MAINTENANCE AND DECLINE OF ADULT MENTAL ABILITIES:

II. Susceptibility to Experimental Modification

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INTRODUCTION

In the preceding paper (Schaie & Willis, 1981), it was noted that many older adults beginning in the 60-year age range are found to be increasingly disadvantaged with regard to intellectual performance in comparison to younger adults. Data were discussed which imply that this difference can be attributed largely to two sources. There are the consequences of cumulative effects of ill health and unfavorable environments, commonly described as age-related decrement, and the effects of socio-cultural change leading to the partial obsolescence of the older individual, referred to in the earlier paper as generational or cohort differences. However, the data also clearly indicated that individual differences tend to increase across the adult life span, leading to the observation that some older adults are still functioning within the average range of the young. There is then the implication that there continues to be substantial plasticity in intellectual development even into late life (Baltes & Willis, 1977; Willis & Baltes, 1980). This observed plasticity can be attributed to the fact that some older adults appear to avoid or to compensate successfully for cumulative physical and environmental losses, and others manage to overcome the potential for socio-cultural obsolescence. In fact, examination of characteristics of persons who continue to demonstrate a high level of intellectual performance in old age suggests that, in addition to being in good health, such persons seem to have developed spontaneously an ongoing individual life scheme which includes continual updating and intensive life involvement (Gribbin, Schaie & Parham, 1980). It would therefore seem reasonable to explore whether paradigms can be developed which experimentally can induce higher levels of intellectual performance in the elderly—whether as remediation of prior performance decrement or as a means of actually increasing their stable level of performance so as to become more comparable to that of younger age/cohorts (Willis & Baltes, 1980).

The purpose of this paper is to discuss some theoretical and empirical issues related to the attempt to improve experimentally intellectual performance in the elderly. First we will review some of the empirical cognitive intervention research, designed to examine the modifiability of current levels of performance. We will discuss in more detail an ongoing program of training research in which the first author is involved. Next we will examine interventive research focusing on non-ability-specific factors and processes which may affect intellectual performance. Finally, we will suggest implications of cognitive intervention research for life-long learning.

A BRIEF REVIEW OF COGNITIVE INTERVENTION RESEARCH

Cognitive intervention studies have tended to be couched within the three main approaches to intelligence noted in the previous paper (Schaie & Willis, 1981)—the experimental analytic, the Piagetian cognitive developmental, and the psychometric approach.

Experimental-Analytic Approach

Consistent with descriptive research within the experimental-analytic approach to adult intelligence (Arenberg & Robertson-Tchabo, 1977; Rabbitt, 1977), training studies have focused on variables such as task characteristics, reinforcement conditions, and cognitive strategies involved in forming concepts and solving complex laboratory-type problems. Training involving concept formation tasks has frequently employed modeling and/or strategy training procedures in which the experimenter models desirable problem solving behavior on exemplar problems or verbally states solution strategies giving concrete examples. Denney (1974) used modeling procedures in facilitating classification performance on a free classification task with geometric stimuli. Meichenbaum (1974) has likewise been able to facilitate the performance of elderly adults on concept learning problems with a model procedure. And, Crovitz (1966) found that elderly individuals' performance on a card sorting task improved after observing a model sort the cards three different times according to different dimensions. Sanders, Sterns, Smith, and Sanders (1975), likewise conducted a concept formation training study assigning elderly adults to one of four conditions—reinforced (monetary) cognitive training, no monetary reinforcement, practice with feedback, and a non-treatment control. Both the reinforced training and non-reinforced training conditions led to better performance on the posttest than did the practice or the control conditions.

Other training studies within the experimental-analytic approach have focused on modifying behavioral rigidity and set induction. Research by both Heglin (1956) and Lycette (1973) has shown that middle-aged and older adults' tendency to continue to use the same response strategies even when inappropriate can be modified with instruction. Recently, Levin and Overton (1979) demonstrated that brief instruction on flexibility in thinking (i.e., breaking set) led to improved performance on a spatial perspective-taking transfer task.

Finally, a few studies have applied operant reinforcement paradigms to cognitive training (see Baltes & Barton, 1977, for a review). For example, Coleman (1963) utilized three reward conditions (positive verbal statement, money, or sound of bell) to train geriatric institutionalized patients with chronic brain syndrome or psychosis to shift their sorting criterion on a concept formation task. Training was effective, but there was no significant difference among the reward conditions. The Sanders et al. (1975) study referred to above also involved some operant procedures in that the training program involved a programmed learning sequence and one training condition involved monetary reinforcement.

Piagetian Cognitive Development Approach

Recently there also have been several studies aimed at modifying older adults' performance on tasks involving concrete and formal operations (see Hooper & Sheehan, 1977, for a review). Schultz and Hoyer (1976) investigated the effects of training on spatial egocentrism. Subjects were given verbal

feedback and were shown designs from several different spatial perspectives. Such training resulted in an increase in correct responses. Hornblum and Overton (1976) successfully trained subjects on several surface area conservation tasks. On the posttests subjects showed improvement on other conservation tasks suggesting transfer-of-training, and such training effects for some subjects were maintained over a six-week period. In a study by Tomlinson-Keasey (1972) middle-aged women were successfully trained on several formal operational tasks.

It is important to note that virtually all of the cognitive intervention studies conducted within the experimental-analytic and Piagetian approaches in the last decade have reported significant improvement in adults' level of intellectual functioning. Such consistent positive findings across multiple cognitive tasks and multiple approaches to intelligence, of course, offer considerable support for the concept of intellectual plasticity in the elderly as well as the feasibility of intervention by means of experimental paradigms.

Unfortunately, neither the experimental-analytic nor the Piagetian literature provides the type of longitudinal data base needed for an adequate interpretation of the findings of these training studies. That is, it is unclear from this cross-sectional intervention research the extent to which lost intellectual skills are being remediated or whether new strategies and cognitive structures not previously within the repertoire of the subjects are being developed. Further, the experimental-analytic literature provides little in the way of theoretical models which could guide our thinking in the absence of such longitudinal data. By contrast, the Piagetian literature is rich in theory, yet the postulates of the theory pose difficulties for interpretation of training studies in adulthood (Bearison, 1974; Hooper, Fitzgerald, & Papalia, 1971; Piaget, 1972). A strict theoretical exposition would hold that all persons in adulthood have reached the stage of concrete operations, and some the stage of formal operations; thus, some older adults' failure to perform concrete operational tasks suggests cognitive regression. However, the possibility of regression to a lower level has not been adequately addressed by the theory (see Bearison, 1974; Flavell, 1970; Overton, 1976). Until there are further empirical and theoretical extensions of these approaches (see Labouvie & Chandler, 1978 Overton, 1976; Schaie, 1977/78), interpretation of the nature of changes induced by the Piagetian-type training studies will remain controversial.

Our strategy, therefore, once again is to link our major analysis of cognitive training research to the psychometric tradition. For it is within that tradition that we have an adequate descriptive data base regarding the nature of intellectual change across the life-span as well as theoretical models regarding the structure-of-intellect in adulthood (Botwinick, 1977; Cattell, 1971; Guilford, 1967; Matarazzo, 1972; Schaie, 1979) which permit a more adequate theory-based and empirically grounded analysis of cognitive intervention.

Psychometric Approach to Cognitive Training

A variety of mental abilities (inductive reasoning, figural relations, space, memory) well documented within the psychometric approach have been the focus of cognitive training research. We will briefly review a few of these intervention studies and then report in more detail on an ongoing research program in which the first author is involved. A series of training studies focusing on inductive reasoning has been conducted by Labouvie-Vief and associated (Labouvie-Vief 1976; Labouvie-Vief & Gonda, 1976; Panicucci, 1975). The Labouvie-Vief and Gonda (1976) study included four conditions: cognitive

strategy training, a combinational strategy training plus anxiety reduction condition, a no-feedback practice, and a no-treatment control condition. On an immediate posttest, both strategy training conditions were superior to the no-treatment control group. However, on a two week delayed posttest, performance of the practice control group also differed significantly from the no-treatment control group; and this practice group also showed transfer of training effects to another test of reasoning (e.g., Raven Progressive Matrices). In the Panicucci research (1975) a no-feedback practice group also showed significant training effects. Thus, an interesting finding replicated in these two studies is the significant improvement in intellectual performance of even a practice control condition, which involved practice on test items with no feedback regarding the correctness of responses or training on relevant cognitive strategies.

A recent training study by Quayhagen (1979) focusing on spatial ability involved groups of middle-aged and older women. Subjects were randomly assigned to experimental and contact control groups. Significant training effects occurred for the predicted spatial tasks. Training gains for the older group of women raised their level of performance comparable to that of the middle-aged control group. On a two-week delayed posttest training effects were maintained and, in addition, retest effects were found for all groups. To determine whether training was indeed specific to spatial abilities, perceptual speed measures were also administered at posttest occasions and, as predicted, no training transfer effects were found for the perceptual speed tasks.

Memory span tasks have also been the target of successful training research. In a series of studies by Taub (Taub & Long, 1972; Taub, 1973) young and older adults practiced two memory span tasks over five training sessions. Older subjects' memory performance was found to improve with practice. Specifically, when adults were required to recall six to eight digit series, their performance across practice sessions increased significantly in the number of digits recalled correctly per trial and in the number of trials which were recalled correctly. Secondly, and more important, was the finding that these improvements remained relatively stable over a six-month interval. This suggests that even a few practice sessions may be useful in providing a long-lasting effect on memory performance. Research by Hultsch (1974) also documents improvement in memory performance with practice; moreover, this study indicated that with a minimum amount of practice a learning to learn phenomena (i.e., transfer of higher order habits or learning skills) appeared to occur. Subjects were given ten practice trials on each of two lists of thirty words. Recall performance on the second list was superior to that for List I, suggesting a learning to learn phenomena. This learning to learn effect was most evident in later practice trials on List II.

While lending support to the notion of intellectual plasticity in later adulthood, the training research conducted within the psychometric approach has been somewhat limited both in the number of studies conducted and their conceptual and methodological design. With respect to design, a more systematic theory-guided approach to the examination of intellectual modifiability would appear useful. A theory-guided approach allows for the systematic testing of a series of theory-derived hypotheses. Such an approach may contribute to the further development of a specific theory and allow for the examination and linking of new data within an existing conceptual framework. A program of intervention research can be said to be theory-guided in several respects. First, selection of the target of intervention is guided by theoretical assumptions. Thus, the behavior and abilities targeted for intervention, rather

than being arbitrarily chosen, are derived from a specific theory of intellectual development. Secondly, the specific intervention strategies and procedures utilized can be guided by theoretical considerations. Third, and most important, a psychometric theory of intelligence provides a structural model of intelligence within which training and training transfer effects can be assessed. It would be hypothesized that the pattern of training effects would be ordered according to the structural relationships specified by the theory. In addition to a theory-guided approach, it would appear important that the design of intervention research allow for examination of the temporal stability or maintenance of training effects. If training affects level of functioning with regard to specific abilities, such changes in intellectual performance should be maintained after training. Moreover, temporal stability of training effects is an important factor in generalization of intervention research to broad-scale educational programming. However, few training studies have examined maintenance of training effects over an extended time period.

The Penn State Adult Development and Enrichment Project (ADEPT)

A program of cognitive intervention research currently in progress is attempting to address the issue of intellectual plasticity within such a theory-guided approach (Baltes & Willis, 1981). The primary focus of the Penn State Adult Development and Enrichment Project (ADEPT) is to examine the range of individual modifiability in intellectual functioning in later adulthood which can be effected through experimental, educative intervention strategies. The theory of fluid and crystallized intelligence as postulated by Cattell and Horn (Horn & Cattell, 1966; Cattell, 1971; Horn, 1978) serves as the primary theory base for ADEPT research. The fluid-crystallized theory postulates a hierarchical, structural model of intelligence couched within factor-analytic methodology. Two broad, second order dimensions of fluid and crystallized intelligence are postulated which are said to show differential development patterns across the life span. Fluid intelligence is hypothesized to develop early in the life span and to show a normative pattern of gradual decline beginning in early adulthood. In contrast, crystallized intelligence is postulated to develop somewhat later than fluid intelligence and to show a normative pattern of stability or increment across much of the adult period.

The target of ADEPT training research has been several components of fluid intelligence, including inductive reasoning, figural relations and memory/attention. The aim was to examine the degree to which the assumed normative decline in fluid intellectual performance in later adulthood is modifiable by means of educational training efforts. Secondly, ADEPT is theory-guided with regard to the design of the educational intervention treatments. That is, task analyses of criterion fluid intelligence tests were undertaken to identify relational rules and strategies used in solving fluid test items. The training programs were then designed in relation to such task analyses. Third, and most importantly, ADEPT training research is theory guided with regard to the training transfer assessment battery. A pattern of differential training transfer was predicted across a battery of fluid and crystallized intelligence tests with greater training transfer predicted to measures most closely related to the target of the training program.

In this paper two studies conducted within this program of research will be reported on briefly. In the first study, the range of variability in intellectual performance as a function of practice (retest) effects was examined. Such a study explored intellectual modifiability under minimal intervention conditions;

subjects participated in multiple retest sessions with no instruction on cognitive strategies and no feedback regarding correctness of response. In the second study, subjects received training on cognitive strategies required in solution of the target fluid ability tasks. Training effectiveness was assessed with regard to both durability (maintenance) of training effects and transfer to a theory-based pattern of ability measures.

Research on retest-practice effects. Thirty older subjects (X age = 69.2 years, SD = 5.18) participated in eight one-hour retest sessions (Hofland, Willis, & Baltes, in press). At each retest session, subjects were administered under standard testing conditions two measures, representing the two fluid abilities of Figural Relations and Induction respectively. The Culture Fair test (Scale 2, Power Matrices Scale 3; Cattell & Cattell, 1961) was identified from previous research (Cattell, 1971) to represent the Figural Relations ability; the Induction ability was marked by an Induction Composite test including Letter Sets (Ekstrom, French, Harman, & Derman, 1976), Number Series and Letter Series (Thurston, 1962) tests. No external feedback regarding correctness of responses was given during the retest sessions.

The mean percentage of correct solutions for each measure was computed for each of the eight retest sessions and is shown graphically in Figure 1. A one-factor analysis of variance with repeated measurement across the eight trials was performed on the raw scores for each of the two retest measures. Significant performance gains ($p < .001$) were found across the eight trials for each of the two measures (Figural Relations: $F = 16.81$, $df = 7,203$; Induction: $F = 26.42$, $df = 1,29$). Total improvement in mean scores on both measures was roughly equivalent to one standard deviation. With regard to the performance pattern across the eight sessions, subjects exhibited small, steady gains between consecutive trials. Separate trend analyses for the two measures indicated that only a linear component was significant ($p < .001$). No apparent performance asymptote was reached.

Training research. Modifiability of fluid intellectual performance in the elderly has also been examined as a function of a series of short-term longitudinal training studies each focusing on one target fluid ability. In one such study (Willis, Blieszner, & Baltes, 1981) involving the target ability of Figural Relations, training effectiveness was assessed by comparing posttest performance of randomly assigned experimental and control groups (Total N = 58, X age = 69.8, SD = 5.7). Experimental subjects participated in five one-hour training sessions focusing on cognitive strategies identified in task analyses to be involved in solution of Figural Relation-type problems. The two criteria for assessing training effectiveness were durability (maintenance) of training effects over three posttest occasions (1 week, 1 month, 6 months) and transfer (generalizability) of training across a broad battery of seven fluid and crystallized measures. With regard to training transfer, a hierarchical theory-based pattern of transfer was predicted with the largest training effects occurring for the three near transfer measures representing the target fluid ability: ADEPT Figural Relations (Plemons et al., 1978), Culture Fair (Cattell & Cattell, 1959), Raven (Raven, 1962). Less or no training effects were predicted for two levels of far transfer, involving far fluid transfer to the fluid ability of Induction and far nonfluid transfer to Crystallized Intelligence and Perceptual Speed. Induction was represented by two measures: ADEPT Induction (Blieszner, Willis, & Baltes, in press) and Induction Composite (Ekstrom et al., 1976; Thurstone, 1962) tests. Crystallized Intelligence was marked by a

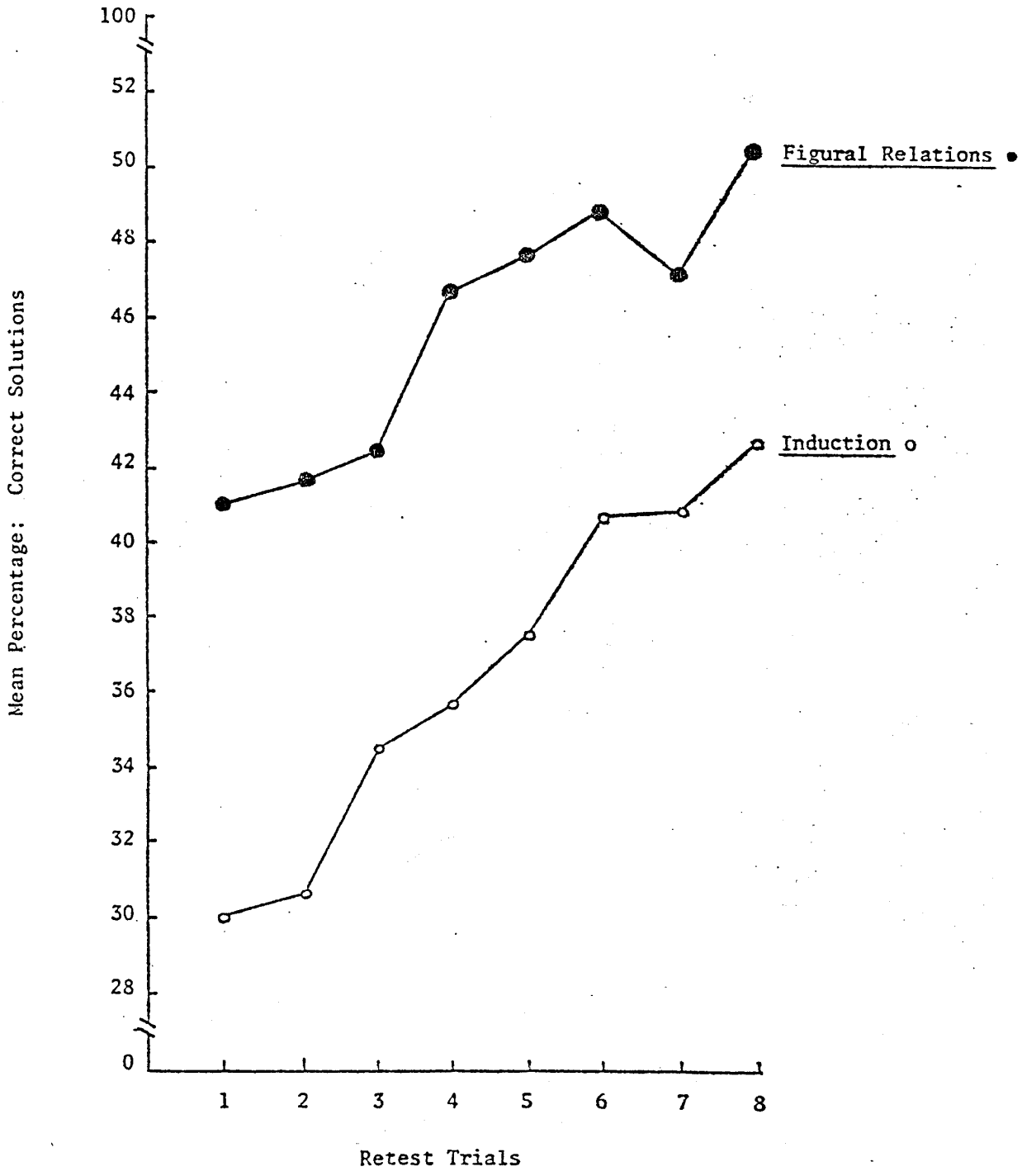

Figure 1. Mean Percentage of Correct Solutions Across Retest Trials for Measures of Figural Relations and Induction.

Vocabulary measure (Ekstrom et al., 1976) and Perceptual Speed by the Identical Pictures test (Ekstrom et al., 1976).

The entire data matrix (across treatments and occasions) for each of the seven posttest measures was standardized using the control group's score on that measure at Posttest 1 as the standardization base with a mean of 50 and standard deviation of 10. This standardization procedure was employed to provide a common baseline of performance on each measure to which all other data points for that measure could be compared and to eliminate scale level differences between measures, thus facilitating comparison of transfer effects across measures. A graphic summary of the training and control groups' standardized mean scores for the seven transfer measures, averaged across the three posttest occasions, is shown in Figure 2. Mean scores of the training group were larger than the control's scores for all seven measures at each of the three posttests. The pattern of training transfer is represented by the relative difference between the standardized mean scores for the training and control groups for each measure. Note that the difference between mean scores for training and control groups appears larger for the three near, Figural Relations, measures than for the four far (fluid and nonfluid) measures.

An overall analysis as a general assessment of training effects was performed across all measures and occasions, using standardized scores. That is, a 2 (Treatment: Training, Control) x 3 (Occasion: Posttests 1, 2, 3) x 7 (Measures) analysis of covariance with repeated measures was conducted using the pretest score on the ADEPT Figural Relations test as the covariate. There was no significant difference between training and control groups at pretest. This analysis resulted in a significant Treatment main effect ($F\,[1, 54] = 11.81$, $p < .001$), and a significant Treatment x Measure interaction ($F\,[6,336] = 2.25$, $p < .05$) suggesting differential treatment effects across the seven transfer measures as predicted. A significant Occasion main effect ($F\,[2.112] = 12.00$, $p < .001$) was obtained and interpreted as suggesting retest effects common to both training and control groups). A significant Measure main effect ($F\,[6,336] = 3.43$, $p < .05$) occurred as a function of differential training and retest effects by measure, given the standardized procedure.

Follow-up analyses via the Tukey WSD conducted separately by measure indicated that training and control groups differed significantly on each of the three near transfer measures across posttests: ADEPT Figural Relations ($p = .000$), Culture Fair ($p = .008$), Raven's ($p = .018$). No significant differences between training and control were found for the four far transfer measures separately: ADEPT Induction ($p = .151$), Induction Composite ($p = .16$), Vocabulary ($p = .138$) and Perceptual Speed ($p = .122$). However, increasing the statistical power by using a repeated measures analysis of covariance on just the four far transfer measures resulted in a significant Treatment main effect ($F\,[1,54] = 4.15$, $p = .047$) for the four far transfer measures.

Findings from both the retest and training studies suggest considerable variability in intraindividual intellectual performance in later adulthood. In the retest study significant performance increments were found for each of two measures, representing Figural Relations and Induction abilities. Such retest effects occurred under a minimal interventive practice condition in which subjects received no training or feedback, thus, suggesting subjects possessed or were able to generate on their own cognitive strategies and/or test-taking skills useful in improving their performance. In the Figural Relations training study a pattern of differential training transfer was found with significant training and transfer effects being established and maintained for the three near transfer measures. Such training effects for the three measures represent a broad

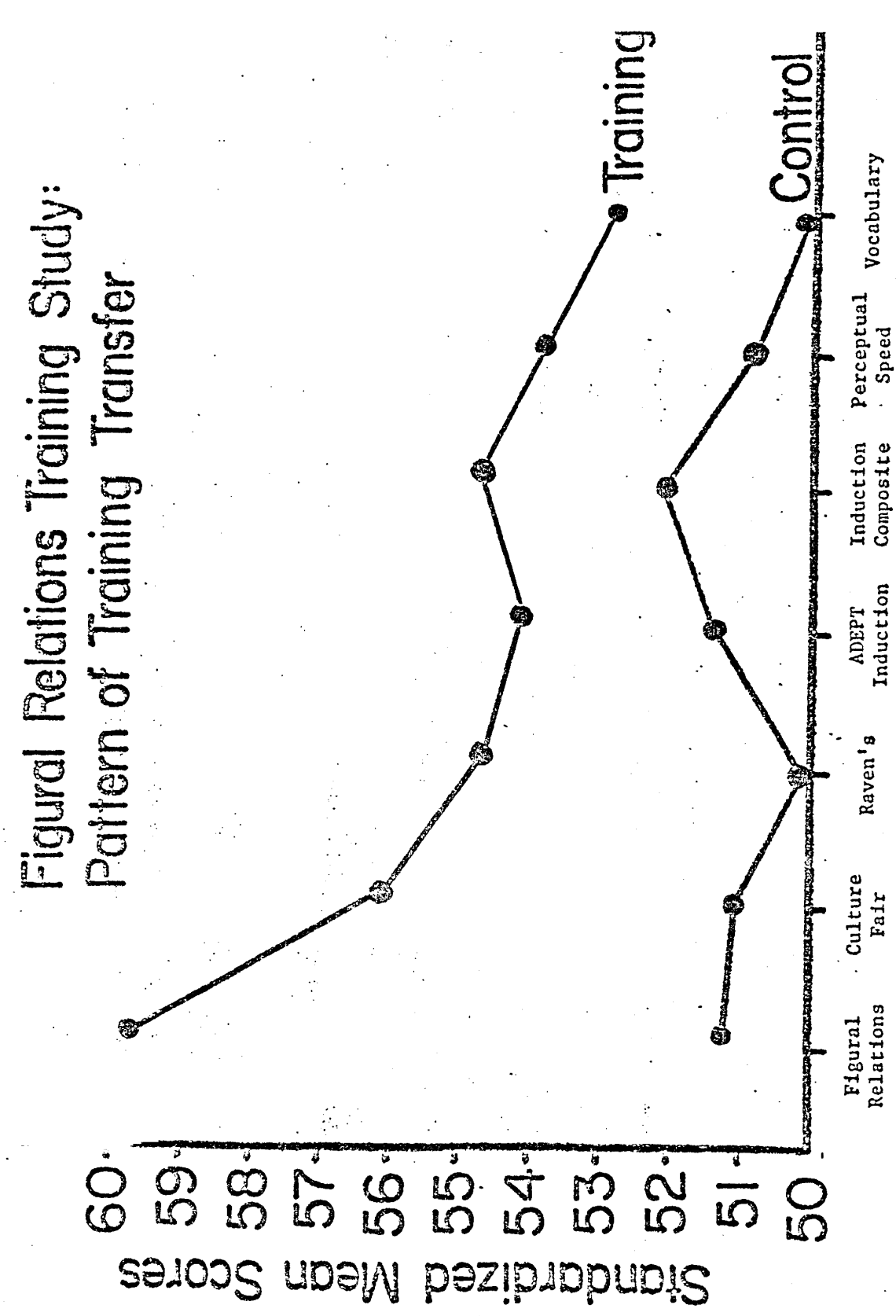

Figure 2. Standardized Mean Scores on Seven Transfer Measures for Training and Control Groups Averaged across Three Posttest Occasions.

continuum of training transfer within the target ability. Moreover, these training effects were maintained over a six-month period.

Data from the training study also suggests that transfer effects extended, although to a lesser degree, beyond the target ability. The training group's scores on all four far transfer measures at all posttest occasions were larger than those for the control. In our view, such an effect on far transfer measures is less likely to result from ability-specific improvement. Rather it may reflect generalized, non-ability-specific transfer attributable to situational or ability-extraneous factors (e.g., increases motivation, anxiety reduction) which were accrued as a function of the training treatment but are not intrinsic to performance on the target ability per se. Such non-ability-specific transfer would affect performance on a wide variety of ability measures and would show a general effect across the far transfer measures was found. The likelihood of non-ability-specific transfer occurring may be greater for educationally and/or test-disadvantaged populations, such as the elderly. Considerable retest effects were also found in the training study. They were differentiated from ability-specific training effects as being general such that retest effects occurred for both experimental and control groups and did not follow the predicted pattern of differential transfer.

The Relevance of Non-Ability-Specific Performance Factors to Cognitive Training

The retest effects and non-ability-specific transfer effects such as appear to occur in ADEPT and other intervention research suggests the operation of a number of performance variables which are likely to affect and/or confound interpretation of cognitive training effects on psychometric abilities. Such non-cognitive factors are said to influence the individual's performance on psychometric tests but are not considered intrinsic to the mental abilities represented by such measures. Recently there have been attempts to examine the effects of such performance variables either by designing intervention procedures aimed at modifying performance factors per se (e.g., increasing response speed) or by examining whether training on cognitive tasks results in transfer to such non-cognitive dimensions (e.g., transfer to perceptual speed measures). We will briefly discuss several such factors which have received some experimental attention. These include the effects of speed, anxiety, cautiousness, and differential reinforcement schedules on intellectual performance.

Speed

As noted in the preceding paper (Schaie & Willis, 1981), there is evidence of age-related slowing in response speed. Many psychometric tests are at least slightly speeded for older adults, and the question arises whether training paradigms train on the specific mental abilities or the speed component of the task. The issue whether speed of test response can be experimentally modified in the elderly has been addressed in two studies by Hoyer, Labouvie, & Baltes (1973) and Hoyer, Hoyer, Treat & Baltes (1978). In these studies it was hypothesized that the elderly's tendency to respond more slowly than young adults in many situations may be a result of experiential or environmental factors which inhibit or do not reinforce speeded responding. The researchers attempted to increase the speed of performance of elderly women on some perceptual speed tasks by providing verbal feedback regarding speed of performance and by reinforcing increases in speed of responding. Whether the resulting improvement

in response speed would transfer to improved performance on intellectual tests that contained a speeded component was also examined. Results of both studies indicated that subjects could be trained to respond more quickly on speeded tasks. However, there was no significant improvement on the ability measures.

Anxiety

Frequently, test anxiety has been suggested as a possible factor influencing performance on intelligence measures. However, most of the research today has focused on examining the relationship between anxiety and level of intellectual functioning, rather than on designing intervention programs to directly reduce anxiety and then assess such transfer to intellectual performance. In the Labouvie-Vief and Gonda (1976) Induction training study one treatment condition involved a combination of cognitive strategy training and a procedure aimed at reducing anxiety through verbal self-monitoring procedures. On both immediate and delayed posttests this combination cognitive strategy/anxiety reduction condition performed significantly better than a no-contact control group. However, again, it is difficult to assess the relative effectiveness of the anxiety procedure since it was implemented in conjuction with cognitive strategy training.

In the retest study conducted within the ADEPT project a state anxiety measure was administered at the first and eighth retest sessions (Hofland et al., 1981). The level of anxiety reported decreased significantly from the first to eighth session, while level of performance on the two fluid abilities tests increased by approximately one standard deviation. However, no causal relationship between decreased anxiety and increased test performance can be established.

Cautiousness and Risk Taking

Cautiousness and avoidance of risk taking behavior have also been associated with performance on cognitive tasks. In early studies of cognitive ability and cautiousness it was concluded that cautiousness in later life was a function of decline in cognitive abilities; however, Botwinick (1973) suggested that the reverse may be true, i.e., that decline in ability may be attributed to an age-related increase in cautiousness. Botwinick (1966, 1969) investigated cautiousness in relation to risk-taking using "life situations" with problems and consequences specific to the generations studied. The older adults were more cautious than the younger ones, and often exercised the option of not selecting a risky course of action regardless of success. When this option to avoid a decision in a risk-taking situation was deleted, there were no age differences in cautiousness noted. It was concluded that older subjects tend to avoid decision situations.

In another study, Birkhill and Schaie (1975) investigated high and low risk levels in situations where the omission of responses were differentially reinforced. The data supported previous findings that older subjects in a low risk situation will perform better only when they realistically have the option to omit responses, and they are more hesitant to become involved where risk is high. The findings, that performance is improved where subjects in high risk conditions are discouraged in the option to omit responses, suggests the possibility that cautiousness may be minimized if there is high anxiety with high risk.

Reinforcement

Although there is extensive literature regarding the effects of various types and schedules of reinforcement on intellectual functioning for younger age groups, the research in later adulthood is quite meager. Three types of reinforcement (monetary, positive social reinforcement, and informational feedback regarding correctness of response) have been examined. Monetary reinforcement has been utilized in training procedures focusing on both non-cognitive performance factors (response speed) and cognitive tasks. The Hoyer et al. studies (1973, 1978) used monetary reinforcement in conjunction with informational feedback to increase response speed, but with no transfer to intellectual performance. In the Sanders et al. (1975) financial reinforcement in combination with cognitive strategy training was found to significantly improve performance on a concept formation task; however, a cognitive strategy training procedure without reinforcement was also found to be effective. Likewise, the research by Coleman (1963) on set induction showed significant but nondifferential effects for monetary, social praise, and information feedback conditions.

Several studies (Hornblum & Overton; Labouvie-Vief & Gonda, 1976 Sanders et al., 1975; Schultz & Hoyer, 1976) have involved practice conditions varying in whether or not informational feedback regarding correctness of response was provided. In two studies involving Piagetian tasks (Hornblum & Overton, 1976; Schultz & Hoyer, 1975) poorer performance was found for a no-feedback practice condition than for a practice with feedback condition. However, Induction training studies by Labouvie-Vief and Gonda (1976) as well as the ADEPT retest study (Hofland et al., 1981), indicate that marked improvement in cognitive functioning can occur even in no-feedback practice groups.

IMPLICATIONS FOR LIFELONG LEARNING

When all is said and done, the societal relevance of cognitive training effects must lie in the inferences which we can draw towards modification of individuals' competencies in real life situations. Such modification, of course, will typically involve the application of educational technology in formal as well as non-traditional educational settings.

The conclusions which can be drawn from our discussion of intellectual change and modifiability of intellectual performance in adulthood, argue persuasively that, for some individuals, socio-cultural influences (including educational opportunities) can be important mediators of intellectual change with age. But such changes can be positive as well as negative depending upon the nature of the events precipitating change and the individual's response to such events. Moreover, the successful cognitive training studies suggest substantial plasticity in intellectual function through educational intervention. Indeed, our analysis of the training literature suggests that the magnitude of training gains in laboratory paradigms appears, on average, to be equivalent to or greater than the average negative change within individuals from middle adulthood to early old age. Given these findings from both descriptive and experimental research we would like to conclude this paper by suggesting some implications for a life-long approach to learning (see also Baltes & Willis, 1978; Schaie & Willis, 1978).

In this context we will discuss the goals of life-long learning related to the maintenance and enhancement of intellectual competence and the avoiding of the socio-cultural obsolescence.

Educational Goals for the Adult Learner

Traditionally, formal education has begun in childhood and ended in early adulthood. However, it is now becoming apparent that learning must truly be life-long—throughout adulthood. This exhortation becomes more credible if one attends to the fact that more than two-thirds of the average life-span is covered by adulthood. What then could be goals of education of the middle-aged and older adult which will help ensure continuing optimal intellectual functioning?

At least five different objectives can be identified (Schaie & Quayhagen, 1978). Education may be sought by the adult learner first to assist him in comprehending changes in his own body and behavior which reflect maturation and aging. Second, the mature learner may need help in understanding the rapid technological and cultural change characteristics of all contemporary societies. A third objective may be the development of skills for combating the personal consequences of technological and socio-cultural change and obsolescence. Fourth, the adult learner may seek to acquire new vocational skills, the process currently identified as second career education. And, finally, he may find the use of educational technology to be a source of generating satisfactory and meaningful retirement roles.

Education as a means of comprehending one's own aging. One of the major objectives of the older learner should be to understand the manner in which his body and mind changes over is own life course. The human aging process past adolescence is frequently taken for granted as something that one learns to live with and that does not require special attention until there is a physiological or psychological breakdown. Nevertheless, all adults are conscious of physiological and psychological changes, as well as the social stereotypes assigned by an age-graded society (Maas & Kuypers, 1975; Neugarten & Datan, 1973). It is the latter, and their consequences, which are particularly amenable to educational intervention.

Beginning with middle age, there is a substantial need, particularly for the well-educated adult, to seek substantive information on what is known about the biological changes in adulthood, and in particular those changes which relate to memory, learning ability, ability to engage in successful interpersonal behavior (cf. Gribbin, Schaie & Parham, 1980). Significant efforts to bring the older learner into the educational system will fail, unless they are preceded by an effort to educate the adult educator on how the adult learner differs from the younger, and moreover, to educate the adult learner himself on these matters, so that he can enter the educational process with better understanding of his own needs, capabilities and limitations.

Education as a means of comprehending socio-cultural change. One of the difficulties in maintaining comprehension of one's environment and thus exercising at least some modicum of control over one's life is the rapid progression of technological and socio-cultural change. A traditional objective of adult education under the theme of continuing or life-long education has been the effort to interpret to adults past the stage of formal education those new technologies and social transitions which are likely to affect both personal behavior and the course of societies.

Education as a means of combating technological and socio-cultural obsolescence. Although comprehending socio-cultural change is an important educational goal in its own right, there is an even more pressing goal related to

the fact of personal obsolescence. It is quite evident that the educational level attained by most older persons in their youth no longer suffices to cope with their environment many decades later. We are here concerned with the acquisition of additional information as well as the development of learning skills and techniques.

Adult education can be instrumental in overcoming the generational differences in information and skills which have resulted in the obsolescence mentioned earlier. Whether there is need or not for another period of "compulsory" education in late middle age may be of concern to future social policy planners. At the present, however, we see an increase in what has been called the "greying of the universities," as more individuals try to overcome their perceived disadvantage in dealing with social change by reentering the educational process.

Second career education. Past tradition has required that individuals make career choices quite early, prepare for the vocation of their choice, and then maintain their chosen career throughout life. Rapid technological change may preclude this pattern in some fields, but more importantly, changing attitudes towards vocational choice may make it far more desirable to review one's life role in midlife. It is becoming increasingly fashionable for people in their forties and fifties to vocalize their impatience with and seek to change current work roles.

The educational system needs to become accustomed to an increasing number of students who return with a wealth of experience and a far better understanding of what they expect from education than is true in working with the traditional career-entry students. These students do not seek or want a liberal education, nor do they need to be kept around the university to mature sufficiently to enter a vocational role. What they need is the acquisition of new skills and additional information, presented not for their theoretical elegance, or with the hope of providing a generalizable base of knowledge, but rather to meet the specific needs of the individual learner. It is quite reasonable to expect that much more individualized courses of study will be required, since preparation is generally sought for work roles rather than for degrees, even though these may be important if their lack interferes with the mature student's opportunity to enter new roles.

Furthermore, what has often not been addressed sufficiently are the changes in motivational incentive which govern the adult learner. The presumption that change and novelty should be implicitly appealing is based largely on educators' experience in working with the young. For the older learner it seems clear that novelty has much less value, that acquiring new material to be learned must have some ego-centric meaning (cf. Schaie, 1977/78).

Education as a source of generating satisfactory retirement roles. A final objective of the adult learner may be to cope with the problems posed by giving up a work-centered life pattern for one in which leisure may be predominant. Education here, as in second-career education, will focus on developing or sharpening skills, but with the difference that personal satisfaction rather than economic gain will provide the primary learning incentive. As part of this process, educational programs may need to be developed which focus on self-discovery as well as on detailed examination of individual potentials, expectations and resources.

But leisure-oriented skills need not be solely directed to the satisfaction of personal needs. There are many societal roles which are not adequately filled by professionals, and one of the most promising retirement roles may well be greater involvement of the elderly in significant volunteer roles of a quasi-professional nature, particularly in the human services fields and often in service to other less advantaged elderly. Such roles, however, generally do require acquisition of new skills and information as well as placement activities (Seguin & O'Brien, 1976).

A particular problem during the retirement years is the imbalance of life expectancy between men and women, resulting in the high probability of widowhood for most elderly women. Special educational problems arise here in terms of developing or redeveloping skills for independent living outside of a traditional family unit as well as the acquisition of skills required for adequate management of personal economic resources and the development of new interpersonal relationships.

Summary

In this paper we have considered the issue of continued plasticity in intellectual performance in later adulthood. Descriptive longitudinal research, such as was discussed in the previous paper, indicates that some older adults develop mechanisms for compensating for age-related decrements and/or for remediating the effects of cohort-related obsolescence. In the past two decades there has been a growing trend to examine whether compensatory and/or remediation effects can be induced experimentally via cognitive training procedures. Training studies have been conducted from each of the three major approaches to the study of adult intelligence. A brief review of the training literature suggests that modifiability of older adults' intellectual functioning has been demonstrated for a variety of intellectual abilities and cognitive tasks. It was argued that training research couched within a psychometric approach may be particularly fruitful, given the rich theoretical and longitudinal research traditions within this approach. A program of training research framed within the psychometric theory of fluid and crystallized intelligence was described in some detail.

Future training research must progress beyond a simple demonstration of training effects to a broader understanding of the factors and processes associated with improvement. It was suggested that training gain may reflect both ability-related and non-ability-specific performance factors. Future research must include experimental design features which permit differentiating among these factors. It was suggested that conduction of training reseach within a theory-derived framework was useful in making a priori predictions regarding the nature of training effects. Two important features of such a theory-derived approach are the pattern of training transfer effects predicted from the theory and temporal maintenance of effects. Both theory and methodological issues will be important in future development of training research.

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