The Effects of Physical and Mental Training on the Mental Abilities of Older Adults

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Several approaches have been taken to evaluate the effects of physical and mental training interventions on the mental abilities of older adults. A selective review of theory-based research suggests that older adults’ mental functioning may improve following both forms of training; however, the mechanisms that underlie these changes are not well understood. Several multidisciplinary approaches are evaluated that may help to explain how both exercise and mental training interventions may modify or offset age-related declines in mental abilities.

Key Words: cognition, mental health, physical exercise

Advancing age is associated with numerous changes in physiological and psychological functioning. These changes are evidenced physiologically at the subcellular, cellular, organ, and systems levels of analysis (Schneider & Rowe, 1990; Shephard, 1987). Behavioral and intellectual changes are also associated with advancing age. Longitudinal studies of cognitive aging have yielded consistent evidence that decline begins in the 6th decade of life. While a few mental abilities begin to decline substantially at about this time, most show only small, but reliable, declines (Schaie, 1993). Perhaps the most ubiquitous observations are those of general slowing (Birren, 1965; Birren, Woods, & Williams, 1980; Salthouse, 1985) and declines in some aspects of memory (Baddeley, 1984; Salthouse, 1985). While clear age-related declines in physical and mental abilities occur, it is also fairly obvious that the rate of decline is influenced by a multitude of factors (Spirduso, 1995, chapter 9).

Throughout history, numerous methods have been proposed to stave off age-related declines in mental abilities. Two methods that have been consistently suggested to have ameliorative effects are physical exercise and mental exercise. In today’s popular culture, involvement in physical and mental activity is believed to offset declines in abilities associated with advancing age, and articles in popular literature tout the beneficial effects of both physical and mental exercise. Some articles encourage older adults to participate in such physical activities as walking, swimming, and cycling, while others advocate such mental activities as reading, crossword puzzles, and chess. The commonsense belief that physical and mental exercise maintains one’s general health has led to the development of various...
programs designed to improve abilities, prevent the onset of decline of abilities, and restore lost abilities.

Theory-based research designed to assess the effects of training on the mental abilities of older adults has emerged in two relatively independent domains: exercise science and psychology. The study of the mutability of older adults' mental abilities and the mechanisms by which training interventions might fundamentally change the manner in which older adults think and behave is central to research in both domains. Despite these common interests, only limited attempts have been made to integrate the research published within the two domains. This review seeks to (a) describe the research approaches that have been taken to assess the effects of training interventions on older adults' mental abilities, (b) provide examples of studies drawn from exercise science and psychology that have evaluated the effects of training on older adults' mental abilities, and (c) address applied and theoretical issues common to both physical and mental training programs.

Research Approaches

TRAINING INTERVENTIONS

Research has been conducted for several decades to assess the strength of the relation between both physical and mental training and improvements in older adults' cognitive abilities. In exercise science, health status has long been implicated as a factor contributing to individual differences in older adults' mental abilities (see Elias, Elias, & Elias, 1990; Folkins & Sime, 1981; Spiridonov, 1995, chapter 9, for reviews). Conditions such as coronary health status (see reviews by Birren, 1980; and Hertzog, Schaie, & Gribbin, 1978) and hypertension (Elias, Robbins, Schultz, & Pierce, 1990; Sands & Meredith, 1992; Wilkie, Eisdorfer, & Nowlin, 1976) have been shown to be related to performance on tests of cognitive function. Indeed, a recent meta-analysis of a large number of studies revealed consistent relations between health status and mental functioning (Thomas, Landers, Salazar, & Etnier, 1994).

Considerable discussion has been made of the relation between older adults' cardiovascular fitness and cognition. Dustman and his colleagues (Dustman, Emmerson, & Shearer, 1990, 1994; Dustman et al., 1984), for example, have suggested that sedentary lifestyles promote an increase in atherosclerosis and a decrease in the cardiovascular system's ability to transport and utilize oxygen. As a result, older adults exhibit increasing levels of brain hypoxia. In a recent review of research, Dustman et al. (1994) drew from several research areas to support their view that age-related declines in mental abilities are caused by changes in brain functioning and that aerobic exercise slows or reverses these declines. Studies of animal physiology have shown age-related decreases in blood flow, oxygen consumption, and glucose utilization. Further, brain metabolism is reduced because of decreases in neural tissue mass and a reduction in the number of brain stem cells necessary for neurotransmitter synthesis. Cross-sectional research that has examined electrophysiological processes in young and older adults has shown consistently that cardiovascula rily healthy older adults with histories of participation in aerobic exercise display “functional autonomy” that is similar to that of younger adults and superior to that of less healthy older adults. Likewise, cross-sectional research using
measures of behavioral and mental speed show that aerobically fit older adults perform more efficiently than do less aerobically fit older adults.

Findings such as these have resulted in a plethora of aerobic training programs designed for adults (Tomporowski & Ellis, 1986). Several large-scale aerobic research interventions have been conducted with the view that enhancing somatic processes will directly improve older adults’ cognitive abilities.

Training programs in the field of psychology tend to fall into two categories: those that teach participants to use “top-down” general-reasoning and problem-solving skills, and those that have been developed to augment “bottom-up” components of the information-processing system. General top-down problem-solving training interventions are characterized by their emphasis on methods that change the manner in which individuals use their available mental capacity. Paul Baltes and his colleagues (Baltes & Baltes, 1990; Baltes & Schaie, 1976; Baltes & Willis, 1982), for example, have implemented psychological training programs in which older adults are taught to adapt to declines in mental abilities by “selective optimization with compensation.” In these authors’ view, all individuals possess a mental reserve capacity that is drawn upon when they encounter problems. Baltes and his colleagues suggest that performance is determined by one’s active reserve, which reflects the mental capacity that the individual elects to employ, and one’s latent reserve, which reflects the mental capacity that the individual could potentially employ. Young and older adults alike have sizable reserve capacities; however, older adults evidence less plasticity, which limits the extent to which their mental reserves can be activated and employed. Mental training involves teaching strategies and problem-solving skills that are hypothesized to allow older individuals to make the most of their available resources, that is, to modify their cognitive functioning in ways that compensate for the age-related loss in effectiveness of the mental components necessary for problem solving. Successful aging and maintenance of mental abilities are thought to be achieved when older adults channel their available capacity to fewer domains and reorganize their approach to solving problems.

Bottom-up training interventions focus on specific components of the information-processing system that are presumed to underlie general cognitive functioning. Declines in older adults’ performance have been explained in terms of reduction in attentional capacity (Salthouse, 1985, 1991), processing speed (Myerson & Hale, 1993; Nettelbeck & Rabbitt, 1992), and memory processes (Hultsch & Dixon, 1990). Training programs are typically characterized by an attempt to isolate and remediate specific aspects of information processing. Salthouse (1985, chapter 5), discussing the effects of practice and experience on older adults’ mental abilities, enumerated a variety of ways that practice may influence information-processing structures and processes that underlie age-related differences in cognitive performance. He hypothesized that systematic practice of mental exercises could enhance older adults’ performance by improving stimulus encoding and memory abilities, by altering the way specific mental operations manipulate incoming information, or by affecting the development of “automatic” attentional processing.

MEASUREMENT APPROACHES

The effects of training have been assessed at different levels of analysis. The theoretical orientation of some researchers has led them to focus on measures of
elementary units of cognition. These researchers tend to use laboratory-based tests to identify and evaluate the function of basic mental structures and processes such as attention and memory (Detterman, 1982, 1986, 1992; Detterman et al., 1992). With this method, sometimes referred to as the componential-analysis approach, considerable effort is made to assess task conditions that influence individual and group differences in cognitive functioning (Sternberg, 1977, 1985). Training interventions have been proposed to have selective effects on the components of information processing. Stones and Kozma (1988) suggested that mental tests involving speeded processing and movement are particularly sensitive to training effects, while Chodzko-Zajko, Schuler, Solomon, Heinl, and Ellis (1992) and Chodzko-Zajko and Moore (1994) suggested that tasks which require effortful mental processing are more sensitive to the effects of physical fitness than are more simple or overlearned tasks.

Other researchers have measured changes in participants' performance on psychometric tests of intellectual functioning (e.g., the Wechsler Adult Intelligence Scale [WAIS; Wechsler, 1958] and the Stanford–Binet Intelligence Scale). Considerable research has been conducted on the psychometric properties of intelligence. Early psychometric theories of intelligence (e.g., Galton, 1869) proposed that complex behavior is governed by a unitary general factor, g, that provides a template for mental functioning. General intelligence in these theories was viewed as genetically based and influenced minimally by training interventions (see Jensen, 1987). Later psychometric theories of intelligence proposed that intelligence is actually composed of a number of relatively independent factors that are reflected behaviorally as abilities (Fleishman & Quainbance, 1984; Guilford, 1967; Thurstone, 1935). An influential theory developed by R.B. Cattell (Cattell, 1957, 1963; Horn, 1982; Horn & Cattell, 1966, 1967), for example, proposed that general intelligence reflects two factors: fluid intelligence, which determines the ability to adapt and solve all kinds of problems, regardless of previous experience with them, and crystallized intelligence, which reflects the accumulation and use of factual information. It has been suggested that improvements in physical health resulting from exercise may selectively affect processes that underlie fluid intelligence more than crystallized intelligence (Elsayed, Ismail, & Young, 1980).

Several reviews have critiqued studies examining the effects of physical training (Bashore & Goddard, 1993; Chodzko-Zajko & Moore, 1994; Dustman et al., 1994; Stones & Kozma, 1988) and mental training (Cerella, 1990; Salthouse, 1985, 1990, 1991) on older adults' cognitive function. These reviews have a number of striking similarities and differences. Reviews in both academic domains voiced similar interpretive methodological concerns (e.g., the relative merits of cross-sectional and longitudinal designs, the need for clear operational definitions of cognitive functioning, and differences in the implementation, duration, or intensity of training interventions). Discussion of theoretical issues were, however, relatively domain specific. Critiques of physical exercise programs tended to emphasize the relation between changes in biological variables and cognitive functioning, whereas evaluation of mental training programs tended to reflect theories of cognition that are currently in vogue. The following review was conducted in an attempt to bridge the two research domains. Central to the review is the hypothesis that the effects of both physical and mental training interventions may be understood in terms of multidisciplinary theories that synthesize biological and psychological processes
affected by training. The studies selected for evaluation provide examples of theory-based training programs conducted on normally aging older adults (i.e., individuals who did not present specific neuropathologies, disease states, or trauma-produced injuries to the central nervous system). It is not the intent of this review to provide a detailed methodological critique of the studies selected, since extensive reviews of each research area are available. Of interest is the extent to which the outcomes of physical and mental training programs can be explained parsimoniously.

PHYSIOLOGICALLY BASED TRAINING INTERVENTIONS

Several training studies support the hypothesis that older adults’ mental abilities can be modified via aerobic exercise. An early study conducted by Elsayed, Ismail, and Young (1980) contrasted the performance of sedentary and physically fit men in their mid-30s and sedentary and physically fit men in their mid-50s on psychometric tests of fluid and crystallized intelligence before and after a 4-month cardiovascular exercise program. Participants’ physical fitness training consisted of 90 min of jogging, calisthenics, and recreational activities performed three times per week. Measures of fluid intelligence, obtained from the Culture Fair Intelligence Test, yielded indices of participants’ abilities in concept formation, perception of relations, reasoning, and abstracting. Crystallized intelligence was measured using the Cattell Sixteen Personality Factor Questionnaire. Following training, physically fit subjects, regardless of age, scored higher on tests that measured fluid, but not crystallized, intelligence.

Dustman and his colleagues (Dustman et al., 1984) conducted one of the first well-controlled studies that examined the effects of cardiovascular exercise on older adults’ mental abilities. Sedentary adults 55 to 70 years old were matched on age and randomly assigned to one of three conditions: an aerobic exercise program (which consisted mostly of fast walking with occasional slow jogging), a strength and flexibility exercise program, or no exercise. Subjects in the exercise programs met for three 1-hr sessions per week for 4 months. A battery of psychoneurological tests, administered prior to and following training, included global measures of mental abilities (Culture Fair Intelligence Test) and specific measures of information processing (WAIS Digit Span and Digit Symbol, dot estimation, simple reaction time, Critical Flicker Fusion Threshold, and Stroop Test). When an overall neuropsychological index was calculated for each subject, pre- to posttest improvements in performance were noted for those who participated in both aerobic and strength/flexibility programs. Subsequent analyses indicated that the greatest gains were made by subjects in the aerobic program, who improved on all measures of information processing.

Hawkins, Kramer, and Capaldi (1992) evaluated the effects of a 10-week aquatic aerobic exercise program on older adults’ (mean age 68 years) performance on information-processing tests of auditory and visual attention. Exercisers made more rapid attentional shifts and performed dual-task tests of information processing more efficiently than nonexercisers. Similar improvement in information-processing abilities of older adults following a 16-week aerobic exercise program was reported recently by Moul, Goldman, and Warren (1995). On the basis of these studies, it appears that aerobic training positively affects both componential and psychometric measures of mental ability.
Several studies, however, have failed to obtain evidence in favor of a relation between cardiovascular improvement and cognitive functioning. Blumenthal and his colleagues conducted a series of experiments that found no exercise treatment effect. Blumenthal et al. (1989), Blumenthal et al. (1991), Blumenthal and Madden (1988), and Madden, Blumenthal, Allen, and Emery (1989) evaluated the effects of aerobic exercise (jogging) and anaerobic exercise (strength/yoga) programs ranging from 4 to 14 months in duration on older adults' performance on a number of tests of psychological functioning. While exercise produced significant improvements in subjects' physical characteristics, it was not related to any systematic change in their performance on tests of reaction speed, on psychometric-based tests of memory or perceptual motor function, or on information-processing tests of attention, memory-retrieval ability, or memory-search speed.

Other researchers have also failed to obtain evidence for the relation between aerobic training and cognitive function. Panton, Graves, Pollock, Hagberg, and Chen (1990) assigned adults in their mid-70s to aerobic training, strength training, and control conditions. Neither form of exercise was found to be related to a subject's reaction time or movement speed. Emery and Gatz (1990) reported that an aerobic exercise program failed to influence cognitive function; however, the interpretation of this study is limited, as the exercise program also failed to significantly improve subjects' cardiovascular function.

The mixed results of research evaluating the effects of aerobic training on cognitive functioning have been explained in a number of ways. The magnitude of the training effect on older adults' cardiovascular efficiency differs among studies, and it has been suggested that the amount of physical improvement engendered is related to the degree of change of mental abilities. Studies showing positive effects of training have tended to demonstrate large changes in individual pre- to postintervention scores for aerobic fitness (Bashore & Goddard, 1993). Dustman et al. (1994) suggested that the lack of clear effects of aerobic training in longitudinal studies on older adults' mental abilities is due to the relatively brief duration of the exercise interventions. In their view, an individual may need to have an extensive history of fitness training before mental functioning improves measurably. Stones and Kozma (1988) also suggested that extended exercise activity may be required to produce physiological changes that postpone or retard chronological-age-related declines in "functional aging," a construct they operationalized via measures of both physical and psychological capacity. Exercise is thought to serve as a physical energizer that promotes generalized "tonic" improvements in physical and mental functioning. Their model of functional aging makes a clear distinction between the general tonic effects of aerobic exercise and the effects of task-specific training. In their model, some but not all cognitive abilities may be maintained with overpractice. The notion that long-term aerobic exercise may moderate the effects of aging on mental processing speed and that long-term practice of tasks demanding fast reaction times results in the maintenance of speeded responding has also been articulated by Bashore and Goddard (1993).

The case has also been made that the failure to obtain strong agreement among aerobic training studies is simply due to methodological factors. Spiriduso (1995, p. 253) described the difficulty of deriving a reliable index of the effects of exercise on physical fitness variables. Chodzko-Zajko and Moore's (1994) review of cross-sectional and longitudinal aerobic training programs identified numerous method-
ological factors that make direct comparisons among studies difficult. They concluded that clear support for the ameliorative effects of aerobic exercise on older adults’ cognitive abilities is lacking.

PSYCHOLOGICALLY BASED TRAINING INTERVENTIONS

Prior to the 1980s, research on changes in mental abilities that accompany normal aging was primarily descriptive in nature; there was relatively little evaluation of treatments designed to modify the intellectual abilities of older adults (Baltes & Lindenberger, 1988). The first systematic studies of the effects of training on such abilities were undertaken as part of the Penn State Adult Development and Enrichment Project (ADEPT) and the Seattle Longitudinal Study (SLS). The focus of both research projects was similar: to assess the extent to which cognitive training modifies specific psychometric measures of mental ability and the extent to which such modifications generalize to other intellectual abilities and are maintained over time.

In the ADEPT project, the effects of a training intervention on three psychometrically defined primary mental abilities (figural relations, induction, and attention) were assessed in a series of studies (Hofland, Willis, & Baltes, 1981; Kliegl, Smith, & Baltes, 1989; Willis, Blieszner, & Baltes, 1981; Willis, Cornelius, Blow, & Baltes, 1983). Adults in their mid- to late 60s met in small groups and participated in five 1-hr educational training sessions. An instructor taught a number of relational rules associated with various problems similar to those used to measure fluid and crystallized intelligence. Following training, tests similar to those used in practice sessions and tests that required mental abilities other than those trained to solve problems were administered to the subjects. The durability of training effects was assessed 1 week, 1 month, and 6 months after training. Figural-relations training enhanced performance on test problems similar to those used during practice and on test items that tapped fluid intelligence; further, performance remained elevated over a 6-month period. Induction training enhanced performance but had relatively little transfer; treatment effects were detected on posttests administered 1 week and 1 month following training. Attention training enhanced performance on three of four tests. Performance on perceptual discrimination, selective attention, and attention switching tests improved significantly; moderate, but nonsignificant, improvements were noted on concentration tests.

A similar approach was used in the SLS project (Schaie & Willis, 1986; Schaie, Willis, Hertzog, & Schlenberg, 1987; Willis & Schaie, 1986). The performance of older adults (mean age 73 years) on tests that tapped spatial orientation and inductive reasoning ability was measured over repeated testing periods. Individuals were then categorized as “decliners” \( n = 122 \) or “stable” \( n = 107 \) on the basis of their performance. Five 1-hr training sessions that taught methods of solving problems of inductive reasoning and spatial orientation were then provided to all subjects. The performance of both groups of subjects improved following training. Decliners were returned to their predecline level, and subjects who were categorized as stable demonstrated enhanced performance. The subjects’ enhanced performance was attributed to the training programs, as improvements were limited to tests that reflected the targeted mental abilities; performance on tests that tapped other mental abilities remained unchanged. It was suggested that training would
likely not return older adults to levels of performance observed in young adults; however, training would produce substantial gains in normally aging adults.

The results of these studies were replicated by Baltes, Dittmann-Kohli, and Kliegl (1986), who assessed older German adults \((n = 204, \text{mean age 72 years})\) randomly assigned to either a cognitive training or a control group. Ten 1-hr training sessions were conducted; five focused on figural-relations problems and five on induction problems. Pre- and posttraining psychometric measures of fluid and crystallized intelligence revealed that training improved only those mental abilities selected for training.

Mental training programs have also been developed to ameliorate specific declines in older adults’ cognitive abilities. Age-related declines in working memory ability have been repeatedly documented under laboratory conditions with a variety of test methodologies (see Craik, 1977, 1986; Hultsch & Dixon, 1990). Working memory tasks are characterized by the simultaneous demand for rehearsing stored information and processing new information. Older individuals’ working memory abilities appear to be particularly compromised as task complexity increases (Hasher & Zacks, 1988; Salthouse, 1988). These observations have generated considerable interest in memory-training interventions. Studies that have employed mnemonics training have consistently demonstrated improvements in the memory performance of older adults. Mnemonics are mental strategies that include mental imagery, semantic associations, and rehearsal. Yesavage and his colleagues (Hill, Sheikh, & Yesavage, 1988; Yesavage & Jacob, 1984; Yesavage, Lapp, & Sheikh, 1989; Yesavage & Rose, 1984a, 1984b) conducted several studies that measured the effects of various types of mnemonic training. Yesavage and Rose (1984a), for example, taught a face-naming mnemonic to young (mean age 27 years), middle-aged (mean age 53 years), and older (mean age 61 years) adults. The mnemonic employed a series of steps for encoding facial features, deriving a high-imagery transformation of the person’s name, and forming a visual image associated with a prominent facial feature. All three age groups showed substantial improvement in recall memory following training; older adults’ recall performance was twice the pretraining level.

Considerable research over the past few decades has attempted to isolate stages of information processing and evaluate the effects of various interventions on those stages. A classic study by Salthouse and Somberg (1982) typifies the approach taken to examine the effects of practice on basic information-processing mechanisms. In their study, 8 young (mean age 22 years) and 8 older (mean age 68 years) adults were given extended practice on four different cognitive tasks, each of which focused on a specific type of mental processing: signal detection, memory scanning, visual discrimination, and temporal prediction. The four tasks were presented to subjects as a computer-based video game. The effects of practice were assessed by measuring changes in performance on training tasks over repeated sessions and by evaluating subjects’ performance on alternative versions of each task administered in lieu of practice tasks following various numbers of training sessions. Practice resulted in dramatic increases in performance by both young and older adults on the four tasks; that is, response accuracy improved and response times declined. The extent to which practice transferred to alternative test forms was found to be task dependent, however. A systematic analysis of subjects’ performances on the various tests led the researchers to conclude that the improvements
resulting from practice were due to the interactive effects of changes in stimulus encoding, sequential processing of information, and attentional allocation.

More recent research has also supported the view that the effects of practice depend on the structure of the task and the type of practice involved. A series of studies conducted by Fisk, Rogers, and their colleagues (Dulaney & Rogers, 1994; Fisk, McGee, & Giambra, 1988; Fisk & Rogers, 1991; Rogers & Fisk, 1990, 1991a, 1991b) have used methods developed by Schneider and Shiffrin (1977; Shiffrin & Schneider, 1977) to assess attention and stimulus detection. These tasks require subjects to respond to target stimuli under conditions in which stimuli and responses are either consistently mapped (CM) or variably mapped (VM). Fisk et al. (1988) examined the effects of extended practice on young (mean age 20.4 years) middle-aged (mean age 41.3 years), and older (mean age 70.1 years) adults' performance on CM and VM tasks. Training systematically improved detection speeds for all age groups on both CM and VM tasks. However, older adults' performance was less affected by practice than was that of young or middle-aged adults; despite performing almost 11,000 training trials, older adults did not improve to the level of adults in the other groups. Similar results have been obtained under a variety of stimulus-identification conditions and detection tasks. Parasuraman and Giambra (1991), for example, found that training improved older adults' ability to sustain attention. These authors examined the vigilance performance of young (mean age 22.9 years), middle-age (mean age 47.4 years), and older (mean age 72.1 years) adults on 30-min tests of sustained attention over a series of 20 sessions. All groups improved with practice; however, younger adults evidenced higher asymptotic performance than did older adults.

Research that has examined the effects of training on older adults' mental processing speed has also been conducted. A number of studies, employing a variety of methods, provide evidence that training affects older adults' processing speed (see Salthouse, 1985, 1991, for reviews). Beres and Baron (1981), for example, demonstrated that extended practice on a digit-symbol substitution task taken from the WAIS markedly improved the number of items completed in 90-s period for both older and young adults. Practice on the digit-symbol task transferred to alternate forms of the tasks but not to other types of matching tasks. Similarly, Falduto and Baron (1986) demonstrated that practice improved the rate of old and young adults' card-sorting abilities. Performance improved on sorting tasks that varied in complexity, and this improvement transferred to other types of sorting tasks and was maintained over time.

Most mental-training programs have reported improvements in older adults' cognition following training. In some instances, performance improvements have been durable and maintained over time. Several reviewers have noted, however, that while cognitive performance improves, young and older adults improve in a similar fashion with younger adults consistently demonstrating higher asymptotic levels of performance than older adults (Higbee, 1985; Kotler-Cope & Camp, 1990; West, 1989). The absence of consistent Age Group × Training interactions in the cross-sectional studies suggests that training may not reverse or remediate age-related declines in basic mental abilities (Salthouse, 1985). Cerella (1990) concluded, after reviewing studies of older adults' information-processing speed, that most of the variance in age-related deficits in response speed was irreversible. Salthouse's (1990, 1991) reviews of the effects of longitudinal mental training programs led him
to propose that studies conducted as part of the ADEPT, SLS, and similar projects suffered both statistical and methodological shortcomings; further, these projects failed to include younger adults who received the same training interventions. As a result, the changes observed in older adults’ performance could not be attributed to the modification of mental abilities.

In response to these criticisms, Willis (1989, 1990) contended that older adults benefit from relatively brief mental training programs because the mental exercises reinstate previously acquired knowledge. Thus, cognitive training functions much differently for experienced older adults than it does for young adults who have yet to learn specific problem-solving strategies. Further, the effects of specific cognitive interventions are hypothesized to depend on the individual’s current level of cognitive decline as well as the specific characteristics of the ability being trained; thus, effective treatments must be tailor-made for each individual. For these reasons, the effectiveness of training is thought to be best assessed in longitudinal studies in which individuals’ cognitive abilities are measured repeatedly over extended time periods. Cross-sectional experiments are deemed to be insensitive to the effects of training interventions because of individual difference factors and cohort differences in performance levels.

In summary, older adults may benefit from mental training programs. Training interventions that focus on both top-down and bottom-up mental processing provide examples of improved performance on a variety of intellectual and information-processing measures of mental ability. At this time, however, it remains open to question whether mental training procedures fundamentally improve older adults’ mental abilities.

Explanatory Frameworks

Older adults’ cognitive performance is affected positively by both physical and mental exercise interventions. It remains to be determined, however, if the two types of interventions produce their effects through totally separate mechanisms or whether there are sufficient commonalities between physical exercise and mental exercise to benefit from common explanatory theories. A general theory would be expected to identify mechanisms that explain how both forms of training could affect the biological and psychological processes that underlie optimal cognitive functioning.

Spirduso (1995, chapter 9) provided a theoretical framework to merge research in the domains of exercise science and psychology. She proposed a general model of aging that describes the interrelationships among exercise, diet, absence of drug abuse, and controlled stress and their effects on the core features of normal primary aging (i.e., cardiovascular integrity, neuroendocrine function, neurotransmitter function, and brain morphology). She also addressed the role of noncognitive, psychosocial factors that contribute to successful aging (1994, chapter 10). Older adults’ perception of competence is known to play a central role in explaining age-related differences in cognitive test performance. It has been suggested that older adults perform more poorly than younger adults because of their unfamiliarity with the tasks, their histories of failure, and the novelty of the testing environment (Vallierand & O’Connor, 1989). Aging is associated with physical decline, cognitive and sensory changes, and alterations in employment and living environments.
In some cases, the attempts made by society to care for older adults may lead to the development of amotivational environments in which older adults come to perceive a lack of contingency between behavior and outcome. As a result, older adults develop low perceptions of their control and competence, their motivation declines, and learned helplessness develops. When older adults are provided greater numbers of choices (Moos, 1981; Perlmutter, Monty, & Chan, 1986; Wolk & Telleen, 1976), greater personal responsibility (Langer & Rodin, 1976; Rodin & Langer, 1977), and environmental control (Haemmerlie & Montgomery, 1987; Schultz, 1976), they exhibit positive changes in adjustment and well-being. Thus, the benefits of physical or mental training may reside more in changed beliefs than in changes in cognitive abilities per se (Cavanaugh, 1990).

Another theoretical framework that may provide a way to synthesize research conducted by exercise scientists and psychologists was developed by Dienstbier (1989, 1991). He hypothesized that declines in mental and physical health, regardless of age, result from insufficient physical and mental challenge, and that controlled and repeated challenge, either physical or mental, builds up the resources and the “mental toughening” needed to meet environmental demands and cope with stress. Dienstbier (1989) provided evidence that normal aging is accompanied by reduced beta receptor sensitivity and reduced levels of peripheral catecholamines. He hypothesized that the decreased neurological integrity associated with chronological age leads to inefficient stress tolerance and immunological responses, which are expressed behaviorally as anxiety, depression, and attention and learning deficits. A review of data obtained from both animal and human research led him to implicate the role of neurotransmitters and neurohormones on levels of arousal and immune functions during and following challenging or stressful conditions. It is believed that the efficiency of these systems is affected by an individual’s history.

An extrapolation of Dienstbier’s thesis suggests that older adults who encounter challenges and meet them successfully are better able to maintain their physical and mental abilities and to reduce or retard age-related declines in mental abilities. This theory holds that the source of the challenge is largely irrelevant and benefits can accrue from either physical or mental training programs. The necessary ingredient for change is the individual’s successful completion of tasks that are appraised by him or her to be challenging. Thus, physical exercise programs or mental exercise programs in and of themselves may not be sufficient to bring about the specific neurohormonal changes that result in mental and behavioral change. Both types of training programs, however, provide a vehicle for presenting challenging tasks.

Older adults’ responses to challenging tasks are predicted to lead to both short-term and long-term physiological and psychological benefits. Experiencing challenge increases levels of arousal and energy, which set the stage for individuals to meet and overcome task demands. An individual’s newly acquired history of success, in turn, motivates him or her to continue to engage in challenging activities. The continued performance of challenging activities by older adults would be expected to lead to practice and its associated maintenance of skilled behavior. Paralleling these psychological and behavioral changes are corresponding improvements in the individual’s immune systems and the capacity for “toughness.” The positive physical and psychological changes associated with mastering
challenging tasks are viewed to be fundamentally different than the negative changes that occur under conditions of uncontrollable stress.

It will remain for future research to clarify the strength of the relationships among controlled challenge, biological factors related to primary aging, and cognitive and noncognitive psychological factors. Research of this type will require objective methods of assessing the demands of training tasks and subjects’ appraisal of their abilities to overcome task demands. Further, it may require different methods of conducting training studies. Rather than employing a generalized training program for a fixed period of time and then assessing its effects via pre- and postintervention performance on a battery of mental tests, researchers will need to design training programs tailored to each subject and assess the effects of training at multiple points during the program. It would be predicted that short-term physiological and psychological changes would be expressed more prominently during “challenging” periods of training than after asymptotic levels of performance are reached. Despite the considerable individual differences within cohorts of older adults in baseline measures of both physical and mental abilities, few studies have examined the effects of training at the level of the individual subject. Physical exercise programs developed for older adults are, by necessity, often designed to place only low levels of physical stress on participants. Differences among individual levels of physical fitness may result in some participants being challenged too little and others stressed too much by the exercise program. Mental training programs also fail to quantify the extent to which specific tasks stress or challenge the individual. The level of difficulty of a task affects an individual’s perception of his or her competence or failure and subsequent performance (Perlmutter & Monty, 1989). Researchers will need to assess the extent to which an individual’s pretraining abilities determine the gains brought about by physical and mental training interventions.

Conclusions

Progress in understanding the impact that training programs have on older adults’ mental abilities may proceed more rapidly with a multidisciplinary approach to research issues. Presently there is relatively little overlap between the literature published in the domains of exercise science and psychology; research published in one area is seldom cited by researchers in the other area. Increased collaboration between researchers in the two domains may lead to the identification of both physiological and psychological factors related to performance improvements. Psychologists have developed a body of knowledge concerning cognitive and noncognitive factors that govern thought and behavior. Psychometric and componential approaches to the study of mental abilities provide the basis for systematic analysis of the effects of both physical and mental training. Exercise scientists have developed a body of knowledge concerning physiological processes that may be affected by training. Advances in understanding age-related changes in physiological processes have been made from the subcellular to the systems level of analysis. Integration of knowledge from both areas will help practitioners develop effective and efficient training programs; further, it will help establish parsimonious theories of cognition that span the domains of psychology and exercise science.
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