Strategy Use and Cognitive Training Effects

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Introduction

A popular interpretation of the poor performance of older adults on complex cognitive tasks has been that many elderly are ineffective in the use of relevant strategies. Previous research on expertise (Charness, 1981) and with younger age groups (Hultsch, Kausler, Craik,) have identified a number of strategies that were related to higher performance on target cognitive tasks.

A strategy has been defined as one of several alternative methods for performing a particular cognitive task. Salthouse (1991) has identified several assumptions regarding strategies as they are studied in cognitive aging: 1) Strategies are specific to particular tasks. 2) Variations in use of strategies have consequences for level of performance on a specific cognitive task. 3) Evidence used to infer the use of strategy must be distinct from that used to indicate the level of performance on the cognitive task.

There has been considerable debate whether the poor cognitive performance of the elderly is due to a production or processing deficit with regard to strategies. The production deficiency position holds that older adults are capable of using strategies but frequently or spontaneously do not use effective strategies (Kausler, 1994). The processing deficiency position holds that some optimal strategies may be very demanding for older adults and hence older adults may be ineffective in using such strategies (Charness, 1985; Guttentag, 1985; Salthouse, 1981).

Debate and research on strategy use has focused primarily on memory processes. There have been numerous experimental studies in which older adults have been given simple instructions to use a specific strategy and their subsequent performance on a memory task compared to other older adult groups not informed on use of a particular strategy (Hertzog, McGuire, & Lineweaver, 1998; Mason & Smith, 1977; Treat & Reese, 1976).

A major problem in the study of strategy use has been the type of evidence used to infer that older adults have indeed been using a particular strategy. Researchers have had difficulty identifying a measure of strategy use that was truly objective and valid and that was distinct from that used to indicate level of performance on the cognitive task. Three types of procedures have frequently been used to assess strategy use, each having major limitations in it's validity as evidence of strategy use. First, retrospective self reports conducted after performance of the memory task have been cited as evidence of strategy use (Camp, Markley, & Kramer, 1983; Hertzog et al, 1998). Hertzog et al. (1998) measured strategy use by assessing the nature of causal attributions for performance reported by subjects after testing. Participants were not directly asked about strategies and therefore only reported strategy use if they felt it had influenced their performance on the memory test. Camp and his colleagues (1983) examined spontaneous memory strategies by asking participants to describe what they had done to help them remember the words in a list recall exercise. Although no intervention was attempted, strategies reported by the participants were categorized according to levels of processing (Craik, 1977; Craik & Lockhart, 1972). Results showed that although a diverse set of strategies were reported, procedures categorized as using deeper levels of processing were associated with better performance on the recall task (Camp et al., 1983).

Second, versions of the think aloud technique have been used during the memory task. In a recent study by Dunlosky and Hertzog (1998) older adults were asked to describe the strategy used, item by item, while performing the memory task. Third, measures of time allocated to

different components if the cognitive task have been used as indicators of facility of strategy use (Salthouse, Legg, Palmon, & Mitchell, 1990; Salthouse & Prill, 1987; Stine, 1990).

Given the prominence of strategy use interpretations of deficits in cognitive performance, many cognitive intervention studies have focused on training strategies shown in prior research to be effective in performance of the target cognitive task. Strategies trained have included imagery and the method of loci (Baltes & Kliegl, 1992; Kliegel, Smith, & Baltes, 1989; Yesavage, Rose, & Bower, 1983), categorization (Rebok, Rasmusson, & Brandt, 1997), and video administered combined training (West & Crook, 1992). Again, most of the cognitive training research with an emphasis on strategies has focused on various aspects of memory performance.

A critical assumption in many of these cognitive intervention studies is that the training of specific strategies was associated with improved performance on the key ability. Just as in the previous experimental studies on the link between strategies and memory performance, the intervention studies have typically provided little direct evidence of enhanced strategy usage and its relation to training improvement. Although Hertzog et al. (1998) found use of optimal strategies to be positively related to recall performance, their results were based on retrospective self-reported strategy use.

The purpose of the present study is to examine strategy use in relation to training studies conducted within the Seattle Longitudinal Study (SLS). Cognitive training research within the SLS has focused on two abilities, inductive reasoning and spatial orientation, shown in prior longitudinal research to exhibit relatively early age-related decline in the mid sixties (Schaie, 1996). Training on both inductive reasoning and spatial orientation focuses on strategies that are unique to the ability trained. The strategies trained for inductive reasoning involve having the participant make specific marks on training items to identify the patterns in a series. Successful training of these strategies should result in subjects trained on inductive reasoning making such marks on inductive reasoning test items at posttest. Since subjects trained on spatial orientation received training on strategies unique to spatial tasks, they should not show training effects on strategies specific to inductive reasoning. The following questions are addressed by the study: 1) Does the increase in strategy use indicated by pattern marking on test problems differ by training group from pre to post-test? 2) What subject characteristics are associated with strategy use? And 3) Is a pre to post-test increase in strategy use associated with training gain on inductive reasoning measures?

Method

Subjects

Subjects were 393 older adults (male = 177; female = 216) from the Seattle metropolitan area, who had been participants in the Seattle Longitudinal Study (SLS) since 1970 or earlier (Schaie, 1983). All subjects were, or had been, members of the Group Health Cooperative of Puget Sound, a health maintenance organization. Mean age of the total sample was 72.9 years (range = 64-95; SD = 6.41) at time of first training (1984 or 1991). Mean educational level was 14.1 years (range = 7-20; SD = 3.05). Mean income level was $21,079 (range = $1,000-$50,000; SD = $8,676).

The sample includes subjects who were trained for the first time in 1984 or 1991 on either Inductive Reasoning or Spatial Orientation. The 1984 sample consisted of 215 older adults (male = 96; female = 119) with a mean age of 72.7 years (range = 64-95; SD = 6.35). The mean educational level of the 1984 sample was 13.90 years (range = 7-20; SD = 3.11). The 1991 sample consisted of 178 older adults (male = 83; female = 95) with a mean age of 73.3 years (range = 64-93; SD = 6.5). The mean educational level of the 1991 sample was 14.4 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 188 subjects with a mean age of 73.0 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 205 subjects with a mean age of 72.9 years (range = 64-95; SD = 6.2). The mean education level of the group was 14.1 years (range = 7-20; SD = 3.0) and they had a mean income of $21,057. There were no age or educational differences between the reasoning and space training subjects. All subjects were community dwelling. Most of the subjects were Caucasian. Prior to entry into the study, each subject's physician was contacted and asked whether the subject suffered any known physical or mental disabilities that would interfere with participation in the study; subjects so identified were not included in the study.

Design and Procedure

Classification of participants. Participants in both 1984 (N=215, aged 64-95) and 1991 (N=178, aged 64-93) 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 training on either inductive reasoning or spatial orientation. Subjects who were identified as having declined on a single 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 spatial orientation were employed as controls for subjects trained on the inductive reasoning. 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 with working with older adults. Following training, subjects were administered a post-test battery of measurements involving the same measures as the pretest.

Measures

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. Three measures assessed the effectiveness of the training on inductive reasoning. The ADEPT Letter Series and the Word Series measures were used in coding of strategy use at pre- and posttest.

ADEPT Letter Series (Blieszner, Willis, & Baltes, 1981). The Adult Development and Enrichment Project (ADEPT) Letter Series test assesses inductive reasoning ability via letter series problems. The subject is shown a series of letters and must select the next letter in the pattern from five answer choices. The score range is 0-20 with each item scored correct (1) or incorrect (0). This test is similar to the Primary Mental Abilities (PMA) Reasoning measure (Thurstone, 1948) but uses additional pattern-description rules.

Word Series (Schaie, 1985). The Word Series test is defined as a near transfer measure of reasoning training. The Word series measure parallels the PMA Reasoning measure, as it used the same pattern-description rules, but uses words such as days of the week or months of the year as stimuli rather than letters. The score range is 0-30 with one point for each item answered correctly.

Primary Mental Abilities (PMA): Inductive Reasoning (Thurstone, 1948). The ability is measured by presenting the subject 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 pattern. Although this is the measure which would be the most direct measure of training gain, it was not coded for strategy use because subjects' answers were recorded on an answer sheet which was separate from the test stimuli and strategy use could not be coded based on the answer sheet.

Training Programs

Inductive Reasoning. Subjects were taught to identify four major pattern description rules (repeats of a letter pattern (aabccdeef...); skips in a letter/number pattern (acegi…); the next number/letter in order in the pattern (abcde…); and backwards letter/number sequences (zyxwv…)). These pattern descriptions have been studied extensively in prior research on inductive reasoning (Kotovsky & Simon, 1975; Hotzman, Pelligrino, & Glaser, 1972). The subjects learned through modeling, feedback and practice procedures to identify the pattern and solve letter and number series problems involving the pattern. In addition, practice problems were employed involving similar rules, but with different content, such as musical notes and travel schedules. No practice items were identical to the problems on the criterion measures.

Subjects were taught and encouraged to use strategies for identifying the pattern shown in previous research to be useful (Pelligrino et al., 1972). Four primary strategies were taught 1) Saying aloud the series, 2) Underlining number or letter repetitions in the pattern (aabccdeef…), 3) Making slash marks to separate repetitions in the pattern (aab/ccd/eef/…), and 4) Making tick marks to indicate skips in a pattern (a'c'e'g…). The use of these strategies (underlining, slashes, and tick marks) required subjects marking on training or test materials and were used in assessing strategy usage.

Spatial Orientation. Spatial orientation involves speed and accuracy in mentally rotating abstract objects in two dimensional space. The subject's task was to identify which of six drawings could be rotated to look like the target drawing. The six drawings are at 45, 90,

135, 180, 225, 270 and 315 degree angles. Some drawings were mirror images of the target drawing.

Subjects were taught strategies for solving spatial problems, that had been identified in prior research (Cooper & Shepard, 1973; Bgan, 1981). These strategies included developing concrete terms for abstract figures, physically rotating objects before mentally attempting rotation, mentally naming the abstract objects which need to be rotated so they were more familiar to the subject and focusing on two or more features of the object while rotating it. None of these strategies involved marking on training or test materials.

The strategies taught in induction and spatial training were specific to the ability being trained; and were very different for each training group. Following training, subjects were administered a post-test with the same measures as the pretest.

Strategy Usage Coding Procedure

Subjects' pre and posttest materials for the ADEPT Letter Series and Word Series tests were coded for strategy use. Only markings associated with the strategies taught.. during the inductive reasoning training were scored for strategy use. Three strategies were coded: 1) slashes between repeats in patterns; 2) tick marks between skipped letters or words; and 3) underlining of repeated letters/numbers in a series. A minimum of two "strategy marks" was required in order for an item to be scored as exhibiting strategy use. In order to identify strategy use on the measures of inductive reasoning, trained coders followed strict guidelines for the coding procedure. Coders were blinded as to the training group of the subject. Inter-rater reliability was assessed among the two coders and was found to be .87.

Each item was coded "0" or "1" for whether or not strategy use was indicated. Total strategy use scores were calculated separately for ADEPT Letter Series and Word Series measures by summing the number of individual items on which strategy use was indicated. Change scores representing post-test minus pre-test changes in strategy use were computed for each subject on both ADEPT Letter Series and Word Series measures and used in regression analyses.

Results

The results address three questions: 1) Does the increase in strategy use indicated by pattern marking on test problems differ by training group from pre to post-test? 2) What subject characteristics are associated with strategy use? And 3) Is a pre to post-test increase in strategy use associated with training gain on inductive reasoning measures? Repeated measures analysis of covariance was performed to examine the effects of training group, gender, decline status, replicate, and age on strategy use. Hierarchical regression was used to investigate the association between increases in strategy use and a number of demographic variables and training gains.

Pre to Post-Test Increase in Strategy Use

Letter Series: For the ADEPT Letter Series measure, a repeated measures Analysis of Covariance (ANCOVA) was performed to investigate the association between a number of variables including age/cohort, training group, gender, inductive reasoning decline status, and change in strategy use, Specifically, a 2 occasion (pretest, posttest) x 2 training group x 2 reasoning status (stable, decline) x 2 replicate (1984, 1991) x 3 age/cohort (64-70 years, 71-77 years, and 78-85 years) x 2 sex ANCOVA was conducted (Table 2). Education was entered into the analysis as a covariate. The dependent variable was pre and post-test strategy use scores. Inductive reasoning status was defined as "decline" if the subject's score at pre-test was one standard error of measurement (SEM) below their 1970 score on the PMA reasoning measure (overall, 4 raw points). Subjects who did not meet this decline criteria for inductive reasoning were classified as having remained stable on reasoning. Full models were run and results examined, all non-significant higher order interactions were excluded from the final, reduced models reported here.

Table 1 shows pre and post-test means and standard deviations for strategy use on the Letter Series inductive reasoning measure. A significant occasion x training interaction ($p < .001$) indicated that subjects trained on inductive reasoning showed significantly greater increase in strategy use from pre to post-test than did subjects trained on spatial orientation. A significant occasion x education interaction ($p < .05$) suggested that irrespective of training group, subjects with higher education showed significant pre to post-test strategy use gain. A significant occasion x age/cohort interaction indicated that pre to post-test strategy use gain differed by subjects' age. Examination of the means revealed that younger subjects (age 64-70) showed significantly greater gain in strategy use from pre to post-test than did older subjects (ages 71-77 and 78-85) (Table 1). Non-significant occasion x sex and occasion x reasoning status interactions indicated that pre to post-test strategy use gain did not differ between males and females or by subjects' reasoning decline status. The occasion x replicate interaction was also non-significant suggesting that increases in strategy use from pre to post-test did not differ across the 1984 and 1991 replicates. All higher order interaction were non-significant (Table 2).

Word Series: A repeated measures analysis of covariance was performed to investigate the association between age/cohort, gender, training group, replicate and inductive reasoning status, and change in strategy use from pre to post-test on the Word Series measure. Specifically a 2 occasion (pre-test, post-test) x 2 sex x 2 training group (reasoning , space) x 3 age/cohort (64-70, 71-77, and 78-85) x 2 replicate (1984, 1991) x 2 inductive reasoning status (stable, decline) ANCOVA was conducted (Table 2). Education was entered as a covariate. The dependent variable was pre and post-test strategy use scores on the Word Series measure. A fully crossed model was run and results were examined. Non-significant higher order interactions were excluded from the final, reduced model reported here.

Table 1 shows pre and post-test means and standard deviations for strategy use on the Word Series measure. A significant occasion x training group interaction ($p < .001$) indicates that subjects trained on inductive reasoning showed significantly greater pre to post-test strategy use gain than did control subjects trained on spatial orientation (Table 2). A significant occasion x education interaction ($p < .01$) suggests that irrespective of training group, subjects with higher education were more likely to show pre to post-test strategy use gain. A significant occasion x age/cohort interaction ($p < .05$) indicates that pre to post-test gain on strategy use differed by

subjects' age. Examination of the means revealed that the youngest group (age 64-70) had significantly greater pre to post-test strategy use gain than did both the middle and older groups (ages 71-77 and 78-85, respectively) (Table 1). Non-significant occasion x sex or occasion x reasoning decline status interactions suggested that pre to post-test strategy use gain did not differ by subjects' sex or reasoning status. A non-significant occasion x replicate interaction indicated that pre to post-test strategy use change did not differ between the 1984 and 1991 replicates. Table 2 shows that all higher order interactions were non-significant.

Strategy Use and Training Gains

Hierarchical regression was used to investigate the relationship between strategy use and pre to post-test training gains. Separate analyses were conducted for Letter Series and Word Series measures. For each measure, the interaction between training group and pre to post-test change in strategy use was entered into the models in the first step since it was the variable of interest. In addition, change in strategy use, decline status on inductive reasoning and training group were also entered in to the first step of the models. In the second step of both models demographic variables including age, gender, and education were added. The interactions between change in strategy use and demographic variables (age, gender, and education) and reasoning decline status and change in strategy use were added in the third and final step of the models. Results are reported separately for each measure.

ADEPT Letter Series: Table 3 shows hierarchical regression results for pre to post-test gains on the ADEPT Letter Series measure. Training group, pre to post-test change in strategy use, reasoning decline status, and the interaction between training group and change in strategy use were entered in the first step of the model resulting in an R^2 of .063. The training group by pre to post-test change in strategy use interaction was found to be a significant ($p < .001$) predictor of pre to post-test gain on Letter Series. Examination of the parameter estimate associated with this interaction revealed that subjects who were trained on reasoning and who showed greater pre to post-test strategy use gain also showed greater pre to post-test gain on the Letter Series reasoning ability measure. Training group was also a significant predictor of pre to post-test gain ($p < .01$). The parameter estimate associated with the training group variable suggests that subjects who were trained on inductive reasoning showed significantly greater pre to post-test gain than did subjects who were trained on spatial orientation. Reasoning stability and change in strategy use were not significant predictors of training gains (Table 3).

In the second step of the model demographic variables (age, education, and gender) were added resulting in a non-significant change in the R^2 of the model ($F(7, 384) = .876$). Table 3 shows that the demographic variables were not significant predictors of pre to post-test change on the Letter Series measure. In the third and final step of the model the interactions between change in strategy use for pre to post-test and demographic and reasoning stability variables were entered resulting in a non-significant change in the R^2 of the model ($F(11, 380) = .962$). None of the interaction terms were significant predictors of training gains.

Word Series: Table 4 shows hierarchical regression results for pre to post-test gains on the Word Series measure. Training group, pre to post-test change in strategy use, stability on inductive reasoning, and the interaction between training group and change in strategy use were added in the first step of the model resulting in an R^2 of .059. Training group was the only significant ($p < .001$) predictor of gain on the Word Series measure. The parameter estimate

associated with the training group variable indicates that subjects trained on inductive reasoning showed significantly greater pre to post-test gains on the word series measure than did subjects trained on spatial orientation. Demographic variables including age, gender, and education were added in the second step of the model resulting in a significant change in the R^2 of the model ($F(7, 384) = 2.32$). Age was a significant ($p < .05$) predictor of pre to post-test change on the word series measure. Examination of the parameter estimate associated with the age variable revealed that younger subjects showed significantly greater gains on the word series measures than did older subjects. The interactions between change in strategy use and demographic and reasoning stability variables were added in the third step of the model resulting in a non-significant change in the R^2 of the model ($F(11, 179) = .867$). Table 4 shows that none of the interaction terms were significant predictors of training gains on the word series measure.

Discussion

The present study examined strategy use and cognitive training gains. Subject characteristics associated with strategy use and the relationship between increased strategy use and training group were investigated. In addition, the association between increased strategy use and performance on inductive reasoning measures was also examined.

Results showed that inductive reasoning training resulted in a significantly greater increase in strategy use for on both the Adept Letter Series and Word Series measures than did spatial orientation training. Moreover, high strategy use as a result of reasoning training was associated with greater gains on the Letter Series measure. Only training group was associated with performance gains on the Word Series measure, possibly because this measure was examined as a transfer measure of strategy use. It is possible that if the training program, had included practice items more closely related to the Word Series measure the interaction of reasoning training and strategy use would have significantly predicted increased ability performance on the Word Series measure.

These results suggest strategy use as the mechanism of training gain in the present study. Because there has been considerable debate whether training results in ability measure gain as a result of practice or through the acquisition of skills (i.e., strategies) these findings are especially interesting. The identification and quantification of strategy use as the possible mechanism of training gain suggests that the acquisition of skills as producing training gains rather than practice per se.

Findings support the production deficiency hypothesis (Kausler, 1994) which states that older adults do not produce or use strategies as effectively as younger adults. Results showed that although most subjects trained on reasoning showed increased strategy use, for both Word Series and Letter Series measures younger participants (age 64-70) were more likely to show significant pre to post-test strategy use gain than were older subjects (age 71-85). These findings also suggest that the relationship between age and cognitive training gains may be moderated by strategy use.

Education was also found to be associated with increased strategy use. Participants with higher education levels showed greater strategy use gain irrespective of training group. Although inductive reasoning represents fluid intelligence; specific skills and strategies used to solve reasoning problems may be related to education and are thus subject to behavioral

interventions. Gender and reasoning decline status were found to be unrelated to strategy use gains and findings did not differ significantly across the 1984 and 1991 replicates. These results further support strategy use as the mechanism of training gain as increased strategy use was found to be unrelated to a number of demographic variables including subjects' decline status in the 14-year period prior to training. Non-significant findings for the relationship between reasoning decline status and strategy use gains indicate that increases in strategy use as a result of cognitive training do not differ by subjects' initial level or ability.

This study presents an objective, item by item concrete measure of strategy use on tests of cognitive ability. Although strategy use has been hypothesized to be related to poor performance by older adults on tests of cognition (Charness, 1985; Guttentag, 1985; Kausler, 1994; Salthouse, 1981), prior studies have been unable to provide an objective measure of strategy use and thus to relate enhanced strategy usage to ability measure gains. Moreover, the mechanism of training gain in the present study can be identified by subjects' markings on test materials.

Further investigation at the item level may help to identify which strategies are most efficacious for older adults, aiding in the creation of training programs which will yield maximum results. Additionally, the possible identification of common errors and strategy misuse at the item level would resulting in further insight into age differences in associative memory and strategy production and use.

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Table 1. Pre-test and post-test means and standard deviations for number of items reflecting strategy use for ADEPT Letter Series and Word Series measures by training group ($\underline{N}$ = 393).

	Letter Series		Word Series	
	Pre-Test	Post-Test	Pre-Test	Post-Test
Trained On Reasoning				
Total	0.25 (0.93)	4.64 (4.07)	0.22 (1.30)	3.33 (5.30)
Decline Status				
Stable on Reasoning	0.43 (1.25)	5.13 (4.49)	0.37 (1.76)	3.59 (5.84)
Decline on Reasoning	0.05 (0.27)	4.11 (3.51)	0.06 (0.39)	3.05 (4.67)
Sex				
Male	0.24 (1.02)	4.93 (4.60)	0.22 (1.55)	0.57 (2.16)
Female	0.26 (0.86)	4.39 (3.58)	0.22 (1.05)	2.80 (4.59)
Age/Cohort				
64-70	0.37 (1.17)	5.36 (4.56)	0.33 (1.66)	4.12 (60.7)
71-77	0.10 (0.41)	3.96 (3.17)	0.12 (0.52)	2.67 (4.23)
78-95	0.07 (0.38)	3.07 (2.75)	0.00 (0.00)	1.46 (2.62)
Replicate				
1984	0.20 (0.73)	4.66 (4.19)	0.13 (0.68)	3.17 (5.17)
1991	0.32 (1.16)	4.61 (3.93)	0.35 (1.83)	3.54 (5.50)
Trained On Space				
Total	0.33 (1.33)	0.62 (1.90)	0.45 (1.99)	0.73 (2.51)
Decline Status				
Stable on Reasoning	0.42 (1.55)	0.73 (2.17)	0.57 (2.32)	0.87 (2.83)
Decline on Reasoning	0.10 (0.40)	0.34 (0.86)	0.14 (0.51)	0.37 (1.39)
Sex				
Male	0.40 (1.56)	0.76 (2.26)	0.65 (2.42)	0.92 (2.88)
Female	0.27 (1.12)	0.50 (1.55)	0.28 (1.54)	0.57 (2.16)
Age/Cohort				
64-70	0.48 (1.65)	0.97 (2.48)	0.58 (2.48)	1.04 (3.16)
71-77	0.09 (0.38)	0.24 (0.61)	0.24 (0.94)	0.28 (1.13)
78-95	0.30 (1.35)	0.07 (0.27)	0.44 (1.63)	0.56 (1.76)
Replicate				
1984	0.21 (1.20)	0.54 (1.78)	0.37 (1.98)	0.65 (2.26)
1991	0.47 (1.47)	0.70 (2.04)	0.55 (2.00)	0.82 (2.80)

Table 2. Repeated measures analysis of covariance results (final models) for items exhibiting strategy use on ADEPT Letter Series and Word Series measures, education entered as covariate ($N = 393$).

	Letter Series			Word Series		
Source	DF	MS	F-Value	DF	MS	F-Value
Occasion	1	7.18	1.07	1	0.15	0.04
Training Group	1	125.87	10.19**	1	403.22	64.58***
Sex	1	23.59	1.91	1	3.43	0.55
Age/Cohort	2	36.68	2.97	2	41.34	6.62**
Replicate	1	1.44	0.12	1	6.96	1.12
Reasoning Decline Status	1	17.74	1.44	1	28.16	4.51*
Occasion x Education	1	47.86	7.17**	1	39.96	9.41**
Occasion x Training Group	1	179.07	26.82***	1	442.92	104.31***
Occasion x Sex	1	8.83	1.32	1	2.83	0.67
Occasion x Age/Cohort	2	20.59	3.08*	2	22.47	5.29**
Occasion x Reasoning Status	1	0.01	0.00	1	2.31	0.54
Occasion x Replicate	1	6.05	0.91	1	13.94	3.28
Occasion x Sex x Train	1	14.30	2.14	1	1.07	0.25
Occ. x Age/Cohort x Train	2	10.50	1.57	2	5.04	1.19
Occ. x Reasoning Decline Status x Training Group	1	0.09	0.01	1	3.36	0.79
Occ. x Train x Replicate	1	0.92	0.14	1	1.36	0.32

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

Table 3. Hierarchical regression results for ADEPT Letter Series measure ($N = 393$)

Predictor	Step 1		Step 2		Step 3	
	β	MS	β	MS	β	MS
Training Group x Strategy Use	0.090***	72.03	0.11***	72.03	0.09***	72.03
Strategy Use	-0.11	10.36	-0.15	10.36	-0.03	10.36
Training Group	0.98**	45.74	1.03**	45.73	1.05**	45.73
Reasoning Status	0.28	2.25	0.21	2.25	0.25	2.25
Age			-0.03	9.61	-0.03	9.61
Gender			-0.17	2.69	-0.14	2.69
Education			-0.02	0.84	-0.01	0.84
Strategy Use x Reasoning Status					-0.05	5.97
Strategy Use x Age					-0.01	0.13
Strategy Use x Gender					-0.05	4.77
Strategy Use x Education					0.02	8.52
$R2$	0.063		0.070		0.079	
$\Delta R2$			0.007		0.009	
(df)	(4, 387)		(7, 384)		(11, 380)	

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

Table 4. Hierarchical regression results for Word Series measure (N = 393)

Predictor	Step 1		Step 2		Step 3	
	β	MS	β	MS	β	MS
Training Group x Strategy Use	0.09	20.13	0.12	20.13	-0.08	20.13
Strategy Use	-0.28	7.97	-0.36	7.98	-0.40	7.98
Training Group	1.65***	187.81	1.70***	187.81	1.49***	185.54
Reasoning Status	0.49	4.70	0.35	4.70	0.34	3.76
Age			-0.06*	57.07	-0.06*	50.91
Gender			0.13	1.63	0.12	1.53
Education			-0.01	0.55	-0.01	0.74
Strategy Use x Reasoning Status					-0.14	13.06
Strategy Use x Age					-0.01	19.19
Strategy Use x Gender					0.07	7.30
Strategy Use x Education					0.01	0.25
R^2	0.062		0.078		0.085	
ΔR^2			0.017*		0.007	
(df)	(4, 387)		(7, 384)		(11, 380)	

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