
9	114.0	33.6	88.8	120.0	74.4
Element	6	7	8	9	10
1	68.0	76.0	69.8	54.0	69.4
2	118.4	60.8	107.2	59.2	34.6
3	53.6	52.8	51.6	47.0	42.4
4	102.4	69.2	76.6	44.0	33.6
5	55.2	152.0	103.0	41.6	40.0
6	37.6	95.2	183.0	32.0	84.0
7	53.6	74.8	68.8	48.0	41.6
8	82.8	72.4	96.0	50.0	30.0
9	91.8	89.2	47.0	28.8	36.0
Element	11	12	13	14	15
7	62.0	82.0	58.6	56.4	48.2
1	65.6	60.6	53.4	51.2	56.8
5	147.6	49.2	45.6	53.6	45.6
8	32.4	86.6	33.6	47.2	28.0
4	105.2	56.0	80.8	114.4	32.0
3	48.0	46.4	41.2	43.2	40.0
2	44.0	52.6	42.6	41.4	81.6
9	42.6	38.6	28.6	28.8	47.2
6	92.0	124.0	77.6	61.6	64.0

Table B (continued)

4HV Segment

Element	Trials 1	2	3	4	5
1	38.4	32.8	31.2	26.0	23.2
2	48.8	27.2	24.8	24.0	21.6
3	52.8	34.4	30.4	24.8	24.0
4	28.4	52.0	19.2	20.0	16.8
5	29.6	63.2	23.2	32.0	20.0
6	21.6	33.6	58.4	23.6	20.8
7	29.2	19.2	17.6	16.0	16.8
8	51.2	53.6	46.4	28.0	37.6
9	34.4	23.2	27.2	21.6	20.0

Element	6	7	8	9	10
1	38.4	32.4	31.2	26.0	21.6
2	26.0	22.8	25.2	20.0	19.4
3	26.4	24.8	24.8	50.0	20.4
4	39.2	12.8	15.8	12.8	12.0
5	22.4	24.8	29.4	18.0	17.6
6	30.4	33.6	24.0	22.0	28.8
7	18.4	17.6	16.6	12.0	11.0
8	34.8	64.8	24.0	43.2	32.0
9	20.0	20.0	21.8	13.0	19.6

Element	11	12	13	14	15
4	15.6	14.6	16.6	12.8	16.8
1	22.0	21.6	20.6	22.4	20.4
8	42.4	48.0	36.0	22.4	26.4
9	15.6	16.0	14.4	12.8	14.8
3	21.6	21.8	20.8	24.0	22.0
6	20.0	55.6	18.4	21.4	36.4
7	12.0	10.4	12.4	11.6	12.6
5	16.4	16.8	16.0	16.0	17.6
2	52.0	19.0	21.2	19.2	21.6

Table C

Actual Cue Referral Times in Seconds for Subject 2

9HV Segment

	Trials				
Element	1	2	3	4	5
1	11.6	36.8	24.0	10.4	14.8
2	8.8	17.6	10.4	8.8	9.6
3	7.2	9.6	10.4	5.6	10.4
4	8.8	16.0	4.8	4.8	8.8
5	14.4	7.2	15.2	3.2	10.4
6	4.0	16.8	8.8	4.0	5.6
7	14.6	16.8	8.0	8.0	6.8
8	9.6	9.6	8.0	5.6	7.2
9	13.6	21.6	16.8	8.0	4.4

Element	6	7	8	9	10
7	8.8	9.2	10.6	12.0	14.0
1	6.4	7.6	8.4	10.6	5.4
5	7.2	5.6	6.4	4.0	3.6
8	5.6	5.6	6.0	6.6	6.4
4	5.6	5.6	6.0	5.6	6.0
3	6.4	4.8	6.4	6.4	4.0
2	7.2	6.0	6.4	7.0	6.0
9	7.2	5.2	4.0	5.2	7.2
6	3.2	5.6	5.6	5.0	3.6

Element	11	12	13	14	15
7	8.4	8.0	6.6	6.8	7.6
1	4.4	5.6	5.6	5.4	5.6
5	6.0	6.4	6.4	7.2	4.0
8	4.6	5.4	6.0	6.8	4.0
4	7.2	6.4	5.6	6.4	7.6
3	6.8	3.6	7.0	6.8	6.4
2	6.4	5.4	8.4	6.4	8.0
9	6.4	5.6	6.8	7.6	5.6
6	7.2	5.6	2.0	3.2	4.4

Table C (continued)

4LV Segment

	Trials				
Element	1	2	3	4	5
1	76.0	50.4	45.6	55.2	36.8
2	86.4	45.6	24.8	26.4	20.4
3	31.6	43.2	29.6	23.2	27.2
4	152.8	61.6	48.0	17.6	24.0
5	36.4	32.8	33.6	32.8	32.8
6	101.2	40.0	33.6	25.6	23.2
7	118.4	41.6	49.6	29.6	24.4
8	48.0	33.6	28.0	25.6	26.0
9	40.0	53.6	33.6	35.2	24.8

Element	6	7	8	9	10
4	26.4	30.4	27.8	27.6	29.2
1	46.0	21.6	20.4	10.6	14.8
8	26.4	20.8	31.4	17.2	16.8
9	29.6	27.2	25.4	22.2	18.0
3	30.4	36.8	24.0	22.6	20.0
6	27.2	32.8	26.4	21.0	18.6
7	26.4	26.4	24.0	24.0	21.8
5	22.0	26.8	20.8	16.0	23.6
2	19.2	20.0	20.0	19.6	20.8

Element	11	12	13	14	15
4	26.4	34.4	12.8	19.8	17.6
1	14.6	10.4	14.0	20.8	10.4
8	18.0	19.0	23.2	20.0	12.4
9	15.6	18.6	19.6	23.2	20.0
3	15.6	20.4	18.0	28.2	15.8
6	15.2	20.6	26.0	17.2	13.2
7	20.0	20.0	26.0	27.2	19.6
5	16.0	14.6	33.6	12.4	15.2
2	18.6	16.4	14.0	14.0	15.8

Table C (continued)

9LV Segment

	Trials				
Element	1	2	3	4	5
1	79.2	154.4	140.0	58.4	80.8
2	120.0	60.0	60.0	38.4	28.8
3	152.8	53.6	52.8	34.4	51.2
4	123.2	64.8	46.4	29.6	26.4
5	68.8	60.0	56.0	32.8	107.2
6	82.4	112.0	74.4	46.4	60.8
7	109.6	40.0	38.4	51.2	33.6
8	40.4	35.2	24.8	26.4	24.8
9	65.2	33.6	39.2	24.0	35.2
Element	6	7	8	9	10
7	31.2	36.0	21.2	26.8	31.2
1	45.6	34.0	40.6	30.0	25.8
5	62.4	34.4	22.4	23.4	14.0
8	27.2	17.6	18.8	20.0	18.8
4	40.0	24.8	24.0	32.8	27.0
3	42.0	38.0	34.0	41.8	41.2
2	49.6	39.2	25.6	22.0	19.4
9	36.0	32.0	26.0	22.4	24.0
6	41.6	24.0	32.0	32.0	42.6
Element	11	12	13	14	15
7	22.6	17.6	18.2	16.0	21.6
1	24.6	30.2	22.8	16.8	20.4
5	35.0	18.4	15.6	14.0	10.0
8	13.2	12.4	12.0	14.4	11.2
4	24.8	25.6	23.4	27.2	19.2
3	32.4	27.6	18.0	17.6	14.4
2	19.2	10.2	13.6	8.8	13.2
9	25.4	15.0	19.4	19.2	19.2
6	21.0	25.2	28.0	18.4	36.0

Table C (continued)

4HV Segment

	Trials				
Element	1	2	3	4	5
1	23.2	12.0	16.0	13.6	16.0
2	8.0	8.0	6.4	5.6	8.0
3	6.4	8.0	5.6	6.4	6.4
4	8.8	6.4	6.4	8.0	5.6
5	8.0	20.0	7.2	4.8	7.2
6	8.0	8.8	6.4	7.2	8.8
7	8.0	6.4	4.0	6.4	4.8
8	6.4	8.8	8.0	7.2	7.2
9	4.8	2.4	4.8	2.4	5.6
Element	6	7	8	9	10
4	14.4	10.4	9.4	12.0	8.4
1	4.8	10.4	4.0	6.6	8.0
8	6.0	7.2	3.8	4.6	5.2
9	4.8	6.4	5.0	6.2	4.0
3	5.6	6.4	5.0	4.6	7.2
6	7.2	8.4	4.8	4.6	6.0
7	6.4	6.4	4.4	4.6	5.2
5	4.0	6.4	4.8	4.6	3.6
2	5.6	4.4	11.6	4.6	6.0
Element	11	12	13	14	15
4	9.4	11.4	13.6	7.6	8.8
1	6.6	6.0	7.4	7.2	5.6
8	6.4	5.6	7.0	6.8	7.2
9	7.4	6.4	8.0	7.2	5.6
3	5.4	5.0	6.6	5.2	5.6
6	8.4	6.0	7.2	6.8	7.2
7	5.6	4.6	6.4	4.4	4.8
5	7.2	5.6	6.8	6.4	5.2
2	6.0	5.0	6.4	5.6	6.4

Table D

Actual Element Performance Times in Seconds

for Subject 2

9HV Segment

	Trials				
Element	1	2	3	4	5
1	38.4	24.0	17.6	20.0	50.4
2	35.2	24.8	13.6	16.8	15.2
3	44.0	17.6	19.2	20.0	31.2
4	35.2	54.4	40.0	44.8	40.8
5	36.0	40.8	27.2	38.4	28.0
6	22.4	19.2	20.8	22.4	21.2
7	41.6	28.0	25.6	22.4	21.6
8	21.6	44.0	21.6	19.2	25.6
9	15.2	8.8	12.8	11.2	26.8
Element	6	7	8	9	10
7	21.6	24.8	20.0	20.4	22.6
1	19.2	18.4	19.4	21.6	24.4
5	27.2	25.6	23.6	33.0	24.0
8	19.4	18.4	18.0	20.0	28.6
4	18.0	29.6	18.0	20.0	26.6
3	16.8	17.2	14.4	17.0	24.0
2	16.0	18.0	18.6	15.6	15.6
9	20.0	23.2	8.6	28.6	13.6
6	20.8	14.6	19.6	21.0	20.4
Element	11	12	13	14	15
7	21.6	20.0	19.2	20.2	20.8
1	19.6	19.6	20.8	24.4	24.0
5	26.6	23.4	24.0	23.2	24.0
8	41.4	17.4	17.4	18.8	20.4
4	22.0	20.4	28.8	18.0	22.4
3	16.0	18.0	20.0	18.0	19.2
2	19.2	24.0	16.6	17.2	14.4
9	12.0	10.4	15.2	11.2	10.4
6	20.6	19.8	20.6	19.2	20.0

Table D (continued)

4LV Segment

	Trials				
Element	1	2	3	4	5
1	23.2	118.4	58.4	32.0	39.2
2	28.8	71.2	56.0	41.6	44.4
3	60.4	40.8	49.6	40.0	110.4
4	42.0	57.6	52.8	204.8	44.0
5	29.6	59.2	53.6	50.4	43.2
6	112.0	86.4	48.8	52.0	52.4
7	56.0	56.8	44.8	49.6	52.4
8	29.6	31.2	28.8	32.0	23.2
9	88.0	44.8	41.6	32.8	40.8
Element	6	7	8	9	10
4	51.6	42.8	42.0	53.2	45.2
1	36.8	43.2	37.6	51.6	42.2
8	31.2	30.4	27.6	35.4	29.8
9	40.8	40.0	41.6	42.4	43.0
3	124.0	40.8	32.0	43.0	42.6
6	48.8	54.4	56.6	107.0	44.0
7	46.8	86.0	45.4	42.4	69.6
5	45.6	49.6	48.0	47.4	45.6
2	44.0	50.0	48.8	44.0	46.2
Element	11	12	13	14	15
4	36.6	43.4	44.6	41.6	41.6
1	44.2	32.6	36.6	50.4	26.4
8	31.6	79.6	30.2	29.6	24.4
9	34.6	39.0	39.2	36.8	35.2
3	39.6	84.6	37.8	42.6	34.2
6	101.6	65.6	52.6	53.6	48.8
7	46.0	40.0	40.6	38.0	38.0
5	44.8	39.6	39.8	40.8	40.2
2	42.8	40.0	43.4	40.4	41.6

Table D (continued)

9LV Segment

	Trials				
Element	1	2	3	4	5
1	84.0	73.6	91.2	85.6	72.8
2	529.6	59.2	72.8	55.2	52.8
3	74.4	219.2	80.8	118.4	44.8
4	40.8	43.2	52.8	36.0	91.2
5	183.2	229.6	53.6	210.4	132.8
6	38.4	48.0	48.0	144.8	157.6
7	56.0	64.8	62.4	46.4	54.4
8	42.4	25.6	39.2	37.6	32.8
9	40.0	42.4	97.6	51.2	43.2
Element	6	7	8	9	10
7	53.6	50.8	56.0	48.0	40.0
1	81.6	76.0	78.0	60.0	80.0
5	68.8	64.8	60.0	57.2	66.6
8	67.2	37.6	34.4	47.0	40.6
4	42.8	45.2	98.6	54.8	75.4
3	61.6	69.6	66.0	56.0	60.8
2	179.2	56.8	145.0	59.6	50.8
9	57.6	48.0	45.0	41.6	52.8
6	47.2	108.8	56.0	103.0	43.0
Element	11	12	13	14	15
7	45.8	45.4	46.0	38.4	58.0
1	60.0	73.4	73.2	71.8	70.8
5	50.6	66.0	65.4	66.2	64.8
8	32.2	32.0	37.4	34.4	32.8
4	54.0	70.0	90.6	52.8	51.2
3	60.8	112.0	61.4	62.4	56.0
2	72.4	55.8	48.6	56.8	63.6
9	52.6	112.0	65.4	70.4	41.6
6	94.0	48.0	53.6	90.4	62.4

Table D (continued)

4HV Segment

	Trials				
Element	1	2	3	4	5
1	34.4	21.6	25.6	20.8	21.6
2	28.0	25.6	24.8	23.2	22.4
3	28.0	24.8	24.8	24.0	24.0
4	17.6	16.0	15.2	12.8	16.8
5	33.6	20.0	22.4	26.4	21.6
6	26.4	20.0	60.0	23.2	61.6
7	12.8	12.8	12.8	12.0	11.2
8	28.8	24.8	29.6	25.6	20.8
9	15.2	14.4	24.0	20.0	19.2
Element	6	7	8	9	10
4	13.6	16.8	16.0	16.0	14.0
1	21.6	25.6	24.0	21.6	22.0
8	20.4	20.8	19.6	20.0	22.6
9	12.8	15.2	14.4	13.6	12.6
3	21.6	23.2	22.4	22.8	22.0
6	21.6	23.6	22.4	22.8	20.8
7	14.4	18.4	14.4	12.4	14.0
5	25.6	22.4	21.6	19.4	19.6
2	23.6	26.8	26.4	26.4	23.6
Element	11	12	13	14	15
4	15.2	22.0	14.0	14.0	14.0
1	21.0	23.0	19.4	19.2	18.0
8	18.6	18.0	18.0	17.2	38.4
9	12.2	12.0	12.6	12.0	12.8
3	19.6	20.4	25.2	19.6	20.0
6	20.4	19.2	20.0	21.6	19.2
7	11.2	13.0	11.6	12.8	11.2
5	21.0	18.4	19.6	25.6	19.6
2	23.6	21.2	22.0	24.8	21.6

Table E

Actual Cue Referral Times in Seconds for Subject 3

4LV Segment

	Trials				
Element	1	2	3	4	5
1	23.2	32.0	28.2	22.4	20.4
2	21.2	17.2	24.0	24.0	15.2
3	16.0	23.2	32.0	23.2	25.6
4	28.8	30.4	20.4	38.4	15.6
5	18.4	16.0	27.2	26.4	11.2
6	16.8	23.6	28.0	26.4	23.6
7	28.0	21.6	18.0	24.0	24.8
8	26.4	36.8	29.6	19.2	16.0
9	22.4	26.4	17.0	27.2	22.4

Element	6	7	8	9	10
1	26.4	16.8	22.0	16.4	26.4
2	20.0	16.8	20.0	15.8	16.0
3	18.4	20.0	12.0	9.4	23.4
4	18.4	14.4	14.4	12.8	15.2
5	12.8	10.4	12.0	14.0	12.4
6	17.6	13.6	12.4	12.0	20.2
7	21.6	15.2	14.6	17.6	22.0
8	17.6	20.8	17.6	17.6	20.8
9	16.0	16.8	16.0	10.0	16.8

Element	11	12	13	14	15
4	26.4	19.6	21.0	16.6	12.8
1	8.6	21.6	11.2	10.4	5.2
8	23.0	18.8	16.0	13.2	10.8
9	24.0	18.0	10.2	31.2	11.6
3	22.0	13.8	22.0	18.0	14.2
6	16.0	33.2	13.6	13.6	13.6
7	12.0	20.0	30.6	11.6	9.6
5	11.4	12.6	12.6	13.6	8.8
2	12.8	15.0	18.6	12.0	10.8

Table E (continued)

9HV Segment

	Trials				
Element	1	2	3	4	5
1	29.2	65.6	13.2	6.4	8.8
2	12.0	16.0	16.4	9.6	8.0
3	15.2	16.4	11.2	6.8	8.8
4	27.2	16.8	16.8	9.6	5.6
5	16.0	18.4	17.2	16.0	11.2
6	16.0	15.2	8.0	7.2	15.2
7	11.2	18.4	10.8	8.0	4.8
8	9.6	10.0	8.8	8.0	5.6
9	23.2	10.8	15.6	14.4	10.4

Element	6	7	8	9	10
1	10.4	10.8	3.0	9.2	4.4
2	12.8	12.0	9.4	5.6	6.4
3	6.0	6.0	8.0	2.4	2.4
4	6.4	9.6	9.6	4.0	4.0
5	9.6	4.4	9.0	3.6	4.0
6	14.4	9.6	4.8	7.6	9.6
7	5.2	4.4	5.2	6.4	4.0
8	3.6	4.6	5.2	4.4	4.0
9	6.4	5.0	4.6	8.0	2.8

Element	11	12	13	14	15
7	3.6	5.6	10.0	4.8	3.2
1	6.0	2.0	1.6	2.4	4.0
5	4.4	1.0	.5	2.4	3.2
8	1.4	1.0	2.4	1.4	4.0
4	4.2	2.8	4.4	4.2	1.6
3	5.0	4.4	2.6	2.8	3.6
2	11.8	3.2	4.0	5.2	2.8
9	4.0	2.8	3.6	2.0	4.8
6	2.8	2.4	2.6	5.2	4.0

Table E (continued)

4HV Segment

	Trials				
Element	1	2	3	4	5
1	36.0	30.4	4.0	19.2	17.6
2	1.6	8.0	4.0	4.8	16.8
3	6.8	12.8	8.0	12.0	29.6
4	6.8	8.0	4.0	8.0	20.0
5	8.8	14.4	4.8	4.0	4.8
6	16.8	13.6	6.8	4.8	4.8
7	5.6	9.6	10.0	10.4	2.4
8	11.2	13.6	9.2	5.6	6.4
9	9.6	18.4	7.6	4.8	10.4
Element	6	7	8	9	10
1	16.8	10.4	6.0	3.2	8.0
2	3.2	2.4	5.6	2.0	3.6
3	4.0	4.0	4.8	1.6	2.0
4	1.2	4.0	3.2	3.6	2.6
5	2.4	4.4	3.2	1.6	2.0
6	2.4	3.6	6.4	5.6	1.4
7	4.8	4.8	2.4	2.0	6.4
8	4.8	3.4	2.0	1.6	6.6
9	2.0	4.8	11.4	1.6	4.0
Element	11	12	13	14	15
4	17.0	6.4	17.4	10.4	4.8
1	.5	9.2	2.0	2.0	1.0
8	2.6	4.0	1.0	3.2	.8
9	7.0	9.2	3.0	3.6	.8
3	2.4	4.0	4.0	1.6	1.6
6	3.1	5.4	1.6	1.0	1.6
7	1.6	3.6	2.4	3.6	2.4
5	1.8	2.0	3.2	2.4	.8
2	2.6	4.6	2.6	5.6	.8

Table E (continued)

9LV Segment

Element	Trials 1	2	3	4	5
1	89.6	117.0	76.0	70.8	60.8
2	31.2	24.8	40.8	38.8	32.0
3	35.2	48.0	36.8	35.2	26.4
4	28.8	31.2	31.2	24.4	26.8
5	26.4	52.0	37.6	28.8	28.0
6	44.0	47.2	49.6	34.4	28.0
7	34.4	31.2	22.4	32.8	14.4
8	27.2	23.2	22.4	27.2	20.0
9	30.4	23.2	22.4	26.4	23.2
Element	**6**	**7**	**8**	**9**	**10**
1	55.2	44.4	40.0	30.4	14.4
2	29.2	26.0	27.0	32.0	12.4
3	23.2	24.0	14.6	18.4	25.2
4	18.4	24.8	12.0	28.0	30.0
5	24.0	25.6	38.0	18.0	22.4
6	22.4	32.0	31.0	22.4	22.4
7	22.4	14.4	21.6	19.6	22.4
8	20.8	20.0	13.0	20.0	14.0
9	24.8	18.4	18.0	16.8	18.2
Element	**11**	**12**	**13**	**14**	**15**
7	17.2	41.4	16.2	16.8	16.4
1	20.0	14.0	9.2	9.6	4.8
5	10.0	15.6	6.0	6.0	5.6
8	16.0	13.8	8.4	8.8	10.4
4	16.4	16.6	10.6	14.4	15.2
3	18.4	18.8	25.6	12.6	18.0
2	8.0	9.4	6.6	10.0	5.2
9	13.6	21.6	9.6	12.2	10.0
6	22.4	28.0	22.4	16.8	19.2

Table F

Actual Element Performance Times in Seconds

for Subject 3

4LV Segment

	Trials				
Element	1	2	3	4	5
1	23.2	12.4	66.8	41.2	63.8
2	39.0	28.0	48.8	28.8	30.0
3	15.2	63.6	27.0	27.2	64.0
4	16.8	31.2	32.8	32.0	29.2
5	27.2	25.6	33.6	24.0	57.6
6	165.6	38.0	28.4	32.0	37.2
7	21.6	75.2	33.2	36.8	24.0
8	69.6	70.4	17.2	84.0	17.6
9	28.0	76.0	30.8	27.2	28.0
Element	6	7	8	9	10
1	27.2	45.6	38.0	19.6	29.4
2	22.4	26.4	17.0	22.0	22.4
3	20.8	30.4	18.0	18.4	46.0
4	23.2	25.6	21.0	17.4	24.8
5	16.8	16.0	15.0	15.6	22.4
6	24.0	21.6	25.0	22.4	27.6
7	85.6	26.4	26.0	20.4	34.4
8	17.6	12.8	12.4	11.2	12.0
9	27.2	22.0	19.0	14.4	44.0
Element	11	12	13	14	15
4	23.4	22.8	20.6	25.4	29.2
1	31.4	19.4	25.6	16.4	34.0
8	16.0	14.4	12.0	16.8	13.2
9	22.4	19.0	61.6	21.6	22.6
3	22.4	16.0	17.0	21.6	17.6
6	46.6	26.6	21.4	27.2	22.8
7	21.4	22.6	27.2	22.0	20.0
5	16.4	20.0	19.0	13.6	19.6
2	17.6	19.6	22.0	20.0	17.6

Table F (continued)

9HV Segment

Element	Trials 1	2	3	4	5
1	32.0	55.2	36.0	50.4	25.6
2	31.6	52.4	30.8	36.0	28.8
3	31.2	28.8	55.2	81.2	51.2
4	34.4	58.0	57.6	25.6	56.0
5	34.0	32.4	33.6	49.6	25.6
6	20.8	27.2	28.4	38.4	20.8
7	60.8	66.4	31.6	35.2	44.0
8	17.6	30.0	23.2	30.8	29.6
9	38.4	22.0	66.8	77.6	13.6
Element	**6**	**7**	**8**	**9**	**10**
1	47.2	25.6	29.0	24.0	30.4
2	36.4	42.0	26.0	36.8	48.0
3	43.2	57.6	24.6	19.6	22.4
4	45.6	30.4	32.4	32.8	32.0
5	28.0	22.0	40.4	32.4	28.0
6	16.0	24.4	34.4	17.6	22.0
7	22.4	23.2	22.0	20.0	22.4
8	16.8	31.4	18.0	20.4	25.6
9	12.0	18.0	9.0	12.4	26.4
Element	**11**	**12**	**13**	**14**	**15**
7	41.2	23.0	23.4	23.2	21.6
1	25.0	44.0	26.4	20.0	19.2
5	30.4	27.2	24.0	29.6	32.0
8	17.6	24.0	22.6	17.8	32.8
4	56.0	37.4	70.4	43.4	57.2
3	20.0	19.0	20.2	22.4	17.2
2	78.4	44.0	35.6	20.4	27.2
9	28.0	18.6	23.8	13.6	19.2
6	20.0	23.8	34.0	17.2	23.6

Table F (continued)

4HV Segment

Element	Trials 1	2	3	4	5
1	50.4	22.4	26.4	27.2	23.2
2	38.4	17.6	51.2	20.0	20.8
3	51.2	29.6	20.0	25.6	4.8
4	17.6	21.2	18.4	33.6	58.4
5	51.2	40.4	22.0	24.8	35.2
6	24.8	29.6	23.6	28.8	24.8
7	18.4	18.8	46.4	21.6	13.6
8	40.0	16.4	38.4	23.2	20.8
9	51.2	20.0	34.4	24.0	42.4

Element	6	7	8	9	10
1	25.6	31.6	29.4	21.4	17.6
2	19.2	18.4	17.4	20.8	23.6
3	22.4	35.2	17.6	14.4	24.0
4	15.6	15.6	15.2	15.6	16.6
5	25.2	18.0	20.2	24.4	16.2
6	21.2	22.4	28.0	33.2	45.4
7	20.0	18.8	15.2	14.4	30.0
8	23.6	30.6	20.0	32.0	39.2
9	36.0	23.2	20.4	52.0	14.8

Element	11	12	13	14	15
4	36.0	32.0	14.0	16.0	15.0
1	28.4	21.0	20.0	18.0	20.0
8	28.4	28.4	22.2	23.2	35.2
9	20.0	37.0	37.6	18.8	17.6
3	20.4	20.8	24.6	30.4	20.4
6	24.5	24.6	22.0	19.0	27.6
7	14.0	13.6	15.6	8.8	13.6
5	22.0	17.0	16.0	14.8	22.4
2	37.6	17.6	16.8	17.4	20.0

Table F (continued)

9LV Segment

	Trials				
Element	1	2	3	4	5
1	163.2	100.0	75.2	66.0	41.6
2	66.4	151.2	102.4	100.4	195.2
3	155.0	93.6	81.6	49.6	35.6
4	18.4	49.6	36.0	43.6	17.6
5	60.4	104.2	96.2	128.0	197.6
6	80.0	24.0	64.8	128.0	37.6
7	36.0	28.0	36.0	44.8	30.4
8	62.4	21.6	38.8	20.4	20.0
9	18.4	64.8	78.4	34.4	23.2

Element	6	7	8	9	10
1	73.6	46.4	40.4	39.2	61.4
2	263.2	174.8	29.0	57.0	29.4
3	35.2	30.4	31.0	36.4	19.2
4	17.6	18.4	39.0	43.2	44.4
5	126.4	60.8	34.0	26.0	50.0
6	75.2	25.6	159.0	53.2	48.0
7	28.8	56.8	54.0	34.6	28.0
8	17.6	22.4	16.0	31.3	22.4
9	28.0	25.6	27.4	17.4	20.4

Element	11	12	13	14	15
7	41.4	31.0	26.4	31.6	36.0
1	42.6	39.6	32.0	38.4	34.0
5	39.6	27.2	29.0	26.0	30.8
8	16.8	24.8	14.0	19.2	22.4
4	84.0	70.4	31.6	59.2	31.2
3	37.0	31.4	66.6	29.8	30.4
2	28.6	28.0	28.0	27.2	29.4
9	24.8	24.8	27.2	19.8	50.4
6	63.0	38.2	62.6	19.2	18.4

Table G

Actual Cue Referral Times in Seconds for Subject 4

4LV Segment

	Trials				
Element	1	2	3	4	5
1	29.6	52.0	57.6	20.8	20.0
2	28.0	29.6	24.8	17.6	17.6
3	29.6	32.8	43.2	24.4	20.0
4	28.8	21.6	38.4	23.2	17.6
5	30.4	26.4	25.2	22.8	21.6
6	25.6	29.2	28.0	18.0	22.4
7	35.2	27.6	20.0	16.0	21.2
8	28.4	24.4	20.0	23.2	18.4
9	29.6	22.4	27.6	19.6	16.4
Element	6	7	8	9	10
4	20.4	19.2	14.0	13.6	12.0
1	18.0	12.8	10.0	10.4	9.0
8	15.6	17.6	18.0	11.2	12.4
9	20.0	20.4	7.0	11.6	16.0
3	20.8	32.4	12.0	11.2	16.0
6	14.6	13.6	11.6	12.8	12.4
7	20.0	16.8	19.6	10.0	13.6
5	20.0	20.8	21.0	10.4	11.2
2	16.8	17.2	15.6	12.0	10.8
Element	11	12	13	14	15
4	18.0	13.6	18.0	15.2	23.8
1	13.6	8.4	8.0	8.0	7.6
8	14.4	10.8	8.0	11.2	9.6
9	18.0	12.6	17.2	11.0	12.0
3	17.2	15.6	9.6	10.0	21.2
6	12.0	10.4	9.4	8.8	12.6
7	16.8	12.0	14.8	13.2	12.4
5	13.4	8.2	9.0	8.0	10.4
2	15.6	10.6	9.8	8.8	11.2

Table G (continued)

9HV Segment

Element	Trials 1	2	3	4	5
1	28.0	74.4	16.8	26.4	20.0
2	24.8	14.4	17.2	9.6	8.0
3	12.4	14.4	15.2	8.0	8.4
4	24.8	20.0	16.0	8.8	8.0
5	19.2	28.8	9.6	9.6	8.0
6	14.8	16.8	12.8	8.0	8.0
7	14.4	19.2	9.6	9.6	8.8
8	9.6	10.4	8.0	8.0	10.4
9	16.0	12.0	11.2	10.4	8.8
Element	**6**	**7**	**8**	**9**	**10**
7	18.8	12.8	28.4	16.0	17.0
1	24.8	8.8	3.6	10.6	12.6
5	12.4	9.6	5.6	10.4	8.6
8	12.0	8.4	14.0	16.8	6.8
4	11.2	8.4	5.6	24.0	10.4
3	11.6	9.2	10.8	28.4	6.6
2	9.6	11.2	12.0	26.0	10.4
9	8.8	7.2	17.6	21.6	6.4
6	12.4	8.0	12.4	16.8	15.6
Element	**11**	**12**	**13**	**14**	**15**
7	11.6	6.0	10.8	10.0	3.2
1	8.0	11.2	17.4	7.4	15.6
5	10.8	6.4	16.0	10.8	30.6
8	9.0	8.4	6.0	5.8	29.6
4	9.4	8.0	8.8	8.8	9.6
3	10.0	5.0	10.2	13.2	10.4
2	9.8	10.0	12.0	12.0	13.6
9	7.6	11.2	6.4	17.6	5.6
6	11.6	10.2	14.0	10.8	5.0

Table G (continued)

4HV Segment

	Trials				
Element	1	2	3	4	5
1	49.2	35.6	6.0	17.0	24.0
2	11.2	16.0	12.0	7.2	5.6
3	11.2	9.6	9.6	5.6	8.0
4	24.0	8.0	7.2	7.2	7.2
5	87.6	13.6	8.4	9.6	8.8
6	38.8	10.4	8.8	8.8	11.2
7	31.2	9.6	10.4	7.2	7.2
8	37.6	10.4	9.2	9.6	8.0
9	19.2	10.4	7.2	8.0	8.8
Element	6	7	8	9	10
4	11.2	10.0	28.0	22.4	18.4
1	9.6	5.6	6.0	10.4	5.8
8	10.4	11.6	10.4	8.8	18.0
9	10.4	12.0	7.2	7.2	6.4
3	12.0	9.6	19.6	6.4	15.6
6	12.0	10.4	8.4	9.4	11.0
7	7.6	8.8	9.0	6.4	5.6
5	8.0	10.4	7.6	5.6	8.0
2	6.8	8.0	17.6	8.0	5.4
Element	11	12	13	14	15
4	38.6	6.4	18.4	20.4	20.8
1	5.6	7.2	7.8	10.0	9.6
8	10.0	5.6	5.6	5.6	16.8
9	7.0	5.0	5.8	7.6	9.2
3	8.0	5.8	5.0	4.8	12.6
6	10.0	5.6	6.8	8.0	24.0
7	10.6	5.6	8.0	3.4	12.4
5	7.0	6.0	6.4	6.4	15.6
2	5.8	4.6	6.4	4.8	13.6

Table G (continued)

9LV Segment

Element	Trials 1	2	3	4	5
1	115.6	147.2	46.8	77.6	40.0
2	43.2	45.6	50.8	41.6	39.2
3	31.2	38.8	32.4	43.2	34.4
4	42.0	31.2	26.8	44.8	32.0
5	32.8	51.2	40.8	48.0	37.6
6	54.8	44.4	67.2	80.0	34.8
7	78.4	44.4	31.2	40.0	22.4
8	33.6	23.2	36.0	33.6	14.4
9	46.4	44.0	14.4	30.4	18.4
Element	**6**	**7**	**8**	**9**	**10**
7	58.8	50.4	26.0	28.8	21.0
1	56.8	28.8	7.6	16.8	10.4
5	68.8	41.6	7.0	8.8	9.2
8	12.4	11.2	8.0	10.4	8.8
4	42.4	26.0	24.4	12.0	12.0
3	27.2	30.0	20.0	17.6	36.4
2	76.0	44.0	14.4	28.0	20.0
9	30.0	20.8	17.6	12.4	13.8
6	47.6	27.2	40.6	43.6	19.6
Element	**11**	**12**	**13**	**14**	**15**
7	24.0	17.0	18.6	13.2	19.2
1	21.0	10.0	6.0	5.2	9.6
5	9.4	6.4	6.4	4.4	7.2
8	9.2	6.4	8.0	4.8	10.4
4	13.6	11.2	9.0	8.4	9.6
3	20.4	8.8	10.4	6.8	8.0
2	27.6	5.6	10.4	6.0	6.4
9	13.2	9.0	11.8	7.2	17.6
6	22.4	16.4	7.6	8.8	7.2

Table H

Actual Element Performance Times in Seconds

for Subject 4

4LV Segment

	Trials				
Element	1	2	3	4	5
1	188.8	78.4	50.4	41.6	34.4
2	53.6	40.0	54.4	66.0	34.4
3	92.8	45.6	39.6	34.4	34.4
4	64.0	79.2	57.6	40.8	37.6
5	64.8	42.8	44.0	34.4	44.0
6	124.8	55.2	54.8	44.0	45.2
7	67.2	40.8	29.6	28.0	20.8
8	33.6	27.2	29.6	23.6	21.6
9	79.2	26.4	27.6	29.6	32.0
Element	6	7	8	9	10
4	47.2	58.4	39.0	38.4	38.4
1	40.8	39.2	38.0	34.0	36.0
8	74.4	40.4	53.4	21.4	23.4
9	36.0	50.0	41.6	50.0	46.4
3	37.6	40.0	40.0	38.4	36.6
6	56.6	48.8	49.2	44.0	46.4
7	32.8	65.6	32.0	20.8	56.0
5	37.6	37.2	45.0	32.8	34.8
2	41.6	43.2	41.6	38.4	40.4
Element	11	12	13	14	15
4	41.2	38.0	37.6	38.0	39.2
1	36.4	37.0	26.6	35.2	37.2
8	24.0	23.6	22.0	25.6	26.4
9	39.2	33.0	21.4	31.0	46.0
3	70.0	36.6	33.6	36.8	29.6
6	44.6	45.2	42.6	44.0	49.8
7	27.6	26.6	23.4	26.0	25.2
5	33.0	40.0	30.2	32.0	30.0
2	39.2	39.8	39.2	39.6	49.2

Table H (continued)

9HV Segment

	Trials				
Element	1	2	3	4	5
1	85.2	40.8	36.0	31.2	34.4
2	89.6	32.0	30.4	24.8	23.2
3	125.2	28.8	49.6	34.4	34.0
4	32.8	30.4	58.4	28.0	34.4
5	43.6	40.0	36.8	33.6	38.4
6	47.2	29.6	28.0	30.4	26.4
7	94.0	31.2	56.4	60.0	86.4
8	26.4	41.6	64.4	32.0	41.6
9	24.8	17.6	14.8	15.2	12.8
Element	6	7	8	9	10
7	33.2	33.6	27.6	51.0	74.0
1	31.2	37.6	48.0	26.4	27.4
5	31.6	41.6	38.0	37.2	38.4
8	25.6	30.0	33.6	16.8	30.6
4	27.2	56.0	28.4	10.4	28.8
3	37.2	48.0	25.6	7.2	46.4
2	24.8	27.6	24.0	15.2	22.4
9	19.6	16.0	43.6	37.2	17.2
6	23.4	26.0	45.6	21.6	74.2
Element	11	12	13	14	15
7	27.2	73.4	36.0	24.6	28.0
1	28.0	26.0	25.0	25.6	32.0
5	43.0	35.6	41.2	35.2	50.4
8	26.4	26.4	31.2	25.2	55.6
4	28.8	33.0	27.6	28.4	46.4
3	31.4	28.0	24.0	24.0	57.6
2	22.4	21.6	22.4	20.8	55.6
9	46.4	18.0	10.0	15.6	37.2
6	26.0	34.0	63.4	19.6	47.4

Table H (continued)

4HV Segment

	Trials				
Element	1	2	3	4	5
1	102.8	68.0	44.4	36.4	45.6
2	24.8	28.0	36.8	28.0	27.2
3	57.6	32.8	39.2	36.4	36.0
4	7.6	18.4	23.6	17.6	20.0
5	12.8	28.0	24.0	25.6	26.4
6	10.0	33.6	36.8	53.6	41.2
7	17.6	17.6	19.6	16.0	18.4
8	8.4	24.8	35.2	32.8	27.2
9	7.6	18.4	24.0	20.8	22.4

Element	6	7	8	9	10
4	20.0	21.6	21.0	60.8	20.4
1	35.2	35.6	49.0	29.6	35.6
8	44.8	31.6	27.0	29.6	31.4
9	23.2	20.8	19.6	20.0	22.0
3	39.2	32.0	30.4	42.0	37.8
6	36.8	30.4	33.6	31.2	34.6
7	16.4	18.4	18.0	19.2	33.4
5	24.4	25.6	23.4	23.6	30.6
2	24.0	24.0	32.0	23.4	31.0

Element	11	12	13	14	15
4	21.8	74.0	20.0	22.0	43.2
1	26.8	26.6	28.6	26.4	29.6
8	26.6	25.8	38.0	32.4	46.0
9	22.8	20.0	20.4	18.4	21.6
3	30.4	42.6	30.0	24.8	30.0
6	45.6	26.6	30.8	26.4	49.2
7	17.2	18.8	18.4	18.6	17.6
5	24.4	26.4	39.0	23.6	49.2
2	24.6	26.4	32.0	28.8	33.6

Table H (continued)

9LV Segment

	Trials				
Element	1	2	3	4	5
1	119.2	156.0	56.8	41.6	50.8
2	180.0	200.4	195.2	123.2	104.0
3	189.6	48.0	40.8	112.8	48.8
4	108.8	100.0	78.4	52.8	32.0
5	309.6	226.4	138.4	114.4	47.2
6	100.8	58.0	44.0	27.2	30.0
7	50.4	50.8	44.0	40.0	39.2
8	31.2	24.8	48.0	20.8	20.8
9	66.4	69.6	24.0	33.6	30.4
Element	6	7	8	9	10
7	44.0	53.6	36.4	36.8	37.0
1	52.0	43.2	52.0	24.0	51.0
5	55.6	54.4	47.6	44.0	54.4
8	24.8	26.8	24.8	12.0	22.4
4	118.4	192.4	85.6	58.8	48.0
3	54.4	41.6	96.8	45.6	39.4
2	120.0	67.2	50.4	48.0	49.6
9	34.4	55.2	25.6	24.4	27.6
6	105.6	98.4	48.0	48.0	65.4
Element	11	12	13	14	15
7	43.2	40.0	40.0	38.0	38.4
1	50.4	50.6	44.0	46.4	48.8
5	49.0	47.4	46.0	46.2	49.6
8	21.6	24.6	20.6	21.6	20.8
4	31.8	29.0	27.2	40.8	28.8
3	43.0	39.0	44.0	28.0	40.8
2	38.8	48.4	47.0	47.2	52.0
9	25.6	26.0	27.2	25.2	26.4
6	42.6	40.0	26.4	105.2	29.6