

THE RELATION OF ACTIVE-PASSIVE MOVEMENT AND
PERCEPTUAL DIFFERENTIATION TO GEOGRAPHIC ORIENTATION

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INTRODUCTION

Spatially oriented movement of man requires differentiation and integration of multisensory information. Information from internal and external cue sources combines to provide a frame of reference for the structuring of space and man's orientation in relation to space. Although cue sources which influence spatial orientation have received attention in the literature, further investigation is needed to delineate the necessary conditions for and contributions of associated peripheral and central mechanisms for learning.

Following the mechanistic model of linear causality, the experimental questions related to skill learning have emphasized a dichotomous relationship between cognitive and motor processes. This convenient distinction between processes is reflected in the general question of whether skill learning is primarily influenced by the association of motor responses to internal cue sources (largely proprioceptive) or is significantly determined by knowledge about relationships in the external environment and requirements of the task (largely cognitive).

Contemporary theorists no longer apply such a simplistic view to the study of human behavior. It is to be expected, however, that the evaluation of a conceptual framework concerning complex organized systems will assimilate some of the empirical findings of earlier research. Clearly, a theoretical model which has the potential for the dynamic explanation of spatially oriented behavior will accommodate the empirical findings which indicate the influence of motor and cognitive variables on the way man organizes cues from both domains to accomplish highly adapted behavior.

Active movement is believed to be a central parameter in the frame of reference by which man structures space. The cue sources from voluntary

movement are both motor and sensory. However, the efference mechanism, which transmits commands to the muscles from the central nervous system, is inherent in voluntary movement and absent in passive movements which involve only sensory cue sources. Therefore, a viable means for inferring the contribution of voluntary movement to the learning of spatially oriented behavior is through the experimental manipulation of actively and passively produced movement conditions.

In addition to sensory and motor cue sources possessing varying degrees of influence on the learning process, it is known that individuals differ in the extent to which they select and use the stimulus information available in their internal and external environments. These individual perceptual differences will undoubtedly contribute to variations in learning. Research in the area of perceptual differentiation has contributed significantly to what is known regarding the basis for individual differences in cue selection. The findings are clear in establishing the consistency of individual behavior in this dimension. Less clear is the influence of these individual modes of perceptual differentiation on the organization of movement behavior. This influence, as well as the relationship of passive and active movement conditions to learning, is the subject under examination in the present study.

The subjects in this experiment were presented with the problem of learning a spatial-motor task. The design of the experiment sought to determine the contributions of internal motor processes, external stimulus sources, and individual differences to the accomplishment of this behavior.

Terminology

afference: sensory impulses transmitted by neurons from sensory sources toward the brain or spinal cord.

corollary discharge: recirculated efference informing CNS of subsequent action.

efference: motor impulses transmitted to the muscles by neurons from the CNS.

exafference: sensory feedback resulting from passive movement and therefore independent of motor impulses.

geographic orientation: the ability to maintain accurate orientation in relation to a spatial pattern and goal.

perceptual differentiation: the selection of information from the body or environment which establishes an internal (field-independent) or external (field-dependent) frame of reference for the organization of space.

reafference: sensory feedback resulting from voluntary movement and therefore dependent on motor impulses.

Learning Theory and the Regulation of Motor Sequences

Spatially oriented behavior has been of interest to researchers from the beginnings of learning theory. In fact, maze learning (one form of spatial orientation) was the task used in all the early human studies and was viewed as a general instance of serial action and complex learning (Holding, 1970). Controlled maze-learning studies led to the formulation of two opposing learning theories. One theory of sequential action for highly learned involuntary movements held that a series of response elements are acquired by the conditioning of each movement segment to the proprioceptive feedback of the preceding segment (James, 1890). After a signal to start, the sequence runs smoothly by the processing of its own feedback loops. The hypothesis was called response chaining (Mott & Sherrington, 1895).

The stimulus-response school of learning emphasized the observable response to eliciting stimuli. To account for the regulation of motor sequences such as running through a maze, response chaining was hypothesized. The observable response with inevitable feedback gave proprioception a prominent position for the explanation of serial learning. In line with stimulus-response theory, proprioception was labeled stimuli to which responses could be learned. Therefore, proprioception was necessary for the learning of relatively long sequences of motor responses. Although the feedback stimuli were usually defined as proprioceptive, the hypothesis was general and in principle could accommodate all types of feedback.

Early attempts to explain the coordination of sensory information and its integration with feedback from muscular responses left many unanswered questions. The hypothesis of skill acquisition as associatively

bonded stimulus-response chains was challenged by goal-directed theories of behavior. The inadequacy of the Hullian stimulus-response model was first exposed by Lashley (1951). In reaction to the peripheralists' view of response learning, the central perceptual theory of learning was proposed. The theory emphasized learning of spatial relationships in the environment and requirements of the task. The major hypothesis regarding regulation of motor sequences stated that learning was the central organization of the behavioral sequence (Lashley & McCarthy, 1926). The concept of the motor program suggested that once started, the program runs off in sequence independent of all feedback and proprioception in particular (Lashley & McCarthy, 1926). Using precise experimental techniques, Lashley interpreted rats' behavior in a maze as being a succession of turns run off independently of stimuli and accomplished by a central record of general direction. Thus, the considerable variation in the actual movements produced could be explained (Lashley & Ball, 1929).

A significant monograph by Honzik (1936) on the relative importance of sensory systems in animal maze learning criticized the response-chaining and central hypotheses. Through use of strict empirical tests, Honzik demonstrated the absence of learning when proprioception was the only source of information. Therefore, in opposition to the response-chaining hypothesis, proprioception was not considered sufficient for learning. Proprioception was also not necessary for learning. Learning occurred with each of the other sense modalities singularly and in combination. The centralists' hypothesis requires that proprioception and all other sources of stimuli are nonfunctional. Although proprioception was found to be nonfunctional, other sensory stimuli were important to learning. In

fact, Honzik demonstrated the dominance of vision in guiding maze behavior and further suggested that spatial learning was based on visual stimuli when available as learning cues.

Tolman's (1936, pp. 89-103) ideas, based on a lifetime of maze studies, were similar to Honzik's. Proprioception was viewed by both men as important to the refinement of movement qualities after considerable practice. Tolman defined learning as the establishment of expectations about the contiguity of events based on repeated past experience with their sequential structure. The position infers that learning is an active process involving interactions between the learner and environment, based on strategies of information processing. With practice, the learner's improvement in performance is due to an improved central strategy for integrating information. This view of the nature of the learning process is vastly different from that of the associationist who considered learning to be the passive product of mechanically established stimulus and response bonds. In the latter view, learning was the strengthening of feedback traces; and therefore central representation was determined by peripheral factors.

Von Holst (1954) also rejected the response-chaining and central control hypotheses. Using a different experimental framework, von Holst combined the central and peripheral hypotheses of the traditional learning theories in his now classic closed-loop theory of eye movement control. The concept of proprioceptive reafference (proprioception combined with central efference) was introduced to describe how motor commands to the oculomotor system influenced the stability of the visual image during eye movements. In sharp contrast to response-chaining notions, proprioceptive reafferent stimuli were seen to be comparable to the efferent reference mechanism for error detection and ultimate

correction. The revolutionary idea that proprioception functions in connection with reference mechanisms changed the focus of motor learning research and theory. Recent closed-loop theories of motor learning are based on the foundation of reference mechanisms to which the feedback from volitional muscular activity are compared (Adams, 1971; Schmidt, 1975). Closed-loop theory would predict that proprioceptive stimuli can guide well learned responses because current proprioceptive stimuli from movement are compared to reference levels from past learning and are recognized as correct (Adams, 1971).

A major concern of theorists is determining how the reference mechanism is acquired. Closed-loop theory predicts that in the early learning stage the reference mechanism is established by afferent information. Therefore, the implication is that the more afference available, the stronger the reference for correctness. However, recent research has indicated that afferent systems contribute unequally to the development of the reference mechanism. In line with Honzik's (1936) work, proprioception was not found to be critical in building the central symbolic representation of movement (Adams, 1972; Adams & Goetz, 1973). Not surprisingly, vision rather than proprioception is most essential to the establishment of the reference mechanism (Stelmach & Kelso, 1975). It was reasoned that in situations where vision and proprioception were both available, vision was spontaneously attended (Jordan, 1972) and proprioceptive information not fully utilized (Klein & Posner, 1974; Rock & Victor, 1964). Most researchers agree that proprioception is used mainly to correct movement form after the reference mechanism has been fully established by other afferent systems (Gibbs, 1970).

The current closed-loop theories, paralleling the changing status of proprioception, have therefore generated investigations on skilled behavior. Research on control of learned response has been carried out using simple discrete, unidirectional movements. As a consequence, the traditional line of complex sequential movement studies has been limited. Spatial learning requires the coordination and regulation of whole sequences of movement. Perception, attention, selection, and movement processes are interlinked to achieve goal-oriented behavior. The question still remains as to how mechanisms co-function in regard to task requirements, environmental restraints, stage of learning for the individual, and past experience.

Factors Related to Geographic-Oriented Movement

Intrinsic organization of human motion is based on postural and bilateral coordinates. Motor organization in relation to environmental requirements includes the horizontal and vertical dimensions of perceived space. Therefore, spatial organization of visually guided behavior is viewed in terms of the geometric properties of the visual stimulation and its orientation together with the spatial and temporal patterning of feedback stimulation arising from the postural and bilateral movement systems of the body. There is much that is not known about how the major coordinates of visual space are related to the corresponding coordinates of human motion (Smith & Smith, 1962). Although temporal factors regulate the flow of motion, the major component of human movement is space. Spatial-orientation behavior may be classified according to the two axes that are required for the specification of an orientation. Both axes may be external to the body, both may be internal, or one may be external and the other internal.

One form of spatially oriented behavior, geographic orientation, involves the judgment of body axis in relation to an external-referenced geographical axis. Therefore, geographic orientation is defined as the ability to maintain accurate orientation in relation to a spatial pattern and goal. Learning a geographic-orientation task requires knowledge of the goal and the route to the goal (Pritchatt & Holding, 1966). Performance requires a correspondence of movement to the geometry of the environment. The serial movement studies on which learning theories have in the past been based, fall under the rubric of geographic orientation. Although the literature on learning of complex serial movement is sparse, a few studies have been undertaken regarding the contributions of various mechanisms to simple geographic performance.

The vestibular and visual systems are critically involved in the accomplishment of spatial movement. Also of importance is the internal mechanism of efference for information in its own right and in co-interaction with sensory systems. The vestibular apparatus detects orientation of body position in relation to the gravitational axis. Rotational and linear acceleration and deceleration are also registered (Jones & Milsom, 1970). Witkin (1946) rotated blindfolded subjects in a chair to stimulate their vestibular system. Following the rotation most subjects experienced difficulty in orienting to the walls of the room. Witkin concluded that vestibular information alone does not provide an adequate basis for maintaining orientation. On the other hand, Beritoff (1965) found that vestibular information was adequate for geographic orientation. After one trial, blindfolded subjects retraced a path with the same precision whether they had been pushed

along the route in a chair (where the condition purportedly emphasized vestibular stimulation) or were led through under active locomotion (where the condition purportedly emphasized the stimulation of the motor system). Further, after several trials, blindfolded subjects with nonfunctioning labyrinths could not retrace the route along which they had been pushed or led. Subjects who were led through the experimental pathway received both tactile and proprioceptive stimuli. Apparently the information from these sources was adequate in defining spatial relationships required for performance of the task. Therefore, Beritoff reasoned that information provided by the vestibular system was more critical than proprioception in geographic-orientation tasks.

Beritoff (1965) also studied the influence of the visual mechanism in geographic orientation. Subjects who were shown the floor pattern were more accurate in performance than subjects led through the pattern blindfolded. The results are not unexpected; vision undoubtedly has a strong influence on spatially oriented behavior.

Efference is defined as the commands transmitted to the muscles from the central nervous system during self-produced movement. The subject's intentions in terms of initiating and determining direction of movement are carried out through efference (Adams, 1971). The inference is that self-produced movement focuses the subject's attention on the direction of motion. It has been demonstrated that attention to the direction of movement facilitates learning when direction is important to the accomplishment of the task (Kelso, Cook, Olson, & Epstein, 1975).

It has also been suggested that when motor commands are initiated by the subject, they are recirculated or monitored centrally, informing

the central nervous system of the subsequent action (Pardew, Rosen, & Kornhauser, 1977). This corollary discharge is also assumed to prepare sensory processing systems to receive sensory inputs (Lee, 1974; Teuber, 1964, 1972). The issue for corollary discharge is not whether it exists or not, but how much information it carries (Evarts, 1972). The problem is that the near simultaneity of sensory and motor impulses occurring during a motoric response makes it difficult to observe the unique contribution of each. The major challenge facing researchers lies in elucidating the manner in which central and peripheral processes interact for learning. It is feasible that the combination of self-produced movement information with its sensory feedback results in a stronger central representation relative to the sensory sources alone. However, arguments favoring motoric, sensory, or both processes in combination as contributors to perception of movement are equally plausible.

The research reviewed on mechanisms contributing to geographic-orientation performance point to the importance of vestibular and visual sensory systems. Further, it also appears that self-produced movement is potentially facilitative to learning. Studies investigating the role of self-produced movement in early learning have repeatedly used different forms of guidance to define the spatial pattern which is to be reproduced. Guidance techniques have become a viable means of determining the contributions of sensory and motor systems in the learning process.

Research Techniques

Two techniques have played a major role in delineating the mechanisms which facilitate learning in geographic orientation. One technique, termed "forced-response," requires that the subject's limbs or body be

passively transported by the use of guiding equipment or by the experimenter. The technique does not allow voluntary movement of the subject. The other technique, called "response restriction," permits self-produced movement within the restraining structure set by the training device (Holding & Macrae, 1964). Interest in the effects of self-produced and passively produced movement in learning has generated considerable research using these guidance techniques.

The data from research is in agreement with the finding that the response restriction technique, involving volitional movement, is more beneficial to learning than the forced-response technique. However, it is also known that under certain conditions voluntary responses are not necessary for learning (Lauer, 1951; Solomon & Turner, 1962). The most obvious example of research using forced- and restricted-response techniques is found in the work of Held (1968, pp. 57-62). The basic procedure used by Held is a comparison of the effectiveness of self-produced movement with that of passive movement in the study of adaptation to prismatic displacement. Numerous studies found that the re-adaptation of visual-motor coordination to a displaced visual input depended on self-produced movement during the prism exposure period (Held & Bossom, 1961; Held & Freedman, 1963; Held & Hein, 1958, 1963). Held was clear in presenting a rationale for the necessity of self-produced movement in adaptation. Recently, however, Held has indicated some limitations to his earlier position and adds the qualification that self-produced movement is an essential condition for adaptation only under circumstances in which no other important source of error information is available. Held's original research design did not include enhancement or directed attention to sensory information under the passive-movement condition. Studies with strong sensory-enhancement training procedures have revealed

adaptation (Pick & Hay, 1965; Templeton, Howard, & Lowman, 1966), although it does appear that passive-training conditions were not as effective as active-training conditions (Held & Mikaelian, 1964).

There is considerable evidence that perception based on voluntary movement is quite different from perception based on similar passive movement. Researchers have been interested in the influence of sensory information obtained in learning. Therefore, questions have been raised in the past few years concerning the facilitory effects of active- and passive-movement conditions on learning. Also of concern has been the identification of tasks in which information gained by passive movement is equal or superior to information obtained from active movement.

Intuitively, self-produced movement would appear to be more beneficial to learning, but it may be that the processing of motor commands interferes with identifying and recalling a correct response (Howe & Singer, 1975). This question has been asked in studies that focus on the type of task in which acquiring perceptual information about the goal of the movement is more important than the form of the movement. In a geographic-orientation task, information about the sequence of spatial relationships and alternatives to direction and extent of movement as defined by the environment may be more critical to spatial learning than definitive information concerning the response (Beritoff, 1965; Holding, 1965).

In maze-learning work, guidance techniques have been as much or more directed toward supplying perceptual information as toward shaping the motor pattern of response (Holding, 1970). Guidance is generally viewed as a technique for showing the subject what to do and, therefore, is

effective in use with maze tasks. Several generalizations have been formulated by Holding and his associates about the value of guidance in learning. It was found that with an increase in perceptual load, the value of guidance as a training procedure increased substantially when compared to trial-and-error learning (Holding & Macrae, 1966). The advantage of the forced-response technique appeared to be reduction of the amount of information to be processed by the subject because of the elimination of motor demands (Macrae & Holding, 1966). The subjects also did not experience the effects of erroneous responses which can degrade available information. It was also found that learning was accomplished under forced-response/visual-guidance procedures (Pritchatt & Holding, 1966).

Restrictive-response techniques had the advantage of facilitating response sets based on available internal cues. Response sets could include task demands for adequate speed, direction, or form of movement. Therefore, when training movements are related to test requirements, learning is facilitated (Holding & Macrae, 1964). The difference in effectiveness of forced- and restricted guidance was a result of the differential compatibility of the form of guidance to response demands (Holding & Macrae, 1966).

An unpublished study which investigated several mechanisms operating in geographic orientation found that forced-response with enhancement of sensory cue sources was in fact superior to restrictive-response conditions (Souder, Burroughs, Teeple, Parker, & Bunker, Note 1). The restrictive-response subjects formed the control group. The forced-response subjects received training trials and then performed in the same restrictive-response task. The question which remains is how effective are self-produced-movement training trials in facilitating learning. The present

study tests the question. Performance on the criterion task after restrictive- and forced-response practice conditions was compared to restrictive-response control group performance on the criterion task. The inclusion of vision in both practice conditions created a stringent test of self-produced movement effectiveness in geographic-orientation learning. The question asks if the combination of vision with voluntary movement develops a better central symbolic representation of the geometric pattern than vision alone.

Perceptual Differentiation

Individuals differ in their organization of internal processes or strategies for imposing order on the material to be learned. The term "cognitive styles" has been coined to define the pervasive and consistent modes that characterize the individual's organization and response to sensory information. One dimension of style that has generated a substantial body of research is that of perceptual differentiation (Witkin, Dyk, Faterson, Goodenough, & Karp, 1962; Witkin, Lewis, Hertzman, Machover, Meissner, & Wapner, 1954). Perceptual differentiation refers to the selection of information either from the body or from the environment, which establishes an internal or external frame of reference for the organization of space (Witkin & Goodenough, Note 2).

The basic concept underlying perceptual differentiation parallels the suggestion of developmental psychologists that individuals move from a global, diffuse functioning (which lacks articulation between organism and environment) to a differentiated functioning (which includes the separation of organism and environment). Implicit in the theory is that greater differentiation is associated with greater articulation of experience in the

world. The ontogenetic sequence suggests that individual growth patterns evolve from reliance on external cues to the integration of internal cues. However, this pattern of differentiation is generally not considered an inherent property of the mechanism but is affected by learning, training, and experience in the environmental context.

In terms of perceptual differentiation, when there is segregation of self from environment, internal cues form the basis of spatial organization. Non-segregation of self from environment precludes the use of internal cue sources while specifying the use of external sources. Specifically, the use of internal referents allows for imposing a different structure on an environment from the one suggested by its inherent arrangement (Nebelkopf & Dreyer, 1970). Acting on a field entails either breaking up an organized field (so that its parts are experienced as discrete from background), providing organization to a field which lacks it, or imposing a different organization on a field from the one suggested by its inherent arrangement. The actions involve changing the field, rather than "taking it as is" and are, therefore, designated as acts of restructuring. In contrast, the prevailing organization of the environment as given is likely to be adhered to when external referents are used (Witkin et al., 1954, 1962). The use of this approach makes it less likely that parts of a field will be apprehended as discrete from field when it is well organized or that organization will be provided when the field is not inherently organized. Under such conditions experience is not likely to be well articulated.

In summary, perceptual differentiation involves restructuring -- the tendency to act on the field rather than adhere to its dominant properties. Furthermore, restructuring has its basis in the tendency

to rely on internal referents, which, in turn, are products of the extent of self-nonsel self segregation. Therefore, the way in which the learner orders cue sources into hierarchies of preference influences spatial organization and subsequently the strategies employed for learning. Although there is a considerable body of evidence on the selection of perceptual information for organizing space, no research has been directly concerned with the identification of differences in the use of perceptual information for learning a spatially oriented movement task. The question to be investigated asks whether there is a relationship between reliance on either internal or external cue sources in the organization of space and the selection and use of these cues in the learning of spatially oriented movement.

Strategies Based on Use of Selected Cues

Differences in strategies of learning a geographic-orientation task can be determined by investigating the serial order in which segments of the spatial pattern are learned. There are three major hypotheses used to describe the serial-learning process. The positions differ in their determination of the functional stimulus for learning. These ideas correspond with peripheralist and centralist ideas which have been discussed previously. The response-learning hypothesis stems directly from stimulus-response psychology. Response learning holds that movement patterns are acquired by the conditioning of each movement segment to the proprioceptive feedback of the preceding segment. The goal is reached by making certain responses in relation to the previous response. Therefore, it is predicted that the beginning of the sequence is learned first followed in order by the subsequent segments (Mandler & Anderson, 1971).

In contrast, the place-learning hypothesis stems directly from cognitive psychology and argues that learning entails the perceptual organization of the pattern which then guides the motor response to the location of the goal in space. Therefore, the stimulus for a response is its ordinal position, not the response preceding it in the sequence. It is predicted that the final segment reaching the goal is learned first.

The third hypothesis is that of field organization. Field organization stems directly from Gestalt psychology and proposes that some segments are learned first because of their superior vividness within the total framework of the stimulus configuration. These are usually the first and last segments in the series. Learning consists of establishing a structure for the pattern.

The three hypotheses do not propose mutually exclusive mechanisms for their predicted functional stimuli. Researchers concur that the functional stimulus depends on the perceptual and response set of the subject, the characteristics of the task, and the subject's stage of learning (Bewley, 1972, pp. 187-214). This conception of serial learning suggests that there is no single functional stimulus and therefore no one strategy used by all subjects in all situations. The unanswered question concerns what mechanisms control the order of acquisition. A clearer interpretation of the serial order in which segments of the spatial pattern are learned based on subjects' strategies could be obtained by controlling the stimuli available and identifying the subjects' preferred strategies for organizing space.

The research literature provides very few answers as to how information is serially organized in movement tasks. One suggestion is that

the differences in skill performance depend in part on the degree to which the serial organization of a particular task is undertaken (Connolly, 1970, pp. 161-192; Fitts & Posner, 1967). It is well documented that organized sequences are recalled better than information which is not organized in some distinct fashion. The implication is that organized information is less prone to the effects of interference which influence memory.

The few studies that have investigated order of segment acquisition in serial motor tasks have centered their discussions around the primacy-recency principles. The terms "primacy" and "recency" define situations rather than describe mechanisms (McGeoch, 1942). Primacy, for example, refers to the situations in which first segment is learned first; it has the advantages of absence of prior learning, an emphasis resulting from the uniqueness of position, and proactive interference affecting the next segments. Recency refers to situations in which the last segment is learned first; it also has the advantages of uniqueness of position and retroactive interference affecting the segments coming before it. Effects of proactive and retroactive interference can cause serial ordering because first segments would have reduced effects of proactive interference and latter segments would have less retroactive interference. Segments in the middle would have more of each kind of interference. When proactive interference effects are greater than retroactive, the advantage of primacy over recency occurs.

Motor learning studies have supported a pattern whereby the initial portion of a series is acquired prior to the second part. Cratty (1963) divided a locomotor maze in half and measured the time of traversal for both portions. The initial part of the maze was learned first. The second half of the maze was not learned until the first half was acquired,

which indicated proactive interference. It should be pointed out, however, that the subjects in this study were learning the maze by the trial-and-error discovery method. The subjects traversed the maze using only tactile cues as guidance. The amount of organization imposed on the task is questionable because the tactile cues were continuous and required only that the subject keep both hands on the guide railings which defined the path. Zaichkowsky (1974) also found a proactive-interference effect using a serial task with high verbal-mediation possibilities. The result was anticipated, because in verbal learning studies proactive interference is usually found and attributed to more rehearsal of items at the beginning of a series. Magill (1976), using a more cognitive than motor sequential lever-positioning task with knowledge of results, found proactive interference. Therefore, the data support a pattern indicating that the initial portion of a series is acquired prior to the second part. However, primarily due to task problems, the order of segment acquisition for a motor task is questionable.

The questions of serial-order acquisition become less obscure when viewed in the context of literature on motor memory. The literature on memory gives the interference theory relatively strong status in explaining motor short-term forgetting. The laws that have been generated for short-term motor forgetting appear to hold for long-term forgetting as well. In fact, the distinction between short- and long-term memory has become less popular (Craick & Lockhart, 1972). Levels of processing instead of multiple storage have been suggested. The levels begin with sensory analysis and end with semantic and cognitive elaborations. Retention would be a function of the level of depths at which a stimulus is processed. Therefore, memory is essentially continuous with perceptual

attentional processes on the input side and melds with a variety of other cognitive processes on the storage and output side (Flavell & Hill, 1969).

At the present time, there is strong support for retroactive interference and marginal support for proactive interference in memory studies. It has been found that the amount of forgetting in a continuous tracking task after retroactive interference was positively related to the amount of interpolated learning (Lewis, McAllister, & Adams, 1951; McAllister, 1952; McAllister & Lewis, 1951). Further, retroactive interference when similar to criterion interpolated movements caused recall movements to be longer or shorter than required, depending on long or short interpolated activity (Stelmach & Walsh, 1972). Retroactive interference was found for a stylus-maze serial task after motor-interpolated responses on the same task but opposite in direction to the criterion response (Burroughs, 1972). Interpolated responses caused retroactive interference in a long-term retention design using a motor-retention interval task on the same apparatus as the criterion task (McFann, 1953).

Experiments showing retroactive interference when interpolated activity requires the use of the same tasks as the criterion response suggest that intratask similarity could cause interference. On a maze task, for example, segment similarity could reasonably affect retention by virtue of the fact that the acquisition of each segment retroactively interferes with the retention of the previous segment. Although the literature deals mainly with proprioceptive interference in discovery trial-and-error designs, research on visual representation of spatial patterns also supports retroactive-interference theory.

In a study of serial presentation of visual forms, retroactive interference was found (Gibson & Raffel, 1936). A meaningless

geometrical form was shown followed by several others in a series. When shown with succeeding forms, its reproduction was very much less accurate than when one form was presented alone. In fact, support for the regressive ordering (the learning of forms from the end of the series to the beginning) was demonstrated. It also appeared that the effect depended principally on subsequence of serial position rather than on recency as such (Welch & Burnett, 1924). Instead of laws of primacy and recency, future investigations should look at the complex of possible interference influences which may be at work among the items in a series of impressions and on their position character and membership in a temporal group (Gibson & Raffel, 1936).

As would be predicted, the backward elimination of errors in visual maze learning was found (Peterson, 1920). The subject verbally indicated letters which labeled the paths of the maze which eventually led to the finish. The maze was in view for the entire experimental session. Interestingly, some subjects continued to repeat errors, staying with the familiar rather than venturing into the novel--a tendency that in this case directly hindered learning and differentiated markedly between the good and poor maze learners. The individual differences with respect to repeating unprofitable responses were so noticeable that Peterson related them to the perseverative tendency noted by various experimenters on certain types of disorganized minds.

A more recent study on visual maze learning investigated subject differences in spatial organization (Gorman, 1968). A significant difference between subjects classified as using internal or external referents for spatial organization was found. Subjects using internal

referents performed a paper and pencil maze with vision faster than subjects using external referents. The results indicated the effect of perceptual differentiation and the effect of trials were significant. However, the interaction effect of perceptual differentiation by trials was nonsignificant indicating that the rate of learning was equal but at different levels for the perceptual-differentiation groups. Performance of the maze task suggested that subjects using internal referents controlled their movements, whereas those using external referents were more impulsive. Impulsive behavior in maze tracing shows itself in going outside the maze boundaries, false starts, and random movements. The behavior is also likely to produce higher time scores in completing the maze successfully.

Because serial learning is facilitated and directed by organizational strategies of learning and memory, the subject must differentiate and integrate available cue information for use as the basis for selecting correct responses. The relevant cue sources appear to be dependent on organizational factors that emerge from the experimental experience. Although the subject may use many cues, it is known that cues are ordered into hierarchies. The ultimate task for research is to relate cue preference and associated mechanisms to learning strategies as revealed in serial learning.

Research Problems

The problem of the present study was to determine the relative contribution of efferent information to learning a geographic-orientation task. If learning is facilitated by efference, then the exafferent-information conditions should produce less learning. If, on the other hand, efference interferes with learning, then the exafferent-information condition should produce more learning.

It was assumed that efference existing in the active condition would not interfere with the processing of critical spatial information. The active-practice condition coupled with vision produced a potentially errorless situation thereby eliminating erroneous responses which could degrade available reafferent and efferent information. Further, efference was viewed as potentially facilitative to the development of the central symbolic representation of movement. By initiating movement, efference focuses attention on the directional requirements of the movement pattern to be learned. Corollary discharge of efference is also assumed to prepare sensory processing systems to receive sensory information. In the active-practice condition visual information was available. Therefore, it was reasoned that the combination of efferent and reafferent information results in a stronger central symbolic representation than afferent information alone. It was hypothesized that maze traversal speed for the active-practice group would be significantly faster than the passive- and control-practice groups.

Exafferent visual information was available to subjects in the passive-practice condition. Vision is known to be an influential orientation mechanism and should lead to the development of spatial expectancies of the path to be learned. Passive translation has the advantage of reduced amount of information to be processed and of providing a low error traversal. Therefore, it was reasoned that the exafferent condition would be beneficial to geographic-orientation learning. It was hypothesized that maze traversal speed for the passive-practice group would be significantly faster than the control-practice group.

Also of concern to the present study was the influence on learning of the individual differences in perceptual differentiation. The literature suggests that when visual information is available, subjects who organize space by external referents tend to show perseveration and impulse tendencies which slow performance. On the other hand, subjects who use internal referents are more controlled in their actions and faster in their accomplishment of the task. Therefore, it was hypothesized that maze traversal speed for the field-independent group would be significantly faster than the field-dependent group.

The influence of spatial organization on the development of concomitant strategies of geographic-orientation learning was investigated. The literature reviewed suggested that spatial organization based on visual cue sources produced regressive ordering of serial learning. Regressive ordering was seen as a function of retroactive-interference effects of intramaze segment similarity. It was hypothesized that subjects would demonstrate fastest speed on the final maze segment followed by the middle and initial segments. Additionally, it was reasoned that although available mechanisms influence efficiency of learning, strategies are based on the life history in patterns of internal or external cue-source integration forming the base for spatial organization. Therefore, it was hypothesized that subjects in the active, passive, and control groups would also demonstrate regressive ordering of segment speed on the locomotor maze.

Although it was hypothesized that regressive ordering would be evidenced by the mean segment scores of all subjects, it could very well be that the product represents the average value of separate effects from field-independent versus field-dependent subjects. Field-dependent subjects tend to follow the dominant properties of space. Because

space is not organized by internal referents, the subjects are prone to interference effects. Therefore, retroactive interference causing the dominant regressive ordering organization of segments was hypothesized for the field-dependent group. Regressive ordering of segments for the field-dependent group was also hypothesized for the active-, passive-, and control-practice groups.

In contrast, field-independent subjects actively organize space. Information that is organized is not subject to interference effects and in turn the dominant regressive order. To predict how information is ordered by field-independent subjects, the requirements of the task must be analyzed. The learning of mazes is essentially a procedural skill depending on the retention of sequential, spatial information (Holding, 1965) and information regarding the alternatives to direction and extent of movement (Souder et al., Note 1). Whereas it has been suggested that distance information spontaneously decays from memory and is therefore not a useful reproduction cue, location information can be successfully maintained in memory (Keele & Ellis, 1972; Laabs, 1973; Marteniuk, Shields, & Campbell, 1972; Posner, 1967). Therefore, the spatial mapping of anchor points in a movement maze may be a primary reference cue to recall. There has been speculation that storage of a movement stimulus might well be in the form of a direct representation of the spatial position (Adams & Dijkstra, 1966; Bilodeau & Bilodeau, 1961; Posner, 1967). Therefore, it was reasoned that the field-independent group would structure the maze path by incorporating spatial-position anchor points (Gardner, 1959; Witkin & Goodenough, Note 2). The beginning and end of a series are two outstanding anchor points that could be used for organization of a serial task. It was hypothesized

that the field-independent group would demonstrate fastest speed in the final maze segment followed by the initial and middle segments. Further, the ordering would be reproduced in the active-, passive-, and control-practice groups.

METHOD

Research Focus

The issue of the relative contributions of efferent and exafferent information to spatially-oriented movement is central to understanding the learning process. Also important are differences in the selection and use of cues which influence individual strategies in the structuring of space.

A serial locomotor maze with an irregular pattern was designed to test geographic orientation under efferent-active locomotion and exafferent-passive transport conditions. Differences in approach to structuring space within the geometrical constraints of the maze task were predicted from performances on the tilting chair Rod and Frame Test. The test of perceptual differentiation indicated the degree to which a person relied on external visual (field dependent) or internal non-visual (field independent) cues.

Subjects and Design

Sixty right-handed female students from the Physical Education Activities Program, University of Illinois at Urbana-Champaign, volunteered for the study. The subjects' ages ranged from 17 to 22 years.

An equal distribution of Rod and Frame Test scores was generated for three groups of 20 subjects. Each group was assigned to a practice condition of the Locomotor Maze Test. The three practice conditions were active locomotion, passive transport, and control.

The active- and passive-practice groups received 10 practice trials followed by 10 test trials. The control group received only

the 10 test trials. The study used a five-dimensional factorial design: 3 (conditions) x 2 (perceptual differentiation) x 3 (segments) x 10 (trials) x 48 (subjects nested in conditions and perceptual differentiation), with repeated measures on segments and trials.

Rod and Frame Test Apparatus

The apparatus consisted of a luminous rod and frame and a laterally tiltable chair stationed in a room painted flat black. The rod was .99 m long with a width of 1.91 cm, and the frame was 1.07 m square with the width of each side 1.91 cm. The rod and the frame were covered with phosphorescent tape (Spot-Lite Tape model P4010000, Conrad-Hanovia, Inc.) which was a natural phosphor yellow. The tape assured uniform intensity if activated to the maximum level by artificial light (see Figure 1). The chair had padded arm rests with arm straps, seat and back pads, adjustable foot rest with a cushioned divider and two foot straps, and an adjustable padded head support. Two plastic inflatable inserts (Full Leg Pressure Splint, V. K. Enterprises Co.) were located at each side of the chair. When filled with air, these inserts conformed to the subject's body from a point under the arm to the hip, and flexed to a position that paralleled the thigh and pressed the knee and a portion of the lower leg into the foot rest divider. The system assured both a straight spine in alignment with the head and postural stability when the chair was tilted. Pressure on the two sides of the body from the inflatable pads remained constant during tilt. The chair construction enabled the subject's head to remain directly in front of the Rod and Frame while the rest of the body tilted laterally to the right and the left.

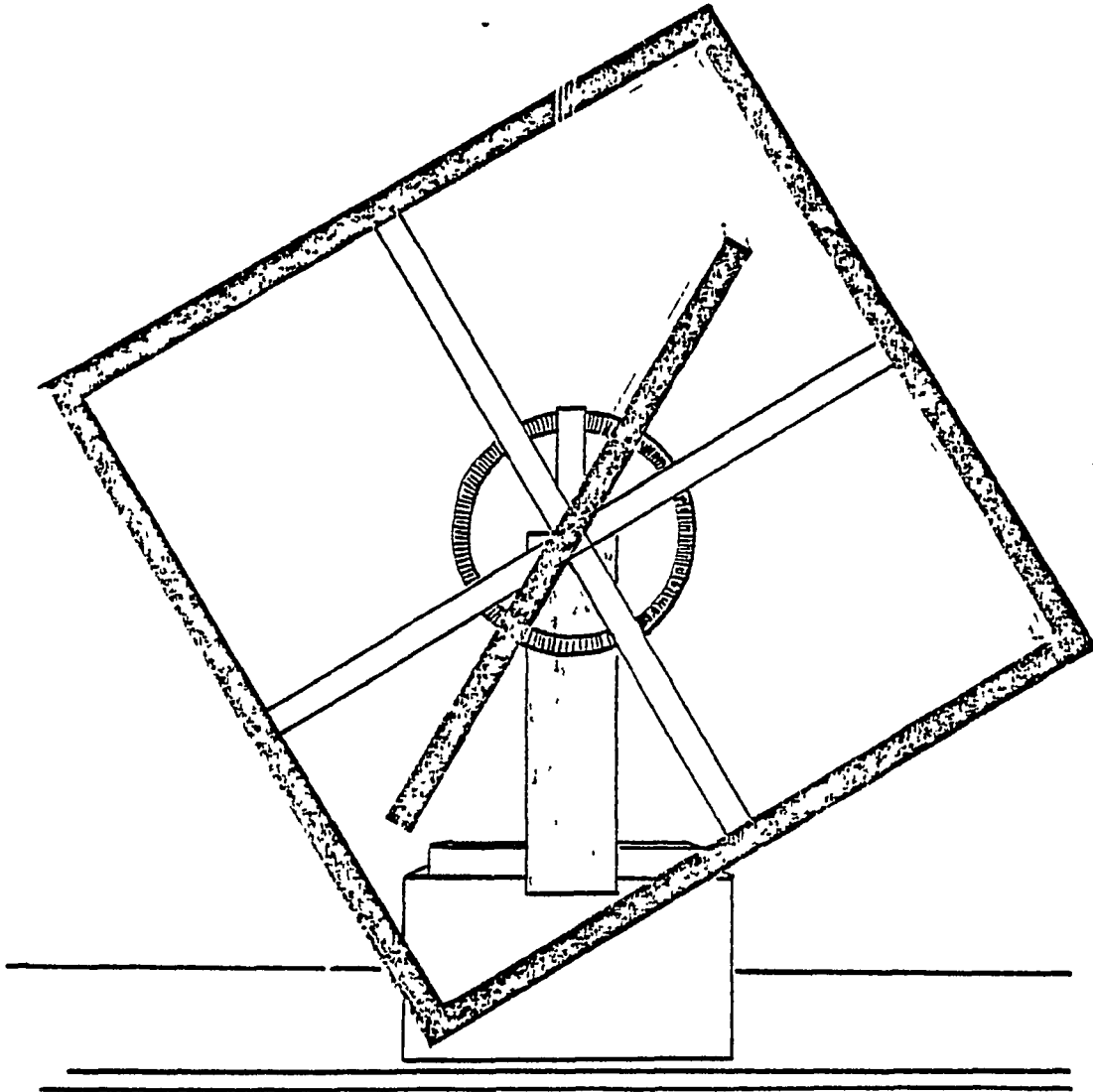


Figure 1. Front View of Rod and Frame Test Apparatus

Rod and Frame Test Procedure

On arrival at the experimental station, the subject was seated outside the black room. Preliminary to testing, a check was made to insure that the subject was right-handed, in the correct age range, and had not performed either the Rod and Frame Test or Locomotor Maze Test anytime in the past. The subject then put on goggles which allowed upward vision, was led into the testing room, and was assisted into the chair. The experimenter adjusted the head support, inflated the plastic inserts, and read the instructions to the subject. The instructions appear in Appendix A and were those used by Witkin (1948). The subject was blindfolded for 4 minutes before testing began to control for dark adaptation. The subject received two pretest trials.

The subject's task was to determine if the rod, surrounded by a tilted frame, was vertical or tilted. After the subject's decision regarding the placement of the rod, the subject was asked in which direction the rod should be moved to make it vertical. The experimenter then moved the rod in intervals of 3° until the subject indicated the rod was vertical.

The test consisted of 12 trials with a 1-minute rest period in the erect position after each set of four trials. In the three sets of four trials the subject's chair was erect for one set, tilted 28° to the left for one set, and tilted 28° to the right for one set. One of six permutation sequences of the three chair positions was randomly assigned to each subject. Also the time lapse between chair positions was equated for all six permutations (see Appendix A). In each set of four trials, the rod and frame (each tilted at 28°) were positioned

in the following order: frame left, rod left; frame left, rod right; frame right, rod right; frame right, rod left. The subject's absolute error score of the rod placement was recorded in degrees from vertical for each of the 12 trials.

The Rod and Frame Test is used to distinguish whether individuals are selecting primarily internal or external cue sources in perception of the vertical. A large degree of deviation when setting the rod to vertical indicates reliance on visual or external information (field dependence). A small degree of deviation when judging the vertical indicates spatial perception based on non-visual or internal information from the body while resisting the influence of the frame (field independence). The selection of either external or internal information was used as a predictor of the organizational strategy applied by the subject to learn the locomotor maze.

Locomotor Maze Test Apparatus

The apparatus for determining geographic-orientation learning was the Locomotor Maze Test designed by the author from a prototype by Cratty (1961). The locomotor maze was of an irregular pattern, 34.14 m long and 61 cm wide, containing no cul-de-sacs (see Figure 2). The maze consisted of strings suspended vertically 20.3 cm apart from overhead conduit designating the path. The strings were connected at their lowest point (61 cm above the floor) by a chain extending for the length of the path (one chain on each side of the path). The horizontal chain kept the strings separated and taut. The chain was cut every 3.05 m to keep wave-type motion throughout the maze to a minimum.

The maze was divided into three equal segments of 11.38 m in length. Pressure sensitive mats connected to a 1/100th-second clock (Athletic

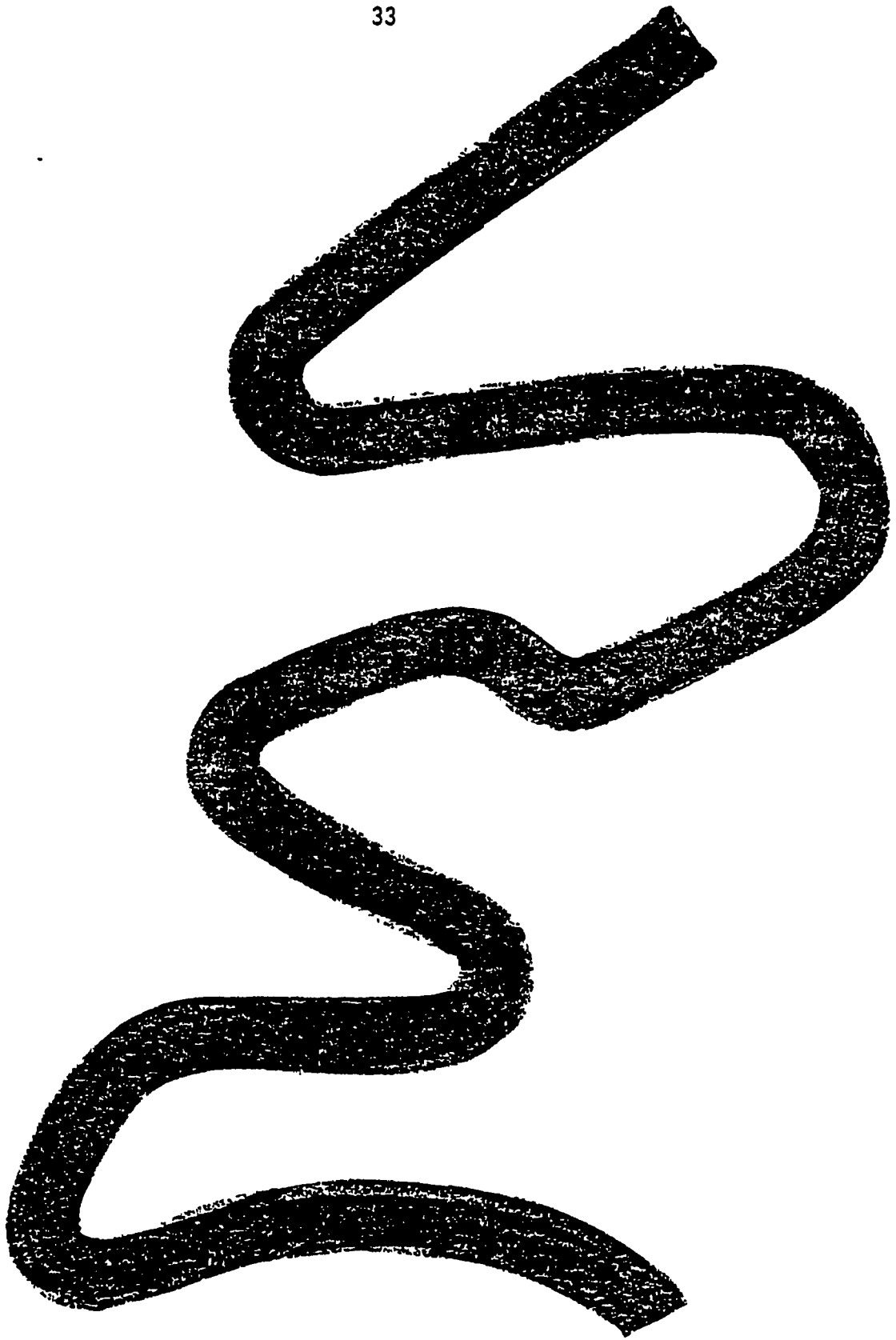


Figure 2. Locomotor Maze Geometric Pattern

START

Performance Analyzer, DeKan Mfg. Co.) were positioned at the start and finish of the maze to measure total traversal time. The circuit closure of the start mat initiated two additional 1/100th-second stop clocks (model 54014, Lafayette Instrument Co.) which were connected through a relay system that served to terminate the two additional 1/100th-second clocks. Therefore, time in each segment could be obtained by subtraction.

A measure of subject's initial movement speed blindfolded was obtained by use of a photo detector and light source connected to a digital 1/100th-second stop clock (model 54016, Lafayette Instrument Co.). This measure was made in a straight segment (4.025 m long) located at the finish end of the maze.

Two practice conditions, active locomotion and passive transport, required confined vision. Goggles which allowed upward vision but not outward or downward vision were used. A neck brace kept the subject from flexing the neck in order to shift the head position to an angle allowing straight-ahead vision. The subjects could see the conduit designating the maze path overhead while not seeing the body or the total maze path. In the passive-transport practice, a wheelchair was used which included a head-support device. In the control condition which was equated with the test trials of the other two groups, all subjects wore complete blindfolds and the neck brace.

Locomotor Maze Test Procedure

Each subject was clothed in a sleeveless blouse, shorts, and tennis shoes. Specific instructions for the active locomotion, passive transport, and control conditions were read to each subject and appear in

Appendix A. Before presentation of practice trials all subjects were allowed to view the maze for 10 seconds. Three pretrials were given using the finish of the maze and proceeding 4.025 m in the opposite direction. The subjects experienced running blindfolded with the neck brace, feeling the strings on the sides of the maze path with arms crossed in front of the body, and feeling the chain attachment with their legs. The source of cues were identified for the subjects. Following preliminary pretrials, the blindfolded subjects were led across the laboratory to the beginning of the maze.

Subjects in the active-locomotion practice group were positioned with both feet on the start line and told to be motionless. Goggles which allowed upward vision replaced the blindfold. The arms were crossed and parallel to the floor. On the ready signal the subject started to run. The first step onto the pressure sensitive mat activated the timing system. The subject was caught at the end of the maze and led back to the starting point. Segment time for each practice trial was recorded for later comparison with segment times for the passive-practice group.

Subjects in the passive-transport practice group were helped into a wheelchair, and the head support and the goggles which allowed upward vision were adjusted. Ten practice trials were given with the experimenter pushing the chair as rapidly as possible through the maze. Segment time per trial was recorded. Knowledge of traversal time was not given on the confined-visual practice trials because the emphasis was on learning the spatial pattern rather than on performance speed.

The non-practice control subjects received 10 test trials which were identical to the test trials of the active-locomotion practice group and passive-transport practice group. During test trials all subjects were completely blindfolded and wore a neck brace. The goal was to move as rapidly as possible through the maze. If the subject reversed direction, immediate correction was communicated verbally by the experimenter. Subjects were caught at the end of the maze and led back to the start position. Knowledge of results was given before the start of the next trial and consisted of total time in seconds. Time in hundredths of a second per segment for each test trial was recorded.

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RESULTS

The study evaluated the effect of active- and passive-movement conditions on learning an irregular-shaped locomotor maze. The subjects' selection of visual or non-visual cues in spatial perception were measured by the Rod and Frame Test. The Rod and Frame Test scores were analyzed in relation to the order in which locomotor maze segments were learned. The subjects' traversal times for the three maze segments were recorded for each of 10 successive trials following the practice trials. The study used a five-dimensional factorial design: 2(conditions) x 2 (perceptual differentiation) x 3 (segments) x 10 (trials) x 48 (subjects nested in conditions and perceptual differentiation), with repeated measures on segments and trials. The preliminary calculations on the Rod and Frame Test, locomotor maze pretrial and practice trial scores are presented in the first section of the chapter. Test trial data are then analyzed in reference to the four specific hypotheses of the study.

Preliminary Calculations

Sixty subjects were tested on the Rod and Frame Test to determine their selection of either visual (field dependence) or non-visual (field independence) cues defining the perceptual differentiation continuum of spatial perception. The subjects' Rod and Frame Test mean absolute scores in degrees deviation from vertical for 12 trials were rank-ordered on a continuum from least to greatest deviation. A stratified random placement of subjects into practice groups was accomplished by the ranking procedure. Twelve subjects were dropped from the analysis because of equipment malfunction during the Locomotor Maze Test. The Rod and Frame Test performance mean and standard deviation for each Locomotor Maze

Test practice group are presented in Table 1.

Table 1
Mean and Standard Deviation of Rod and Frame Test Performance for
Locomotor Maze Test Practice Groups

Group	<u>n</u>	Mean Absolute Degrees Deviation	<u>S.D.</u>
Active	14	10.8	3.9
Passive	18	9.1	3.5
Control	16	10.4	4.2
Total	48	10.0	3.9

A simple one-way analysis of variance showed that there was not a significant difference between the three practice groups on the Rod and Frame Test measure, $F(2, 45) = .87, p > .43$ (see Appendix B).

The Locomotor Maze Test segment traversal time scores (measured in centiseconds) were converted to traversal speed by taking the reciprocal of each score. The transformation of Locomotor Maze Test times normalized the scores and reduced the spurious effect of extremely slow outlier scores. Therefore, all statistical procedures for the Locomotor Maze Test were calculated using speed units (1/time).

To determine if subjects in the Locomotor Maze Test practice groups were equated in ability to move blindfolded through the locomotor maze, a mean initial movement speed measure was obtained. Blindfolded subjects ran through a straight segment of the locomotor maze for three repeated trials. The analysis of variance showed no significant difference between

groups on the initial movement speed pretest, $F(2, 45) = 34, p > .71$ (see Appendix B). It was also of importance to determine if subjects using visual or non-visual cues for spatial organization were affected differently by the visual deprivation condition of the initial movement speed measure. A low but significant correlation, $r = -.29$, was found between the subjects' mean score on the Rod and Frame Test and initial movement speed, which indicated that subjects using non-visual cue sources were faster than subjects using visual cue sources. However, that initial movement speed was unrelated to the subject's Locomotor Maze Test performance was evidenced by the low correlation ($r = .20$) between the mean initial movement speed and the mean speed of maze test trials.

Locomotor Maze Test active- and passive-practice groups received 10 practice trials followed by 10 test trials. Preliminary calculations were made to determine if yoking between the active and passive subjects was accomplished on the practice trials. Active subjects with vision ran the maze path as rapidly as possible. Passive subjects seated in a wheelchair were pushed through the maze in a manner simulating as closely as mechanically possible the active subjects' speed and variance for maze segments. The analysis of variance for the interaction of groups by practice trials by segments was not significant (see Table 2) indicating that yoking was accomplished. During test trials the active subjects ran through the maze path at a significantly faster speed than the pushed, passive subjects (see Table 2). However, the relative serial position of segments by trials were similar between practice groups. In both practice conditions, the first segment was slower than segments two and three for each trial (see Figure 3).

Table 2

Analysis of Variance Summary Table
for Locomotor Maze Test Traversal Speed on Practice Trials

Source	<u>df</u>	<u>ms</u>	<u>F</u>	<u>p</u>
Groups	1	1.69	256.56	.01
Subjects within Groups	30	.01		
Trials	9	.01	15.36	.01
Groups x Trials	9	.01	2.69	.01
Subjects x Trials	270	.01		
Segments	2	.22	331.09	.01
Groups x Segments	2	.02	37.97	.01
Subjects x Segments	60	.01		
Trials x Segments	18	.01	1.75	.03
Groups x Trials x Segments	18	.01	1.30	.18
Subjects x Trials x Segments	540	.01		

The mean segment speed, standard deviation, and range for the active- and passive-practice groups are presented in Table 3. The first and second mean segment speed, standard deviation, and range were larger for the active practice group than the passive group; however, there was little difference between groups on segment three. The proportional similarity of the statistics demonstrated the normal tendency of the standard deviation to become larger as the range of scores increase.

Table 3

Locomotor Maze Segment Speed for Active and
Passive Practice Groups

Segment	Active			Passive		
	Mean	<u>S.D.</u>	Range	Mean	<u>S.D.</u>	Range
1	.122	.009	.028	.058	.004	.012
2	.182	.014	.042	.087	.005	.019
3	.188	.013	.044	.092	.012	.042
Total	.164	.033		.079	.017	

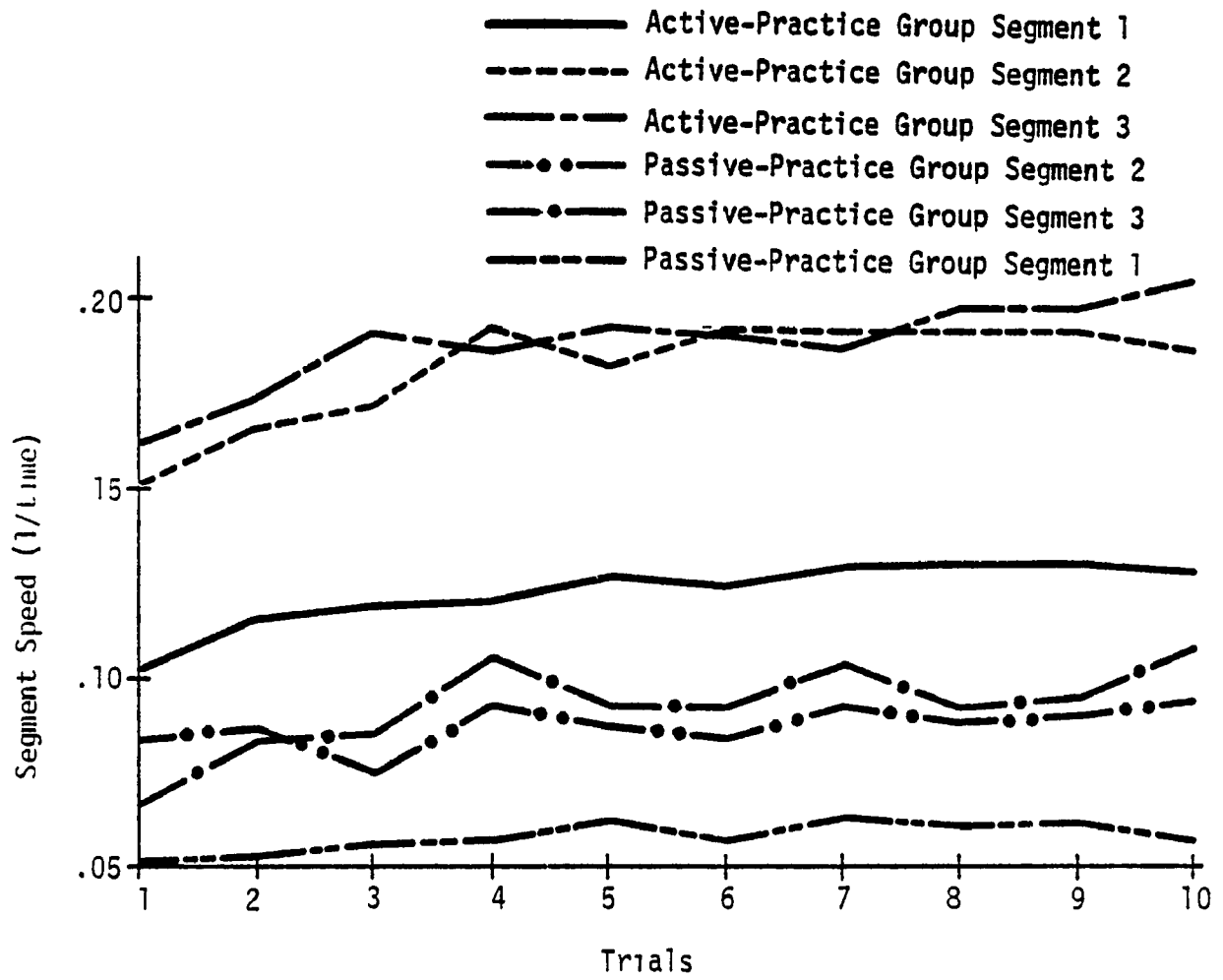


Figure 3. Locomotor Maze Segment Speed for Practice Groups over Practice Trials

To determine whether the significant traversal speed difference on the practice trials between active and passive groups was related to test traversal speeds, the correlation between practice- and test-trial speeds was calculated. It was found that the speed on practice trials was not significantly related to test-trial speed for the active ($r = .16$) or passive ($r = -.16$) group. Additionally, segment speed on the practice trials for both active and passive groups was not significantly related to test-trial segment speed (see Table 4).

Table 4

Correlation between Locomotor Maze Practice Trials and Test Trials Segment Speed for Active and Passive Practice Groups

Group	n	Segments		
		1	2	3
Active	14	.10	-.02	.40
Passive	18	.11	-.01	-.38

Calculations were then made to assess the reliability of the Locomotor Maze Test procedures. The significant Pearson product-moment correlation of $r = .94$ between odd and even numbered test trial traversal speeds indicated high reliability.

Hypothesis One: Active-, Passive-, and Control-Practice Differences

It was hypothesized that there would be a direct relationship between practice groups (active, passive, and control) and traversal speed of the locomotor maze. Subjects receiving the active practice would subsequently traverse the locomotor maze at a faster speed than passive and control subjects. Subjects receiving the passive practice would traverse the

locomotor maze at a faster speed than the non-practice control subjects. The locomotor maze mean traversal speed and standard deviation for practice groups and segments are presented in Appendix D, Table D1. The analysis of variance revealed a significant practice main effect on the Locomotor Maze Test (see Table 5). The post hoc Tukey analysis on the practice group differences (see Appendix C, Table C1) indicated that the active subjects' maze traversal speed was significantly faster than control subjects' speed, but no other differences were significant. The practice groups' speed by trials interaction was significant (see Table 5). The post hoc Tukey analysis for the groups by trials interaction is presented in Appendix C, Table C2. It was indicated that after Trial 5 there were significant differences between traversal speeds for all practice groups. The inference was that active subjects' speed became faster at a greater rate over trials than passive or control subjects as depicted in Figure 4. Further, a nonsignificant difference between trials was demonstrated at Trial 5 for active subjects and at Trials 6 and 2 for passive- and control-group subjects' traversal speed, respectively (see Appendix C, Table C3).

Hypothesis Two: Perceptual Differentiation and Locomotor Maze Test Traversal Speed

It was hypothesized that there would be a direct relationship between the selection of visual or non-visual cues in spatial perception and locomotor-maze traversal speed. Field-independent subjects would traverse the locomotor maze at a faster speed than field-dependent subjects. The perceptual differentiation continuum was dichotomized by dividing the subjects into two groups based on their rank positions for Rod and Frame Test performance. The 24 subjects with the least absolute degrees deviation

Table 5

Analysis of Variance Summary Table for Locomotor Maze Test Traversal
Speed on Test Trials

Source ^a	<u>df</u>	<u>ms</u>	<u>F</u>	<u>p</u>
Groups	2	.05	4.47	.02
PD	1	.01	.31	.58
Groups x PD	2	.01	.05	.95
Subjects within groups	42	.01		
<hr/>				
Trials	9	.01	30.00	.01
Groups x Trials	18	.01	1.70	.04
Trials x PD	9	.01	.68	.72
Groups x Trials x PD	18	.01	1.28	.20
Subjects x Trials	378	.01		
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Segments	2	.03	48.17	.01
Groups x Segments	4	.01	3.23	.02
Segments x PD	2	.01	.05	.95
Groups x Segments x PD	4	.01	.33	.85
Subjects x Segments	84	.01		
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Trials x Segments	18	.01	.90	.57
Groups x Trials x Segments	36	.01	1.07	.36
Trials x Segments x PD	18	.01	.48	.96
Groups x Trials x Segments x PD	36	.01	1.08	.35
Subjects x Trials x Segments	756	.01		

^aPD refers to perceptual differentiation

Table 6

Absolute Degrees Deviation from Vertical on Rod and Frame Test

Group	<u>n</u>	Mean	<u>S.D.</u>	Range
Field independent	24	7.13	1.84	2.58 - 9.75
Field dependent	24	12.93	3.06	9.92 -19.75
Total	48	10.03	3.86	2.58 -19.75

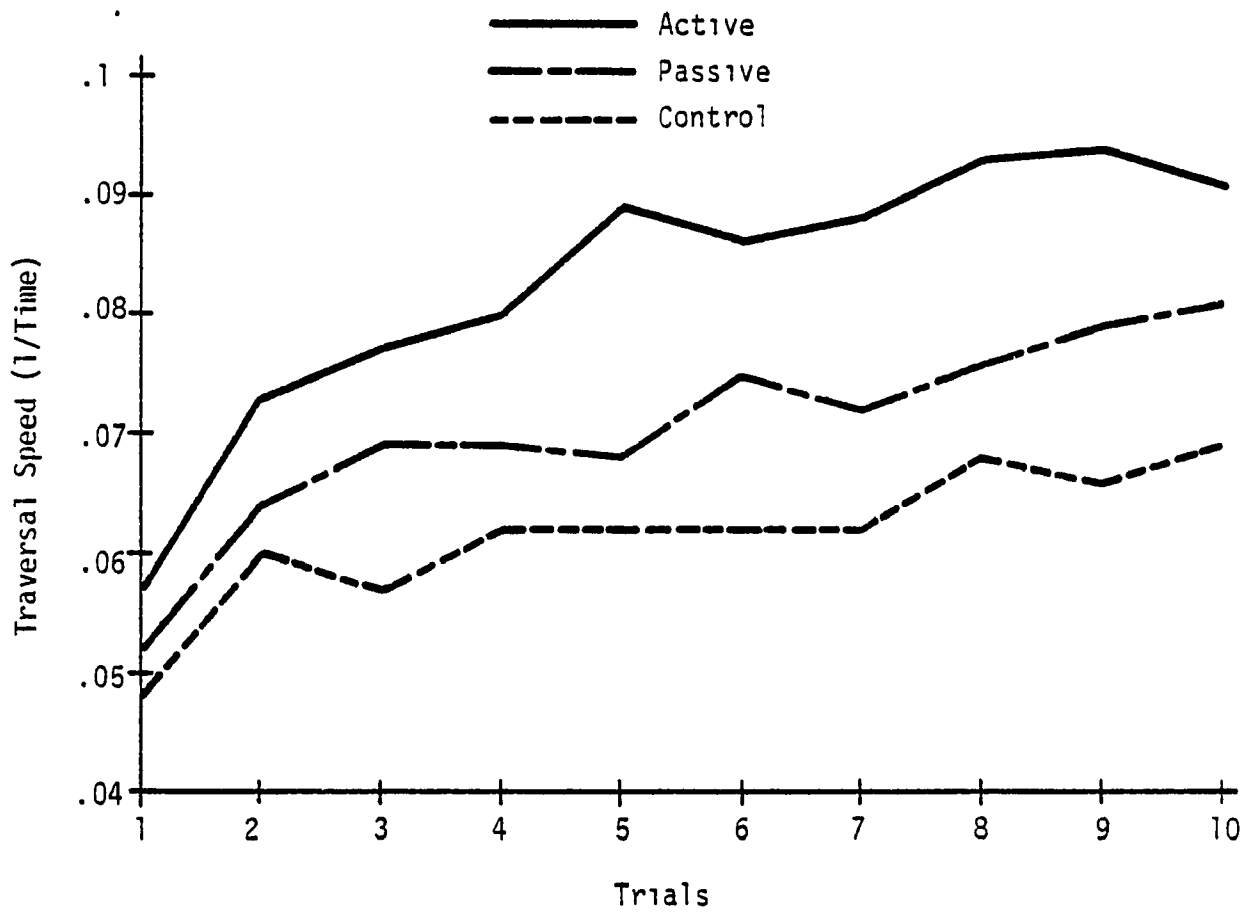


Figure 4. Locomotor Maze Traversal Speed for Practice Groups over Test Trials

from the vertical (indicating selection of non-visual cue sources for the organization of space) formed the field-independent group. The 24 subjects with greatest absolute degrees deviation, indicating use of visual cue sources, formed the field-dependent group. Descriptive Rod and Frame Test data are shown in Table 6. The subjects ranked 24 and 25 had mean scores of 9.75 and 9.92 degrees deviation from vertical, respectively. The distribution of scores within groups determined that 17 field-independent subjects and 18 field-dependent subjects fell within one standard deviation of their respective group means (see Appendix D, Table D2).

The field-independent/dependent subject mean speed and standard deviation for Locomotor Maze Test trials are presented in Appendix D, Table D2. The analysis of variance indicated a nonsignificant difference in speed between the perceptual-differentiation groups and between the groups by trials interaction (see Table 5). However, in terms of probability, it is of interest that the field-independent group demonstrated consistently faster speed per trial than the field-dependent group. Decreasing gain in speed over trials was evidenced by both external- and internal-referent subjects (see Figure 5). A significant speed difference between trials for all subjects was found (see Table 5). Further, it should be noted that the active-practice, passive-practice, and control treatment had more effect on the subjects' speed than did the use of internal or external referents, as shown in Table 7.

Table 7

Locomotor Maze Test Traversal Speed for Practice Groups by
Perceptual Differentiation

Treatment Group	Field Independent		Field Dependent	
	<u>n</u>	mean	<u>n</u>	mean
Active	6	.085	8	.081
Passive	11	.071	7	.070
Control	7	.064	9	.059

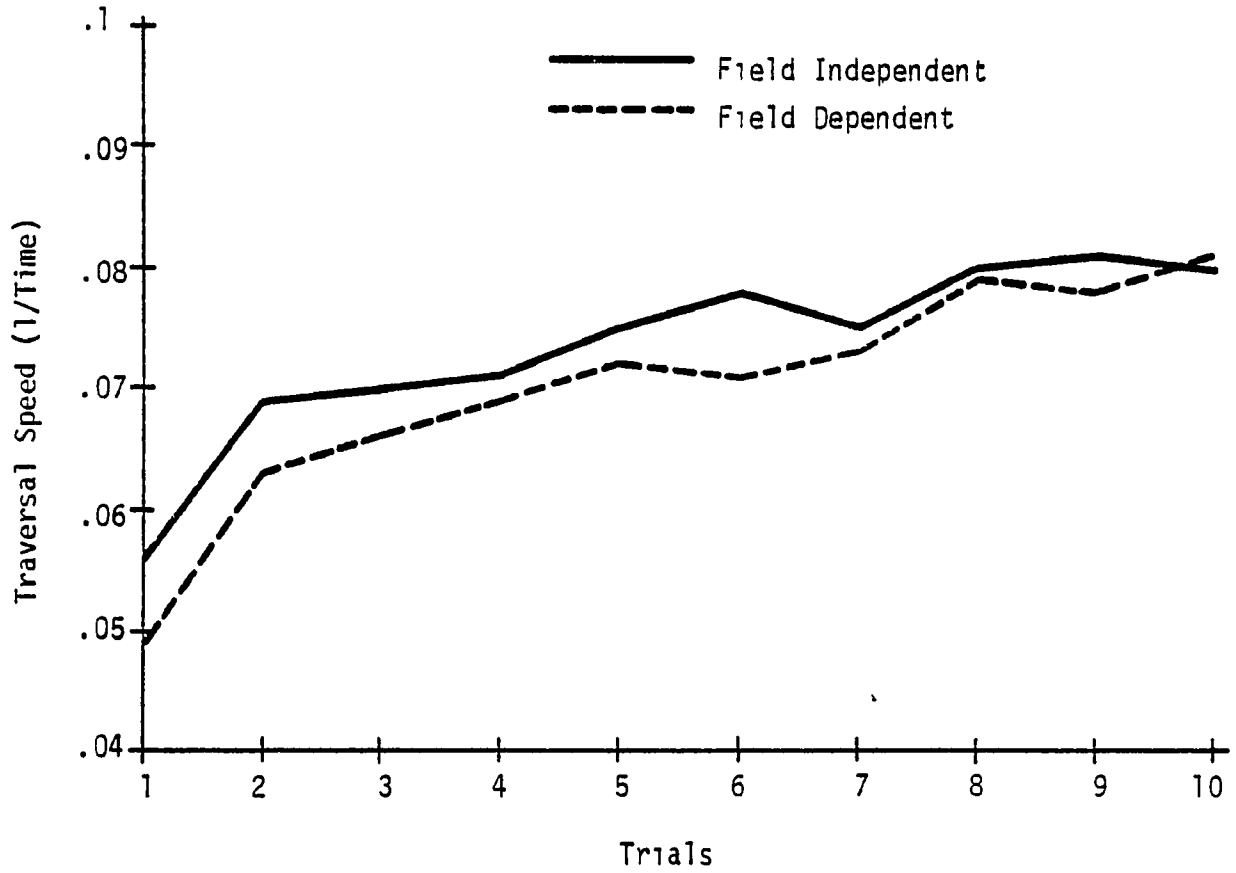


Figure 5. Locomotor Maze Traversal Speed for Field-Independent/Dependent Groups over Test Trials

Hypothesis Three: Traversal Speed of Locomotor Maze Segments

It was hypothesized that there would be a difference in traversal speed of the three locomotor maze segments. Traversal speed of the three segments would decrease in regressive order. Subjects in the active, passive, and control groups would also demonstrate regressive ordering of segment speed on the locomotor maze. The subjects' mean maze segment speed and standard deviation are presented in Appendix D, Table D1. The analysis of variance indicated that there was a significant difference between traversal speed of maze segments (see Table 5). The post hoc Tukey analysis (see Appendix C, Table C4) revealed significant differences between all segment speeds. Regressive ordering of decreasing segment speed was demonstrated. The practice groups by segment interaction was also significant (see Table 5). Active subjects traversed segments two and three at significantly faster speeds than segment one determined by a post hoc Tukey analysis. Passive subjects traversed segment three at a significantly faster speed than segment two, which was traversed at a significantly faster speed than segment one. Control subjects traversed segment three at a significantly faster speed than segment one (see Appendix C, Table C5). The active subjects demonstrated faster speed on all segments followed by the passive and then control groups. All differences between groups on each segment were significant except the difference between passive and control groups on segment one (see Appendix C, Table C6). Further, the post hoc Tukey analysis suggested that the speed of segment one relative to two for the active-practice group increased at a greater rate than that of the control group, and that the increase in speed of segment three relative to two was similar for all groups (see Figure 6). It is notable that the faster

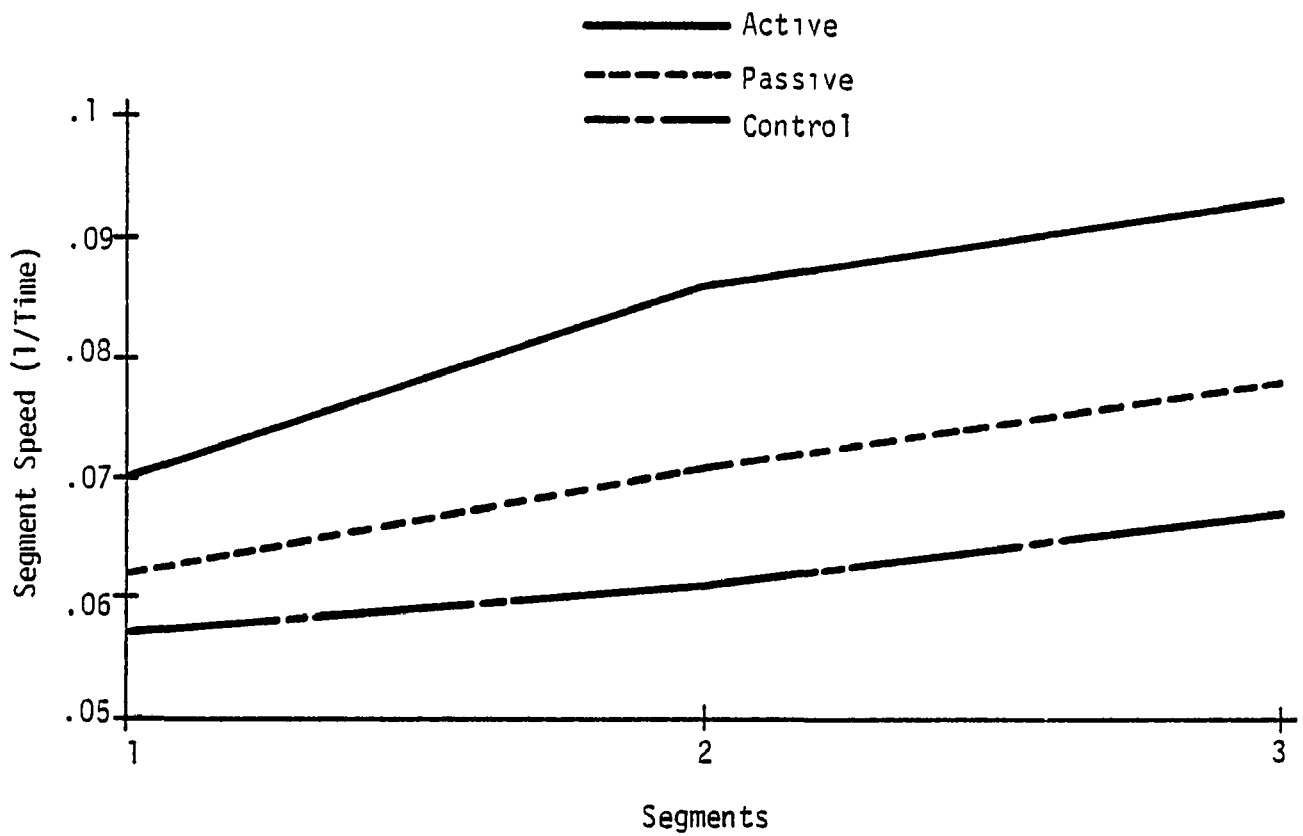


Figure 6. Locomotor Maze Segment Speed for Practice Groups on Test Trials

the speed of the practice group, the faster was the speed of segment two in relation to segment one.

Hypothesis Four: Perceptual Differentiation and Locomotor Maze Test Segment Traversal Speed

It was hypothesized that there would be a direct relationship between the selection of visual or non-visual cues in spatial perception and traversal speed of the three locomotor maze segments. Field-dependent subjects would evidence regressive ordering of segments. Field-independent subjects would demonstrate faster speed on the final maze segment followed by the initial and middle segments. The ordering of segments for both groups would be replicated in the active-practice, passive-practice, and control groups.

The analysis of variance indicated a nonsignificant speed difference between perceptual differentiation groups by segments interaction (see Table 5), as illustrated in Figure 7. Although a post hoc analysis to determine segment speed differences for each perceptual-differentiation group is not warranted, the order of mean segment speeds were similar for each group. The analysis of variance also indicated a nonsignificant speed difference for the practice groups by perceptual differentiation by segments interaction (see Table 5). Although the post hoc analysis to determine segment speed differences for each practice by perceptual-differentiation group is not warranted, the order of segment mean speeds were similar. The ordering of the segment mean speeds for practice groups by perceptual-differentiation groups was consistent with the ordering of segment mean speeds (hypothesis three) (see Figure 8). Further, in terms of probability, it is interesting to note the consistently faster speed of the field-independent group over segments and practice groups by segments interaction than the field-dependent group.

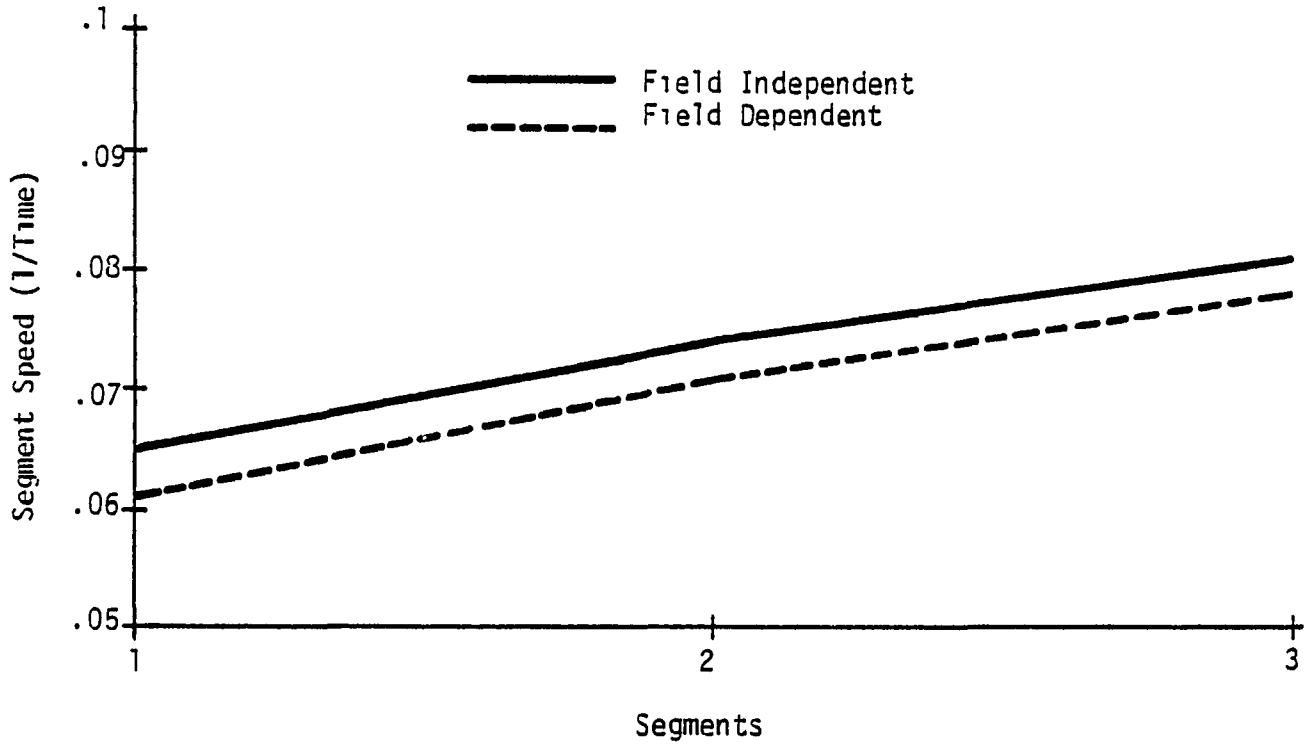


Figure 7. Locomotor Maze Segment Speed for Field-Independent/Dependent Groups on Test Trials

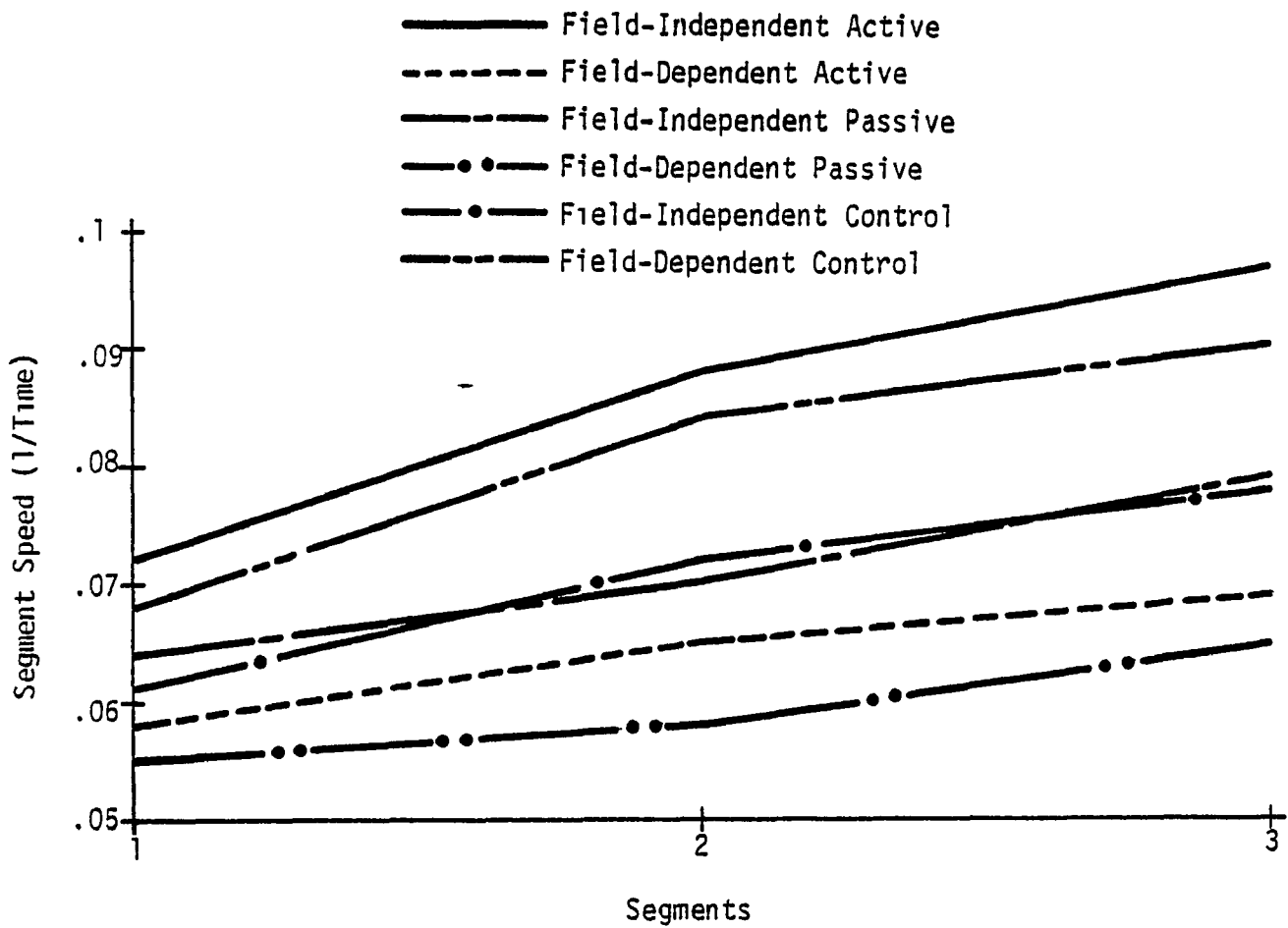


Figure 8. Locomotor Maze Segment Speed for Field-Independent/Dependent Groups by Practice Groups on Test Trials

DISCUSSION

Abstract

The experiment evaluated the influence of active- and passive-movement conditions on the learning of an irregular-shaped locomotor maze. Also subjects were classified as field-independent/-dependent based on the tilting chair, Rod and Frame Test scores. Field-independent/-dependent subjects' performance on the Locomotor Maze Test was analyzed in relation to organizational strategies of learning as indicated by order of maze segment acquisition. A repeated measures ANOVA indicated a significant difference in practice effects. A post hoc Tukey analysis identified the active condition as significantly better than the non-practice control group. There were no differences between field-independent/-dependent subjects' maze traversal speed or order of maze segment acquisition. Both groups learned the maze segments in regressive order. Results are discussed in terms of the influence of efference and perceptual differentiation on spatially oriented movement behavior.

All human gross motor activity is continuous with respect to time in space. The serial structure of skilled action is controlled by goal-directed intention. It is the persistent intention that precedes, directs, and provides the criterion for serial organization (Bruner, 1970). Ultimately, predictable spatio-temporal patterning is achieved. The research effort in motor learning, however, has been to concentrate on the measurement of unidirectional discrete acts or the final result of continuous-movement sequences. Therefore, the present study was designed to delineate the contribution of central efference, the mechanism of

intent, to the learning of a spatially-oriented serial movement. The organizational strategies of serial learning were also investigated in relation to the subjects' use of internal or external referents for the structuring of space.

The literature strongly supports the critical relationship between sensori-motor coordination and active movement which has the benefits of efference (Held & Freedman, 1963; Teuber, 1972). If efference contributes to the learning of a spatially oriented movement, then it would be expected that subjects in the active condition would demonstrate more learning than passive and control subjects. It has also been determined that vision is an influential orienting mechanism. Therefore, if a strong visual exafferent condition facilitates learning a spatially oriented movement, then it would be expected that subjects in the passive condition would learn more than the non-visual control group. The data supported these hypotheses.

The non-practice control group performance served as the baseline for determination of active- and passive-practice effects on learning a locomotor maze task. The control subjects performed 10 test trials under the same non-visual but otherwise normal locomotor test conditions of the active and passive groups. The significant difference between active and control conditions is evidence that active practice trials influenced spatial-orientation learning. Whereas control subjects showed little learning after Trial 2, active subjects' performance speed significantly increased to Trial 5. Further, the level of learning after 10 control trials was less than the learning of the active group on test Trial 2. The control group did not have a spatial image of the pattern and without vision had to discover the correct path by making

errors. It is speculated that the continual error correction of the control group interfered with the formation of a spatial image. The diverging learning curves of the active and control group support this contention and suggest the importance of knowledge of the task to the learning of geographic orientation.

The superiority of the active-treatment group over the control group may have been due to the effects of vision, efference, or both functioning in closed-loop dependence. There is no question that vision is a very strong orienting mechanism in perceiving space. However, the status of vision as a learning variable must be considered. Some researchers contend that vision serves for immediate guidance of the motor response in point-by-point manner. Therefore, vision is viewed as a performance variable, serving to regulate momentary behavior but ineffective as a learning variable with persistence from prior experience. However, the literature on guidance in maze learning suggests that visual information is used to structure the strategy employed in learning a motor task. The salient task variables of maze learning appear to be largely perceptual and involve the sequential spatial organization of cues structuring the task (Holding, 1965). Further, it has been demonstrated that maze learning is facilitated under visual guidance when cues are available relative to correct and incorrect responses at successive points of the performance (von Wright, 1957).

Of major concern to the present study is the compelling evidence that maze learning is facilitated equally under non-visual, passive-transport and visual, passive-model conditions (Souder, Burroughs, Teeple, Parker, & Bunker, Note 1). The non-visual, passive-transport subjects received enhanced exafferent tactile and auditory cues while being pushed

through the locomotor maze in a wheelchair. The passive model condition consisted of enhanced exafferent tactile and auditory cues while viewing the experimenter pushing an empty wheelchair through the maze. Interestingly, a passive, visual-inspection condition consisting of viewing the maze path was not significantly different from the non-practice control group which was identical to the control group of the present study. Therefore, exafferent, visual information without sequential structure was not adequate for learning. The similarity between the non-visual, passive-transport and visual model conditions was that subjects had repeated experience with the sequential structure of the maze path, a factor which Tolman (1936) stated led to the establishment of expectations about the contiguity of events which facilitates learning. It was concluded that vision present in the active-treatment condition of this study served as a facilitative learning variable. Support for this contention comes from the fact that the visual, passive-transport condition also was significantly different from the control group after Trial 5. The passive-transport condition required subjects to assume a relaxed sitting posture in a wheelchair minimizing efferent activity. Tactual stimuli from contact with the strings that defined the maze path as well as vestibular information of linear and rotary components of physical movement from variable velocity transportation through the maze were similar for all groups. The significantly faster speed of active condition subjects in relation to passive subjects after Trial 5 indicated that the difference between active and control groups' performance was not due to visual stimuli alone.

There are several potential explanations of how efference contributed to the superior performance of the active-practice subjects. It is

known that efference initiates and directs movement. The correction of direction by efference commands the learner to attend to error and to the choice of a new response which facilitates learning (Kelso & Stelmach, 1976). The active subjects had to decide which direction to go and could always make the decision correctly. The literature supports enhanced learning in errorless restrictive response conditions when response alternatives are specified (von Wright, 1957). It has also been suggested that efference is effective in practice conditions because it is also present in the response to be learned. That is to say, the more compatible the guidance procedure is to the response demands of the task, the more learning evidenced (Holding & Macrae, 1966). The most probable reason for this finding is the lack of translation difficulties between practice and test trials. The translation from non-efferent to efferent conditions could limit the proficiency of performing a spatial, motor task. Finally, efference emits a corollary discharge which could prepare central sensory processing systems to receive sensory inputs. In the active-practice condition, corollary discharge could heighten the processing of visual stimuli, thereby facilitating learning. Of course, it could be that two sources of information, efferent and visual, are better than visual information alone. The major challenge facing neurophysiologists lies in elucidating the manner in which central and peripheral processes interact for learning. Specifically, the question which guides research is how the central symbolic representation of movement is developed.

Data from the study support the contention that spatially oriented movement behavior emerges from a background of spatial expectancies developed over practice trials. Efference is not sufficient for the

development of spatial expectancies as demonstrated by the non-practice control subjects' absence of learning. That efference is not necessary for learning was supported by the visual, passive-transport group's increased performance speed to Trial 6. However, the active-practice subjects' use of efference in combination with visual information produced the most effective movement behavior. It is speculated that the most effective central symbolic representation of the geometric pattern emerges from simultaneous efferent and visual-reafferent stimuli with practice in discrimination of environmental constraints.

If spatial expectancies are critical to spatial-orientation learning, then behavior should relate to the precision and organization of the central symbolic representation of the geometric pattern. The present study investigated the effect of individual differences in the selection and use of available cues which influence the structuring of space on learning the locomotor maze. It was predicted that field-dependent subjects would exhibit perseveration tendencies and therefore be slower in completing the maze than field-independent subjects. The data revealed no significant difference between field-independent/-dependent groups in speed of accomplishing the task.

The prediction of perseveration tendencies for field-dependent subjects was based on studies using a trial-and-error learning procedure (Gorman, 1968; Peterson, 1920). The present study, on the other hand, used restrictive- and forced-response guidance procedures in practice trials. It could very well be that the amount of learning gained during these errorless trials overcame the initial perseveration effects of non-extreme score field-dependent subjects. In fact the literature does point to equal performance between perceptual-differentiation groups after some learning has taken place (Elliott, 1961). It is also notable that the active, passive, and control conditions had more

effect on the subjects' speed than did the use of internal or external referents. Therefore, internal or external referents for spatial organization might better be represented as a determinant of strategies used for learning the geographic-orientation task. Differences in ordering maze-segment acquisition revealing organizational influences was also investigated.

Motor learning studies have supported sequential acquisition of parts in a series. The initial portion is acquired prior to the second part. The research results again were based on trial-and-error designs (Cratty, 1963) and strong verbal mediation possibilities (Magill, 1976; Zaichkowsky, 1974). The present study used a non-verbal, curvilinear locomotor maze in an errorless guidance design. Predictions were made, therefore, from literature dealing with the retroactive-interference effects of visual-spatial pattern representation. The data supported the hypotheses that maze segments would be learned in regressive order and that the order would be replicated by active, passive, and control groups. There were significant differences between all segments of the maze. However, more interesting was the finding that although all groups showed regressive ordering, only the passive group demonstrated significant differences between all segments. The active group showed no difference between Segments 3 and 2 which were traversed at a faster speed than Segment 1. The control group ran Segment 3 faster than 1, and Segment 2 was not significantly different from either one. It would appear, therefore, that the availability of various mechanisms contributes to the logical natural sub-unit of the maze. Dividing the maze into three equal units for study is of course somewhat artificial. Although neither the number nor length of maze sub-units is clear, it can be said that retroactive interference from intramaze unit similarity is a factor in the regressive ordering of units.

It should be pointed out that the number of maze sub-units is partially determined by time. There are at least two types of timing that are important in serial learning. One type concerns judgment of the appropriate moment for the movement to be made in relation to external cues. The other type of serial timing concerns the serial organization of each muscle activity comprising the movement or the timing of successive movement patterns (Provins, 1956). Timing is responsible for flow, and flow depends on a sense of "how what one is doing now" and "what one anticipates next" fit into the objective of the serial program in operation (Bartlett, 1958).

The classic theme of Gestalt psychology is that the particulars of a pattern must be apprehended jointly. If one observes the particulars separately, they form no pattern. However, subsidiary awareness and focal awareness are mutually exclusive and can account for pattern and segment particulars at the same time. In fact when learning has occurred, exploration of environmental cues of the path ceases. Awareness of cues changes from focal to subsidiary. The goal of the task moves to a focal position. The newly acquired consciousness of the experience is a structural change achieved by repeated mental effort aiming at the instrumentalization of actions in the service of the purpose. The logic of tacit memory and the theory of ontological stratification are indispensable for the understanding of the phenomena of skilled motor acts (Polanyi, 1958). Future research on temporal and spatial determinants of behavior will clarify further the nature of sub-units making up the whole in serial tasks.

The data also supported the prediction that field-dependent subjects would learn the maze segments in regressive order. Field-dependent subjects tend to follow the dominant properties of space. Because space is not organized by internal referents, the subjects are prone to interference effects. Therefore, retroactive interference from intramaze segment similarity would cause regressive ordering. Regressive ordering was also found in the active, passive, and control groups.

Contrary to the hypothesis, it was found that field-independent subjects also evidenced regressive ordering of maze segments which again was replicated in the active, passive, and control conditions. It has been predicted that structuring of space precluding interference would cause the middle segment to be learned after the primary anchor points of the finish and start of the maze. Because the segments at the ends of a homogeneous path are ordinarily the most identifiable because of their unique positions, they would enjoy an advantage for storage in the memory system over the segment embedded in the middle. The learning of the beginning and ending segments (the figure) are separated by the middle segment (the ground) which provides a basis for localizing them within the series (Harcum, 1975). Differentiation facilitates the memory of anchor segments. Whether Segment 3 was learned first because the end of the maze was used as an anchor point or the subjects were in fact influenced by retroactive interference can not be determined by this study. However, it is known that while self-nonsel segregation fosters the development of restructuring ability, people with that competence available to them need not always use it. The option is available to internal-referent individuals to follow the dominant

organization of the field (Witkin & Goodenough, Note 2). It appears that these subjects did follow the dominant spatial properties which infers the retroactive interference explanation because Segment 1, an anchor segment, was learned last.

The active process of structuring or organizing sensory information appears to be an essential operation of long-term storage and retrieval (Atkinson & Shiffrin, 1971; Pribram, 1969). Broadbent (1963) describes interference or facilitation effects in memory in terms of converging or diverging causal lines within the nervous system. In long-term memory, stimuli that are similar will be more likely to be placed in the same category and produce interference in the response. Current literature in memory favors interpretation of interference from this viewpoint of generalized response competition (Tulving & Madigan, 1970, p. 471). What is evident from this line of thinking is that the strategies a subject adopts for learning also apply to memory. Individual differences in perceptual processing of information can, therefore, affect immediate performance and learning through retrieval processes. It was assumed in this study that the saliency of cues was determined by field conditions in the external environment mediated by a cognition of relative difference among stimuli. Accordingly, the isolated stimuli becomes a figure against the remainder of stimuli providing the ground. The central thesis is that serial learning is characterized by a strategy of selective attention to cues in some order for processing and for some order of reproduction. Learning is not a passive association of one event with another, and memory is not a passive reproduction of one event given another. Memory, like perception, is a reconstruction. Gibson (1966)

suggests that perceptual learning may be a process by which the nervous system comes to resonate to a dynamic pattern of stimulation. Gibson (1969) held that perceptual learning was not the supplementation of bare stimuli with associations but the differentiation and extraction of information present in the stimulus. What was learned were the distinctive features and invariants of events. The problem of perception was the over abundance of information; learning was a selective process, filtering and abstracting through the noise to develop a percept or concept. The conclusion is of great importance to learning theory and suggests that work with imagery must be tied in with memory theory in general. Memory, like perception, is an active, problem-solving task of processing stored information to construct an image of the past.

That all action systems have access to a common stock of programs related to resolving spatial, temporal, relational, and identity problems has been proposed (Bernstein, 1967). Therefore, the organization of skill may be considered as the embodiment of programs that are used throughout life not only for the mastery of skilled tasks, but also for problem solving. When skill is viewed as a problem to be solved, the parallelism to perceptual learning and memory is striking.

Central to the understanding of how perceptual, memory, and motor components interact in learning is the functioning of the central symbolic representation of movement patterns. In spatial learning, the mechanisms which contribute to the development of the representation or image must continue to be researched. The present study has concentrated on the effects of efference in combination with vision in a design which allowed for development of an image in errorless trials before test trials; however, there are several other mechanisms besides vision which need to be investigated. The next most important mechanism is

that of the vestibular system. The vestibular system alone and in combination with efference should be analyzed in a similar learning design.

Historically researchers have emphasized verbal and visual images for explaining learning and subsequent memory. It is intuitive that visual cues are important for geographic orientation, and visual cues in combination with efference are important for geographic-orientation learning. The inference is that visual cues can guide the vestibular system which produces a vestibular image of the spatial pattern. It seems a reasonable hypothesis that over repeated traversals of a spatial pattern a vestibular image is formed which can control the motor output when vision is removed. Evidence from lower species supports this contention (Douglas, 1966; Jones & Milsum, 1970; Rosen & Stein, 1969; Shepard, 1959; Watson, 1907). It appears that for rats vestibular information is most important to learning a complex maze.

Implications for Further Research

Future research in human learning needs to be directed toward the hypothesis that the vestibular stimuli generated by movement of the body produces a spatial image of the geometrical pattern which is stored in memory and is most influential for continued improvement. Gibson (1952) stated that the reciprocity of vision and vestibular information in everyday spatial behavior may prove to be not only the key to the problem of upright posture in relation to the visual vertical but also the key to the problem of geographic orientation. Beritoff (1965) concludes that vestibular cues play a major part, along with vision in all forms of spatial orientation. Delineating the contribution of vestibular information to the learning of geographic orientation as

well as elucidating the manner in which central efference and peripheral visual-vestibular processes interact in producing goal-directed movement are major questions to be researched in motor learning.

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APPENDIX A
Instructions

INSTRUCTIONS - ROD AND FRAME TEST

In this test we want to find out how well you can determine the upright-- in other words, the vertical under various conditions. In a few moments when you raise the blindfold and open your eyes, you will see a square frame, and within this frame you will see a rod. Except for the frame and rod the room will be in complete darkness. It is possible for me to tilt the frame to the left or the right. I can also tilt the rod to the left or right. I can tilt the frame alone or the rod alone; or I can tilt them both at the same time, either to the same side or to the opposite side. When you open your eyes at the beginning of each trial, I want you to tell me whether the rod is straight up and down (vertical) or whether it is tilted. In other words, tell me whether the rod is straight with the walls of this room or whether it is tilted. Are there any questions?

It is very important that you keep your eyes closed and blindfold in place, except when I specifically ask you to raise the blindfold and open your eyes. Also, when I ask you to close your eyes and lower the blindfold, please do so promptly. Now if you are ready we shall begin. Raise your mask and open your eyes. Can you see the frame and the rod? Is the rod straight or tilted? I will now turn the rod slowly until you think it is straight. After each turn tell me whether it has been turned enough or whether you want it turned more. Just say "more" or "enough" after each turn. Please make your decisions quickly. Which way shall I move the rod to make it vertical, clockwise or counter-clockwise? Would you tell me now and at the beginning of all subsequent trials whether the rod is straight with the walls of this building or

tilted, and if it is tilted, whether it should be moved clockwise or counter-clockwise to be made straight.

TILTING CHAIR SEQUENCE - SIX PERMUTATIONS

<u>Chair Sequence - left, right, upright</u>	<u>Chair Sequence - left, upright, right</u>
chair upright, pretest 97 secs. motor on movement chair left, test 97 secs. motor on movement chair upright, rest 60 secs. motor off 97 secs. motor on movement chair right, test 97 secs. motor on movement chair upright, rest 60 secs. motor off 97 secs. motor on no movement chair upright, test	chair upright, pretest 97 secs. motor on movement chair left, test 97 secs. motor on movement chair upright, rest 60 secs. motor off 97 secs. motor on no movement chair upright, test 97 secs. motor on no movement chair upright, rest 60 secs. motor off 97 secs. motor on movement chair right, test
<u>Chair Sequence - right, left, upright</u>	<u>Chair Sequence - right, upright, left</u>
chair upright, pretest 97 secs. motor on movement chair right, test 97 secs. motor on movement chair upright, rest 60 secs. motor off 97 secs. motor on movement chair left, test 97 secs. motor on movement chair upright, rest 60 secs. motor off 97 secs. motor on no movement chair upright, test	chair upright, pretest 97 secs. motor on movement chair right, test 97 secs. motor on movement chair upright, rest 60 secs. motor off 97 secs. motor on no movement chair upright, test 97 secs. motor on no movement chair upright, rest 60 secs. motor off 97 secs. motor on movement chair left, test
<u>Chair Sequence - upright, left, right</u>	<u>Chair Sequence - upright, right, left</u>
chair upright, pretest 97 secs. motor on no movement chair upright, test 97 secs. motor on no movement chair upright, rest 60 secs. motor off 97 secs. motor on movement chair left, test 97 secs. motor on movement chair upright, rest 60 secs. motor off 97 secs. motor on movement chair right, test	chair upright, pretest 97 secs. motor on no movement chair upright, test 97 secs. motor on no movement chair upright, rest 60 secs. motor off 97 secs. motor on movement chair right, test 97 secs. motor on movement chair upright, rest 60 secs. motor off 97 secs. motor on movement chair left, test

INSTRUCTIONS - LOCOMOTOR MAZE TEST

Control-Practice Group

This study is designed to test the effects of active and passive conditions on learning a spatial-orientation task. Your problem will be to run through the maze, blindfolded, in the least amount of time possible. Now I'm going to let you view the maze so that you will have a general idea of the space in which you will be moving.

You will have a few minutes of practice before we begin with Trial 1. The purpose of the three pretrials is to move blindfolded as rapidly as possible in a straight path as defined by the maze vertical strings and chain attachment. Keep your arms folded out in front of the body. You will be able to feel the strings on your arms and the chain on your legs. I will catch you at the end of the straight path and lead you back to the start.

[3 Pretrials]

You will now have 10 blindfolded test trials. Run as rapidly as possible. I will catch you at the end of the maze and lead you back to the start. I will tell you the time it took you to traverse the maze before the next trial so that you will have an idea of how you are doing. Remember to keep your arms folded and in front of your body. If you get turned around and reverse directions I will correct you immediately with verbal cues.

Active-Practice Group

This study is designed to test the effects of active and passive conditions on learning a spatial orientation task. Your problem will be to run through the maze, blindfolded, in the least amount of time possible. However, during the first 10 trials of the experiment, we want to see how much you can learn about the maze path while moving through it with confined vision. The goggles you will be wearing will allow you to view the conduit overhead which outlines the maze path. During the last 10 trials you will demonstrate what you have learned by running through the maze blindfolded in the least time possible. Now I'm going to let you view the maze so that you will have a general idea of the space in which you will be moving.

You will have a few minutes of practice before we begin with Trial 1. The purpose of the three pretrials is to move blindfolded as rapidly as possible in a straight path as defined by the maze vertical strings and chain attachment. Keep your arms folded out in front of the body. You will be able to feel the strings on your arms and the chain on your legs. I will catch you at the end of the straight path and lead you back to the start.

[3 Pretrials]

You will now have 10 practice trials with half vision. Run as rapidly as possible. Remember to keep your arms folded and in front of your body. I will catch you at the end of the maze and lead you back to the start.

[10 Active-Practice Trials]

You will now have 10 blindfolded test trials. Run as rapidly as possible. I will catch you at the end of the maze and lead you back to the start. I will tell you the time it took you to traverse the maze before the next trial so that you will have an idea of how you are doing. Remember to keep your arms folded and in front of your body. If you get turned around and reverse directions I will correct you immediately with verbal cues.

[10 Test Trials]

Passive-Practice Group

This study is designed to test the effects of active and passive conditions on learning a spatial-orientation task. Your problem will be to run through the maze, blindfolded, in the least amount of time possible. However, during the first 10 trials of the experiment, we want to see how much you can learn about the maze path while being pushed through the maze as rapidly as possible in a chair rather than actually walking through it. The goggles you will be wearing will allow you to view the conduit overhead which outlines the maze path. During the last 10 trials you will demonstrate what you have learned by running through the maze blindfolded in the least time possible. Now I'm going to let you view the maze so that you will have a general idea of the space in which you will be moving.

You will have a few minutes of practice before we begin with Trial 1. The purpose of the three pretrials is to move blindfolded as rapidly as possible in a straight path as defined by the maze vertical strings and chain attachment. Keep your arms folded out in front of the body. You will be able to feel the strings on your arms and the chain on your legs. I will catch you at the end of the straight path and lead you back to the start.

[3 Pretrials]

You will now have 10 trials with half vision. The experimenter will push the wheelchair as rapidly as possible.

[10 Passive-Practice Trials]

You will now have 10 blindfolded test trials. Run as rapidly as possible. I will catch you at the end of the maze and lead you back to the start. I will tell you the time it took you to traverse the maze before the next trial so that you will have an idea of how you are doing. Remember to keep your arms folded and in front of your body. If you get turned around and reverse directions I will correct you immediately with verbal cues.

[10 Test Trials]

APPENDIX B

Analysis of Variance Tables

Table B1

Analysis of Variance Summary Table Between Locomotor Maze Test Practice Groups for Mean Absolute Degrees Deviation on Rod and Frame Test

Source	<u>df</u>	<u>ms</u>	<u>F</u>
Groups	2	12.93	.87*
Subjects within groups	45	14.93	

* $p = .43$.

Table B2

Analysis of Variance Summary Table Between Locomotor Maze Test Practice Groups for Initial Movement Speed Pretest

Source	<u>df</u>	<u>ms</u>	<u>F</u>
Groups	2	.01	.34*
Subjects within groups	45	.03	

* $p = .71$.

APPENDIX C
Post Hoc Analysis Tables

Table C1

Post Hoc Analysis Between Locomotor Maze Test Treatment Groups
for Mean Speed on Test Trials

Group	Active	Passive
Active		
Passive	2.47	
Control	4.27*	-1.81

* $p < .05$.

Table C2

Post Hoc Analysis of Locomotor Maze Test Practice Groups X Trials
Interaction for Mean Speed on Test Trials

Group		Active	Passive
Trail 1	Active		
	Passive	2.21	
	Control	3.59*	-1.37
Trail 2	Active		
	Passive	3.43*	
	Control	5.08*	-1.64
Trail 3	Active		
	Passive	2.98	
	Control	7.56*	-4.58*
Trail 4	Active		
	Passive	4.16*	
	Control	6.91*	-2.75
Trail 5	Active		
	Passive	7.98*	
	Control	10.15*	-2.18
Trail 6	Active		
	Passive	4.54*	
	Control	9.43*	-4.89*
Trail 7	Active		
	Passive	6.07*	
	Control	9.96*	-3.89*
Trail 8	Active		
	Passive	6.37*	
	Control	9.47*	-3.09
Trail 9	Active		
	Passive	5.50*	
	Control	10.69*	-5.19*
Trail 10	Active		
	Passive	3.70*	
	Control	8.36*	-4.66*

*p < .05.

Table C3

Post Hoc Analysis of Locomotor Maze Test Trials x Practice Groups
Interaction for Mean Speed on Test Trials

Trial	1	2	3	4	5	6	7	8	9
<u>Active Group</u>									
2	-5.71*								
3	-7.14*	-1.44							
4	-8.04*	-2.33	-0.90						
5	-11.34*	-5.63*	-4.20	-3.30					
6	-10.44*	-4.74*	-3.30	-2.40	0.90				
7	-10.91*	-5.20*	-3.77	-2.87	0.43	-0.47			
8	-12.78*	-7.07*	-5.63*	-4.73*	-1.44	-2.33	-1.87		
9	-13.10*	-7.39*	-5.96*	-5.06*	-1.76	-2.66	-2.19	-0.32	
10	-12.06*	-6.35*	-4.92*	-4.02	-0.72	-1.61	-1.15	0.72	1.04
<u>Passive Group</u>									
2	-5.17*								
3	-7.28*	-2.12							
4	-7.04*	-1.87	-0.22						
5	-6.71*	-1.55	0.57	0.33					
6	-9.36*	-4.19	-2.08	-2.32	-2.64				
7	-8.26*	-3.09	-0.98	-1.22	-1.55	1.10			
8	-10.05*	-4.89*	-2.77	-3.01	-3.34	-0.69	-1.79		
9	-11.35*	-6.19*	-4.07	-4.31	-4.64*	-1.99	-3.09	-1.30	
10	-12.04*	-6.92*	-4.80*	-5.05*	-5.37*	-2.73	-3.83	-2.03	-0.73
<u>Control Group 1</u>									
2	-4.60*								
3	-3.64	0.96							
4	-5.26*	-0.65	-1.61						
5	-5.53*	-0.92	-1.88	-0.27					
6	-5.29*	-0.69	-1.65	-0.03	0.23				
7	-5.26*	-0.65	-1.61	0.00	0.27	0.04			
8	-7.75*	-3.15	-4.11	-2.49	-2.23	-2.46	-2.49		
9	-6.87*	-2.26	-3.22	-1.61	-1.34	-1.57	-1.61	0.88	
10	-8.10*	-3.49	-4.45	-2.84	-2.57	-2.80	-2.84	-0.34	-1.23

*p < .05.

Table C4

Post Hoc Analysis Between Locomotor Maze Test Segments for
Mean Speed on Test Trials

Segment	1	2
2	-8.46*	
3	-14.09*	-5.64*

* $p < .05$.

Table C5

Post Hoc Analysis of Locomotor Maze Test Segments x Practice
Groups Interaction for Mean Speed on Test Trials

Segment	Segment	1	2
Active Group	2	-7.52*	
	3	-10.75*	-3.23
Passive Group	2	-4.55*	
	3	-8.47*	3.92*
Control Group	2	-2.17	
	3	-4.88*	-2.71

* $p < .05$.

APPENDIX D
Means and Standard Deviations

Table C6

Post Hoc Analysis of Locomotor Maze Test Practice Groups x
Segments Interaction for Mean Speed on Test Trials

	Group	Active	Passive
Segment 1	Passive	3.63*	
	Control	6.28*	-2.65
Segment 2	Passive	7.36*	
	Control	12.12*	-4.76*
Segment 3	Passive	7.11*	
	Control	12.85*	-5.74*

* $p < .05$.

Table D1

Mean and Standard Deviation of Locomotor Maze Traversal Speed
for Practice Groups, Segments, Trials, and Perceptual Differentiation on Test Trials

Group	<u>n</u>	Mean Speed	<u>S.D.</u>
Active	14	.083	.031
Passive	18	.071	.010
Control	16	.062	.012
Segments			
1		.063	.019
2		.072	.030
3		.079	.031
Trials			
1		.053	.020
2		.066	.020
3		.068	.026
4		.070	.027
5		.072	.029
6		.075	.028
7		.074	.028
8		.078	.029
9		.080	.027
10		.080	.031
Perceptual Differentiation			
Field Independent	24	.073	.021
Field Dependent	24	.070	.020

Table D2

Rod and Frame Test Means (12 trials) for 48 Subjects

Field Independent		Field Dependent	
S#	Mean	S#	Mean
1	2.58	25	9.92
2	3.50	26	10.17
3	4.75	27	10.33
4	5.25	28	10.50
5	5.33	29	10.50
6	5.67	30	10.50
7	5.75	31	10.75
8	6.50	32	11.00
9	7.08	33	11.17
10	7.08	34	11.83
11	7.42	35	11.92
12	7.58	36	12.00
13	7.92	37	12.00
14	8.00	38	12.08
15	8.25	39	12.17
16	8.33	40	12.25
17	8.42	41	12.33
18	8.42	42	13.08
19	8.50	43	14.25
20	8.50	44	16.17
21	8.75	45	17.67
22	8.83	46	18.50
23	8.92	47	19.58
24	9.75	48	19.75
Group Mean	7.13	Group Mean	12.93
Range	7.17	Range	9.83

VITA

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Universities Attended:

University of Illinois
Urbana, Illinois

B.S. in Physical Education, 1969
M.S. in Physical Education, 1972
Ph.D. in Physical Education, 1979

Professional Experience:

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Motor Learning and Development Laboratory
Urbana, Illinois
Graduate Research Assistant, 1969-1977

University of Illinois
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Graduate Teaching Assistant, 1969-1977

Grants:

Research Board of University of Illinois
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"The Effect of Knowledge of Results on Accuracy of Kinesthetic
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Proposal submitted by Majorie A. Souder, Ph.D. for appointment
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Scholarships:

Teacher Education Scholarship
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Academic Honors:

B.S. Degree with Honors, 1969
Honors Day Convocation for Superior Academic Records, 1969

Merit Awards:

Alpha Sigma Nu, Physical Education Honorary for Women (aca-
demic and activity) 1968

Shorter Board, University Senior Women Honorary (academic
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Merit Awards: (continued)

Carita Robertson Outstanding Senior Award, Department of Physical Education, 1969

Offices Held in Professional Societies:

Physical Education Majors Club, University of Illinois
Historian, 1966
Junior Representative, 1967
President, 1968

Illinois Association for Health, Physical Education, and Recreation
President of Student Section, 1968
Coordinator of Media Center, 1975

Kappa Delta Pi, National Honor Society in Education, 1969

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Graduate Research:

M.S. Thesis Title, "Short-Term Motor Forgetting in Early Acquisition with KR and KR Withdrawal: Decay vs. Interference"

Ph.D. Dissertation Title, "The Relation of Active-Passive Movement and Perceptual Differentiation to Geographic Orientation"

Publications:

Burroughs, S.L. "Perception and Motor Learning," In Laboratory Experiences in the Bioscientific Foundations of Man Moving, edited by J. Teeple. Champaign, Illinois: Stipes Publishing Company, 1975.

Souder, M.A., Burroughs, S., Parker, N., & Bunker, L. Stylus-maze learning under conditions of action-information feedback. Perceptual and Motor Skills, 1975, 40, 847-854.

Souder, M.A., Burroughs, S., Teeple, J., Parker, N., & Bunker, L. The Relation of Passive and Active Movement to Geographic Orientation, Manuscript submitted.

Monographs:

Souder, M.A., Bunker, L.K., and Burroughs, S.L. Enhancement of human effectiveness in visual space perception. Human Movement Research Laboratory, Monograph #1, 1970. University of Illinois, Urbana, Champaign.

Souder, M.A., Bunker, L.K., and Burroughs, S.L. Enhancement of human effectiveness in perceptual-motor learning and performance. Human Movement Research Laboratory, Monograph #2, 1970. University of Illinois, Urbana-Champaign.

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- Burroughs, S.L. Dynamic variation of correspondence between visual and kinesthetic space perception. Motor Learning and Development Laboratory, Monograph #5, 1972. University of Illinois, Urbana-Champaign.
- Burroughs, S.L. Procedures for maintenance and use of laboratory equipment. Motor Learning and Development Laboratory, Monograph #6, 1973. University of Illinois, Urbana-Champaign.

Speeches:

- 1974 Speech given at the Illinois Association of Health, Physical Education, and Recreation Convention, "Forgetting in Early Acquisition of a Complex Motor Skill: Decay vs. Interference."
- 1975 Speech given at the Midwest District of the American Alliance for Health, Physical Education and Recreation Convention, "Implications of Research on Individual Differences in Perceptual Differentiation for Skill Acquisition."
- 1976 Speech given at the Illinois Association of Health, Physical Education, and Recreation Convention, "Practical Application of Research: Dialogue Between a Theorist and Practitioner."

Apparatus Design and Construction:

- Tilting Shield-Printed Circuit Board of Standard and Reverse Stylus Maze Patterns Apparatus, 1971.
- University of Illinois Locomotor Maze, 1974.

