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Decomposing the relationship between cognitive functioning and self-referent memory beliefs in older adulthood: what's memory got to do with it?

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ABSTRACT

With advancing age, episodic memory performance shows marked declines along with concurrent reports of lower subjective memory beliefs. Given that normative age-related declines in episodic memory co-occur with declines in other cognitive domains, we examined the relationship between memory beliefs and multiple domains of cognitive functioning. Confirmatory bi-factor structural equation models were used to parse the shared and independent variance among factors representing episodic memory, psychomotor speed, and executive reasoning in one large cohort study (*Senior Odyssey, N* = 462), and replicated using another large cohort of healthy older adults (*ACTIVE, N* = 2802). Accounting for a general fluid cognitive functioning factor (comprised of the shared variance among measures of episodic memory, speed, and reasoning) attenuated the relationship between objective memory performance and subjective memory beliefs in both samples. Moreover, the general cognitive functioning factor was the strongest predictor of memory beliefs in both samples. These findings are consistent with the notion that dispositional memory beliefs may reflect perceptions of cognition more broadly. This may be one reason why memory beliefs have broad predictive validity for interventions that target fluid cognitive ability.

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Introduction

The relationship between memory beliefs and memory performance has been a major topic of investigation in cognitive aging for the past three decades (Beaudoin & Desrichard, 2011; Berry, 1999; Dixon & Hultsch, 1983; Gilewski & Zelinski, 1986; Hertzog, Dixon, & Hultsch, 1990; Rebok & Balcerak, 1989; Stine-Morrow, Shake, Miles, & Noh, 2006; West & Yassuda, 2004). However, little attention has been given to

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understanding the extent to which poor subjective memory beliefs may reflect broader changes in general cognitive functioning. Age-related declines occur in a constellation of abilities, including changes in executive reasoning, psychomotor speed, and episodic memory (Park et al., 1996), and these declines are strongly inter-correlated (McArdle, Ferrer-Caja, Hamagami, & Woodcock, 2002; Payne et al., 2014), forming a "positive manifold" (Deary, Penke, & Johnson, 2010; Tucker-Drob, 2011; cf. Spearman, 1904) of general fluid cognitive functioning. In the current studies, we assessed whether older adults' self-perceptions of memory reflect variation in multiple cognitive domains. Specifically, we aimed to test whether self-referent memory beliefs were uniquely related to variation in episodic memory performance after accounting for variation in performance in non-memorial cognitive domains.

Subjective memory beliefs and memory aging

Older adults' beliefs about the effectiveness of their own memory functioning have been shown to play a substantial role in the domain of memory aging (Crumley, Stetler, & Horhota, 2014; Hertzog & Hultsch, 2000). With advancing age, older adults show marked decline in episodic memory performance (Park et al., 1996), and a concurrent decline in positive subjective beliefs about their memory (Berry, 1999; Lineweaver & Hertzog, 1998). Importantly, memory performance has been shown to have a modest but reliable relationship with beliefs about memory, with some suggesting that age-related declines in memory beliefs are partially responsible for declines in episodic memory (Berry & West, 1993; Parisi et al., 2011; Stine-Morrow et al., 2006). A recent meta-analysis of over 100 studies by Beaudoin and Desrichard (2011) has shown that the meta-analytic correlation between memory beliefs and memory performance is statistically significant, but rather modest (r = .15), with substantial variability in effect sizes across studies.

A major topic in the literature on self-efficacy beliefs more generally revolves around the domain specificity and generality of self-efficacy measures (Pajares, 1997). A distinction is made in the literature between at least two conceptions of (and measurement approaches to) self-referent memory beliefs (Beaudoin & Desrichard, 2011; Berry, 1999; Hertzog & Hultsch, 2000). One set of models focuses on task-specific metacognitive judgments about the ability to carry out specific memory tasks (Berry, West, & Denehey, 1989). Task-specific approaches to assessing memory beliefs (i.e., *concurrent memory self-efficacy*; Beaudoin & Desrichard, 2011) highlight the situational and domain-specific nature of memory assessments, as they concern performance judgments for very specific memory tasks, such as reporting confidence in the ability to memorize 10 words in a verbal learning memory trial. Another approach focuses on the stable and global dispositions that older adults may hold about their memory. *Global memory self-efficacy* reflects an individuals' generalized perception of his or her usual memory ability abstracted across task contexts (Hertzog & Dixon, 2005; Hertzog, McGuire, Horhota, & Jopp, 2010).

Within the domain of memory, there is evidence that measures of self-efficacy that more closely assess the task and goal demands of a memory task tend to be more predictive of performance than dispositional measures of global memory beliefs (see Berry, Hastings, West, Lee, & Cavanaugh, 2010 for a review), consistent with the broader self-efficacy literature (Bandura, 1994). Moreover, measures of task-specific memory self-efficacy are more predictive of memory than those that assess general self-efficacy and related constructs (e.g., control beliefs; Lachman & Agrigoroaei, 2012). However, much less is known about how beliefs about memory manifest themselves in the context of cognitive aging, in which age-related declines in cognitive abilities tend to intercorrelate. There exists almost no research examining the specificity of memory belief measures in terms of their discriminant relationships with memory performance compared to performance in other cognitive domains. Thus, an important, and as yet unaddressed, question in the literature exists: Do older adults' self-perceptions of memory specifically reflect memory ability or variation in cognitive function more generally?

Recently, some studies (Haslam et al., 2012; Jopp & Hertzog, 2007; Payne et al., 2012) have considered broader relationships between memory beliefs and cognition (i.e., outside the domain of memory per se). For example, a recent epidemiological study examined relationships between subjective memory complaints, memory performance, and cognitive impairment in a large (*N* = 16,964) sample of elderly women (Amariglio, Townsend, Grodstein, Sperling, & Rentz, 2011). In addition to showing an association between number of memory complaints and delayed verbal recall, memory complaints were associated with a higher risk of cognitive impairment. Importantly, because poorer memory performance is related to higher risk of cognitive impairment (e.g., Bennett et al., 2002), the relative contributions from memory-specific performance and non-memorial cognitive performance to memory complaints is not clear. Haslam and colleagues (2012) assessed the influence of negative age-related stereotype threat related to memory on both general cognitive function and episodic memory performance. They found evidence for domain-specific stereotype-threat effects: when older adults were primed with negative stereotypes about memory, they selectively showed poorer performance on memory tasks, but when primed with negative stereotypes about cognition more generally, a larger proportion of older adults scored below threshold on a general test of cognitive function. Although this study is relevant to the current aims, it is not entirely clear how stereotype threat and general dispositional beliefs about memory are related in adulthood (Hess, 2014). In the current study, we used a confirmatory bi-factor model approach to examine the relative contributions of different cognitive domains to memory beliefs in older adulthood.

Bi-factor model of cognitive ability

Bi-factor models have their roots in early factor analytic studies of intelligence (e.g., Holzinger & Swineford, 1937; Schmid & Leiman, 1957). More recently, bi-factor models have gained resurgence in structural equations modeling (SEM) and item-response-theory (IRT) approaches (Reise, 2012). These models have been commonly applied to the problem of how to assess construct multidimensionality in topics ranging from intelligence to health behaviors to psychopathology (Chen, West, & Sousa, 2006; Lahey et al., 2012; Reise, Morizot, & Hays, 2007). Generally, the bi-factor model allows for a partitioning of variance among observed manifest variables, such that latent variables are formed for both a domain-general factor, as well as a set of domain-specific factors that are called bi-factors. In the bi-factor model, each observed variable is allowed to have a positive loading on a general factor, as well as on one or more bi-factors. Bi-factors, then, are domain-specific latent factors from which domain-general variance has been partialled out.

The most useful psychometric property of bi-factor models is the emergence of orthogonal latent factors that represent unique variance among more conceptually narrow factors. Regarding the factor structure of cognitive ability, this representation allows for modeling of both a general factor (e.g., g_f) as well as domain-specific factors (e.g., speed of processing, inductive reasoning, episodic memory). Because each factor is uncorrelated, the factors represent a partitioning of variance among observed variables into general and specific latent traits, which can then be used to predict another construct of interest in the structural part of the model. We can use this formulation to examine unique variation in memory, reasoning, and speed, after accounting for the shared variance among these domains, as well as to examine the relationships between each cognitive factor and distal covariates such as memory beliefs (e.g., Chen, Hayes, Carver, Laurenceau, & Zhang, 2012; Simms, Grös, Watson, & O'Hara, 2008; cf. McCabe, 2010).

The current study

In the current study, we adopted the bi-factor model to test the unique relationship between memory beliefs and memory performance, while simultaneously assessing the relationships between memory beliefs and other cognitive domains. This model is particularly advantageous in developing a multivariate measurement model of cognitive abilities among older adults, given that the so-called positive manifold (i.e., the observation of moderate-to-high positive correlations across all cognitive tasks; Deary et al., 2010) has been reported to increase with advancing age, a phenomenon referred to as de-differentiation (de Frias, Lövdén, Lindenberger, & Nilsson, 2007; Tucker-Drob, 2011).

To the extent that measures of memory beliefs reflect perceptions of cognition more generally, the relationship between memory performance and memory beliefs may be partially accounted for by a broader domain-general cognitive functioning factor (g_f; made up of psychomotor speed, executive reasoning, and episodic memory). On the other hand, if memory beliefs are uniquely tied to memory performance, then one would expect the magnitude of the association between memory beliefs and memory performance to remain similar or even increase after accounting for non-memory specific variation present in the memory factor.

To test the replicability and generalizability of this model across samples and test measures, we fit the same set of models separately in two data sets of healthy older adults. Our test sample included the baseline sample of 462 older adults from the Senior Odyssey cognitive intervention (Stine-Morrow, Parisi, Morrow, & Park, 2008, 2014). The validation sample included 2802 older adults from the Advanced Cognitive Training in Independent and Vital Elderly (ACTIVE) randomized controlled trial (Ball et al., 2002; Rebok et al., 2014; Willis et al., 2006).

Study 1

Method

Participants

This test sample is the baseline measurement from the Senior Odyssey intervention (Stine-Morrow, Parisi, Morrow, Greene, & Park, 2007; Stine-Morrow et al., 2008, 2014).

Table 1. Sample demographics for Study 1 and Study 2.

Variable	Mean or *N*	Standard deviation or percent	Observed range
Test Study 1: Senior Odyssey (*N* = 462)			
Age	72	7.71	60, 94
Years of education	15.50	2.63	9, 20
Female	341	74%	–
MMSE	27.27	1.99	23, 30
Validation Study 2: ACTIVE (*N* = 2802)			
Age	74	5.91	65, 94
Years of education	13.53	2.70	4, 20
Female	2162	76%	–
MMSE	27.31	2.01	23, 30

MMSE: Mini-mental state examination.

Participants included 462 older adults ranging in age between 60 and 94 years (M = 72, SD = 7.71). Table 1 presents the descriptive and demographic information.

Measures and cognitive tasks

Subjective memory beliefs were measured with the memory capacity and memory change subscales the Metamemory in Adulthood scale (MIA; Dixon, Hultsch, & Hertzog, 1988). Each scale includes 18 items indexing the self-perception of memory capacity and memory change with ratings of performance on particular tasks (e.g., “I am good at remembering names,” and “I am less efficient now at remembering things than I used to be,” for capacity and change, respectively). Positive scores indicate higher capacity and stability.

Three measures were used to assess verbal episodic memory. Two measures were derived from the Hopkins Verbal Learning Task (HVLT; Benedict, Schretlen, Groninger, & Brandt, 1998), the sum of the total number of words correctly recalled across the first three trials and the number of words remembered at the delayed recall. The third measure was sentence memory (proportion propositions recalled) after self-paced reading (e.g., Stine-Morrow et al., 2008). Participants read sentences on a computer screen a word at a time, and then were asked to recall the sentences aloud. Sentences were scored for total number of correct propositions recalled.

Psychomotor speed was measured with the letter and pattern comparison tasks (Salthouse, 1996), the identical pictures test, and the Finding A’s test (Ekstrom, French, Harman, & Dermen, 1976). These tasks collectively require participants to make simple speeded responses to a number of stimuli (e.g., judge whether a string of letters are the same or different) and performance is scored as the total number of items correctly identified in a fixed period of time.

Reasoning was measured with the letter sets, number sets, letter series and word series tests (Ekstrom et al., 1976), and the everyday problem-solving test (Marsiske & Willis, 1995). Collectively, the Ekstrom et al. (1976) tests require participants to identify patterns in a series of items and either generate the next item in the series (letter series and word series) or decide which item did not adhere to the pattern (letter sets and number sets). In the EPS task, participants were presented with several hypothetical situations in everyday domains ranging from food preparation to transportation. Participants were asked to solve problems, such as calculating how many pills to take over a 2-day period, given information from a prescription drug label. Performance on these measures was scored in terms of number of correct responses within a timed interval. See Appendix for additional descriptive information on measures.

Analytical approach

Our data analysis plan consisted of a two-stage approach to model cognitive performance. First, we fit a structural equation model with correlated latent factors for episodic memory, speed, and reasoning. These factors were then regressed onto a latent factor for memory beliefs to examine the influence of each cognitive function on memory beliefs (see Figure 1) without accounting for the shared variance among the factors. In the second stage, we fit a bi-factor model (Holzinger & Swineford, 1937; Reise, 2012) to the data. In the bi-factor model (see Figure 2), each cognitive test item was allowed to have a positive loading on a domain-general fluid cognition factor. We maintained the individual domain-specific factors for episodic memory, speed, and reasoning, which are orthogonal to each other and to the general factor. Thus, the general factor represents the shared variance between all cognitive test items, and the domain-specific bi-factors represent unique variance in each cognitive domain. These factors are simultaneously regressed onto memory beliefs in order to test whether any bi-factors maintain a unique relationship with memory beliefs after accounting for the domain-general influence of

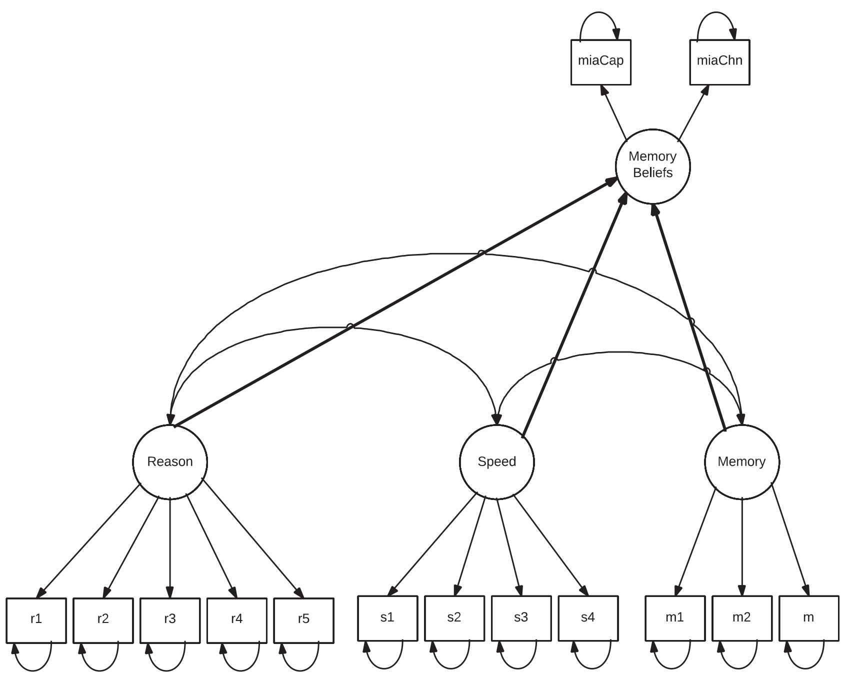

Figure 1. Structural equation model diagrams for correlated latent factors model predicting memory beliefs. Note: miaCap: capacity subscale from MIA; miaChn: change subscale from MIA; Reason: latent reasoning factor; Speed: latent speed factor; Memory: latent memory factor; r1–5 = manifest reasoning variables; s1–4: manifest speed variables; m1–3: manifest memory variables.

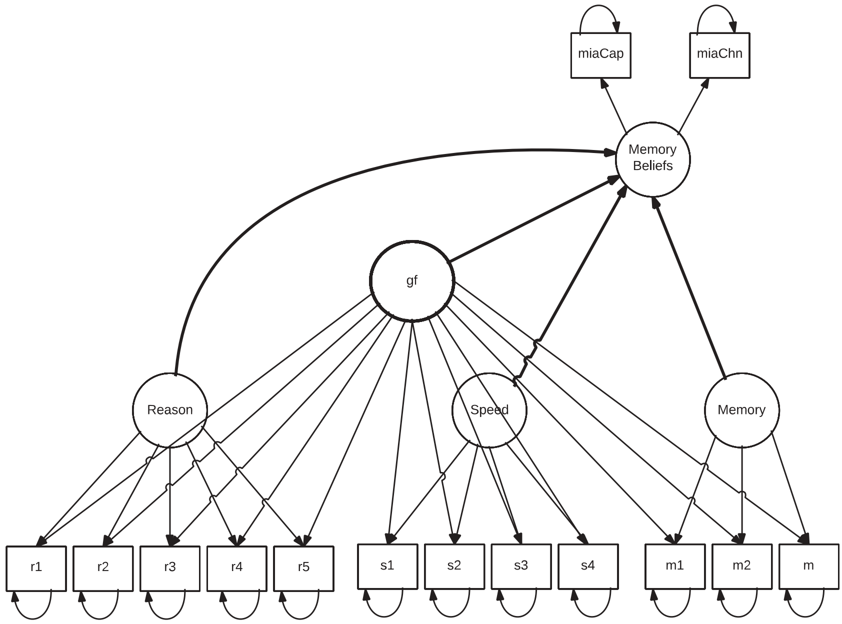

Figure 2. Structural equation model diagram for bi-factor model predicting memory beliefs. Note: miaCap: capacity subscale from MIA; miaChn: change subscale from MIA; Reason: latent reasoning factor; Speed: latent speed factor; Memory: latent memory factor; g_f: latent general fluid cognition factor; r1–5 = manifest reasoning variables; s1–4 = manifest speed variables; m1–3 = manifest memory variables.

cognition on memory beliefs. Taken together, these two sets of models allow us to examine the domain-general, as well as unique predictive validity of episodic memory, speed, and reasoning on subjective memory beliefs.

Results

Correlated latent factors model

Figure 1 shows a simplified SEM diagram of the correlated latent factors model. This model showed adequate fit to the data, $\chi^2(47) = 208.45$; RMSEA (root mean square error of approximation) = .06; CFI (comparative fit index) = .96. Factor loadings for the measurement part of the cognitive model are presented in Table 2. Shared variance among the latent cognitive factors was modeled by allowing for intercorrelations among these factors. As expected, the latent factors were substantially correlated. The latent speed factor was moderately correlated with both latent episodic memory (r = .53) and latent reasoning (r = .57). Likewise, reasoning and memory were highly correlated (r = .78). By regressing a latent memory beliefs factor on each cognitive factor simultaneously, we examined the unique prediction of memory beliefs from speed, reasoning, and memory (Table 3). While speed had no relationship with memory beliefs, both memory performance and reasoning performance were predictive of memory beliefs. Importantly, reasoning showed approximately the same magnitude of relationship with memory beliefs, suggesting subjective memory beliefs are not solely influenced by objective memory performance.

Table 2. Standardized factor loadings among cognitive measurement models in Study 1 and Study 2.

Test Study 1: Senior Odyssey							
	Correlated latent factors model			Bi-factor model			
Cognitive test battery	Memory	Reasoning	Speed	Memory	Reasoning	Speed	g_f
HVLT-sum	.89			.71			.54
HVLT-delayed	.87			.70			.53
Sentence recall	.45			.14			.50
Letter sets		.80			.27		.75
Number sets		.73			.50		.61
Letter series		.85			.40		.77
Word series		.87			.15		.87
Everyday PS		.80			.19		.77
Letter comparison			.78			.32	.67
Pattern comparison			.72			.53	.55
Identical pictures			.75			.52	.58
Findings A's			.58			.28	.48
Validation Study 2: ACTIVE							
	Correlated latent factors model			Bi-factor model			
Cognitive test battery	Memory	Reasoning	Speed	Memory	Reasoning	Speed	g_f
HVLT-sum	.84			.46			.65
AVLT-sum	.77			.69			.55
Rivermead	.57			.18			.57
Letter Series		.92			.56		.75
Letter Sets		.70			.34		.71
Word Series		.90			.49		.75
UFOV1			.45			.13	.37
UFOV2			.74			.31	.59
UFOV3			.79			.77	.38
UFOV4			.54			.40	.56

Table 3. Standardized latent regression estimates and 95% confidence intervals (CIs) from correlated factors and bi-factor models predicting subjective memory beliefs (CIs that do not include zero indicate significant effects).

Test Study 1: Senior Odyssey (N = 462)				
	Correlated factors		Bi-factor	
	Beta	95% CI	*Beta*	95% CI
Speed	.03	[−.13, .18]	−.03	[−.18, .12]
Memory	.12	[.01, .22]	.07	[−.04, .20]
Reasoning	.12	[.02, .22]	<.01	[−.17, .16]
g_f	–		.19	[.06, .30]
Validation Study 2: ACTIVE (N = 2802)				
	Correlated factors		Bi-factor	
	Beta	95% CI	*Beta*	95% CI
Speed	−.04	[−.10, .02]	.04	[−.02, .09]
Memory	.28	[.21, .34]	.07	[<.01, .13]
Reasoning	.15	[.09, .21]	−.03	[−.11, .04]
g_f	–		.45	[.38, .52]

Bi-factor model

Building on the above model, we next tested the bi-factor model representation of cognition (see Figure 2), to examine the domain-general and domain-specific relationships between cognition and memory beliefs. In this representation, the shared covariance between each cognitive factor is explained by a domain-general fluid cognitive functioning factor, so that the resulting domain-specific bi-factors represent unique variation in each ability, independent of the positive manifold in cognitive function represented by the general factor. This model showed good fit to the data, χ^2 (42) = 92.67; RMSEA = .05, CFI = .98. Table 2 shows the factor loadings for the cognitive measurement model, and Table 3 shows the standardized regression estimates between the cognitive factors and memory beliefs. The general cognition factor was the strongest predictor of memory beliefs, with an effect size that was 36% larger than that of memory (Table 3). The unique, domain-specific relationship between memory and memory beliefs was attenuated by 42% and no longer statistically significant after accounting for this general cognitive ability factor. Unique variation in memory performance, independent of general cognitive function, explained less than 1% of the variation in older adults' memory beliefs.

Discussion

Results revealed that memory self-efficacy beliefs were related to memory performance in older adulthood, consistent with prior findings (e.g., Hultsch, Hertzog, Dixon, & Small, 1998). However, our modeling results also showed that reasoning abilities shared a relationship with memory beliefs of a similar magnitude, calling into question the domain-specificity of the relationship between memory performance and memory beliefs in older adulthood. Results from the bi-factor model confirmed this general finding. After accounting for the shared variance among all cognitive test items (conceptualized as g_f), domain-specific variance in memory performance was attenuated and no longer reliable in predicting memory beliefs. Indeed, the largest effect size in predicting memory beliefs came from the general cognitive factor. Collectively, these findings suggest that memory beliefs are not primarily related to memory performance, but rather share a robust relationship with general cognitive ability.

At the same time, the effect size for the relationship between memory beliefs and memory performance was not initially large in the correlated factors model (see Table 2). Also, structural equation model results are rarely validated across samples, though it has long been suggested that this approach be undertaken, especially for more complex measurement models, such as the bi-factor model (Bollen, 1989; Bollen & Pearl, 2013). Thus, the goal of the second study was to validate and generalize the findings from Study 1, not only with a larger and more diverse sample of older adults, but also with varying measures of both subjective memory beliefs and cognition.

Study 2

Method

Participants

Participants included 2802 older adults ranging in age between 65 and 94. This validation sample is the baseline measurement sample from the Advanced Cognitive Training in Independent and Vital Elderly randomized controlled trial (Ball et al., 2002; Jobe et al., 2001; Willis et al., 2005). Table 1 presents the descriptive and demographic information.

Measures and cognitive tasks

Subjective memory beliefs were measured with Memory Functioning Questionnaire (MFQ; Gilewski, Zelinski, & Schaie, 1990). Each scale included 18 items meant to index the participant's self-perception of memory and forgetting in specific domains, along with ratings of memory strategy use. Factors were defined based on four item subscales from the MFQ: Frequency of forgetting, recall of information from reading a novel, recall of information from reading a newspaper, and mnemonics usage. Positive scores were associated with more positive memory beliefs.

Three measures were used to assess verbal episodic memory. Two measures were the sum of the total number of words correctly recalled across the first three trials of the HVLT and the Rey Auditory Verbal Learning Test. The third measure was the paragraph recall subtest from the Rivermead Behavioral Memory Test (Wilson, Cockburn, & Baddeley, 2003; cf. Payne et al., 2014; Sisco, Marsiske, Gross, & Rebok, 2013).

Psychomotor speed was measured with the four subtasks from the Useful Field of View (UFOV) (Ball & Owsley, 1993; Wechsler, 1981) task: stimulus identification, divided attention, selective attention, and selective attention in conjunction with same/different discriminations (see Edwards et al., 2006). Because these tasks are based on reaction time (so that lower values indicate better scores), parameter estimate signs for factor loadings, standardized regression estimates, and correlations were inverted to keep interpretation consistent across measures (i.e., larger values indicate better performance).

Reasoning was measured with the Letter Sets, Letter Series and Word Series tasks from the Schaie–Thurstone Adult Mental Ability Test (Schaie, 1985).

Analytical approach

The analytical plan was identical to Study 1. Although Figures 1 and 2 were path diagrams specific for Study 1, the models are identical in the ACTIVE sample, only differing in the manifest variables used to define the latent factors.

Results

Correlated latent factors model

This model showed adequate fit to the data, $\chi^2(71) = 812.27$; RMSEA = .06; CFI = .95. Factor loadings are presented in the bottom panel of Table 2. The latent speed factor was correlated with both the episodic memory factor ($r = .58$) and reasoning factor ($r = .62$). Likewise, latent reasoning and memory were both correlated ($r = .64$). The bottom panel of Table 3 presents the regression weights predicting memory beliefs from each cognitive factor. Memory performance reliably predicted memory beliefs. Importantly, while speed was not predictive of memory beliefs, reasoning was significantly related to memory beliefs, replicating the findings in the correlated latent factors model in the first sample.

Bi-factor model

We then examined the bi-factor model representation of cognition, in order to examine the domain-general and domain-specific relationships between cognition and memory beliefs. This model showed good fit to the data, $\chi^2(63) = 587.55$; RMSEA = .05, CFI = .97.

Factor loadings are presented in the bottom panel of Table 2, and regression weights predicting memory beliefs are presented in the bottom panel of Table 3. Results from Table 3 revealed that the general cognition factor was the strongest predictor of memory beliefs among older adults, explaining approximately 20% of the variation in memory beliefs. Importantly, the unique, domain-specific relationship between memory and memory beliefs, while still marginally statistically significant, was attenuated by 75% and explained less than 1% of the variance in older adults' memory beliefs, replicating the results from the bi-factor model in the Study 1.

Discussion

The findings from Study 2 were directly in line with the findings from Study 1. First, we replicated the shared relationship between memory beliefs with both memory and reasoning in the correlated latent factors model. Second, we showed that the relationship between memory and memory beliefs was attenuated after accounting for the shared variance among all cognitive test items (g_f), with the memory bi-factor explaining less than 1% of the variation in memory performance in both samples. Importantly, as in Study 1, we showed that the general cognition factor, which is defined by the shared variance among all cognitive test items, was the strongest predictor of memory beliefs. Collectively, the pattern of findings in Study 1 appeared to hold across a larger and more diverse sample, and across varying measures of memory beliefs and cognitive ability.

General discussion

Although normative age-related declines are observed for a number of cognitive processes, age-related memory loss is perhaps the biggest concern among the aging population (Berry et al., 2010; Naveh-Benjamin & Ohta, 2012). Negative beliefs about aging and memory are robust and can have a direct influence on memory performance (Hess, 2014). What is less well understood is how negative memory beliefs manifest themselves in the context of declines in other cognitive abilities, such as reasoning and processing speed, which also show substantial age-related declines. The current study aimed to address whether dispositional memory beliefs are uniquely related to objective memory performance, or whether they are more reflective of broader age-related declines in cognition.

Across two large independent samples with different measurement batteries to identify key constructs, we found that individual differences in episodic memory and inductive reasoning shared unique variance with subjective memory beliefs. Importantly, however, once the shared variance among all cognitive test items was accounted for in the bi-factor model, the relationship between memory performance and memory beliefs was attenuated. Indeed, the most striking finding was that the general cognition factor (g_f) was the strongest predictor of memory beliefs among older adults in both samples, suggesting that older adults reports of negative memory beliefs may stem from more general declines in cognitive functioning, rather than from a unique deficit in memory performance.

Several studies have found evidence that global memory belief measures show weaker correlations with memory performance than do concurrent metacognitive assessments of memory (Gardiner, Luszcz, & Bryan, 1997; Luszcz & Hinton, 1995). Beaudoin and Desrichard (2011) argue that scores on global assessments of memory beliefs reflect a perception of "usual global memory ability" that is independent of situational characteristics. Because of this, global measures do not tap into the task-specific and situational factors thought to affect concurrent assessments of memory beliefs scores and memory performance in specific tasks, but rather reflect stable dispositions or attitudes about memory capacity. However, global assessments of memory beliefs may not only reflect a stable belief about one's memory status (Hertzog & Hultsch, 2000). Indeed, some studies have shown that global measures of memory beliefs are inversely associated with depression and endorsement of negative personality traits (e.g., neuroticism), leading some to argue that global memory belief measures show attenuated relationships with observed cognitive performance because of developmental changes in these dispositions and traits (Hertzog & Dixon, 2005; Pearman & Storandt, 2004). The findings from the current study indicate that memory beliefs do indeed share robust relationships with cognitive performance in old age; however, these relationships are not domain-specific. Individual variation in memory beliefs in older adults instead seem to be tightly linked with individual differences in general fluid cognitive ability, while unique variation in memory performance is only very weakly related to self-referent memory beliefs.

Because the models presented in the current study are cross-sectional in nature, the results do not address the causal directionality of the relationship between subjective-memory beliefs and cognitive functioning. The relationship between performance and memory beliefs may be reciprocal and dynamic (Berry, 1999; Parisi et al., 2011; Touron & Hertzog, 2004). Indeed, it has been argued that negative memory beliefs may "be an underlying factor that precipitates avoidance of cognitively challenging situations" (Valentijn et al., 2006, p. 165). Results from cognitive training studies are consistent with this claim in showing that negative memory beliefs are associated with poorer responsiveness to non-memorial training interventions (Payne et al., 2012). The results from the current study suggest that internalizing negative dispositions toward memory beliefs have farther reaching relationships with cognitive ability than had previously been considered in the literature.

Lastly, the results from this study showed that the bi-factor model fit the empirical data well, demonstrated validity in parsing variance among multivariate cognitive performance, and proved to be a valuable tool for testing targeted hypotheses about the domain-specific and domain-general relationships between cognition and memory beliefs (cf. Chen et al., 2006). Note that our claim is not that the bi-factor model used in the current study is necessarily the true underlying latent structure of cognitive functioning (cf. Miyake et al., 2000; Salthouse, 2004). In fact, some researchers hold a "primitive" precedence for some facets of cognitive functioning over others. For instance, Salthouse and colleagues (reviewed in Salthouse, 2010) have argued that measures of processing speed are primitive abilities that predict individual variation in episodic memory and fluid reasoning ability. Another perspective by Hertzog and colleagues (Hertzog, Park, Morrell, & Martin, 2000; Jopp & Hertzog, 2007) has been that memory ability itself is separable from general cognition (g_f) and mediates the relationship between general fluid cognition and memory beliefs. Rather, we take a neutral point on the primitive precedence of any of these measures of cognitive functioning in this cross-sectional study, and instead use the bi-factor model as an analysis tool for providing a conservative test of domain-generality versus domain-specificity in the prediction of memory beliefs, treating the status of all cognitive constructs equally. Moreover, although SEM applications in memory and cognitive aging research are now widely used, it is rare for models to be validated or replicated across multiple samples and operationalizations of constructs in psychology (Penke & Deary, 2010; Raykov, Tomer, & Nesselroade, 1991) or in health research more broadly (Ioannidis, 2005). This is important, as good model fit does not indicate that a particular structural equation model will generalize (Bollen, 1989; Breiman, 2001; Preacher & Merkle, 2012). That our findings replicate across two large independent samples of older adults, with varying measures of key constructs, indicates that these findings are robust. This is particularly striking given that the two key measures of memory beliefs (the MIA and the MFQ subscales), while reflecting the same construct, vary in their surface form and specific item attributes. Although some work has shown considerable convergence between these two measures in predicting memory performance (Hertzog, Hultsch, & Dixon, 1989; Cook & Marsiske, 2006), this study is the first to our knowledge to conceptually replicate latent variable relationships between multiple cognitive abilities and memory beliefs across two independent studies with differing measures.

In conclusion, a growing number of studies examining relationships between memory beliefs and memory performance have established modest but reliable correlations between these two processes. The findings from the current study suggest that this relationship is partially accounted for by individual variation in general fluid cognitive ability, suggesting that negative self-referent beliefs about memory are not necessarily reflective of specific age-related declines in memory. Instead, dispositional memory beliefs appear to reflect individual variation in cognition more generally, suggesting that self-reports of memory status have broader and more robust relationships with cognitive functioning in older adulthood than previously assumed.

Disclosure statement

No potential conflict of interest was reported by the authors.

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Appendix

Table 1A. Means and SDs of manifest variables used in Study 1 and Study 2.

Test Study 1: Senior Odyssey (N = 462)		
	M	SD
MIA capacity	2.99	.59
MIA change	2.59	.63
HVLT sum	23.74	5.1
HVLT delay	8.42	2.72
Sentence memory	.46	.17
Letter comparison	7.26	2.27
Pattern comparison	13.5	3.5
Identical pictures	24.27	6.28
Finding A's	27.02	8.92
Letter sets	6.44	3.26
Number series	4.65	2.96
Letter series	7.88	3.64
Word series	13.43	5.54
Everyday problem solving	12.79	4.35
Validation Study 2: ACTIVE (N = 2802)		
	M	SD
MFQ Freq forget	45.1	9.52
MFQ Recall novel	10.34	2.85
MFQ Recall newspaper	15.97	4.02
MFQ mnemonics	11.09	6.6
HVLT sum	25.58	5.97
AVLT sum	47.24	11.21
Rivermead	−.09	1.01
UFOV Stim ID	26.76	36.52
UFOV Div ID	94.16	110.23
UFOV Sel Attn	271	138.64
UFOC Discrim	431	91.64
Letter sets	6.26	2.88
Letter series	12.05	5.98
Word series	11.28	4.42

UFOV: Useful field of view.