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Introduction to the Special Section on Cognitive Training in Later Adulthood

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During the past two decades, a number of cognitive training studies have examined the modifiability of older adults' cognitive functioning through brief experimental interventions (Denney, 1982; Willis, 1987; Yesavage, Lapp, & Sheikh, 1989). The impetus for these training studies came from the findings of descriptive research on the wide individual differences in cognitive functioning in old age and on the salience of experiential as well as health factors in accounting for these individual differences (Elias, Elias, & Elias, 1990; Gribbin, Schaie, & Parham, 1980; Siegler & Costa, 1985). Contrary to cross-sectional findings of steep and pervasive intellectual decline beginning in middle age, longitudinal studies have indicated (a) that reliable decrements begin to occur, on average, in the sixties (Cunningham, 1987); (b) that the onset of normative decline varies across cognitive processes and abilities, with earlier decline occurring for abstract reasoning and speeded tasks and later decline occurring for acculturated abilities, such as vocabulary, that are practiced in daily life (Schaie, 1989); and (c) that there are wide individual differences in the onset and pattern of cognitive decline.

Moreover, sequential studies have indicated that there are cohort differences in level of cognitive performance when cognitive functioning of different birth cohorts is compared at the same chronological age (Schaie, 1983). The pattern of cohort differences varies across abilities and skills. Positive cohort trends have been shown for some abilities, such as vocabulary and inductive reasoning, whereas curvilinear trends have been shown for skills such as mathematical computation. Experiential factors associated with sociocultural change, such as the rising level of education across birth cohorts, have been related to positive cohort trends in cognitive functioning (Willis, 1989).

Given that variability in cognitive functioning has been associated with experiential factors, the first wave of cognitive training studies focused on the plasticity or range of individual variability that could be produced by brief training interventions. The targets of training in both the early studies and more recent studies have been those abilities and processes that longitudinal research has shown to exhibit earlier patterns of normative decline (Cunningham, 1987). Thus, training has focused on abilities and skills such as abstract problem solving (Denney, 1982), fluid intelligence (Willis, Blieszner, & Baltes, 1981), Piagetian formal operations (Hornblum & Overton, 1976), perceptual speed (Hoyer, Labouvie, & Baltes, 1973), and associative memory and memory span (Poon, 1985; Yesavage et al., 1989). Significant improvement through training was found in a majority of the studies comparing treatment and control groups of the same chronological age. Moreover, a few studies showed maintenance of training effects 6 months to 1 year after training (Sheikh, Hill, & Yesavage, 1986; Willis et al., 1981).

More recent training research has progressed from asking whether older adults' cognitive performance can be improved to examining the nature of training gain and the conditions under which improvement occurs. Three questions are of concern in current cognitive training research. First, what is the nature of the improvement? That is, what cognitive processes or aspects of behavior change as a function of training effects, or what is the relative magnitude of change in one component versus another? The second question deals with the experimental conditions associated with cognitive improvement. The third question focuses on identifying those individual difference variables associated with training gain. These questions are addressed in the four training studies presented in this special section.

Nature of Training Improvement

Campbell and Charness (1990) examined change in error rates for young, middle-aged, and older adults as a function of training and practice on a mental arithmetic algorithm. Change in two types of errors, calculation and working-memory errors, was assessed. Although both types of errors decreased, training and practice were more effective in reducing errors in calculation than in working memory. In fact, initial age differences in calculation-error rates were eliminated as a function of training. Subjects also performed these complex mental arithmetic problems twice as fast following training and practice.

Gratzinger, Sheikh, Friedman, and Yesavage (1990) examined the effects of mnemonic strategy training on older adults' ability to remember faces and names. Significant training gains indicated that older adults were able to learn the mnemonic involving imagery and to use it in forming associations between faces and names.

The Kliegl, Smith, and Baltes (1990) study focused on another mnemonic strategy (Method of Loci) and a different memory process (serial recall). The ability of young and older adults to use the Method of Loci in recalling lists of words under varying speeded conditions was examined. Both older and young adults learned to use the method of loci, as indicated by significant training gains. Speed of processing appears implicated in the finding that older adults showed less training gain when recall occurred under highly speeded conditions.

In a 7-year longitudinal study, Willis and Nesselroade (1990) examined the effectiveness of multiple phases of cognitive

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training on the maintenance of fluid ability performance with advancing age. Experimental subjects were taught strategies for identifying the rule or pattern required in problem solutions. Significant improvement at each of three training phases indicated that subjects were able to use these strategies. As a function of multiple training interventions, subjects in their seventies and early eighties performed at a higher level than they had demonstrated in their late sixties. Accuracy rate also increased from 50% to 75% across study phases.

Experimental Conditions Associated With Training Improvement

The relative effectiveness of three auxiliary training conditions in facilitating older adults' learning and use of a mnemonic was examined in the Gratzinger et al. (1990) study. Prior to training on the mnemonic, subjects received imagery, relaxation, or verbal elaboration training. The three auxiliary conditions were not found to be differentially effective in enhancing use of the mnemonic and in improving face–name recall. The comparison of alternative treatments to facilitate use of a cognitive strategy illustrates an important concern in training research with older adults. Although use of cognitive strategies and mnemonics has been found to enhance cognitive performance in both the child and adult training literature, many older adults do not spontaneously use these strategies. Thus, a challenge for cognitive training research in later adulthood is to identify conditions that facilitate the older adults' learning and use of these strategies.

The question of whether greater training improvement occurs earlier or later in the intervention was examined in the Kliegl et al. (1990) and the Willis and Nesselroade (1990) studies. Both studies found that the greatest training gain occurred in the early stages or phases. Willis and Nesselroade also observed that greater training improvement occurred when phases of training were closely spaced. Kliegl et al. found greater improvement in list recall at slower presentation rates than at faster rates for both young and older adults.

Individual Differences in Training Improvement

The examination of individual differences in magnitude of training gains has received considerable attention because this approach provides information on correlates or predictors of the modifiability of cognitive performance and may indirectly provide insight into the processes associated with cognitive aging. The individual difference variables that were examined varied across studies. In the Kliegl et al. (1990) and the Campbell and Charness (1990) studies, age was the major individual difference variable because both studies included young and older adult samples. In the Campbell and Charness study, age differences in error rates were examined; in the Kliegl et al. study, age differences in list recall under different presentation rates were assessed. In the Gratzinger et al. (1990) study, personality factors (neuroticism, extraversion, openness to experience) as predictors of differential effectiveness of different treatment conditions were examined. In the Willis and Nesselroade (1990) study, the major focus was on intraindividual change, comparing subjects' later training improvement with their own baseline performance 7 years before.

The comparison of age differences in training effects for young and older adults has been the focus of a number of training studies. The concern has been with identifying cognitive processes or behaviors that are associated with differential gains for young and older groups. Age-difference studies have often made the assumption that if the poorer performance of the elderly is associated with experiential variables, then training procedures should be effective in eliminating age differences in the particular cognitive process or behavior. However, several methodological issues need to be considered with regard to age differences in training effects. It is rarely possible to equate young and older adult samples on variables such as presence of chronic diseases, vision and hearing, prescription drug medications, or educational level, factors that have been shown to be related to cognitive functioning (Siegler & Costa, 1985). Moreover, young and older adult samples differ not only in chronological age but also in birth cohort. Since cohort-related differences have been found for a number of cognitive variables, differences in training effects may be associated with cohort membership, as well as with chronological age. If a positive cohort trend has occurred for the target of training, then elimination of age differences would involve both elimination of cohort differences and remediation of potential age-related decline.

When considered from a life-span perspective, the directionality of training effects may differ for both children and young adults versus older adults. That is, for children or young adults, training effects typically represent an improvement above performance levels exhibited at younger ages. However, the directionality of training effects for older adults vary depending on prior developmental patterns. For older adults experiencing previous age-related decline, training effects reflect some degree of remediation. In contrast, for older adults whose cognitive functioning has remained stable from young or middle adulthood, training effects reflect improvement above prior performance levels, similar to comparisons made for younger adults. Because longitudinal studies have indicated that a number of older adults do not suffer reliable decline until the seventies or beyond, interpreting the nature of training improvement in old age can be complex. Data on the subject's cognitive performance at earlier developmental periods is necessary to determine the directionality of effects. Unfortunately, none of the present studies included longitudinal data, although these issues have been addressed in other training research (Schaie & Willis, 1986).

Complementarity of Training Research in Childhood and Adulthood

A review of cognitive training research in the child development and gerontological literatures suggests several areas of complementarity. At both life stages, the focus of training research has been on examining the range of variability or plasticity in the individual's level of cognitive functioning under optimizing experiential conditions. The search has been for those processes and skills that are implicated in enhancing cognitive functioning or that underlie age-related decline or cohort-related differences. In both the child and aging literatures, there has been interest in comparing actual versus potential levels of functioning. This is reflected in the Kliegl et al. (1990) discussion of developmental reserve capacity in old age. In the child development literature, Vygotsky's theory of a zone of proximal or potential development (Luria, 1961; Vygotsky, 1978) has received renewed attention in work with learning disabilities and in alternative testing procedures that examine range of potential (Brown & French, 1979; Embretson, 1987). Recent studies have suggested that there has been too pessimistic a view of the cognitive capabilities of both children and older adults. Their level of cognitive functioning may be more substantial than previously assumed or demonstrated (Schaie & Willis, 1986; Uttal & Wellman, 1989).

The differentiation of mediation versus production proficiencies (Flavell, 1970) in cognitive performance has been of concern in both the child and aging literatures. This concern is reflected in Campbell and Charness's (1990) discussion of alternative explanations for age differences in errors in working memory in mental arithmetic problems. These researchers suggested that the less efficient working-memory performance of the elderly may not be due entirely to slower information-processing capacities. Rather, the longer reaction times may reflect the well-known bias among the elderly for accuracy over speed when performing complex tasks. Whereas proceeding slowly will likely improve accuracy on calculations, it will also increase susceptibility to working-memory failure as a function of memory decay. There has also been interest at each end of the life span in metacognition (Cavanaugh & Perlmutter, 1982; Dixon & Hultsch, 1983), which includes knowledge and utilization of optimal combinations of strategies (e.g., trade-off of accuracy and speed of processing).

Contributions of Cognitive Training Research to the Study of Intellectual Aging

Cognitive training research contributes in three ways to our perceptions of cognitive capabilities and our understanding of cognitive mechanisms in old age. First, this literature highlights the considerable plasticity in older adults' cognitive performance. Normative descriptions must be supplemented with experimental and training research to gain a comprehensive understanding of the range of variability in cognitive functioning in old age. If some of the improvement through training in the elderly represents remediation of previous age-related decline, then training research is useful in examining the question of in which individuals, for what abilities, and under what conditions intellectual decline is irreversible or remediable.

Second, findings from cognitive training research contribute to our understanding of the cognitive processes associated with developmental change in old age, particularly those involved in age-related decline. Coupled with findings from longitudinal studies, training research can examine questions related to whether the same processes are associated with decline and with its remediation or in what instances compensation for cognitive loss involves different mechanisms and processes.

Finally, cognitive training research has the potential to contribute relevant information to the development of programs and services for the elderly that will enhance their ability to live independently and productively in our society.

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