Prediction of Fluid Intelligence Training Gains in Older Adults

Michael Marsiske & Sherry L. Willis

S-113 College of Health and Human Development

Pennsylvania State University

University Park, PA 16802

Poster paper presented at the 44th Annual Scientific Meeting of the Gerontological Society of America, November 1991, San Francisco, CA.

The research reported in this article was supported by Grant AG08082 from the National Institute on Aging to S. L. Willis. Mr. Marsiske was partially supported by NIA Training Grant T32-AG-00048 awarded to the Pennysl vania State University.

Abstract

This study examines predictors of cognitive training effects at two occasions of training; 140 older adults were trained in 1979 (Time 1), and 51 subjects were followed-up and given "booster" training sessions in 1986 (Time 2). One group of subjects (*N* = 38) received *Figural Relations* training, while a second group (*N* = 102) received training in *Inductive Reasoning*. At Time One, subjects (25 M, 115 F) had a mean age of 70.8 years (*SD* = 6.34 years), and mean educational level of 11.1 years (*SD* = 2.94 years). Subjects participated in a pretest-treatment-posttest design. At both Times 1 & 2, subjects received a broad intellectual ability battery at pretest and posttest.

The present analyses sought to identify salient predictors of individual differences in training-related gain. Concurrent predictors of gain at Time 1 included: low pretest score on target ability to-be-trained, having high Internal locus-of control, returning at Time 2, and receiving Figural Relations training (R^2 = .43, $p < .001$). Examining the lagged (Time 1) predictors of Time 2 training gain, subjects with higher Time One pretest scores, higher levels of training gain at Time One, and who received Figural Relations training showed greater training gain at Time Two (R^2 = .67, $p < .001$).

Discussion focused on the need to identify individual differences between subjects who do, and do not, profit from cognitive training interventions.

Prediction of Fluid Intelligence Training Gains in Older Adults

In the mid-1970s, research examining the intellectual plasticity of older adults demonstrated that older adults could profit from training programs designed to improve their performance on measures of fluid intelligence (Blieszner et al., 1981; Willis et al., 1981). Subsequent research has replicated this finding (Baltes, Dittmann-Kohli, & Kliegl, 1986; Willis & Schaie, 1986).

More recently, attention has been focused on examining the predictors of individual differences in training gain (Gruber-Baldini, Schaie, & Willis, 1989; Kliegl & Thompson, 1991, Willis, 1991). These studies have suggested that persons with cardiovascular disease, higher levels of motor-cognitive rigidity, and lower levels of working memory/perceptual speed profitted less from cognitive training interventions. Willis (1991) has also shown that older cohorts tend to improve less than younger cohorts under training conditions.

Identifying the predictors of individual differences in training gain may have important diagnostic and practice implications. Sowarka et al. (1990) found that early Alzheimer's disease patients showed low or no performance increase following a cognitive training intervention, a pattern quite unlike that found with normal older adults. Outcomes of training themselves may actually serve as an early predictor of cognitive deficits. Furthermore, to the extent that cognitive training programs may ultimately prove useful for the enhancement of everyday functioning (Willis, in press), identification of individual difference predictors of cognitive training gains may ultimately assist in the tailoring of training programs to meet individual strengths and weaknesses.

In the present study, three questions were addressed: 1) Was the pattern of pre-post training change significant at both longitudinal occasions? 2) What were the salient concurrent predictors of individual differences in training gain? 3) What were the lagged (Time 1) predictors of Time 2 training gain?

Method

Subjects

The initial sample in 1978/79 comprised 140 subjects (25 males and 115 females). The mean age of the subjects at Time One was 70.8 years (*SD* = 6.34 years, *range* = 60-88 years). Mean educational level was 11.1 years (*SD* = 2.94 years, *range* = 4-20 years). Fifty one (6 males and 45 females) returned to the study. At Time Two (1986/87) subjects had a mean age of 76.9 (*SD* = 4.90, *range* = 67-93 years). On average, subjects rated their general health, hearing, and vision as good.

Participants were Caucasian community-dwelling Pennsylvania residents. They were recruited from church groups and community centers. Subjects were paid at the rate of $2.00/hour at Time One; returning subjects were paid $5.00/hour at Time Two.

Subject attrition. Eighty-nine subjects did not return for the longitudinal followup at Time Two. Reasons for attrition were as follows: Moved (4 subjects), not located (4 subjects), family illness (4 subjects), vision problem (1 subject), too ill (24 subjects), moved to nursing home (4 subjects), lack of interest (11 subjects), death (32 subjects) and ineligible to return (5 subjects). Significant attrition group differences were found on the following demographic variables: education (*t*[138] = 2.81, *p* < .01); age (*t* [138] = -2.41, *p* < .02); self-reported health (*t* [138] = -4.67, *p* < .001), and self-reported vision (*t* [138] = -2.89, *p* < .01). No attrition group differences were reported for hearing, and the two groups did not differ significantly on their pretest ability score. In all cases, the returning subjects were more advantaged than the non-returning subjects. Selective subject attrition is a common problem in longitudinal studies of aging, and caution must be taken in generalizing the findings of such studies to the broader population of older adults (Baltes, Schaie, & Nardi, 1971; Berk, 1983; Cooney, Schaie, & Willis, 1988).

Design and Procedure

The design used in this study was a longitudinal pretest-treatment-posttest design. Subjects initial participated in a 2-hour pretest at Time One (1978/79). The pre- and posttest battery is described in detail in Willis et al, (1981) and in Blieszner et al. (1981). Following this initial testing, subjects were then assigned to either a Figural Relations training condition (*N* = 38 at Time One), or an Inductive Reasoning training condition (*N* = 102 at Time One). At Time Two, 18 Figural Relations-trained subjects returned, and 33 Induction-trained subjects returned.

The training program for each fluid intelligence ability consisted of 5 1-hour training sessions at Time One. Following the training, all subjects received a posttest measurement battery which was equivalent to the pretest.

At Time Two, the same research design was employed. Returning subjects again received the pretest ability battery, followed by booster training sessions in the same intellectual ability as at Time One. All subjects again received the ability battery at the Time Two posttest.

All testing was conducted in groups of 15 or fewer people. Training sessions were conducted by a separate trainer (who did no testing), and was conducted in smaller groups. Details of the training programs are also reported in Blieszner et al. (1981) and Willis et al. (1981).

Measures

Ability measures. Pretest score and training gain for Induction training subjects was assessed via the ADEPT Induction test (Blieszner et al., 1981). For Figural Relations training subjects, the ADEPT Figural Relations Diagnostic Test (Plemons, Willis, & Baltes, 1978) was used. Subjects received these measures in the context of a broader ability battery, outlined in greater detail in the references above. For the purposes of the present analyses, further details of the ability measurement procedure will not be discussed.

Personal control and self-efficacy belief measure. Subjects received the Personality-In-Contexts inventory (Lachman, Baltes, & Willis, 1980), a domain-specific locus-of-control measure thought to reflect individuals' self-efficacy with regard to, and concern about, intellectual aging.

Demographic and health information. Subjects were administered a personal data questionnaire. At Time One, subjects responded to a brief set of questions about age, gender, income, education, occupational and marital status, health, hearing, and vision. At Time Two, an expanded version of this questionnaire was administered, with additional questions about specific health conditions, leisure activities, and life events.

Derivation of scores

All ability and personal control variables were standardized to the Time One pretest base, with a mean of 50 and a standard deviation of 10, to facilitate cross-measure comparisons. Scores for all subsequent occasions (Time One posttest, Time Two pretest and posttest) were also standardized to this Time One pretest base, to preserve all longitudinal and attrition effects.

For both Time One and Time Two, pretest-to-posttest change scores were computed by subtracting the pretest score from the posttest score. When training gain was incremental, the posttest score would be higher than the pretest score, and the resulting subtraction would yield a positive gain score.

Results

Analysis of training gain

For the total sample at Time One, there was significant pre-post gain in performance on the trained measure; mean gain was 8.75 standardized score points (SD = 8.03), t (139) = 12.89, $p < .0001$. For the returning subjects at Time Two, there was also significant pre-post training gain following the booster training sessions: mean gain was 6.05 T-score points (*SD* = 5.46), *t* (50) = 7.91, *p* < .0001.

Table 1 presents the mean pretest and posttest scores of all subjects at Time One and Time Two, both for the total training sample and separately by training group. As Table 1 illustrates, gain was positive and incremental for both training groups at both occasions; the returning subjects at Time Two had a higher baseline of performance at the Time Two pretest (relative to the total group at Time One), but achieved similar posttest levels of performance at Time Two to that those of the total sample at Time One.

Insert Table 1 about here

Concurrent predictors of Time One training gain

Bivariate Pearson Product-Moment correlations between Time One training gain and Time One pretest variables were examined. Variables whose correlation with training gain was significant or approximated significance (*p* < .10) were entered into an ordinary least squares (OLS) regression, with Time One training gain as the dependent variable. Table 2 presents the reduced regression model, in which only the variables with significant parameter estimates were retained. As Table 2 displays, subjects with lower pretest scores, who expressed higher levels of Internal control beliefs, who were employed at least part-time, who received Figural Relations training (as opposed to Induction training) and who did not drop out of the study at Time Two demonstrated higher levels of training gain at Time One.

Insert Table 2 about here

Lagged (Time One) predictors of Time Two training gain

Bivariate Pearson Product-Moment correlations between Time Two training gain and Time One pretest variables were first examined. Variables whose correlation with training gain was significant or approximated significance ($p < .10$) were again entered into an ordinary least squares (OLS) regression, with Time One training gain as the dependent variable. Table 3 presents the reduced regression model, in which only the variables with significant parameter estimates were retained. As Table 3 displays, subjects with higher Time One pretest scores, who had higher training gain scores at Time One, and who received Figural Relations training at both occasions demonstrated higher levels of training gain at Time One.

Insert Table 3 about here

Discussion

We have found that personal and demographic variables, along with a locus-of-control scale, are predictive of fluid intelligence training gain in older adults. This is supportive of a growing literature which suggests that individual differences predictors of cognitive training gain can be identified.

At the same time, the results of the present study differ from others (e.g., Gruber-Baldini et al., 1989) which suggested that lower age, more education, lower motor-cognitive rigidity, and absence of disease may be predictive of greater training gain. We suspect that our inability to replicate these earlier results is a joint function of our health measures and our sample size. At Time Two, we have measured health in much more detail than at Time One (with a detailed inventory of prescription drug use, as well as subject self-ratings of health on 15 different conditions). Unfortunately, with only 51 returning subjects, it was impossible to explore the simultaneous effects of all of these health predictors on training gain at Time Two. At Time One, on the other hand, our assessment of subject health relies solely on a one-item 6-point Likert-type self-rating.

One question which must be addressed is why the Time One pretest is _negatively_ related to training gain at Time One, but is _positively_ related to training gain at Time Two. There is not an easy answer to this question, but clearly "regression toward the mean" (Campbell & Stanley, 1963) may be implicated. Persons who score at scale extremes at pretest will tend to approach the scale mean in the absence of an intervention. Furthermore, persons who are performing closer to the scale maximum may be i) performing closer to their performance optimum, and ii) have less "room to improve" on the measure. Over time, however, the higher pretest levels of individuals may reflect that they are at higher levels of cognitive functioning than other subjects. If we assume both overall mean decline in ability performance with advancing age and the presence of interindividual stability of performance, then persons with lower pretest scores at Time 1 should also have lower pretest scores at Time 2. Sowarka et al.'s (1990) results, however, suggest that at some point individuals may reach a threshold beneath which it is difficult for them to improve from cognitive training. The presence of a positive relationship between Time One pretest and Time Two training gain may suggest that fewer persons with high pretest scores at Time One have fallen beneath the effective "training threshold" of cognitive ability at Time Two. Without more detailed assessments of subject mental status, these results are merely speculative.

Importantly, two interesting new results have emerged from these analyses. First, we find that persons with lower levels of perceived internal control gain less from training interventions. In other work, we have reported that lower levels of intellectual self-efficacy appear to be influenced by levels of everyday intellectual functioning (Willis et al., in press). In other words, on average, persons with lower levels of intellectual functioning demonstrate resultant lower levels of intellectual self-efficacy over time (cf. Lachman & Leff, 1989). Extrapolating from these results, the relationship between internal control beliefs and training gains in the present study may suggest that persons are becoming _aware_ of restrictions in cognitive plasticity, and do _in fact_ demonstrate less plasticity. Another plausible explanation (which finds less support in the literature on the direction of causality between intellectual functioning and intellectual control beliefs) is that persons with low intellectual self-efficacy do not believe in their ability to improve under conditions of cognitive training, and apply less effort to the training. In this case, the intellectual control beliefs are seen as introducing a self-fulfilling prophecy. Implications which proceed from these ideas are: 1) cognitive training should improve intellectual self-efficacy (partially supported by the findings of Dittmann-Kohli et al., 1991), and 2) self-efficacy building interventions may need to be incorporated into cognitive training paradigms for subjects with low intellectual self-efficacy. Findings to date have not been encouraging: in a cognitive restructuring intervention to promote adaptive memory beliefs in older adults, Lachman et al. (1990) found that such interventions improved self-efficacy beliefs, but did not add to the memory gains of subjects, even when cognitive restructuring was combined with memory training.

The second interesting finding has emerged from this study's longitudinal perspective on training. These results suggest that persons who showed positive gain at Time One were more likely to also show positive gain at Time Two. This suggests that there may be some enduring characteristics of persons (which have not yet been fully identified) which allow them to profit more from training than others. The important point to note is that these characteristics are somewhat stable over time.

In summary, these analyses suggest that there may are future avenues of investigation which must be pursued. The existing literature on intellectual training gains in older adults has answered the question CAN older adults improve. Future research must examine the _mechanisms_ of training improvement. These questions extend beyond identifying the specific skills, strategies and knowledge bases which are influenced by training interventions (e.g., Kliegl & Thompson, 1991, Willis, 1988). They also suggest that we must identify subtypes of individuals who may benefit from different kinds of training intervention (Weaver & Lachman, 1991; Gruber-Baldini et al., 1989). Finally, we must also acknowledge the biological and disease-related constraints on training gain that will occur in advanced old age (Gruber-Baldini et al., 1989; Sowarka et al., 1990).

Table 1. Mean pre- and posttest scores of cognitive training subjects at Time One and Time Two

TIME ONE:

	Figural Relat. (n=38)	Inductive Reasoning (n = 102)	Total Group (n=140)
Pretest	49.71 (10.54)	50.72 (8.43)	50.45 (9.02)
Posttest	65.53 (11.29)	56.83 (10.16)	59.19 (11.13)

TIME TWO:

	Figural Relat. (n=18)	Inductive Reasoning (n = 33)	Total Group (n=51)
Pretest	58.17 (12.82)	51.48 (8.20)	53.84 (10.45)
Posttest	64.83 (9.21)	57.19 (10.02)	59.89 (10.33)

Note: Standard deviations in parentheses. All prepost changes were significant ($p < .05$)

Table 2. Summary of concurrent multiple regression results for the prediction of Time One training gain (N = 140)

Predictor	standard b	Model R^2
Time 1 pretest	-.20**	
Future dropout	-.23**	
Employed	.17*	
PIC Internal locus-of-control	.20**	
Figural Relations training	.46***	.43

* $p < .05$
** $p < .01$
*** $p < .001$

Table 3. Summary of lagged multiple regression results for the prediction of Time Two training gain (N = 51)

Predictor	standard *b*	Model R^2
Time 1 pretest	.83***	
Time 1 training gain	.27*	
Figural Relations training	.26*	.67

* $p < .05$
** $p < .01$
*** $p < .001$

References

Baltes,P.B., Dittmann-Kohli, F., & Kliegl, R. (1986). Reserve capacity of the elderly in aging-sensitive tests of fluid intelligence: Replication and extension. Psychology and Aging, 1, 172-177.

Baltes, P.B., Schaie, K.W., & Nardi, A.H. (1971). Age and mortality in a seven-year longitudinal study of cognitive behavior. Developmental Psychology, 5, 18-26.

Berk, R.A. (1983). An introduction to sample selection bias in sociological data. American Sociological Review, 48, 386-398.

Blieszner, R., Willis, S.L., & Baltes, P.B. (1981). Training research on the fluid ability of inductive reasoning. Journal of Applied Developmental Psychology, 2, 247-265.

Campbell, D.T., & Stanley, J.C. (1963). Experimental and quasi-experimental designs for research. Chicago: Rand-McNally.

Cooney, T.M., Schaie, K.W. & Willis, S.L. (1988). The relationship between prior functioning on cognitive and personality dimensions and subject attrition in longitudinal research. Journal of Gerontology: Psychological Sciences, 43, P12-P17.

Dittmann-Kohli, F., Lachman, M.E., Kliegl, R., & Baltes, P.B. (1991). Effects of cognitive training and testing on intellectual efficacy beliefs in elderly adults. Journal of Gerontology: Psychological Sciences, 46, P162-P164.

Gruber-Baldini, A., Schaie, K. W., & Willis, S. L. (1989). Health and rigidity predictors of cognitive change and training gain. Paper presented at the 42nd Annual Scientific Meeting of the Gerontological Society of America, Minneapolis MN, November 1989.

Kliegl, R. & Thompson, L.A. (1991). Cognitive abilities and adult age-differential training gains in mnemonic skill. Symposium paper presented at the XITH Biennial Meetings of the International Society for Behavioral Development, Minneapolis MN, July 1991.

Lachman, M. E., Baltes, P. B., & Willis, S. L. (1980). Development of a contextual measure of personality: The ADEPT Personality-in-Intellectual-Aging Contexts (PIC) Inventory. In-house technical report on procedure. College of Human Development. Revised September 1980.

Lachman, M. E., & Leff, R. (1989). Perceived control and intellectual functioning in the elderly: A 5-year longitudinal study. Developmental Psychology, 25, 722-728.

Lachman M.E., Weaver, S.L., Bandura, M., & Elliot, E. (1990). New tricks for improving memory in older adults. Paper presented at the 43rd Annual Scientific Meeting of the Gerontological Society of America, Boston MA, November 1990.

Plemons, J.K., Willis, S.L., & Baltes, P.B. (1978). Modifiability of fluid intelligence in aging: A short-term longitudinal training approach. Journal of Gerontology, 33, 224-231.

Sowarka, D., Kuhl, K-P., Baltes, M.M., & Gutzmann, H. (1990). Early diagnosis of Alzheimer's Disease in a non-clinical sample: The notion of cognitive plasticity. Paper presented at the 43rd Annual Scientific Meeting of the Gerontological Society of America, Boston MA, November 1990.

Willis, S. L. (1988). Myths of cognitive training research. Paper presented at the Second Cognitive Aging Conference, Atlanta GA, April 1988.

Willis, S.L., (1991). Cognitive training research in the 1990s. Symposium paper presented at the XITH Biennial Meetings of the International Society for Behavioral Development, Minneapolis MN, July 1991.

Willis, S.L. (in press). Cognition and everyday competence. In K.W. Schaie (Ed.). Annual Review of Gerontology and Geriatrics (Vol 11.). New York: Springer.

Willis, S. L., Blieszner, R., & Baltes, P.B. (1981). Intellectual training research in aging: Modification of performance on the fluid ability of figural relations. Journal of Educational Psychology, 73, 41-50.

Willis, S. L., Jay, G. M., Diehl, M., & Marsiske, M. (in press). Longitudinal change and prediction of everyday task performance in the elderly. Research on Aging.

Willis, S.L. & Schaie, K.W. (1986). Training the elderly on the ability factors of spatial orientation and inductive reasoning. Psychology and Aging, 1, 7-12.