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Modeling Change in Memory Performance and Memory Perceptions: Findings from the ACTIVE Study

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Abstract

Within the context of the ACTIVE study, the current investigation explored the relationships between objective memory and two components of subjective memory (frequency of forgetting and use of external aids) over a five-year period. Relationships were assessed using parallel process latent growth curve models. Results indicated that changes in objective memory were associated with changes in perceived frequency of forgetting, but not with use of external aids (calendars, reminder notes) over time. Findings suggest that memory complaints may accurately reflect decline in objective memory performance, but that these memory changes are not necessarily related to compensatory behaviors.

Keywords

objective memory; subjective memory; latent growth curves; later adulthood

The aging process is often accompanied by a multitude of cognitive changes. Although research indicates that age-related changes in processing speed, working memory, inductive reasoning, spatial orientation, and word fluency are normative, there is considerable inter-individual variability in the rate of such changes (Anstey, Hofer, & Luszcz, 2003; Hultsch, Strauss, Hunter, & MacDonald, 2008; Schaie, 2005). Increased age is also accompanied by a reduction in the subjective report of cognitive function (Cutler & Grams, 1988; Zarit, Cole, & Guider, 1981). In fact, perceived decline in memory performance is one of the most common complaints among even the healthiest older adults (Bassett & Folstein 1993;

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Hertzog, Park, Morrell, & Martin, 2000). According to the accuracy monitoring hypothesis, individuals are able to accurately identify their current level of memory ability, as well as monitor changes in memory performance over time (e.g., Hertzog & Hultsch, 2000; Lane & Zelinski, 2003). As such, a greater number of memory complaints would be expected when confronted with age-related changes in cognitive ability. Moreover, theories of compensation (e.g., Bäckman & Dixon, 1992) suggest that older adults who perceive these cognitive declines may begin to use external aids (such as note taking, calendars, and reminder notes) or other strategies as a means of maintaining activities dependent on memory function.

Previous cross-sectional and longitudinal investigations have demonstrated significant associations between frequency of memory complaints and objective performance on memory tasks (e.g., Bolla, Lindgren, Bonaccorsy, & Bleeker, 1991; Lane & Zelinski, 2003; Ponds & Jolles, 1996; Reese & Cherry, 2006; Zelinski, Gilewski, & Anthony-Bergstone, 1990; Zelinski, Gilewski, & Schaie, 1993); although findings are mixed (e.g., Dixon & Hultsch, 1983; McDonald-Miszczak, Hertzog, & Hultsch, 1995; Sunderland, Watts, Baddeley, & Harris, 1986; Taylor, Miller & Tinklenberg, 1992). Likewise, there are inconsistencies in the literature concerning the relations between use of mnemonic techniques, including external memory aids, and actual memory ability. Although few in number, an interesting finding has been that greater use of external aids is associated with better rather than worse performance on memory tasks (Cook & Marsiske, 2006; Intons-Peterson & Fournier, 1986); however, most studies have found no relationship between use of these compensatory aids and memory self-efficacy or actual memory performance (Bolla et al., 1991; McDonald-Miszczak, Gould, & Tychynski, 1999; McDougall, 1995). These inconsistencies may be partly due to the differences in study design (e.g., cross-sectional vs. longitudinal) and sample selection (e.g., healthy vs. cognitively impaired), as well as the definition and measurement of both objective and subjective memory.

The present investigation examines the dynamic associations between performance on objective tests of memory function and two components of subjective memory (frequency of forgetting and use of external aids) within the context of the Advanced Cognitive Training for Independent and Vital Elderly (ACTIVE) study (Ball et al., 2002). The main purpose of ACTIVE was to examine the effectiveness and durability of cognitive interventions on basic measures of cognition, as well as immediate and long-term transfer effects to everyday activities. Because ACTIVE employed multiple longitudinal measures of both objective and subjective memory performance, this study provides a unique opportunity to examine the extent to which age-related decline in memory performance is associated with both self-reported memory limitations and use of external aids over time.

Methods

Participants

Data were collected as part of the Advanced Cognitive Training for Independent and Vital Elderly (ACTIVE) study (see Ball et al., 2002; Jobe et al., 2001 for detailed description of recruitment procedures and study design). Briefly, participants ($N = 2,802$) were randomized into one of three ACTIVE cognitive training interventions (memory ($n = 703$), reasoning ($n = 699$), and processing speed ($n = 702$)) or to a no-contact control condition ($n = 698$). Participants assigned to one of the three treatment groups received 10 training sessions (each approximately 1 to 1.5 hours in duration) over the course of 5 to 6 weeks. To evaluate the effects of ACTIVE training, measurement of cognitive and functional skills were obtained at baseline, immediate post-training, and 1, 2, 3, and 5 years following the intervention (efforts are currently underway to collect 10-year follow-up data). For purposes of the present

investigation, data from the ACTIVE memory training and control groups were used for analyses.

The analytic sample was comprised of 1,401 healthy, independently-living older adults. At baseline, participants ranged in age from 65 to 94 years ($M = 73.8$ years; $SD = 6.0$), had an average of 13.5 years of formal education, and did not display significant cognitive impairment or dementia (as indicated by Mini-Mental State Exam (MMSE) scores > 23 ; Folstein, Folstein, & McHugh, 1975) ($M = 27.3$; $SD = 2.0$). The majority of participants were female (75%), White (73%), and reported their health as good, very good, or excellent (85%). No significant differences were found between the memory trained and no-contact control conditions for age, education, sex, race, cognitive status (MMSE; Folstein et al., 1975), depressive symptoms (Center for Epidemiologic Studies Depression Scale (CES-D); Radloff, 1977), or self-rated health status (measured on a 5-point scale ranging from Excellent (1) to Poor (5)) at baseline (all $ps > 0.05$).

Measures

Objective Measure of Memory Functioning—*Objective Memory Functioning* was assessed via three measures of episodic verbal memory performance: Hopkins Verbal Learning Test (HVLT; Brandt, 1991; Brandt & Benedict, 2001), Rey Auditory Verbal Learning Test (AVLT; Rey, 1964; Schmidt, 2004), and Rivermead Behavioral Memory Test-Paragraph recall (RBMT; Wilson, Cockburn, & Baddeley, 1985). Scores for each test were first standardized to their baseline mean and standard deviation using Blom transformation procedures (Blom, 1958). These standardized scores were averaged to create a composite memory measure to be used for analysis. Because alternate versions of these measures were administered across study time points, the composite memory measure was further adjusted using an equipercentile equating procedure to account for differences in test difficulty. This procedure ensures that all forms have a comparable mean and standard deviation, thus allowing for valid within-person comparisons over time (see Kolen & Brennan, 1995).

Subjective Measure of Memory Functioning—*Subjective Memory Functioning* was assessed via an abbreviated Memory Functioning Questionnaire (MFQ; Gilewski, Zelinski, & Schaie, 1990; Zelinski et al., 1990), a self-report inventory that aims to assess how people appraise their memory abilities.¹ Questions from two subscales were administered as part of the ACTIVE assessment battery and used in analyses: *Frequency of Forgetting*, which assessed perceptions of difficulty when performing certain tasks (e.g., remembering phone numbers, personal dates, things people tell you; 14-items); and *External Aids*, which asked how frequently the following memory aids were used as memory reminders (4-items): keeping an appointment book, writing reminder notes, making lists of things to do; and keeping things you need to do in a prominent place where you will notice them. Individuals rated each item on 7-point scale (1 = always; 7 = never). To form each subscale, responses to individual items (within each of the subscales) were averaged together and used for analysis. Lower numbers are indicative of increased subjective memory complaints (for frequency of forgetting subscale) or greater use of external aids.

Data Analysis

The longitudinal relationships between objective and subjective memory were examined using parallel process growth curve modeling (Muthén, 1997; Muthén & Muthén, 2008). Parallel process models are a type of latent growth curve model in which latent intercepts

¹The full version of the MFQ consists of 64-items and assesses: (a) General Frequency of Forgetting, (b) Seriousness of Forgetting, (c) Retrospective Memory Functioning, and (d) Mnemonic Usage (see Gilewski et al., 1990).

and slopes for one growth process (i.e., objective memory) are regressed on or correlated with corresponding intercepts and slopes for another process (i.e., subjective memory processes) (MacKinnon, 2008). This analytical technique allowed us to simultaneously model the growth curves of objective memory (defined by the equipercentile equated memory composite measure) and subjective memory (defined by the Frequency of Forgetting and External Aids subscale scores). Specifically, we examined: 1) whether baseline objective memory performance is associated with changes in MFQ scores over time; 2) whether MFQ scores at baseline are associated with changes in objective memory performance over time; and 3) to what extent change in objective memory performance is correlated with longitudinal change in subjective memory performance over a five-year period.

All analyses were conducted using the MPLUS (version 5.21) software package (Muthén & Muthén, 2008). Model parameters were estimated using a robust full-information maximum likelihood estimation procedure that assumes data are missing at random and makes the chi-square test and standard errors robust to non-normality (Yuan & Bentler, 2000). Overall goodness of model fit was assessed with standard model fit indices, including: chi-square tests (Jöreskog & Sörbom, 1996), root mean square error of approximation (RMSEA; Steiger, 1989), comparative fit index (CFI; Bentler, 1990), and the standardized root mean square residual (SRMR; Browne & Cudeck, 1993). An RMSEA smaller than 0.05, a CFI larger than 0.95, and SRMR smaller than 0.08 indicate excellent model fit (Hu & Bentler, 1999).

Initial analyses were conducted to ensure correct model specification (results not presented). Briefly, unconditional growth models (without covariates) were first estimated separately for the objective memory composite measure and the two subjective memory components (frequency of forgetting and use of external aids) to determine the shape of the individual growth trajectories. Once a suitable fit was obtained for each process, a parallel process model was employed to simultaneously model and analyze these three growth curves.² All slope growth factor means and variances differed significantly from zero, suggesting considerable inter-individual variability in the growth rates for both objective and subjective memory. Due to the potential confounding relationships with both objective and subjective memory, the final model adjusted for age, years of education, sex, and ethnicity, as well as for depressive symptoms (CES-D; Radloff, 1977) and self-reported health status, all measured at baseline (see Figure 1 for final model specification). This model provided an excellent fit to the data (Table 1).

Results

We present relations between latent variables from the final adjusted model (Figure 1). For each measure of memory, we first present standardized regression coefficients describing the association between covariates and intercepts and slopes before discussing the relations between objective memory and subjective memory.

²In our initial conceptualization of this work, we anticipated differences between memory-trained and control groups. This model was first estimated in a two-group analysis to see if the structural regression relationships between the latent growth parameters differed across training groups. To accomplish this, parameters were first constrained to be the same in each intervention condition, and in a subsequent model, parameters were allowed to vary across groups. Likelihood ratio tests were used to test for equality of regression parameters between the two models, with a significant value indicating that rate of growth varies as a function of treatment condition. We found that freeing parameters did not significantly improve the model fit, $X^2(7, N = 1,401) = 4.48, p = 0.72$, indicating there were no significant differences between the treatment groups. Analyses proceeded using a single-group parallel process model that did not distinguish between treatment groups.

Objective Memory

At baseline, individuals who were younger ($\beta = -0.39$), female ($\beta = 0.25$), White ($\beta = 0.24$), had more years of education ($\beta = 0.29$), and reported fewer physical health complaints ($\beta = -0.11$) and fewer depressive symptoms ($\beta = -0.10$) demonstrated better baseline performance on the objective memory composite measure (all $ps < 0.01$; results not shown in Table 1). Only age ($\beta = -0.36$), sex ($\beta = -0.13$), and education ($\beta = -0.17$) were associated with the rate of change over time, such that older, male, and less educated individuals had a steeper annual rate of decline on the memory composite. We did not find any evidence to suggest that objective scores at baseline influence the trajectories of frequency of forgetting or use of external aids over time. Similarly, trajectories of change in objective memory performance were not associated with initial status of either MFQ subscale (Table 1).

Frequency of Forgetting

For frequency of forgetting, individuals who were younger ($\beta = -0.12$), White ($\beta = 0.14$), had more years of education ($\beta = 0.16$), and reported fewer physical health complaints ($\beta = -0.23$) and fewer depressive symptoms ($\beta = -0.21$) reported less difficulty in performing certain memory tasks (e.g., remembering phone numbers, dates) (all $ps < 0.001$) at baseline. Older adults ($\beta = -0.17$) and those who initially reported lower rates of forgetting at baseline ($\beta = -0.29$) reported more memory complaints over time ($ps < 0.05$; Table 1).

In our final (adjusted) model we allowed the intercept and slope of objective memory to correlate with the corresponding intercepts and slopes for each of the subjective memory components (see Figure 1).³ This enabled us to examine both the cross-sectional associations between objective and subjective memory, as well as the extent to which change in objective memory performance is correlated with longitudinal change in subjective memory performance over a five-year period. After adjusting for the effects of covariates (age, education, race, sex, and physical and mental health status), we found that the intercepts for frequency of forgetting and objective memory were positively related ($pr = 0.29$, $p < .01$), suggesting that the initial level of performance on memory tasks is associated with the initial report of memory complaints. More interestingly, the slopes of these two processes were also positively related ($pr = 0.44$, $p < .01$) after adjusting for demographic and health characteristics. In other words, findings suggest that change in objective memory performance is associated with change in self-reported frequency of forgetting over the five-year period, supporting the notion that individuals can accurately detect changes in memory ability over time (Table 1).

External Aids

For use of external aids, at baseline, individuals who were White ($\beta = -0.15$), female ($\beta = -0.20$), and had more years of education ($\beta = -0.25$) reported using external aids more frequently (all $ps < 0.01$). Additionally, individuals who reported less initial use of these mnemonic techniques reported greater use over time (Table 1). No demographic characteristics significantly predicted change in usage over the five-year period (all $ps > 0.05$). In contrast to findings for the MFQ frequency of forgetting growth process, neither the intercept nor slope for use of external aids was significantly correlated with the intercept and slope for objective memory, suggesting that baseline level and change in use of external aids were not associated with objective memory performance.

³Correlations obtained from an unconditional model (without covariates) were largely unchanged once covariates were added to the model.

Discussion

Over several decades of memory research, the question of whether older adults are truly accurate in monitoring memory problems is still debated. In the present study, the use of parallel-process models allowed us to simultaneously model and analyze the growth curves of objective and subjective memory to determine the relations between these two memory processes. Our findings suggest that changes in the report of frequency of forgetting are associated with concomitant change in objective memory performance and corroborate findings from other studies demonstrating reliable associations between the MFQ Frequency of Forgetting subscale and memory performance over time (e.g., Lane & Zelinski, 2003). As such, self-reported memory difficulties (e.g., remembering personal dates, phone numbers) appear to reflect age-related changes in cognitive ability, thus providing some support for the accuracy monitoring hypothesis. Moreover, given the prevalence of memory complaints among older adults, these self-appraisals may be used as a clinical indicator of age-related declines in cognition, and therefore, potentially useful to clinicians in the identification and treatment of memory impairments (LaRue, Small, McPherson, & Komo, 1996).

It was also expected that if individuals were accurate in detecting memory limitations, they would use external aids to a greater degree in order to compensate for these declines (and therefore demonstrate better performance on memory tasks). This may partly explain why older adults tend to report greater use of external aids, including writing notes, using calendars, making lists, and keeping objects and things in specific places so they can be easily found (Bolla et al., 1991; Cavanaugh, Grady, & Perlmuter, 1983; McDougall, 1995; Reese & Cherry, 2006; Schmidt, Berg, & Deelman, 2001). In the present study, however, increased use of external aids was not associated with either the intercept or slope of perceived frequency of forgetting. Because only a limited number of MFQ items were administered in the ACTIVE study, it is possible that the selected external aids (e.g., keep an appointment book, make lists of things to do) were largely unrelated to the type of memory limitations (e.g., trouble remembering text when engaged in reading activities) assessed. Further, we did not find any evidence to suggest that use of compensatory aids was related to actual memory performance. It should be mentioned that, on average, individuals in the ACTIVE sample frequently reported using external aids (e.g., calendars, reminder notes) across the five-year period (means ranged from 2.72 to 2.87 on a 7-point scale; 1 = always, 7 = never). Therefore, the limited variability of responses may have hindered our ability to reliably detect relationships between external aids and memory performance.

Although it is likely that subjective evaluations of memory performance reflect age-related decline to some extent, other factors may also influence this relationship. First, the subjective-objective memory association may be confounded by age since we found that older age was associated with both greater memory complaints and more decline in memory performance over time (Gilewski et al., 1990; Hultsch, Hertzog, & Dixon, 1987; Zelinski et al., 1993). Second, self-reports of memory may reflect negative expectations about age-related decline in memory performance (e.g., Cavanaugh et al., 1983; McDonald-Miszczak et al. 1995), instead of personal insight into one's level of memory ability. Lastly, we may have failed to include other variables that may be related to memory performance and/or perceptions (e.g., personality; Lane & Zelinski, 2003; Pearman & Storandt, 2004).

The current findings may also partly reflect the way in which objective and subjective memory were assessed. In the ACTIVE trial, objective memory was assessed via three measures of verbal episodic memory (HVL: Brandt, 1991; AVL: Rey, 1964; Schmidt, 2004; RBMT: Wilson et al., 1985). It may be that the relationship between objective and subjective memory processes would have differed if objective memory tasks tapped into other components of memory performance. For instance, the use of external aids (e.g.,

appointment book, reminder notes) may have stronger relations with remembering to perform a future task (i.e., prospective memory). With regard to the MFQ, frequency of forgetting asks how often certain tasks (e.g., phone numbers, words, losing the thread of thought in conversation) present a problem and does not ask specifically about memory beliefs, memory competency, seriousness of the memory difficulty, or perceived *change* in memory ability over time. Additionally, we only assessed external strategies; thus, we cannot determine if the same relationships would be found for use of internal, self-generated (and perhaps more cognitively complex) memory techniques. Further, only a small sample of external strategies (4-items) was assessed, possibly limiting the reliability of findings for this subscale. Using these indicators, we found that individuals who initially reported fewer memory problems or less use of external aids experienced an increase in perceived memory problems and used more external strategies over the five-year period. Although we acknowledge that this may represent regression to the mean, the inclusion of multiple assessments and a large sample size increases confidence in these findings.

Our findings are informative given that few studies have examined the longitudinal associations between subjective and objective memory, often resulting in inconsistent findings. It has been suggested that one of the reasons that the literature has produced mixed findings regarding the subjective-objective memory relationship is because "...this relationship is modest at best, and many studies do not have sufficient sample sizes to confirm the finding" (Zelinski, Burnight, & Lane, 2001, p. 250). The ACTIVE study includes a large enough sample size and repeated administration of measures spanning across several years, which allows us to reliably detect relations between objective and subjective memory processes. Although we found a significant association of moderate strength between objective and subjective memory over a 5-year period, it is plausible that these relations may change over a longer time frame. Replication within this sample over a 10-year period (data are currently being collected) may yield additional findings on the relations between these memory processes.

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Figure 1. Parallel Process Latent Growth Model of Subjective and Objective Memory

Parallel process model of objective and subjective growth processes across six measurement occasions. Latent variables were regressed on covariates, which included age, education, sex, self-rated health, race, and depressive symptoms, measured at baseline. Residual variance components (error variances) are shown by smaller arrows going towards the observed (boxed) and latent (circled) dependent variable components in the model. Numbers on arrows going from latent growth parameters to observed time points indicate factor loadings. OBJ = objective memory; MFQ = Memory Functioning Questionnaire (subjective memory); T = time of assessment.

Table 1
Associations Between Initial Status and Change in Objective Memory and MFQ Subscales

	Objective Memory		Frequency of Forgetting		External Aids	
	Standardized Coefficient	95% CI	<i>pr</i>	Standardized Coefficient	95% CI	<i>pr</i>
Residual Correlations						
OBJ Intercept with MFQ Intercept			0.29 **			-0.10 **
OBJ Slope with MFQ Slope			0.44 **			-0.04
Regressions						
OBJ Slope on OBJ Intercept	0.24 *	(0.07, 0.41)				
OBJ Slope on MFQ Intercept			0.06	(-0.09, 0.21)	-0.11	(-0.23, 0.02)
MFQ Slope on MFQ Intercept			-0.29 *	(-0.45, -0.13)	-0.23 *	(-0.38, -0.07)
MFQ Slope on OBJ Intercept			0.13	(-0.05, 0.32)	0.15	(-0.07, 0.37)
Model Fit Statistics						
RMSEA (90% CI)	0.026 (0.022, 0.030)					
CFI	0.986					
SRMR	0.036					

Note. OBJ = objective memory (equipercntile equated memory composite score). MFQ = subjective memory (ratings made on a 7-point scale; 1 = always, 7 = never); *pr* = partial correlation. Results (presented here) adjusted for age, education, sex, race, self-rated health, and depressive symptoms at baseline.

* $p < 0.05$.

** $p < 0.01$.