Cognitive Training in Normal Elderly:
Predictors of Training Gains and Maintenance of Effects

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Poster presented at the Annual Meeting of the Gerontological Society of America
San Francisco, November, 1999

The research reported in this paper was supported by grant no. AG08055 from the National Institute on Aging.
The first author was supported by a Pre-doctoral Fellowship from the National Institute of Mental Health

Introduction

Cognitive decline is one of the most feared consequences of old age. The inability to care for oneself and, eventually, the loss of independence are among the outcomes of cognitive decline of which the elderly are most afraid. While cognitive decline does appear to be largely irreversible with pathology, behavioral interventions are examining the extent to which cognitive functioning can be maintained and enhanced for normal non-demented elderly. Review of the literature reveals that cognitive training research has resulted in encouraging findings that normative, non-pathological cognitive decline on the primary mental abilities of spatial orientation and inductive reasoning is reversible in many elderly (Baltes, Kliegl & Dittmann-Kohli, 1988; Blieszner, Willis, & Baltes, 1981 Schaie & Willis, 1986; Willis & Schaie, 1986).

Spatial orientation and inductive reasoning are two primary mental abilities which are often the focus of cognitive training efforts because they have been identified, through previous research, to exhibit early patterns of normative, age-related decline (Schaie, 1983). Because of the wide span of individual differences in the decline of these two mental abilities, training effects may reflect remediation of decline, or improvement of cognitive ability beyond that experienced in the past, in those who have remained stable.

Much cognitive training research has been conducted on inductive reasoning. Inductive reasoning is involved in everyday activities such as understanding directions on medicine bottles and interpreting bus schedules. A number of studies have found that, with training, many older adults can show statistically significant improvements on the mental ability of inductive reasoning (Baltes, Kliegl & Dittmann-Kohli, 1988; Blieszner, Willis & Baltes, 1981; Hayslip, 1989; Schaie & Willis, 1986; Willis, 1990; Willis & Schaie, 1986).

Spatial orientation is another primary mental ability which has shown, through research, to exhibit decline early in old age (Schaie, 1983). The mental ability of spatial orientation is involved in activities such as reading road maps or interpreting floor plans. Cognitive tests measuring spatial orientation involve the subject's ability to rotate two dimensional abstract objects in his or her head under speeded conditions. Although training research on spatial orientation is not as well documented as that on inductive reasoning, studies have shown that with training older adults can show statistically significant improvements on spatial orientation (Willis & Schaie, 1986).

While immediate training effects are encouraging, understanding the factors associated with the maintenance of training gains is also important in determining whether cognitive training can be useful for prolonging independent living in older adults. Training gains seen as a result of ability training have shown maintenance on follow-up testing. Booster training sessions were also found to be most effective in the maintenance of ability training gains (Blieszner, Willis & Baltes, 1981; Schaie, 1996; Willis & Nesselroade, 1990).

Research questions

The purpose of the following study is to identify individual predictors of initial training gains on inductive reasoning and spatial orientation and predictors of seven-year maintenance of these effects. Although much research has focused on the magnitude of training effects, less attention has been given to identify the individual predictors of training gains and the maintenance of these gains.

Method

Participants

Participants were 407 older adults (male = 183; female = 224) from the Seattle metropolitan area, who had been participants in the Seattle Longitudinal Study (SLS) since 1970 or earlier and were at least 64 years of age (Schaie, 1983). All participants were, or had been, members of the Group Health Cooperative of Puget Sound, a health maintenance organization. Mean age of the total sample was 73.1 years (range = 64-95; SD = 6.49). Mean educational level was 14.2 years (range = 7-20; SD = 2.96). Mean income level was $21,079 (range = $1,000-$50,000; SD = $8,676).

All participants were community dwelling. Most of the participants were Caucasian. Prior to initiation of the study, each participant's physician was contacted and asked whether the subject suffered any known physical or mental disabilities that would interfere with participation in the study; participants so identified were not included in the study.

Participants were initially trained in 1984 or 1991. The 1984 sample consisted of 228 older adults (male = 97; female = 131) with a mean age of 72.8 years (range = 64-95; SD = 6.43). The mean educational level of the 1984 sample was 13.9 years (range = 7-20; SD = 2.9). The 1991 sample consisted of 179 older adults (male = 86; female = 93) with a mean age of 73.4 years (range = 64-95; SD = 6.6). The mean educational level of the

1991 sample was 14.5 years (range = 7-20; SD = 3.0). There were no age or educational differences between the 1984 and 1991 samples.

The Inductive Reasoning training group (combined across the 1984 and 1991 samples) consisted of 195 participants with a mean age of 73.1 years (range = 64-93; SD = 6.7). The mean education level of the inductive reasoning training group was 14.1 years (range = 7-20; SD = 2.9) and the group had a mean income of $20,137. The Spatial Orientation training group consisted of 212 participants with a mean age of 73.1 years (range = 64-95; SD = 6.3). The mean education level of the group was 14.1 years (range = 7-20; SD = 3.2) and they had a mean income of $21,057.

Design and Procedure

Classification of participants. Participants in both 1984 (n = 229, aged 64-95) and 1991 (n = 178, aged 64-95) were classified into those who had declined and those who had remained stable on the Thurstone (1948) Primary Mental Ability (PMA) Inductive Reasoning and Spatial Orientation measures over the 14-years prior to training. The statistical criterion for "decline" was one standard error of measurement (SEM) or greater (Reasoning = 4 raw points; Space = 6 raw points) below their 1970 score or 1977 score, respectively (Schaie & Willis, 1986).

Assignment of Subjects. Subjects were assigned to five one-hour training programs on inductive reasoning or spatial orientation. Subjects who were identified as decliners on a target ability were assigned to a training program in that ability. Subjects who were identified as stable or decliners on both target abilities were randomly assigned to one of the training programs.

Procedure. A pretest-posttest control group design was used. Subjects trained on one target ability were employed as controls for subjects trained on the other target ability. The Reasoning training group served as a control group for the Spatial Orientation training group and vice versa. The training involved five one-hour training sessions usually conducted in the subject's home by one of three middle-aged trainers with prior experience working with older adults. Following training, subjects were administered a post-test battery of measurements involving the same measures as the pretest.

Training Programs

Inductive Reasoning. Reasoning ability involves identifying a pattern or rule required to solve a serial problem and using that pattern to solve subsequent incidents of the problem. Participants were taught to identify four major pattern description rules (repeats, next, skips and backward next) involving letters. The participants learned through modeling, feedback and practice procedures to learn to identify and solve the problems. Practice problems were administered, completed and discussed. The practice problems employed similar rules, but had different content, such as musical notes and travel schedules. No practice items were identical to the problems on the criterion measures. Inductive reasoning ability relates to everyday tasks such as understanding directions on a medicine bottle or reading a chart or table of information.

Participants were encouraged to read aloud, make tick marks or slashes to identify skips, and to underline repeats in the sets to help them identify the pattern (Saczynski & Willis, forthcoming). Once the participant had identified the pattern, the trainer taught him or her how to identify a series within the pattern and identify the next letter by following the rule.

Spatial Orientation. Spatial orientation involves speed and accuracy in mentally rotating abstract objects in two dimensional space. These cognitive skills are used in daily life when performing such tasks as reading a road map or interpreting floor plans. Prior to solution of practice problems, participants were taught cognitive strategies to improve their performance (Saczynski & Willis, forthcoming). These strategies included developing concrete terms, such as times on a clock, associated with each angle rotation, physically rotating objects before mentally attempting rotation, naming the abstract objects which need to be mentally rotated so they are more familiar to the subject, and focusing on two or more features of the object while rotating it. Following training, participants are administered a post-test with the same measures as the pretest.

The participant's task was to identify which of six drawings could be rotated (not flipped as a mirror image) to look like the target drawing. The six drawings are at 45, 90, 135, 180, 225, 270 and 315 degree angles. Some drawings presented to the subjects are mirror images of the target drawing. The participant had to identify all drawings which could be rotated to look like the target figure in order to get credit for the question.

Measures

Participants in the 1984 and 1991 training study were assessed on a battery of tests. The measures were used to assess participants' inductive reasoning and spatial orientation abilities (Thurstone's Primary Mental Ability (PMA) Reasoning and Space, 1949), life satisfaction, and activity levels (Gribbin, Schaie, & Parham, 1980). All tests were administered by trained testers and where appropriate by means of take-home surveys.

Primary Mental Abilities: Reasoning (Thurstone, 1948). This measure involves being able to solve a problem using linear logic. The ability is measured by presenting the participant with a series of letters in a pattern. The subject must detect the pattern and identify the next letter in the series according to the rule they have hypothesized. The test contains 30 items and has a time limit of six minutes.

Primary Mental Abilities: Space (Thurstone, 1948). This measure involves both speed and accuracy in mentally rotating objects in two dimensional space. The subject is presented with a target object and must choose which of six answer choices could be rotated to the target object, rather than mirror images. The test contains 20 items and has a five-minute time limit.

The Primary Mental Ability (PMA) scores at pre and post-test were converted to t-scores separately by measure with a mean of 50 and a standard deviation of 10 for the entire Seattle Longitudinal Study (SLS) population (N = 4,134) at subject's first testing occasion. Thus scores of training subjects are calibrated in terms of SLS population values. Results for initial training gains are reported first, followed by maintenance of training gains.

Life Complexity Inventory (LCI) (Gribbin, Schaie, & Parham, 1980). This measure collects demographic information and examines a broad range of adult activities and interests. Information from the LCI related to the demographic and activity factors, life satisfaction, and marital status were used in the research.

Life satisfaction was measured on a five-point Likert Scale with ratings from "very happy" to "very unhappy" (1 = very happy; 2 = somewhat happy; 3 = happy; 4 =

somewhat unhappy; and 5 = very unhappy). Marital status was assessed along a five-point nominal scale (1 = single; 2 = divorced; 3 = separated; 4 = widowed; and 5 = married). For the purposes of this research, subjects was be categorized into married, non-married, and widowed (1 = married; 2 = not-married; and 3 = widowed).

Development of activity factors. The leisure activity measure is a list of 34 leisure activities based on the work of Lowenthal and associates (Lowenthal et al. 1975). Activities such as exercise, cultural activities, social activities, religion, educational activities and household chores are represented in this section of the Life Complexity Inventory. Exploratory and confirmatory factor analyses were performed on samples in 1977 and 1984 to create six activity factors and associated factor weights (O'Hanlon, 1993). Because the 1977 and 1984 samples are generalizable to the present sample used in this study, the same six activity factors (household, social, educational/cultural, fitness, solitary and communication) and factor weights were used.

The same procedures were followed in creation of the activity factors as in the O'Hanlon (1993) study. The data for each of the leisure activity variables was inspected and outlying cases were trimmed to be within three standard deviations of the mean for each variable. To achieve normality of the distribution of scores, the activity variables were transformed using square root and logarithmic transformations. Transformations which normalized the present data were consistent with those used by O'Hanlon (1993). Transformed scores were used in all subsequent analyses. Factors were computed from the transformed scores.

Results

The results of the study answered two questions proposed in the introduction: What are the training factors, individual lifestyle, and demographic variables predicting initial training gains? What are the training factors, individual lifestyle, and demographic variables predicting seven-year maintenance of training effects? Results for initial training gains are presented first, followed by results for the seven-year maintenance of training gains.

Creation of Activity Factors

Activity variables from the Life Complexity Inventory (LCI) (Gribben, Schaie, & Parham, 1980) were hypothesized to be associated with cognitive training gains on spatial orientation and inductive reasoning ability measures. The original 34 items werereduced to 17 activity variables which were used in all subsequent analyses (O'Hanlon,1993). Activities were dropped for a number of reasons including less than 25% of the O'Hanlon sample had participated in the activity and less than 20% of the variance in these variables being explained by the model, as determined by further analyses using LISERL (O'Hanlon, 1993).

The data were trimmed using two methods. First, a sum of the total hours reported on the 17 activity variables was computed for each subject. Extreme values were trimmed back to three standard deviations from the mean (142 hours). Subjects who reported less than 10 hours total a week of activity were eliminated from all analyses and treated as missing data. In addition, the data for each variable was inspected for extreme scores. Outlying cases were trimmed back to be within three standard deviations of the mean participation for each variable. The variables were then transformed to normality by means of logarithmic transformations. These transformations lowered the skewness and kurtosis of each variable, many of which were highly negatively skewed, and the transformed scores were used in all subsequent analyses.

The factor loadings obtained by O'Hanlon in her six factor solution of the LCI leisure activity variables (see Table 1) were used to calculate factor scores for each individual. Factor weights were calculated by squaring each factor loading and dividing it by the sum of the column (or factor).

Predictors of Initial Training Gains

The results for initial training gains are presented separately for inductive reasoning and spatial orientation. For each ability, the full models are described but only the reduced, final, models are presented.

Inductive Reasoning. Hierarchical regression was used to examine the relationship between the pre to post-test change score (representing pre to post-test gain) on the PMA inductive reasoning measure and a number of predictor variables including training group, decline status on ability trained, six activity factors, sex, education level, and age.

In the full model, training group was entered into the model first, followed by the total sum hours of activity (across activity domains) reported per week and decline status of the subject in the second step. In the third step of the full model, the six activity factors and demographic variables (sex, age, education) were entered followed by the interactions between the training group variable and the lifestyle, demographic, and decline variables in the fourth and final step of the model. Non-significant variables were eliminated from the model and the reduced final model, reported here, was run (Table 2). The six activity factors were eliminated from the reduced model as they did not account for a significant amount of the variance explained. The training group, sum of activity hours, and demographic variables were retained in the final model as they accounted for a significant amount of the explained variance and had high interpretive power.

In the final model, training group was entered in the first step, followed by activity hours and decline status variables in the second step. The demographic variables were entered in the third step, followed by the interactions between the training group variables and demographic, activity hours, and decline status variables in the fourth and final step of the model. Table 2 shows that training group accounted for a significant amount of the explained variance in pre to post-test gains on the inductive reasoning measure [R^2 = .194, (F (1, 405) = 97.69; p < .001],indicating that training group was a significant predictor of training gains. The parameter estimate for the training group variable indicates that subjects who were trained on inductive reasoning showed significantly greater pre to post-test gains on the reasoning measure than did the control subjects trained on spatial orientation. The addition of the total number of hours per week of leisure activity and subject's decline status results in a significant change in the R^2 [R^2=.224, ΔR^2=.029, F(3,401)=7.75; p<.001]. Both decline status and sum hours variables accounted for a significant amount of the explained variance. Examination of the parameter estimate associated with the activity hours shows that subjects reporting more hours of leisure activity were more likely to exhibit greater pre to post-test gains on the PMA reasoning measure. The parameter estimate associated with the decline status variable indicated that subjects who were classified as having declined were more likely to show pre to post test gains on the reasoning measure.

The addition of age, education, and gender, in the third step of the model resulted in a non-significant change in the R^2 [R^2=.226, ΔR^2=.002, $F(6,398)$=.376]. None of the demographic variables accounted for a significant amount of the variance explained. In the fourth and final step of the model, the interactions between the training group variable and the demographic variables, decline status, and sum hours were added into the model resulting in a non-significant change in the R^2 [R^2=.231, ΔR^2=.005, $F(11,393)$=.544]. As shown in table 2, none of the interactions were significant predictors of pre to post-test gain, suggesting that the relationship between training group and pre to post-test gain on the inductive reasoning measure was not moderated by the sum of hours, decline, or demographic variables investigated in this analysis.

Spatial Orientation. As for inductive reasoning, hierarchical regression was used to examine the relationship between pre to post-test gains on the PMA spatial orientation measure and a number of predictor variables including training group, decline status, total hours per week reported of leisure activity, age, education and gender. As with the previous analysis, a full model was run, non-significant predictors were eliminated, and the final model, reported here, was run. The final model for spatial orientation is identical to that for inductive reasoning; the training group variable was entered in the first step followed by the sum of hours and decline status variables in the second step. In the third step, demographic variables were entered as predictors followed by the interactions between the training group variable and decline, sum of hours and demographic variables in the fourth and final step of the model.

In the final model, training group accounted for a significant amount of the explained variance in the pre to post-test gain on the spatial orientation measure [R^2 =

.059, $F(1,405)=25.39$, $p<.001$]. Examination of the parameter estimate associated with the training group variable reveals that subjects trained on spatial orientation were more likely to show pre to post-test gains on the spatial orientation measure (see Table 3). The addition of the activity hours and decline status variables in the second step of the model results in a significant change in the R^2 ($R^2 = .108$, $\Delta R^2 = .049$, $F(3,401) = 11.09$; $p<.001$]. Table 3 shows that both the sum of hours and decline status variables are significant predictors of pre to post-test gain on the spatial orientation measure. The parameter estimate associated with the sum of hours variable indicates that subjects reporting more hours per week of leisure activity were more likely to show pre to post-test gain. The parameter estimate associated with the decline status variable shows that subjects who were classified as having declined were more likely to show pre to post-test gains on the spatial orientation measure.

In the third step, age, education and gender were added to the model resulting in a non-significant change in the R^2 [$R^2 = .121$, $\Delta R^2 = .012$, $F(6,398) = 1.89$] indicating that these variables did not account for a significant amount of the explained variance in the pre to post-test change variable. The individual F-values associated with each of the demographic variables indicated that these variables were not significant predictors of the dependent variable (see Table 3). In the final step, the interactions between the training group variable, decline status, sum of hours and demographic variables were entered into the model as predictor variables. The inclusion of these interactions resulted in a non-significant change in the R^2 [$R^2 = .137$, $\Delta R^2 = .017$, $F\,(11,393) = 1.51$]. As Table 3 shows, none of the interactions were significant predictors of pre to post-test gain on the spatial orientation measure, suggesting that the relationship between the training group variable and pre to post-test gain was not moderated by the sum of hours, demographic, and decline status variables investigated in this analysis.

Predictors of Maintenance of Training Gains

The results for predictors of the seven-year maintenance of training gains are presented in the following section. Results are presented for inductive reasoning and spatial orientation separately. Full models were run and non-significant variables were removed. The final, reduced, models include only those variables which were significant predictors of maintenance of training gains or had specific interpretive significance. Reduced models are presented in the following section.

Inductive Reasoning. A hierarchical regression analysis was performed to determine the association between a number of lifestyle and demographic variables and the maintenance of training gains from pre-test 1984 to pre-test 1991 on the PMA inductive reasoning ability measure. Lifestyle variables included the six activity factors and the sum hours per week the subject reported participating in the 17 leisure activities. Demographic variables included age, gender and education level. In addition to the lifestyle and demographic variables, subjects' decline status, being classified as having remained stable or declining on the ability trained in the 14-year period prior to training, was also entered into the regression analysis.

In the full model, training group and decline status of the subject were entered into the model first, followed by the lifestyle variables in the second step and the demographic variables in the third step. Finally, in the fourth step, the interactions between the training group variable and the lifestyle, demographic, and decline variables were added into the model. Non-significant variables were eliminated from the model and a reduced final model, reported here, was run. The six activity factors were eliminated in the reduced model as they did not account for a significant amount of the variance explained. In the final model, training group of the subject was entered into the model in the first step followed by activity hours and decline status variables in the second. In the third step of the model, demographic variables were entered and in the fourth and final step, interactions between the training variable and the demographic, decline status, and activity hours variables were entered.

In the final model, training group accounted for a significant amount (6.3%) of the explained variance in the maintenance of inductive reasoning training gains [$R^2 = .063$, F $(1, 127) = 8.42$; $p < .01$], indicating training group was a significant predictor of the maintenance of training gains. The parameter estimate for the training group variable indicates that subjects trained on inductive reasoning show significantly more maintenance of training gains than participants in the control group who were trained on spatial orientation (see Table 4). The addition of the total number of hours per week of leisure activity, in the second step of the model, results in a significant increase in the R^2 of the model [$R^2 = .098$, $\Delta R^2 = .035$, F $(2, 126) = 4.88$; $p < .01$]. Examination of the F-value associated with the activity hours variable revealed that it was a significant predictor of the maintenance of inductive reasoning ability. The parameter estimate associated with the activity hours variable indicates that subjects, irrespective of training group, who report more hours per week spent engaging in leisure and domestic activities showed greater maintenance of inductive reasoning ability.

In the third step, age, education level, and sex were entered into the model as predictor variables. These demographic variables did not contribute a significant amount of explained variance in the dependent variable [$R^2 = .119$, $\Delta R^2 = .021$, F (5, 123) = .973]. The individual F-values and parameter estimates associated with the demographic variables indicate that none of the variables were significant predictors of maintenance of training gains. In the fourth and final step, the interactions between the training group variable and demographic and activity hours variables were added to the model resulting in a significant change in the R^2 [$R^2 = .176$, $\Delta R^2 = .057$, F (9,119) = 2.07; $p < .05$]. The individual F-values and parameter estimates indicate that none of the interactions contribute a significant amount of explained variance in maintenance of training gains, however there was a trend found for the training group x gender interaction [$F = 3.23$; $p = .074$]. The parameter estimate associated with this interaction suggests that women trained on inductive reasoning were more likely to show maintenance of inductive reasoning training gains than were men trained on inductive reasoning as well as men and women trained on spatial orientation. The non-significance of these interactions also suggested that the relationship between training group and the maintenance of training gains was not moderated by the lifestyle or demographic variables explored in this model.

Spatial Orientation. A hierarchical regression was performed to determine the relationship between a change score representing pre-test 1991 minus pre-test 1984 and a number of lifestyle and demographic variables in addition to subjects' decline status in 1984. As in the previous analysis predicting the seven-year maintenance of inductive reasoning training gains, lifestyle variables included the six activity as well as a variable representing the total number of hours per week subjects reported participating in leisure activities. Again, the life satisfaction variable was eliminated from this analysis because of a lack of sufficient variability. Demographic variables included age, gender and education level. Decline status, assessed in the 14 year period prior to training, was also entered as a predictor variable.

As for inductive reasoning, a full model was run first and non-significant variables were taken out and a reduced model was run. Results reported here represent the findings from the reduced model. In the full model, training group and decline status variables were entered into the model in the first step, followed by the lifestyle variables in the second and the demographic variables in the third. In the fourth and final step of the model the interactions between the training group variable and lifestyle and demographic variables were entered into the model. As for inductive reasoning, the six activity factors were eliminated from the final model as they did not account for a significant amount of the explained variance. The training group, sum of hours, and demographic variables were retained as they accounted for a significant amount of the explained variance.

In the final (reduced) model, the training group variable was entered into the analysis in the first step of the model followed by the sum of activity hours variable in the second. In the third step, demographic variables were entered as predictors followed by interactions between the training group variable and the demographic and sum of hours variable in the fourth and final step of the model.

In the final model, training group accounted for a significant amount of the explained variance in the maintenance of spatial orientation training gains [$\underline{R}^2 = .036$, $\underline{F}$ (1, 127) = 4.66; $\underline{p} < .05$]. Examination of the parameter estimate associated with the training variable indicates that subjects trained on spatial orientation were more likely to show maintenance of spatial orientation ability (see Table 5) The addition of the activity hours variable, in the second step of the model, resulted in a significant change in the R^2 [R^2 = .092, ΔR^2 = .056, F (2, 126) = 7.81; $p < .01$]. The parameter estimate associated with sum of hours variable indicates that subjects who report more hours per week of leisure activity show significantly greater maintenance of spatial orientation ability irrespective of training group.

In the third step, age, gender and level of education were added into the model resulting in a non-significant change in the R^2 [R^2 = .108, ΔR^2 = .017, F (5,121)= .005], indicating that these demographic variables do not significantly contribute to the explained variance in the maintenance of spatial orientation training gains. The individual F- values associated with each of the demographic variables indicate that the variables were not significant predictors of the dependent variable (Table 5). In the final step, the interactions between the training group variable and the activity hours and demographic variables were entered into the model. The inclusion of these interactions resulted in a significant change in the R^2 of the model [R^2 = .145, ΔR^2 = .037, F (10, 118)= 5.09; $p < .01$]. As shown in Table 5, none of the individual interactions were significant predictors of maintenance of training gains, suggesting that the relationship between the training group variable and maintenance of spatial orientation training gains was not significantly moderated by the sum of hours or demographic variables investigated in this analysis, but that as w hole they did influence the dependent variable.

Discussion

The discussion section will provide and overview of the results of the present study. Possible explanations for significant and non-significant associations between demographic and lifestyle variables and inductive reasoning and spatial orientation initial training gains will be presented. In addition, possible explanations for significant and non-significant associations between demographic and lifestyle variables and the seven-year maintenance of training gains will be discussed. Finally, limitations of the study will be considered.

Initial Training Gains

Inductive Reasoning. Training group was found to be a significant predictor of pre- to post-test on the PMA Inductive Reasoning ability measure (Thurstone, 1948). Subjects who were trained on inductive reasoning showed greater training gains than control subjects trained on spatial orientation. These findings support the work of Blieszner, Willis and Baltes (1981) who found that the ability training group showed the greatest improvements from pre-test to the first and second post-tests on inductive reasoning measures than did the control group. These results are also in accordance with findings by Schaie and Willis (1986) who found that subjects trained in 1984 on inductive reasoning showed significantly greater improvements from pre- to post-test on reasoning ability measures than did the control group who were trained on spatial orientation. Thus, combined 1984/1991 analyses support the original 1984 findings.

Although there were significant training gains, these gains did not differ by the demographic variables explored in this study, age/cohort, gender, and education level. It is encouraging to find that training gains were not affected by demographic variables, indicating that the training program implemented is appropriate for many older adults, irrespective of their demographic characteristics.

It was surprising to find that education level did not affect inductive reasoning training gains. These results also support the findings of Schaie and Willis (1986) who found that, although education was associated with ability decline, covarying on it did not significantly alter any of the training effects. Although subjects with lower education levels may show more rapid or earlier cognitive decline, the magnitude of training gains is similar across levels of education.

Subjects' stability was a significant predictor of initial training gains. Subjects who were classified as having declined on one or both target abilities showed greater training gains. These findings suggest that subjects who had declined prior to training may have not had the opportunity in their daily lives to use the cognitive skills utilized in training. Thus, training "reactivated" these skills. Looking at the magnitude of training gain would enable us to determine if subjects' performance after training was simply boosted to their pre-decline level or was greater than that which they had experienced in the past. These results agree with the results found by Schaie and Willis (1986) who found that subjects who were classified as having declined on one or both abilities were more likely to show training gains, suggesting support for the disuse theory.

Total hours of activity per week was also a significant predictor of initial inductive reasoning training gains. It is possible that activity level is a proxy for health in the present research. In that case, the present findings would suggest that participants who spend more hours per week engaging in leisure activity are healthier and therefore more likely to show cognitive training gains. The finding that activity level is related to cognitive training gains also supports the "Use It or Lose It" theory, which states that if you keep your mind and body active, they will continue to serve you well.

Spatial Orientation. The findings for spatial orientation and predictors of initial training gain were identical to those of inductive reasoning. Training group was a significant predictor of initial training gains. Participants in the spatial orientation training group showed greater pre to post-test training gains on the PMA spatial orientation measure than did control subjects trained on inductive reasoning. Similar to inductive reasoning, none of the demographic variables investigated in the present study were significant predictors of initial spatial orientation training gains. It is surprising that there were not gender differences as gender differences in level of spatial ability favoring men have been identified, across the life-span, for spatial orientation (Willis & Schaie, 1988). These findings support Willis and Schaie's 1988 suggestion that given the skills, women can perform at a comparable level to men.

As for inductive reasoning, subjects who were classified as having declined showed greater pre to post-test training gains. Again, these results support the findings of Schaie and Willis (1986) and are in accordance with the disuse theory. Activity level was also a significant predictor of training gains, higher activity levels were predictive of greater immediate training gains. As for inductive reasoning, it is possible that activity level is a proxy for health.

Maintenance of Training Gains

Inductive Reasoning. Training group was found to be a significant predictor of pre-test 1984 to pre-test 1991 seven-year maintenance of inductive reasoning ability. Subjects who were trained on inductive reasoning showed more maintenance on the PMA inductive reasoning measure. Stability status was not a significant predictor of seven-year maintenance, suggesting that although stable subjects may have shown more initial training gain, decliners showed comparable maintenance of inductive reasoning ability.

Although the demographic variables explored in the present study were not significant predictors of maintenance of training gains, there was a trend for women who were trained on inductive reasoning to show greater maintenance than men trained on inductive reasoning and women and men trained on spatial orientation. It is possible that these findings are a result of the fact that because of life-expectancy men are, at all ages, closer to death than are women. It is likely that women were more likely to integrate the skills learned in training into their everyday lives, resulting in maintenance of inductive reasoning.

Activity level was also a significant predictor of maintenance of inductive reasoning ability. Subjects who reported more hours per week of leisure activity were more likely to show seven-year maintenance of inductive reasoning ability. It would be interesting to look at the change in activity level over the seven year period to see if that would also be associated with maintenance. In other words, do those who start active remain active and does this effect maintenance of cognitive ability?

Spatial Orientation. The findings for the seven-year maintenance of spatial orientation were quite similar to those of inductive reasoning. Subjects trained on spatial orientation were more likely to show spatial orientation maintenance than were control subjects trained on inductive reasoning. The demographic variables investigated in the present study (education, age, and gender) were not significant predictors of maintenance of spatial orientation training gains. The lack of gender differences in maintenance of spatial orientation adds to Wills and Schaie's 1988 theory that given the skills women can perform at a comparable level to men on spatial orientation tasks. The present study extends these findings, showing that not only can women perform at a comparable level initially, they can also maintain these abilities as well as men.

As for inductive reasoning, activity level was found to be a significant predictor of maintenance of spatial orientation training gains. Again, it is possible that activity level is a proxy for overall health and it would be interesting to look at the pattern of change in activity level over the seven year period in predicting maintenance of cognitive ability.

In summary, immediate training gains and the seven year maintenance of these gains of both inductive reasoning and spatial orientation training were associated with training on the target ability and activity level. Pre to post-test training gains in both inductive reasoning and spatial orientation were greater in subjects who were classified as having decline on the target ability in the 14-years prior to training although decline status was not a significant predictor of maintenance of training gains.

Limitations. There are a number of limitations to the present study. Although the results were not affected by education, the sample was highly educated and therefore not generalizable to a sample of lower educated individuals. In addition, all of the subjects were in good health and the sample had a high mean income level. Although this sample may not be representative of all older adults, it is comparable to that of most cognitive training efforts.

As in most longitudinal research, selective positive attrition could be affecting the results. Subjects who were in poor health or were having a problem with the training program would have been more likely to drop out before seven-year follow-up, which could have resulted in a healthier and cognitively superior sample of subjects on which the maintenance of training effects were assessed.

Table 1. Lisrel maximum likelihood estimates for final activity model.

Variable	Household	Social	Educ/Cult.	Fitness	Solitary	Comm.	Unique Variance
Cooking	.807						.348
Chores	.733						.463
Shop	.427	.261					.654
Be Visited		.682					.535
Visit		.696					.516
Social		.363	.288				.701
Educ			.625				.609
Cult			.565				.681
Self			.504				.745
Sport				.386			.851
Fit				.618			.618
Outdoor				.301	.194		.848
Alone					.487		.763
Craft					.603		.637
Talk						.749	.440
Dream						.533	.715
Write	.296					.356	.710

Note: Table from O'Hanlon (1993). Abbreviations: Educ/Cult. = educational or cultural activities, Comm. = communication activities (such as talking and writing).

Table 2. Summary of hierarchical regression analysis for demographic and lifestyle variables predicting pre- to post-test gains on the Primary Mental Ability Inductive Reasoning measure. (N=405).

Predictor	Step 1		Step 2		Step 3		Step 4	
	β	MS	β	MS	β	MS	β	MS
Training Group	-4.90***	2439.65	-5.07***	2467.36	-5.09***	2467.36	-3.39***	2467.36
Activity Hours			0.02*	136.23	0.02*	136.23	0.03*	136.23
Decline Status			1.40	195.05	1.53**	195.06	2.30**	195.05
Education					-0.02	2.04	0.01	2.04
Sex					0.06	0.20	0.28	0.20
Age					-0.04	26.11	-0.03	26.11
Training Group x Activity Hours							-0.02	11.58
Training group x Decline Status							-1.41	48.07
Training Group x Education							0.02	0.25
Training Group x Gender							0.53	6.28
Training Group x Age							-0.01	0.07
R^2	0.194		0.224		.256		.231	
ΔR^2			0.029**		.002		.005	
(df)	(1,405)		(3,401)		(6,398)		(11,393)	

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

Table 3. Summary of hierarchical regression analysis for demographic and lifestyle variables predicting pre- to post-test gains on the Primary Mental Ability Spatial Orientation measure. (N=407).

Predictor	Step 1		Step 2		Step 3		Step 4	
	β	MS	β	MS	β	MS	β	MS
Training Group	3.12***	989.44	2.87***	979.86	2.84***	979.86	3.04***	979.86
Activity Hours			0.02*	150.32	0.02*	150.32	0.01*	150.32
Decline Status			2.60***	679.64	2.75***	679.64	2.32***	679.64
Education					-0.06	97.21	-0.24	97.21
Sex					0.79	69.47	0.78	69.47
Age					-0.04	41.91	-0.04	41.91
Training Group x Activity Hours							0.06	245.97
Training Group x Decline Status							0.84	15.69
Training Group x Education							0.14	16.51
Training Group x Gender							0.12	0.06
Training Group x Age							-0.01	0.66
R^2	0.059		0.110		.121		.137	
ΔR^2			0.049**		.012		.017	
(df)	(1,405)		(3,401)		(6,398)		(11,393)	

Note: * p< .05
** p< .01
***p<.001

Table 4. Summary of final model of hierarchical regression analysis for lifestyle and demographic variables predicting post-test 1984 to pre-test 1991 maintenance of training gains on the PMA inductive reasoning ability measure. (N=128).

Predictor	Step 1		Step 2		Step 3		Step 4	
	β	MS	β	MS	β	MS	β	MS
Training Group	-2.78**	247.60	-2.53**	247.60	-2.61**	257.38	-10.07**	257.38
Activity Hours			0.05*	138.17	0.06*	146.39	0.02*	146.39
Education Level					0.26	61.96	0.50	61.96
Gender					-0.11	0.18	-1.35	0.17
Age					-0.25	1.77	-0.92	1.77
Training Group x Activity Hours							0.12	56.97
Training Group x Education							-0.60	55.82
Training Group x Gender							4.40	89.82
Training Group x Age							1.91	23.74
R^2	0.063		0.098		0.119		0.231	
ΔR^2			0.035**		0.021		0.069*	
(df)	(1,127)		(2,126)		(5,123)		(9,119)	

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

Table 5. Summary of hierarchical regression analysis for lifestyle and demographic variables predicting post-test 1984 to pre-test 1991 maintenance of training effects on the PMA spatial orientation ability measure. (N=128).

Predictor	Step 1		Step 2		Step 3		Step 4	
	β	MS	β	MS	β	MS	β	MS
Training Group	2.64*	222.92	3.04*	222.92	2.97*	216.20	2.88*	216.20
Activity Hours			0.09**	351.39	0.08**	358.51	0.06**	358.51
Education Level					-0.95	18.60	-0.02	18.60
Gender					-0.67	5.34	0.04	5.34
Age					-1.72	77.95	0.14	77.95
Training Group x Activity Hours							0.04	41.38
Training Group x Education Level							-0.11	7.75
Training Group x Gender							-1.26	2.78
Training Group x Age							2.59	95.64
Training Group x Age x Decline Status							-4.19	82.47
R^2	0.036		0.919		0.108		0.145	
ΔR^2			0.056		0.017		0.037**	
(df)	(1,127)		(2,126)		(5,121)		(10,118)	

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

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