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ABSTRACT

It has been hypothesized that the use of techniques to enhance motor skill acquisition and retention in the elderly may retard the onset of retirement, result in the continuation of a productive professional career, allow continued participation in recreational activities, and possibly slow the decline in physiological functions that normally accompanies aging. Recently there has been extensive research on mental operations and the ways in which a person can use certain cognitive strategies to enhance learning and performing of skilled movements. This paper: (1) examines the efficacy of using cognitive strategies as a method to enhance motor skill learning; (2) analyzes some of the differences between older and younger learners in their ability to learn and perform movement skills to better understand how aging affects motor skill acquisition and performance processes; and (3) suggests ways in which the elderly can learn and perform skills more effectively through the use of cognitive strategies. (NB)

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THE USE OF COGNITIVE STRATEGIES TO ENHANCE

MOTOR SKILL ACQUISITION AND RETENTION IN THE ELDERLY

by

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Persons of all ages play an active role in the mental processes associated with learning motor skills. The ability to acquire and retain motor skills repeatedly has been shown to entail extensive use of cognitive operations (Anshel and Singer, 1980; Singer, 1980; and others). But only recently has there been more extensive investigation on the nature of these mental operations and of the ways in which a person can use certain techniques - referred to as cognitive strategies - to enhance the learning and performing of skilled movements. It is hypothesized that the use of techniques that enhance motor skill acquisition and retention in the elderly can, potentially, retard the onset of retirement result in the continuation of a productive professional career, and allow continued participation in recreational acctivities. In addition, it is possible that a decrease in physiological functins that normally accompanies aging will be slowed (Spirduso, 1975).

Thus, the purposes of this paper are: (1) to examine the efficacy of using cognitive strategies as a method to enhance motor skill learning; (2) to analyze briefly some of the differences between older and younger learners in their ability to learn and perform movement skills to better understand how aging affects motor skill acquisition and performance processes; and (3) to suggest ways in which the elderly can learn and perform skills more effectively through the use of cognitive strategies.

Strategies have been defined differently by various researchers. To understand the proper use and potential advantages of a cognitive strategy, it is important to agree upon its definition.

A cognitive strategy is a psychological process imposed on or originated by the learner that acts upon or manipulates incoming information to improve learning (Gagne, 1977). Strategies are skills employed by learners to regulate internal processes such as attention, thinking, learning, and remembering. Strategies also signify operations that may be used to retrieve information from permanent (long-term) memory (LTM) (Rigney, 1978). For example, a strategy called imagery has been used to enhance the acquisition and performance of sports skills. In this technique, learners are asked to formulate and "hold" in their minds vivid visual images of a model demonstrating the to-be-performed skill. In recent years investigators have examined the effects of different learner strategies in psychomotor research.

Evidence of the improved performance of motor skills has been demonstrated with the use of strategies such as rhythm (Beisman, 1967; Mikol and Denny, 1955), rhythm and music (Anshel and Marisi, 1978), imagery (Housner and Hoffman, 1978; Singer, Gerson, and Ridsdale, 1979), imagery with verbal labels (Zimmerman and Rosenthal, 1974), anticipation (Flowers, 1978), and chunking (Singer, Ridsdale, and Korienek, 1980). In addition, it has been clearly shown that the learner's use of particular mental operations will result in significantly superior performance in the learning of verbal material (see O'Neil and Spielberger, 1979, for a review). Thus, it is apparent that the use of learner strategies, either along or in combination, shows promise as a vehicle to affect the learning and performance outcomes in a positive manner.

Shea (1977) and Hagenback (1978) each investigated the effect referred to as labeling on motor short term memory. Using an arm-repositioning skill, subjects were asked to reproduce movements at locations designated with relevant or irrelevant labels. Groups consisted of relevant labels which described the criterion position, irrelevent labels, in the form of low concrete nouns (Shea) or numbers (Hagenback), and a no-label control group. In both studies it was found that a 5-sec retention interval produced no differences in retention between the groups but that the relevant labeling group was significantly more accurate than the other groups after a 60-sec period prior to recall. Thus, it appears that learners need additional time to learn and implement a cognitive strategy - a finding that concurs with the findings of other studies in the use of imagery on learning.

As described earlier, imagery entails the use of vivid mental pictures to enhance the storage and retrieval of information. However, the process of encoding - placing information into the system to facilitate its storage into and subsequent retrieval from LTM - takes additional time (Gagne, 1977). This time-consuming process is especially true when using a mental imagery strategy because information is often encoded and stored in two forms instead of one: verbal (linguistic) and nonverbal (imaginal) (Paivio, 1971). Paivio describes this process as dual-coding and helps explain the successful use of imagery when "sufficient" inter-stimulus time intervals are available to learners.

For example, it was found in Hagenback's study on motor skill learning (mentioned earlier) that the use of imagery (subjects who imagined their limb to be the second hand on a clock) resulted in superior performance after a 60-sec but not a 5-sec time interval. The importance of giving ample opportunity to the learner to incorporate proper strategy usage is particularly important with children (Brown and Campione, 1977) and, as will be discussed later, with elderly learners. Other studies lend support to the use of cognitive strategies in learning motor skills.

Anshel and Singer (1980) examined the effectiveness of a combination of cognitive strategies - imagery, directed attention, rhythmic verbalization, and paraphrasing - on motor skill acquisition and long-term retention. Different skills related to juggling three beanbags served as the criterion tasks. The directed attention strategy was used to assist learners in focusing on the most relevant components of the to-be-learned skill such as where to direct their visual attention. For the rhythmic verbalization strategy, learners were required to attach a label to each of a series of movements and overtly verbalize that label in rhythm wih the movement during task performance. Paraphrasing, a technique in which learners communicate in their own words nformation derived from novel stimuli, was used when subjects were asked to teach subskill to a partner. Imagery was described earlier.

The authors used the four strategies alternately and in combination. The results of the study indicated that subjects who used the strategies performed each of a series of juggling skills significantly better than non-users of strategies on both the acquisition and retention tests. Results of an earlier study by Anshel (1978) on the combined use of cognitive strategies were similar to Anshel and Singer.

It is apparent that cognitive strategies have been effectively employed to benefit significantly the learner's ability to learn and retain motor skills. In all of these studies, however, younger persons have served as subjects. There is an apparent dearth of research on the effects of cognitive strategies on the learning and performnce of older individuals. Prior to examining the potential usefulness of mental techniques for elderly learners of motor skills, it is important to review the similarities and differences in performance capabilities as a function of aging. The information processing model will form the basis of these comparisons.

Information Processing

Essentially, three processes are affected by aging in motor skill acquisition, retention, and performance: (1) the perception that an event has occured; (2) a decision in response to the event; and (3) the carrying out of an action based on the decision (Welford, 1977).

In the perceptual mechanism, data from the various modalities are identified, classified, and enhanced (supplemented) by data from LTM. It is here where input is given meaning (Singer, 1978). This process differs from that of detection in that through detection, the organism mearly acknowledges the existence of an object. Thus, upon completion of the perceptual mechanism, the system has analyzed relevant features of the input, consolidated these features into recognizable units, and applied meaning to the information to make an appropriate decision prior to computing a physical response.

The decision mechanism includes several steps: the retrieval of information from LTM, a comparison of this information with the learner's present knowledge of the environment, knowledge of the goal to be achieved, and the selection of an appropriate motor program - a predetermined set of neural commands which controls muscular activity (Klapp, 1976). The decision to respond is transferred to a centralized (effector) mechanism which programs a phased sequence of muscular actions for response execution.

The action is carried out through the transmission of a sequence of efferent neural commands to the chosen muscles in preparation for muscular contraction (Keele and Summers, 1976). Simultaneously, a replication of these commands, called the collary discharge is emitted to a temporary (short-term) memory store for the sensory consequences of the upcoming movement (Singer, 1978). A search is then made of LTM to match the movement goal with the feedback. This comparison process is central to the skill learning process and serves as one important factor in the comparison of younger and older learners.

Differences Between Younger and Older Performers

It is apparent that aging is a factor in the learning and performance of many motor skills. However, some internal processes that produce performance outcomes are more affected by age than others. As indicated earlier, perceiving, decision-making, and physically responding to one or more stimuli are three of these primary processes.

Perception

The ability to perceive (give meaning to) stimuli changes with age. However, the degree to which older and younger performers differ is often a function of the type of task. Some tasks make significantly greater cognitive demands on the person than others. The component of a task that makes the greatest cognitive demand on the person and is most responsible for differences in performance between age groups is speed (Welford, 1977).

Successful performance is often based on the ability to attend to a plethora of information and to register, store, and retrieve this data as quickly as possible to meet task demand and perform skills competently. There appears to be a deficit in each of these processes with the elderly with an increase in speed of to-be-learned tasks with both verbal material (Adamowicz, 1976) and motor skills (Cratty, 1975).

It has been shown that the older learner needs additional time to store information in LTM (Hartley and Anderson, 1983; Welford, 1958, 1980), retain less after a single trial (presentation), and need more trials to reach a criterion on skill (Cratty, 1975; Gilbert, 1941). Welford found that older subjects took more time to perform on the first trial and improved more slowly on later trials than younger persons. However, when the elderly have registered and stored information, i.e. have learned, it is well-remembered. Hartley and Anderson concluded that elders have poor problem-solving strategies in that they deal with relatively little information at one time despite the higher cognitive demands of a task.

Anshel (1978), using a limb repositioning task and Wimer and Wigdor (1958) using a paired-associate word task, found that elders remembered what they had learned at similar levels to younger performers. The self-paced nature of the tasks in both studies help explain this finding. Tasks which include more rapid presentation of stimuli as opposed to slower, self-paced tasks, usually results in performance decrement as a function of age, a phenomenon referred to as a registration phase deficit (Adamowicz, 1976).

Making rapid and accurate decisions is a function of the rate at which incoming data can be matched with previously learned information and acquired skills (Schmidt, 1982). The speed of this process, experimentally regulated by viewing time of a novel stimulus and duration of the inter-stimulus interval, usually results in the older learner more negatively affected than the younger learner (Adamowixa, 1976; Welford 1977). This has been labeled the retrieval deficit hypothesis (Craik, 1968).

Retrieval from LTM can take longer for the elderly under either of two conditions: (1) where the identification of incoming data involves an extensive search of memory (Riegal and Birren, 1965); or (2) where fine discriminations have to be made (Park, Ruglisi and Lutz, 1982). For example, in a task in which subjects sorted cards according to letters printed on them, the performance of older subjects was more impaired than that of younger subjects by additional, irrelevant letters on the cards, i.e. when the number of the stimuli requiring one response was increased (Rabbitt, 1965). In another study, Rabbit (1964) found that performance of elders was lower compared to younger performers with an increase in the number of different responses. One possible explanation for the retrieval deficit hypothesis is the effect of interference of past learning experiences on older, as opposed to younger learners.

Typically, it is to the learner's benefit to associate new learning tasks with previously stored information (Gagne, 1977). In fact, one unique trait of an elderly learner that often causes superior performance as compared to children and young adults is the ability of older persons to use past experience and previously used techniques to master new skills. For example, in tasks for which accuracy and speed are required, elders are more cautious than younger people resulting in a slower rate of response but with either similar or greater accuracy than younger persons (Welford, 1980).

This "slow but sure" approach to motor tasks exhibited by older performers may well be due to their tendency to employ a variety of cognitive strategies which is frequently absent in young children (Brown and DeLoache, 1978), although both children and the elderly are capable of learning and using complex mental operations that improve memory and problem-solving when they are taught these skills (Brown and DeLoache, 1978; Denny and Denny, 1982). Thus, the expanded source of information available to the older person from permanent memory storage as compare to the relatively limited cognitive repertoire of the young child can be used by elders to approach and complete cognitive an motor tasks with success. However, improved performance outcomes due to previously learned skills can work in reverse.

Researchers (Shooter, Schonfield, King and Welford, 1956) have measured decrements in performance due to the mastery of earlier tasks, a phenomenon referred to as proactive interference (Schmidt, 1982). In these studies, the inhibitory effects of retraining began from "the 40's" and older if learners had no previous experience on the criterion task.

Probably the single major cause of performance differences between the young and elderly on decision-making tasks is the tendency of older performers to be more cautious and concerned with accuracy at the expense of speed. This is especially true on fast-paced motor tasks.

It has been observed consistently that older people show a tendency to inspect incoming data or a longer time before making a decision (Botwinick, Brinley, and Robbin, 1958; Welford, 1978). Older people are simply more cauticus and more reluctant to make a positive, accepting response (Welford, 1958). For example, in one study (Craik, 1969), older subjects, more than younger ones, gave a higher proportion of negative replies when deciding whether or not a faint tone had been sounded (tones for audibility had been equated for each subject before the study).

Even when the demands of making rapid decisions are significantly reduced, as in a simple reaction time (RT) task, responses become slower as a function of age. Evidence for this is based on the effect of altering the foreperiod - the time interval between "ready" and the onset of a signal to "go" - on RT. Although persons of all ages are affected by very short (less than 1 second) or very long (more than 4 seconds) foreperiods, this affect is more pronounced on the elderly (Botwinick and Brinely, 1962). Welford (1978) suggests that older people are less able than the younger to prepare their responses before arrival of the signal to "go".

In summarizing use of the perceptual and decision-making mechanisms as a function of age, three points are salient: (1) The elderly need additional time to register, store, and retrieve information about skilled movements from LTM as compared to younger persons - a characteristic that is particularly salient when to-be-performed activities are relatively complex; (2) When subects ae able to learn and perform at their own rae (a self-paced task) as opposed to an externally-regulated pace, differences in performance as a function if age are significantly reduced; an (3) When the older person registers and stores new input successfully, i.e. when something is learned, it is usually remembered.

A multitude of studies in both the laboratory and industry have been completed in which the effect of aging on speed of movement was examined. Speed of work production has been shown to increase between the ages of 35 to 45 years and either remains constant (Breen and Spaeth, 1960) or declines slowly (Clay, 1956). Laboratory results indicate greater decline in (slower) reaction time as compared to field data (see Welford, 1977, for a review). As Welford hypothesizes, this is probably due to the "survival of the fittest" (p. 487) in which the numbers employed in production jobs decline sharply from the late forties onward; "those who leave tend to be less fit than those who remain" (p. 487). Perhaps two factors: (1) past experience which compensates for a loss in speed capacity in a field situation and (2) the absence of using compensatory strategies in laboratory studies, particularly when measuring reaction and movement time, might help explain why reduced speed of industrial tasks is due not so much to the speed of movement execution but to the time necessary to plan and decide which actions to take.

The utilization of cognitive strategies, therefore, should be based on the following summation of the preceding material:

(1) The time needed to store new information in LTM increases with age.

(2) Elders take longer to inspect incoming data than younger persons. This is especially true for tasks in which the stimulus source is environmentally controlled, i.e. initiated by the performer, and demanding of a rapid response. Under such conditions, the time needed to make decisions is slower for older persons.

(3) Older performers are more cautious and show greater concern for accuracy than speed as compared to younger performers in making decisions.

(4) Relatively complex tasks which are characterized by a rapid series of signals and requiring fast responses result in greater performance deficits in the elderly when compared to the younger learner. This is contrary to tasks in which the performer initiates the rate of stimulus-presentation and response and contains relatively longer inter-stimulus interval periods and longer stimulus viewing time. Under the latter conditions, the performance of older and younger persons are often similar.

(5) When the older performer has stored (acquired) newly learned information or motor skills, it is usually retained and performed at levels similar to younger persons.

(6) Previous experience on tasks similar to the new to-be-learned skill has been shown to affect the older learner more negatively than the younger learner - a result of proactive interference.

(7) The reduced speed of responding to a stimulus in elders is due to the required time to plan and decide on the response and not so much as a deficit in movement execution.

Suggested Use of Strategies

The primary objective of cognitive strategy usage with older persons is to make novel stimuli more salient, meaningful, and familiar to the learner. Cues of this will expedite the rate at which information is percieved, stored in, retrieved from LTM (decision-making), and put into action.

Perception

Often in performing an open skill in which the environment is relatively unstable and the demands of the task quickly vary, the process of stimulus perception can be very rapid. Where the demands of the task necessitate faster responses, it is suggested that strategies such as directed attention, anticipation , and labeling be used.

To use directed attention effectively, the learner must exclude from consideration inputs known in advance to be irrelevant and be able to identify relevant components (Singer, 1978). For example, when learning and performing a juggling skill, the person should keep his or her eyes at the optimal height of the tossed items (Carlos, 1974). The location of where the items ae caught and their placement in the hands must be ignored.

The need to focus visually at the optimal height of tossed items is predicated on the use of location information as a reference point in central informational processing, also referred to as cognitive mapping (Lindberg and Garling, 1982 among many others). According to the authors, information about the location of reference points in the environment may be stored in permanent memory with the practice of a physical task. In order for this storage to occur: (1) the distance and direction of stimuli must be attended to; and (2) information about the location of the reference points (the height of tossed items in the present example of juggling) is compared between actual and desirable performance outcomes and updated through practice.

Thus, the acquisition of information about both relative locations of reference points and the locomotion path (of the juggled objects in flight, for example) underlie the importance of observing tossed items at their apex in flight and eliminating the need to focus on the catching component of the skill.

Anticipation appears to be a very relevant cognitive strategy for the elderly. As previously discussed, the ability to respond to rapid and irregular signals deteriorates as a function of age. A combination of the decreased ability of elders to anticipate the onset of new stimuli and their propensity to monitor the previous response are purported to be two primary reasons for differences in performance due to age. Singer and Gerson (1979) have used the terms readiness strategy to describe techniques that better prepare the learner to receive stimuli. Anticipation is one such technique.

Singer and Gerson define the strategy of anticipation as conscious energy directed toward potential task events based on prior experiences and probability. Anticipating the onset of a signal requires several mental events: (a) maintaining the proper arousal level; (b) a high degree of task familiarity; (c) possession of an internal model of the external world from which predictions about the future can be made; and (d) the presence of a sensory set in which attention is directed toward the expected stimulus. In the proper use of anticipation, it is important that minimal attention be given to the previous response.

Finally, labeling may be used to attach verbal tags, which are personally meaningful to the learner, to form connections between skill (task) components. For example, retention might be improved if the learner associated either the source of a stimulus or the direction and target of a response with the face of a clock. The dials on a control panel might indicate three o'clock. Or performers may need to direct their response toward a location synonomous with twelve o'clock. This is exactly the strategy used by gunners on war ships when shooting at aircraft. In another example, more rapid and effective

communication can occur using stimuli of different colors which can be labeled according to meaningfulness: blue lights might indicate height, i.e. the sky, in which the source of a stimulus is above eye level; yellow lights indicate safety; and red lights represent danger, etc.

Storage

Given the need to increase the amount of time for information storage in older age, it would appear that the rate of presenting information or skills should be slowed to accommodate the learner. The learning process should not be hurried. Because the comprehension of information requires additional time with older learners, an instructional strategy of learning at the individual's own pace would be advantageous.

The use of self-contained learning modules, although not widely available in published form in the learning of sports skills, could be used for the purpose of self-paced storage (see Singer and Dick, 1980, on the construction of such modules). One study (Anshel and Singer, 1980) has indicated superior learning and performance outcomes due, in part, to the use of modular instruction as oppose to the traditional (group) teacher-centered approach in motor skill learning.

Learner strategies that could be used to enhance storage, particularly on relatively rapid tasks, include: rehearsal , in which the learner identifies to-be-remembered information and covertly repeats it to oneself; chunking, where single "bits" of information or subskills are grouped in larger, more meaningful units which serves to reduce the amount of information that must be stored (Miller, 1956; and mental imagery, whereby the learner is required to create a vivid mental picture of the to-be-performed task or to-be-remembered skill - a particularly effective strategy when the learner has enough time to construct the images (Winograd, Smith, and Simon, 1982).

Decision-making/Retrieval

The causes of longer times in decision-making and reaction tasks by elders are subject to much interpretation. Welford (1978) hypothesizes that the most likely explanation of slower reactions by older persons when offered very short foreperiods - particularly following a previous response - is "that the translation mechanism is busy monitoring the previous response or data from the warning so that data from the new signal are delayed" in the processing of information (p. 474).

There are several cognitive strategies that may be used by the older learner to work harmoniously with the habit of cautious and accurate responses, preferrably on a self-paced task. Three such strategies are paraphrasing (also referred to as self-verbalization), elaborate rehearsal and elaboration.

Paraphrasing is a technique in which the learner transforms and interprets verbal material or motor skills into one's own words. Two conditions must exist for paraphrasing to occur. The two statements (of the teacher and the learner): (a) have no substantive words (nouns or verbs) in common; and (b) when they are equivalent in meaning (Anderson and Kulhavy, 1972). A paraphrase is related to the original sentence in meaning but unrelated as to the shape or sound of the words. Thus, paraphrasing presupposses comprehension of the original sentence.

Labourie-Vief and Gonda (1976) used paraphrasing (referred to by the authors as a covert self-instructional or self-monitoring strategy) with elderly subjects on the training and tansfer of verbal material. Subjects performed a problem solving task while talking aloud to themelves, then while whispering, and finally, covertly without visible lip movements. They found significant increments in intellectual performance as compared to older subjects not using this technique. The authors also suggested, based on their review of the literature, that older persons are less effective in utilizing experimenter-imposed strategies but, rather, would perform better when generating their own strategies. The suggestion, therefore, is to teach a series of cognitive strategies to learners based on the type of task to be performed (see Singer and Gerson, 1981, for the proper use of strategies by task classification) and allow learners to choose their own technique.

Elaborate rehearsal is referred to as a meaningful-connections strategy (Weinstein, 1978) which enhances the long-term retention of the information. The objective using this technique is to enhance the meaningfulness of stimuli by forming associations, sentences, and images that organize information into patterns familiar to the learner. The repetition of these patterns facilitates their recall. This technique is particularly useful for more complex material (skills). Thus, instead of the mere repetition of information, the learner connects stimuli into oranized units. This strategy is similar to another technique referred to as elaboration.

Similar to elaborate rehearsal, elaboration entails the construction of incoming data into organized and meaningful units, such as subskills of a higher-order complex skill. The difference between elaborate rehearsal and elaboration is that in the latter the mental operations include greater use of creativity. Upon viewing and practicing the to-be-learned skill, the person might: (a) use elaboration to create a phrase or sentence to relate or connect to the skill or subskill; (b) reinterpret information into his or her own words, and/or (c) use mental images which connect verbal information to movements.

Concluding Remarks

A plethora of comparative studies exist on the effects of aging on learning and retention although there are relatively fewer in the psychomotor area as compared to the verbal learning literature. The results of many of these studies indicate the limitations of older persons to perform similarly to younger subjects on a variety of cognitive and motor tasks. However, several issues need to be raised which challenge the efficacy of these conclusion.

Factors about the subjects in most studies which rarely have been taken into account, i.e. controlled, include: (1) education level and intelligence (whereas "younger" subjects are often college students, elders may not have completed grade school); (2) initial skill level and past experience in the experimental task (researchers rarely determine the learner's entering behavior); (3) health of subjects as influenced by physical fitness (Spirduso, 1975, found that cardiovascular fitness eradicated age differences between elderly and younger performers on reaction time and movement time); and (4) motivation/arousal levels.

In addition, researchers have defined "old age" differently from study to study. Gerontologists divide old age into two groups: early old age, 65 to 74 years, and advanced old age, 75 years and above (Butler and Lewis, 1977). Considering that cognitive processes associated with learning, retention, and performance are different between ages 65 and 85 years, generalizing the results of studies to all older people is not always valid (Atchley, 1977). Birren (1957) emphasizes the distinction between development and aging. "Aging is not simply negative growth" (p. 13). To Birren, the variables leading to development of the organism do not apply in the aging process. Whereas form, size, and function of the child grow and change toward a final state, these qualities are both durable and persistent in the mature adult. This it is the persistence of this "steady state" and not its deterioration that best characterizes the older person. "Although researchers should continue to study when and how performance limits are attained with age, the elderly should be perceived as capable and, in many situations consistent in their performance. Birren contends that "many differences between young and olderly persons are not due to aging but to differences arising from shifts in nutrition, ...education, public health, and attitudes" (p. 23).

It is clear that the elderly subjects of today's research are not likely to resemble older persons 30 to 50 years from now. There are currently 26.3 million Americans age 65 and over with a projection of over 35 million (about 26% increase from the 1980 census) by the year 2000. With such an extensive source of experience and knowledge, further research on the effects of aging on motor skill learning and performance to harbor this potentially valuable resource is warranted.

References

1. Adamowicz, J. K. Visual short term memory and aging. Journal of Gerontology, 1976, 31, 39-46.
2. Anderson, R. C. & Kulhavy, R. W. Learning concepts from definitions. American Educational Research Journal, 1972, 9 385-390.
3. Anshel, M. H. Effect of aging on acquisition and short-term retention of a motor skill. Journal of Perceptual and Motor Skills, 1978, 47, 993-994.
4. Anshel, M. H. & Marisi, D. Q. Effect of music and rhythm on physical performance. Research Quarterly, 1978, 49, 109-113.
5. Anshel, M. H. & Singer, R. N. Effect of learner strategies with modular versus traditional instruction on motor skill learning and retention. Research Quarterly for Exercise and Sport, 1980, 51, 451-462.
6. Atchley, R. C. The social forces in later life (2nd ed.). Belmont, CA: Wadsworth, 1977.
7. Beisman, G. Effects of rhythmic accompaniment upon learning of fundamental motor skills. Research Quarterly, 1967, 38, 172-176.
8. Birren, J. E. Principles of search on aging. In J. E. Birren (Ed.), Handbook of aging and the individual: Psychological and biological aspects. Chicago: Univ. of Chicago Press, 1959.
9. Botwinick, J., Brinley, J. F., & Robbin, J. S. The interaction effects of perceptual difficulty and stimulus exposure time on age differences in speed and accuracy of response. Gerontologia, 1958, 2, 1-10.

10. Botwinick, J. & Brinley, J. F. Aspects of RT set during brief intervals in relation to age and sex. Journal of Gerontology, 1962, 17, 296-301.

11. Breen, L. Z. & Spaeth, J. L. Age and productivity among workers in four Chicago companies. Journal of Gerontology, 1960, 15, 60-70.

12. Brown, A. & Campione, J. C. Memory Strategies in learning: Training children to study strategically. In H. Pick, H. Leibowitz, J. Singer, A. Steinschneider, & H. Stevenson (Eds.), Application of basic research in psychology. N. Y.: Plenum, 1977.

13. Brown, A. DeLoache, J. S. Skills, plans, and self-regulation. In R. Siegler (Ed.), Children's thinking: What develops. Hillsdale, NJ, Lawrence Eilbaum, 1978.

14. Butler, R. N. & Lewis, M. I. Aging and mental health (2nd ed.). St. Lewis: Mosby, 1977.

15. Carlo. The juggling book. NY: Vintage Books, 1974.

16. Clay, H. M. A study of performance in relation to age at two printing works. Journal of Gerontology, 1956, 11, 417-424.

17. Craik, F. M. I. Short term memory and the aging process. In G. A. Tallard (Ed.), Human aging and behavior. New York: Academic Press, 1968.

18. Craik, F. M. I. Applications of signal detection theory to studies of aging. Basel: Karger, 1969.

19. Cratty, B. J. Movement behavior and motor learning (3rd ed.). Philadelphia: Lea & Febiger, 1975.

20. Denny, N. W. & Denny, D. R. The relationship between classification and questioning strategies. Journal of Gerontology, 1982, 37, 190-196.

21. Flowers, K. A. The predictive control of behavior: Appropriate and inappropriate actions beyond the input of a tracking task. Ergonomics, 1978, 21, 109-122.

22. Gagne, R. M. Conditions of learning. New York: Holt, Rinehart & Winston, 1977.

23. Gilbert, J. C. Memory loss in senescence. Journal of Abnormal and Social Psychology, 1941, 36, 73-86.

24. Hagenbech, F. I. Strategy utilization in the acquisition and retention of a serial motor task. Unpublished master's thesis, Florida State University, 1978.

25. Hartley, A. A., Anderson J. W. Task complexity and problem-solving performance in younger and older adults. Journal of Gerontology, 1983, 38, 72-77.

26. Housner, L. D. & Hoffman, S. J. Imagery and short term motor memory. In G. C. Roberts & K. M. Newell (Eds.), Psychology of motor behavior and sport-1978, Champaign, IL: Human Kinetics, 1979.

27. Keele, S. W. & Summers, J. J. The structure of motor programs. In G.E. Stelmach (Ed.), Motor control: Issues and trends. NY: Academic Press, 1976.

28. Klapp, S. T. Short-term memory as a response preparation state. Memory and Cognition, 1976, 4, 721-729.

29. Klatzky, R. L. Human memory: Structures and processes. San Francisco: W. H. Freeman, 1975.

30. Labourie-Vief, G. & Gorda, J. N. Cognitive strategy training and intellectual performance in the elderly. Journal of Gerontology, 1976, 31, 327-332.

31. Lindberg, E. & Garling, T. Acquisition of locational information about reference points during locomotion: The role of central motor processing. Scandinavian Journal of Psychology, 1982, 23, 207-218.

32. O'Neil, H. F., Jr. & Spielberger, C. D. Cognitive and affective learning strategies. New York: Academic Press, 1979.

33. Paivio, A. Imagery and verbal processes. New York: Holt, Rinehart & Winston, 1971.

34. Park, D. C., Ruglisi, J. T. & Lutz, R. Spatial memory in older adults: Effects of intentionality. Journal of Gerontology, 1982, 37, 330-335.

35. Rabbit, P.M.A. Age and time for choice between stimuli and between responses. Journal of Gerontology, 1964, 19, 307-312.

36. Riegal, K. F. & Birren, J. E. Age differences in associative behavior. Journal of Gerontology, 1965, 20, 125-130.

37. Rigney, J. W. Learning strategies: A theoretical perspective. In H. F. O'Neil, Jr. (Ed.), Learning Strategies I. New York: Academic Press, 1978.

38. Schmidt, R. A. Motor control and learning. Champaign, IL: Human Kinetics, 1982.

39. Shea, J. B. Effects of labeling on motor short-term memory. Journal of Experimental Psychology: Human Learning and Memory, 1977, 3, 92-99.

40. Shooter, A., Schonfield, A. E., King, H. F. & Welford, A. T. Some field data on the training of older people. Occupational Psychology, 1956, 30, 204-215.

41. Singer, R. N. Motor skills and learning strategies. In H. F. O'Neil, Jr. (Ed.), Learning strategies. New York: Academic Press, 1978.

42. Singer, R. N. & Dick, W. Teaching physical education: A systems approach (2nd ed.) Boston: Houghton Mifflin, 1980.

43. Singer, R. N. & Gerson, R. F. Learning strategies, cognitive processes, and motor learning. In H. F. O'Neil & C. D. Spielberger (Eds.), Cognitive and affective learning strategies. New York: Academic Press, 1979.

44. Singer, R. N. & Gerson, R. F. Task classification and strategy utilization in motor skills. Research Quarterly for Exercise and Sport, 1981, 52, 100-116.

45. Singer, R. N., Gerson, R. F., & Ridsdale, S. A conceptual orientation to the study of motor behavior. Technical Report TR-78-Th-9, U.S. Army Research Institute for the Behavioral and Social Sciences, December, 1978.

46. Singer, R. N., Ridsdale, S. & Korienek, G. G. Achievement in a serial positioning task and the role of learners' strategies. Journal of Perceptual and Motor Skills, 1980, 50, 735-747.

47. Spirduso, W. W. Reaction and movement time as a function of age and physical activity level. Journal of Gerontology, 1975, 30, 435-440.

48. Weinstein, C. E. Elaboration skills as a learning strategy. In H. F. O'Neil, Jr. (Ed.), Learning strategies I. New York: Academic Press, 1978.

49. Welford, A. T. Aging and human skill, Westport, CT: Greenwood Press, 1958.

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

51. Welford, A. T. Mental work load as a function of demand, capacity, strategy, and skill. Ergonomics, 1978, 21, 151-167.

52. Welford, A. T. Motor skill and aging. In C. H. Nadeau, W. R. Halliwell, K. M. Newell, & G. C. Roberts (Eds.), Psychology of motor behavior and sport-1979. Champaign, IL: Human Kinetics Press, 1980.

53. Wimer, R. E. & Wigdor, B. T. Age differences in retention of learning. Journal of Gerontology, 1958, 13, 291.295.

54. Winegrad, E., Smith, A. D. & Simon, E. W. Aging and the picture superiority effect in recall. Journal of Gerontology, 1982, 37, 70-75.

55. Zimmerman, B. & Rosenthal, T. L. Observational learning of rule-governed behavior by children. Psychological Bulletin, 1974, 81, 29-42.