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Research Article

The Relationship Between 10-Year Changes in Cognitive Control Beliefs and Cognitive Performance in Middle and Later Adulthood

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Abstract

Objectives: The present study used a cross-lagged panel design with longitudinal data to test if there is a reciprocal relationship between cognitive control beliefs and cognition (e.g., executive functioning and episodic memory) over 10 years, whether frequency of engaging in stimulating cognitive activities mediated this relationship, and if these relationships varied by age.

Methods: Data were collected as part of the second (M2, 2004–2005) and third (M3, 2013–2014) waves of the Midlife in the United States Study. The analysis sample included 2,532 participants with all variables at M2 and M3. Participants' ages ranged from 33 to 83 ($M = 54.92$, standard deviation = 11.13) at M2.

Results: There was a reciprocal relationship between cognitive control beliefs and executive functioning. Higher executive functioning was related to greater maintenance of cognitive control beliefs for older, not younger, adults. Higher cognitive control beliefs were related to less decline in executive functioning. Though cognitive control beliefs predicted 10-year changes in episodic memory, the inverse relationship was not supported. Frequency of engaging in stimulating cognitive activities mediated the relationship between executive functioning and 10-year changes in cognitive control beliefs, but not cognitive control beliefs and 10-year changes in cognition.

Conclusions: Cognitive control beliefs are a promising mechanism to help protect against age-related declines in both executive functioning and episodic memory. Moreover, executive functioning also affects cognitive control beliefs. Specifically, those with higher executive functioning engage more frequently in stimulating cognitive activities, which helps maintain higher cognitive control beliefs.

Keywords: Beliefs, Cognition, Executive function, Memory, Sense of control

Sense of control refers to an individual's beliefs and expectancies regarding their ability to achieve desired goals and outcomes (Hong et al., 2021; Lachman et al., 2011). Previous research indicates sense of control peaks in midlife and declines throughout later adulthood (Cerino et al., 2023; Lachman et al., 2009). This decline has been attributed to the increased losses relative to gains that are experienced as individuals age (Baltes, 1987; Lachman et al., 2009). This represents an important issue for individuals entering middle to later adulthood, as sense of control has been identified as a mechanism to promote cognitive health (Soederberg et al., 2000).

An individual's sense of control may differ across life domains and may be affected by the salience of a given domain (Brandtstadter & Rothermund, 1994; Lachman et al., 2011). For example, older adults are more likely to report a lower sense of control over domains that decline with age, including cognition (Lachman, 1986; Parisi et al., 2017). Research has shown that domain-specific measures of control beliefs are stronger predictors of outcomes and changes therein in their respective domains relative to general measures (Lachman, 1998). Considering both control beliefs and cognitive performance decline with age (Bielak et al., 2007; Hahn & Lachman, 2015; Raldiris et al., 2021), domain-specific cognitive control beliefs may be relevant for cognitive abilities as individuals enter middle to later adulthood.

Cognitive Control Beliefs and Cognition

Cognitive control beliefs encompass beliefs regarding the extent to which an individual can influence and minimize age-related declines in cognition (Lachman et al., 2006). Moreover, cognitive control beliefs are related to an individual's subsequent cognitive performance (Raldiris et al., 2021) and an individual's cognitive performance is related to their perceived level of control (Bielak et al., 2007; Parisi et al., 2017). Given these findings, many investigators have proposed that there is a reciprocal relationship between control beliefs and cognitive functioning (Bielak et al., 2007; Neupert & Bellingtier, 2020; Parisi et al., 2017; Robinson & Lachman, 2017), such that changes in one leads to changes in the other.

Only one study to date has tested this reciprocal relationship empirically (Parisi et al., 2017), using data collected as part of the Advanced Cognitive Training for Independent

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and Vital Elderly (ACTIVE) trial (Ball et al., 2002; Jobe et al., 2001; Rebok et al., 2013, 2014). During the ACTIVE trial, participants received an intervention that aimed to improve memory, reasoning, or processing speed (10 sessions; 60–75 min/session). Cognitive assessments and cognitive control belief measurements from the Personality in Intellectual Aging Contexts (PIC) scale (Lachman, 1986) were collected at several time points to assess the effects of the training. Results showed that higher memory and reasoning performance at baseline were related to less decline in intellectual self-efficacy over time. Lower performance across all 3 tasks was associated with greater increases in concerns about intellectual aging over 10 years. Although baseline control beliefs about cognition were not related to declines in cognition over time, changes in concerns about intellectual aging were associated with changes in cognition for memory and reasoning tasks. However, these relationships were not moderated by the cognitive training intervention. Whereas these findings suggest that initial control beliefs may be unrelated to one's subsequent cognitive performance, Parisi et al. (2017) examined these relationships in the context of a cognitive training intervention with adults over the age of 65 and did not examine mediating mechanisms.

Health-Promoting Behaviors

Although there is evidence to suggest that cognitive control beliefs predict cognition (Raldiris et al., 2021) and that cognition predicts cognitive control beliefs (Parisi et al., 2017), few studies have tested the reciprocal relationship or potential mediators that underlie this relationship (Lachman et al., 2006). One conceptual model (Robinson et al., 2016; Soederberg Miller & Lachman, 1999), suggests that engaging in health-promoting behaviors underlie the relationship between control beliefs and positive health outcomes. Specifically, individuals with a higher sense of control are more likely to engage in health-promoting behaviors that benefit different aspects of health, including cognition. Consistent with this idea, research has demonstrated that the relationship between sense of control and cognition is mediated through behaviors like effective strategy use (Lachman et al., 2006) and physical activity engagement (Robinson & Lachman, 2020).

Past work has also attempted to understand the factors that reduce certain individuals' ability to engage in health-promoting behaviors. For example, Hall and Fong (2007), have suggested that individuals with lower executive functioning experience a decreased capacity to regulate their prepotent, or automatic, responses, which reduces their ability to engage in health-promoting behaviors. The investigators propose that this is likely due to the perceived benefits and costs associated with health-promoting behaviors. Put differently, health-promoting behaviors often involve immediate costs (e.g., discomfort) and distal benefits (e.g., sustained/improved health) whereas health-damaging behaviors involve immediate benefits (e.g., pleasure) and distal costs (e.g., poor health).

Stimulating Cognitive Activities

Engaging in stimulating cognitive activities represents one type of health-promoting behavior that may benefit both cognition and cognitive control beliefs. Indeed, there is evidence to suggest that individuals who engage more frequently in stimulating cognitive activities are likely to maintain or improve their cognition (Daugherty et al., 2018; Fragkiadaki et al., 2016; Hertzog et al., 2008; Lövdén et al., 2010; Rebok et al., 2014), and those with poorer or declining cognition are less likely to remain engaged with these types of activities (Bielak et al., 2014). Moreover, engaging in stimulating cognitive activities has been shown to promote higher memory control beliefs (Bielak et al., 2007; Thana-Udom et al., 2021) and individuals with higher control beliefs are more likely to continue engaging in stimulating cognitive activities (Lachman, 2006; Lachman & Agrigoroaei, 2012). Whereas it is clear that there are associations between engaging in stimulating cognitive activities and both cognition and cognitive control beliefs, no study (to our knowledge) has tested if engaging in stimulating cognitive activities mediates the relationships between cognitive control beliefs and cognition.

The Present Study

The present study tested a reciprocal relationship between cognitive control beliefs and cognition (e.g., executive functioning and episodic memory) over a 10-year period in a large nationwide sample of adults in middle and later adulthood. We predicted that cognitive control beliefs at the first occasion would be positively related to 10-year changes in cognition and that cognition at the first occasion would be positively related to 10-year changes in cognitive control beliefs. Additionally, we tested whether engaging in stimulating cognitive activities at baseline mediated these relationships. We predicted that more frequent engagement in stimulating cognitive activities would mediate the reciprocal relationships between cognitive control beliefs and cognition (both episodic memory and executive functioning). Lastly, we tested whether the nature of these relationships varied by age.

Method

Participants

Data were obtained from the second (M2) and third (M3) waves of the Midlife in the United States Study (MIDUS; Radler & Ryff, 2010). MIDUS is a longitudinal sample of individuals ranging from young to late adulthood who were recruited using random-digit dialing from across the United States. The first wave of MIDUS (M1) was initiated in 1995–1996 and involved a telephone interview and two self-administered questionnaires. The original participants ($n = 7,108$) were aged 24 to 74 [$M = 46.40$, standard deviation (SD) = 13.00], predominantly female (52%), and the majority had at least a high school degree or equivalent (90%). The second wave (M2; $n = 4,963$) of data was collected in 2004–2006 and the third wave (M3; $n = 3,577$) in 2013–2014. To increase the representation of African American individuals within the study sample, additional random samples were drawn from Milwaukee, WI at M2 ($n = 592$) and M3 ($n = 508$). A telephone-administered cognitive battery and a measure of cognitive control beliefs were also introduced at M2. Additional information regarding the sample selection and attrition is available (Hughes et al., 2018; Radler & Ryff, 2010).

We included participants ($N = 2,532$) in our analysis if they had demographic, survey, and cognitive assessments from M2 and M3. At M2, participants were aged between 33 and 83 years old ($M = 54.92$, $SD = 11.13$), women comprised 58% of the sample, and 87% of the sample were non-Hispanic Whites. Participants included in the analysis sample had an average of 14.47 years of education (out of 20 years; $SD = 2.65$; see Supplementary Table A).

To investigate the differences between the participants included in our analysis sample and those not included due to either participant drop-out or missing data, we computed independent samples t-tests. Our findings of selective attrition were consistent with the findings of previous longitudinal studies including MIDUS (Hughes et al., 2018; Radler & Ryff, 2010), see Supplementary Table A.

Measures

Cognitive control beliefs

Participants completed a 9-item measure of cognitive control beliefs which contained eight items derived from the PIC Inventory Control Scales (Lachman, 1986; Lachman et al., 1982) and one item from the Memory Controllability Inventory (MCI) Inevitable Decrement subscale (Lachman et al., 1995). The PIC includes questions that assess beliefs about one's ability to maintain cognitive abilities (e.g., "*The older I get the harder it is to think clearly.*") and the MCI-decrement subscale measures the extent to which an individual feels memory-related decline is inevitable (e.g., "*There's not much I can do to keep my memory from going downhill*"). Responses were rated on a scale ranging from 1 = "Strongly Agree" to 7 = "Strongly Disagree." Two items were reverse coded prior to computing a score. A mean score was computed by averaging each of these items together, with higher scores reflecting greater cognitive control beliefs, intellect, and aging. These items were available for the second- and third-wave assessments. The cognitive control beliefs scale demonstrated adequate internal consistency at M2 ($\alpha = 0.94$) and M3 ($\alpha = 0.70$).

General sense of control

Participants completed a 12-item Sense of Control scale (Lachman & Weaver, 1998) that was included as part of the self-administered questionnaire. The Sense of Control scale includes two subscales that measure personal mastery and perceived constraints. The doue-item personal mastery scale includes items such as, "I can do just about anything I really set my mind to." The 8-item perceived constraint scale includes items such as, "There is little I can do to change the important things in my life." Participants were asked to rate their responses on a scale ranging from 1 = "Strongly Agree" to 7 = "Strongly Disagree." All personal mastery items were first reverse coded. Following this, a mean score was computed by averaging each of the items together, with higher scores reflecting greater perceived control. Scores range from 1 to 7.

Cognitive performance

Cognitive performance was assessed using two factors of episodic and executive functioning that were computed from the Brief Test of Adult Cognition by Telephone (BTACT; Tun & Lachman, 2008). The BTACT was administered via telephone and has been shown to have reliability and validity consistent with in-person tests (Lachman et al., 2014). Participants in M2 and M3 were administered the BTACT at their preferred time and were instructed to be in a place without distractions and not to write anything down during testing. The BTACT is comprised of seven subtests that include two measures of episodic memory (Word Immediate and Delayed Recall; immediate and delayed free recall of 15 words), a measure of working memory (Backwards Digit Span; the longest series of digits repeated correctly in the backward order), a measure of verbal ability/speed (Category Fluency; the total number of unique responses in 60 s), a measure of executive functioning/inhibitory control (stop-go-switch task; the average of the median latencies for switch and non-switch trials multiplied by −1), a measure of fluid intelligence/reasoning (number series; the number of series that were completed correctly) and a measure of speed of processing (30-s and counting task; the number of digits produced in 30 s when counting backward from 100).

The episodic memory and executive functioning factors were originally computed in previous studies (Hughes et al., 2018; Lachman et al., 2014). The episodic memory factor was composed of two items (e.g., immediate and delayed recall) and the executive functioning factor was composed of five items (e.g., digit-span backward, number series, backward counting, stop-go-switch task latency, category fluency). Factor scores were standardized based on M2 means and *SD*s at both occasions.

Frequency of engaging in stimulating cognitive activities

Frequency of engaging in stimulating cognitive activities was computed by averaging the self-reported frequencies in four stimulating cognitive activities (e.g., reading books magazines, or newspapers; word games, like cross-word puzzles; attending educational lectures and courses; and writing letters, journal entries, or stories) on a scale ranging from 1 = "*Never*" to 6 = "*daily*" (Liu & Lachman, 2020).

Covariates

Participants' chronological age, sex, education, race, and self-rated health were included as covariates. For all analyses, sex and race were coded as dichotomous variables (e.g., sex: 0 = male, 1 = female; race: 0 = non-White, 1 = White). Education was recoded to reflect the total number of years of formal education (6–20 years). Additionally, participants rated their physical health on a 5-point scale ranging from 1 = *excellent* to 5 = *poor*, and scores were reverse coded such that higher scores represented greater self-rated health.

Analytic Strategy

All analyses were computed using R (R Core Team, 2021). Descriptive statistics and Pearson Correlations were first computed for all variables, see Table 1.

To test if there is a positive reciprocal relationship between cognitive control beliefs and cognition and if these relationships are mediated by frequency of engaging in stimulating cognitive activities at M2, we computed a cross-lagged panel model using the Lavaan package (Rosseel, 2012). The cross-lagged panel model approach is appropriate in instances in which at least two variables have been measured across a minimum of two occasions. The model first examined the cross-lagged associations between cognitive control beliefs and cognition (i.e., executive functioning and episodic memory) from M2 to M3, while controlling for M2 age, sex, education, race, and self-rated health. We updated the model to include additional parameters that allowed us to test if the significant relationships between cognitive control beliefs and cognition were mediated by engaging in stimulating cognitive activities at M2. Lastly, we included interaction terms (M2 executive functioning by M2 age, M2 episodic memory by M2 age, and M2 cognitive control beliefs by M2 age) into our

Table 1. Means, Standard Deviations, and Correlations for All Variables in Midlife in the United States (MIDUS) Longitudinal Analysis Sample, *N* = 2,532

Variables	Mean (*SD*)	Range	1	2	3	4	5	6	7	8	9	10	11	12
1. M2 Age	54.92 (11.1)	33 to 83												
2. Sex (proportion women)	0.58 (0.5)	0 to 1	−.01											
3. Race (proportion White)	0.87 (0.3)	0 to 1	.08*	−.06*										
4. M2 Education	14.47 (2.6)	6 to 20	−.11*	−.14*	.14*									
5. M2 Self-rated health	3.66 (1.0)	1 to 5	−.06*	−.04	.17*	.25*								
6. M2 Cognitive activities	3.09 (0.9)	1 to 6	.12*	.15*	.00	.24*	.07*							
7. M2 Cognitive control beliefs	4.96 (1.0)	1 to 7	−.06*	−.09*	.13*	.25*	.26*	.17*						
8. M2 Sense of control (*N* = 2,500)	5.59 (1.0)	1 to 7	.02	−.10*	.06*	.16*	.28*	.11*	.40*					
9. M2 Episodic memory	0.13 (1.0)	−3 to 4	−.23*	.22*	.13*	.20*	.14*	.17*	.14*	.08*				
10. M2 Executive functioning	0.16 (0.9)	−5 to 3	−.33*	−.13*	.29*	.44*	.27*	.15*	.27*	.15*	.38*			
11. M3 Cognitive control beliefs	4.77 (1.0)	1 to 7	−.14*	−.03	.13*	.21*	.23*	.15*	.61*	.35*	.16*	.29*		
12. M3 Episodic memory	−0.02 (1.0)	−3 to 4	−.36*	.24*	.08*	.17*	.14*	.12*	.16*	.09*	.53*	.35*	.23*	
13. M3 Executive functioning	−0.19 (0.7)	−6 to 2	−.43*	−.11*	.24*	.38*	.25*	.09*	.25*	.14*	.34*	.77*	.34*	.42*

Notes: *M* = mean; M2 = MIDUS 2; M3 = MIDUS 3; range = minimum, maximum; *SD* = standard deviation. The number of participants included in the descriptive statistics for M2 sense of control was 2,500. The number of participants included in all other analyses was 2,532. Significant correlations (*$p < .05$).

model, which allowed us to test whether the nature of these relationships varied by age.

Results

On average, participants had higher cognitive control beliefs ($M = 4.96$, $SD = 0.97$), episodic memory ($M = 0.13$, $SD = 0.97$), and executive functioning ($M = 0.16$, $SD = 0.94$) at M2 relative to M3 (cognitive control beliefs $M = 4.77$, $SD = 1.00$; episodic memory: $M = -0.02$, $SD = 1.00$; executive functioning: $M = -0.19$, $SD = 0.75$). Paired samples t-tests showed that these declines were statistically significant (cognitive control beliefs: $t(2{,}531) = 11.03$, $p < .001$; episodic memory: $t(2531) = 7.95$, $p < .001$; executive functioning: $t(2531) = 29.18$, $p < .001$). We also compared the correlations of general control beliefs and cognitive-specific control beliefs with cognitive performance. Consistent with previous findings, the domain-specific control measures were more strongly related to episodic memory (M2: general $r = 0.08$ vs domain $r = 0.14$, $Z = 2.43$, $p < .001$; M3: general $r = 0.09$ vs domain $r = 0.16$, $Z = 2.68$, $p < .01$) and executive functioning (M2: general $r = 0.15$ vs domain $r = 0.27$, $Z = 4.33$, $p < .001$, M3: general $r = 0.14$ vs domain $r = 0.25$, $Z = 4.18$, $p < .001$). Thus, we included only the domain-specific cognitive control measure in all models.

Cross-Lagged Analyses

Using a crossed-lagged panel design, we first tested if there was a reciprocal relationship between cognitive control beliefs and cognition (e.g., executive functioning and episodic memory) over 10 years, while controlling for M2 age, sex, education, self-rated health, and race. We trimmed the full model by removing all non-significant paths which included a non-significant path from M2 episodic memory to M3 cognitive control beliefs. With these modifications the model fit was good, $\chi^2(6) = 50.23$, $p < .001$; CFI = 0.99; TLI = 0.95; RMSEA = .05; SRMR = .01.

We found support for a reciprocal relationship between cognitive control beliefs and executive functioning, such that M2 cognitive control beliefs predicted 10-year changes in executive functioning ($\beta = 0.04$, $p < .01$) and M2 executive functioning predicted 10-year changes in cognitive control beliefs ($\beta = 0.09$, $p < .001$). Additionally, M2 cognitive control beliefs significantly predicted 10-year changes in episodic memory ($\beta = 0.09$, $p < .001$; see Table 2).

We also tested whether the relationship between M2 executive functioning and 10-year changes in cognitive control beliefs was greater than that of M2 cognitive control beliefs and 10-year changes in executive functioning by adding an additional parameter to our model which tested the difference between their intercepts. The relationship between M2 executive functioning and 10-year changes in cognitive control beliefs was stronger than the relationship between M2 cognitive control beliefs and 10-year changes in executive functioning ($\beta = 0.05$, $p < .01$; see Figure 1).

We updated our model to test if engaging in stimulating cognitive activities mediated the significant relationships between cognitive control beliefs and both cognitive factors as well as from executive functioning to control beliefs. The model remained a good fit, $\chi^2(8) = 51.66$, $p < .001$; CFI = 0.99; TLI = 0.96; RMSEA = 0.05; SRMR = 0.01. Engaging in stimulating cognitive activities mediated the relationship between M2 executive functioning and 10-year changes in cognitive control beliefs. Those with higher M2 executive functioning engaged more frequently in stimulating cognitive activities at M2 ($\beta = 0.12$, $p < .001$), which led to greater maintenance of cognitive control beliefs over the 10 years ($\beta = 0.04$, $p < .05$). However, engaging in stimulating cognitive activities at M2 did not mediate the relationship between cognitive control beliefs and 10-year changes in cognition (e.g., executive functioning and episodic memory), see Table 2.

As a final step, we tested whether the nature of these relationships varied by age. The model fit was good, ($\chi^2(14) = 71.71$, $p < .001$; CFI = 0.99; TLI = 0.96; RMSEA = 0.04; SRMR = 0.01), and results were consistent with those reported above. The relationships between M2 cognitive control beliefs and changes in cognition (episodic memory: $\beta = 0.00$, $p = .13$; executive functioning: $\beta = -0.00$, $p = .44$) and M2 episodic memory and changes in control

Table 2. Unstandardized Cross-lagged Path Coefficients of Cognitive Control Beliefs, Episodic Memory, and Executive Functioning, *N* = 2,532

Variables	Model 1	Model 2
	Estimate (*SE*)	Estimate (*SE*)
M3 Episodic memory		
M2 Age	−0.02*** (0.0)	−0.02*** (0.0)
M2 Sex	0.35*** (0.0)	0.35*** (0.0)
M2 Education	0.02*** (0.0)	0.02*** (0.0)
M2 Race	0.11* (0.0)	0.11* (0.0)
M2 Cognitive control beliefs	0.09*** (0.0)	0.09*** (0.0)
M2 Episodic memory	0.41*** (0.0)	0.41*** (0.0)
M3 Cognitive control beliefs		
M2 Age	−0.01*** (0.0)	−0.01*** (0.0)
M2 Sex	0.09** (0.0)	0.08* (0.0)
M2 Race	0.10* (0.0)	0.12* (0.1)
M2 Self-rated health	0.05** (0.0)	0.05** (0.0)
M2 Cognitive control beliefs	0.59*** (0.0)	0.58*** (0.0)
M2 Executive functioning	0.09*** (0.0)	0.08*** (0.0)
M2 Stimulating cognitive activity		0.04* (0.0)
Indirect effect		0.01* (0.0)
Total effect		0.04*** (0.0)
M3 Executive functioning		
M2 Age	−0.02*** (0.0)	−0.02*** (0.0)
M2 Education	0.02*** (0.0)	0.02*** (0.0)
M2 Race	0.14*** (0.0)	0.14*** (0.0)
M2 Self-rated health	0.02* (0.0)	0.02* (0.0)
M2 Cognitive control beliefs	0.03** (0.0)	0.03** (0.0)
M2 Executive functioning	0.50*** (0.0)	0.50*** (0.0)
M2 Stimulating cognitive activity		0.00 (0.0)
Indirect effect		0.00 (0.00)
Total effect		0.08*** (0.0)
M2 Stimulating cognitive activities		
M2 Age		0.02*** (0.0)
M2 Sex		0.32*** (0.0)
M2 Education		0.07*** (0.0)
M2 Race		−0.26*** (0.1)
M2 Self-rated health		−0.02 (0.0)
M2 Cognitive control beliefs		0.11*** (0.0)
M2 Episodic memory		0.08*** (0.0)
M2 Executive functioning		0.11*** (0.0)
R^2		
M2 Cognitive activities		0.15
M3 Episodic memory	0.37	0.37
M3 Cognitive control beliefs	0.40	0.40
M3 Executive functioning	0.63	0.63

Notes: CFI = comparative fit index; M2 = MIDUS 2; M3 = MIDUS 3; RMSEA = root mean square error of approximation; *SE* = standard error; SRMR = standardized root mean square error of approximation; TLI = Tucker-Lewis index. Model 1 Fit: $\chi^2(6) = 50.23$, $p < .001$; CFI = 0.99; TLI = 0.95; RMSEA = .05; SRMR = .01. Model 2 Fit: $\chi^2(8) = 51.66$, $p < .001$; CFI = 0.99; TLI = 0.96; RMSEA = .05; SRMR = .01.*$p < .05$. **$p < .01$. ***$p < .001$.

beliefs ($\beta = 0.00$, $p = .51$) did not significantly vary by age. However, there was a significant interaction between M2 executive functioning and age on changes in cognitive control beliefs ($\beta = 0.04$, $p < .01$). We used an analysis of simple slopes to probe this interaction which showed the relationship between M2 executive functioning and changes in cognitive control beliefs was significant at older ($\beta = 11.25$, $p < .001$), but not younger ages ($\beta = 7.49$, $p = .07$), see Figure 2 and Table 3.

Discussion

The present study examined whether cognitive control beliefs and cognition were reciprocally associated over time and if

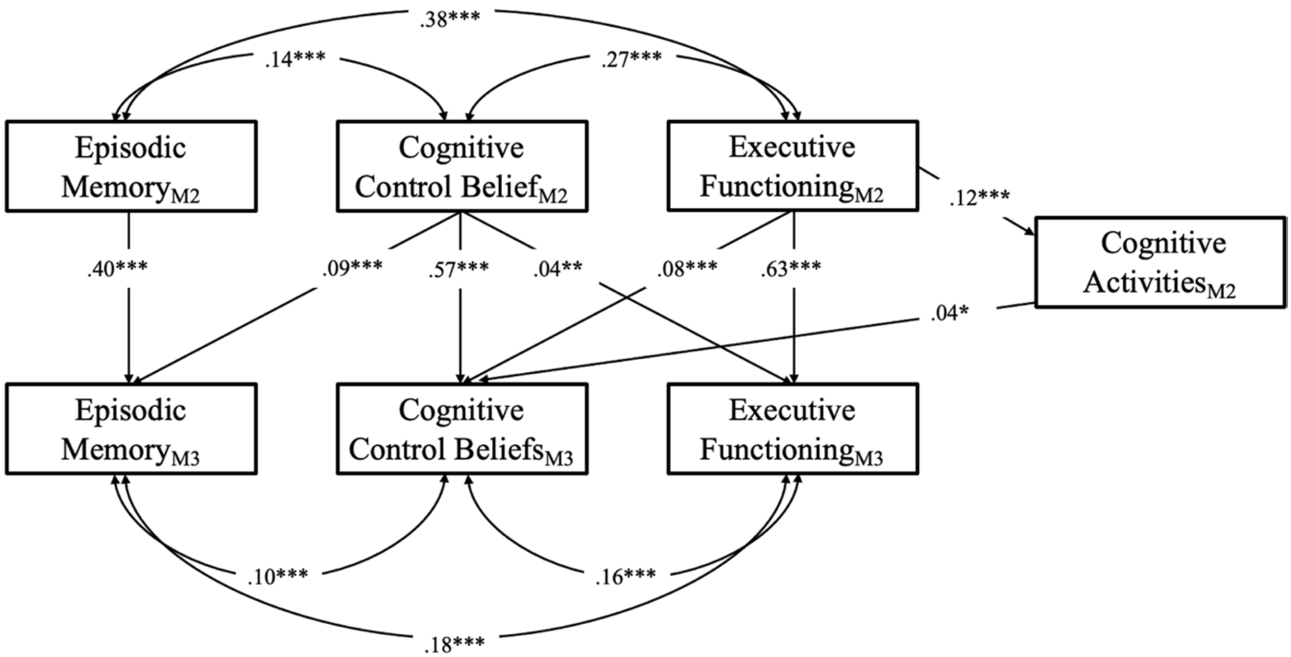

Figure 1. Cross-lagged panel model showing the associations between cognitive control beliefs, stimulating cognitive activities, and cognition over 10 years. M2 = MIDUS 2; M3 = MIDUS 3; Covariates included: M2 age, sex, race, education, and self-rated health. Only significant paths are shown. **p* < .05. ***p* < .01. ****p* < .001.

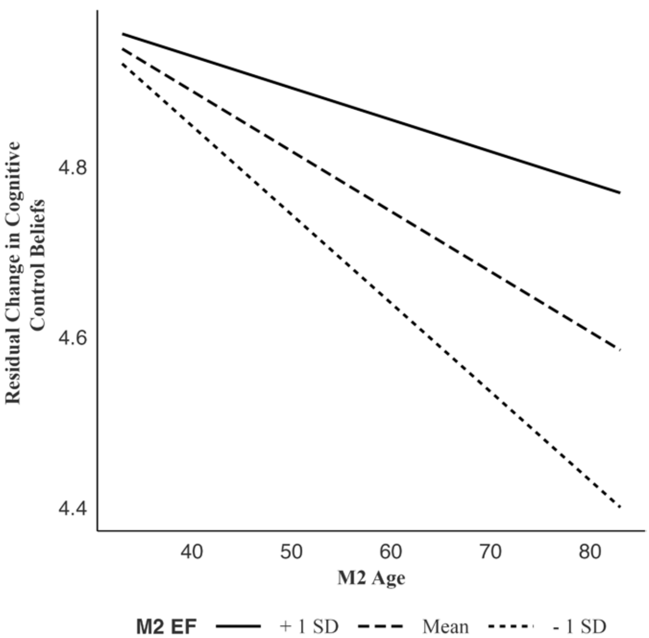

Figure 2. The relationship between M2 executive functioning (EF) and 10-year changes in cognitive control beliefs varies by age. M2 = MIDUS 2; M3 = MIDUS 3; SD = standard deviation. Covariates included: M2 age, sex, race, education, and self-rated health.

the nature of these relationships varied by age using longitudinal data collected from a large U.S. national sample of middle-aged and older adults. We found support for a positive reciprocal relationship between cognitive control beliefs and cognition, although these relationships varied by the dimension of cognition that was measured and by age. While higher baseline cognitive control beliefs were related to less decline in executive functioning over time, higher baseline executive functioning showed an even stronger association with maintenance of cognitive control beliefs. The relationship between executive functioning and changes in cognitive control beliefs also varied by age, such that higher executive functioning led to greater maintenance of cognitive control beliefs in older but not younger adults. Lastly, higher cognitive control beliefs were related to less decline in episodic memory over 10 years, although the inverse relationship was not supported. Taken together, these findings add to a large body of work that has shown control beliefs are associated with cognitive performance (Hahn & Lachman, 2015; Neupert & Allaire, 2012; Raldiris et al., 2021) and that cognitive performance also predicts control beliefs (Bielak et al., 2007; Parisi et al., 2017). Furthermore, the results extend these findings by demonstrating that the directionality and nature of these relationships may vary by the dimension of cognition that is measured and by age.

It is interesting that the relationship between executive functioning and 10-year changes in cognitive control beliefs was stronger than the relationship between cognitive control beliefs and 10-year changes in executive functioning, as this is consistent with previous findings (Parisi et al., 2017). Furthermore, this relationship varied by age, indicating poor executive functioning was related to greater declines in cognitive control beliefs especially for those who were older adults and less so for those in middle age. It is possible these individuals are able to less effectively engage in health-promoting behaviors which results in lower cognitive control beliefs. In support of this idea, we found that the relationship between executive functioning and changes in control beliefs was mediated by the frequency of engaging in stimulating cognitive activities. However, it is possible that cognitive control beliefs reflect an accurate perception of declines to executive functioning.

Our study's findings differed from Parisi et al. (2017), in that we found that higher executive functioning, but not episodic

Table 3. Unstandardized Cross-Lagged Path Coefficients Showing Cognitive Control Beliefs, Episodic Memory, and Executive Functioning, *N* = 2,532

Variables	Model 1
	Estimate (*SE*)
M3 episodic memory	
M2 Age	−0.02*** (0.0)
M2 Sex	0.35*** (0.0)
M2 Education	0.02*** (0.0)
M2 Race	0.11* (0.0)
M2 Cognitive control beliefs	0.09*** (0.0)
M2 Episodic memory	0.41*** (0.0)
M2 Age × Cognitive control beliefs	0.00 (0.0)
M3 Cognitive control beliefs	
M2 Age	−0.01*** (0.0)
M2 Sex	0.08** (0.0)
M2 Race	0.12** (0.1)
M2 Self-rated health	0.05** (0.0)
M2 Cognitive control beliefs	0.58*** (0.0)
M2 Executive functioning	0.09*** (0.0)
M2 Age × Executive functioning	0.00** (0.0)
M2 Stimulating cognitive activity	0.04* (0.0)
Indirect effect	0.01* (0.0)
Total effect	0.09*** (0.0)
M3 Executive functioning	
M2 Age	−0.02*** (0.0)
M2 Education	0.02*** (0.0)
M2 Race	0.14*** (0.0)
M2 Self-rated health	0.02* (0.0)
M2 Cognitive control beliefs	0.03** (0.0)
M2 Executive functioning	0.50*** (0.0)
M2 Age × Cognitive control beliefs	−0.00 (0.0)
M2 Stimulating cognitive activity	−0.00 (0.0)
Indirect effect	0.00 (0.0)
Total effect	0.03** (0.0)
M2 Stimulating cognitive activities	
M2 Age	0.02*** (0.0)
M2 Sex	0.32*** (0.0)
M2 Education	0.07*** (0.0)
M2 Race	−0.25*** (0.1)
M2 Self-rated health	−0.02 (0.0)
M2 Cognitive control beliefs	0.11***(0.0)
M2 Episodic memory	0.08*** (0.0)
M2 Executive functioning	0.11*** (0.0)
R^2	
M2 Cognitive activities	
M3 Episodic memory	0.37
M3 Cognitive control beliefs	0.40
M3 Executive functioning	0.63

Notes: CFI = comparative fit index; M2 = MIDUS 2; M3 = MIDUS 3; RMSEA = root mean square error of approximation; *SE* = standard error; SRMR = standardized root mean square error of approximation; TLI = Tucker-Lewis index. Model 1 Fit: $\chi^2(14) = 71.71$, $p < .001$; CFI = 0.99; TLI = 0.96; RMSEA = 0.04; SRMR = 0.01.
*$p < .05$. **$p < .01$. ***$p < .001$.

memory, was related to greater maintenance of cognitive control beliefs. We also found that higher cognitive control beliefs were related to less decline in executive functioning and episodic memory. Parisi et al. (2017) found that baseline memory predicted changes in cognitive control beliefs, but not that cognitive control beliefs predicted changes in memory, reasoning, or processing speed. It is possible that these different findings may be attributable to the age differences between the MIDUS and ACTIVE samples. Participants in the Parisi et al. (2017) sample were on average 74 years of age at the start of the ACTIVE trial and 84 years of age by the end of the study. In contrast, individuals included in the present study were on average 55 years of age at the initial assessment and 64 years of age at the second occasion. Hence, it is possible individuals in the ACTIVE trial had experienced greater age-related declines in their cognition and cognitive control beliefs relative to the MIDUS participants. Consistent with this idea and Parisi et al. (2017), we found that the relationship between executive functioning and changes in control beliefs was significant for older and not younger participants.

Moreover, the incidence of cognitive impairment in the ACTIVE study could account for the relationships they found between memory and changes in cognitive control beliefs because the ACTIVE study recruited individuals with an increased risk of cognitive impairment (Tennstedt & Unverzagt, 2013) and about 13% of the participants went on to develop dementia (Begley & Stat, 2016). Hence, it is possible that early signs of pathological changes to cognition reduced the effect of cognitive control beliefs on cognition and enhanced the effect of memory on cognitive control beliefs for the ACTIVE participants. In contrast, the present findings indicate that in a younger and relatively healthy sample, cognitive control beliefs may protect against declines in cognition.

Furthermore, a third possible factor contributing to the differences in results is that the Parisi et al study (2017) was a cognitive training intervention. Specifically, the ACTIVE trial cognitive intervention resulted in improved cognitive performance, which could have affected the cognitive control beliefs that were measured at the posttest (Ball et al., 2002).

As an additional aim of this study, we examined if engaging in stimulating cognitive activities at baseline mediated the relationship between cognitive control beliefs and 10-year changes in cognition. Although our results showed that individuals with higher cognitive control beliefs were more likely to engage in stimulating cognitive activities, engaging in stimulating cognitive activities did not significantly mediate the relationship between cognitive control beliefs and 10-year changes in cognition. These findings are consistent with some previous work that has also reported null associations between frequency of activity engagement and changes in cognitive performance over time (Bielak et al., 2007, 2014). However, it is likely that these null associations reflect the tendency for individuals experiencing declines in cognition to disengage from tasks that are high in cognitive demands, an idea originally proposed by Bielak et al. (2007, 2014). Our findings also indicated that there was a positive correlation between M2 age and engagement in cognitively stimulating activities $r = 0.12$, $p < .001$. One possibility is that individuals entering retirement may have more free time for leisurely pursuits, like engaging in stimulating cognitive activities. Furthermore, there is work to suggest that individuals entering retirement are more likely to engage in cognitively stimulating activities relative to those who remain working, which can protect against changes in cognition (Lee et al., 2019).

Consistent with our expectations, engaging in stimulating cognitive activities mediated the relationship between executive functioning and 10-year changes in cognitive control beliefs. These findings are similar to previous work which has shown that executive functioning is heavily implicated in many of the self-regulatory processes involved in engagement in health-promoting behaviors (Hall & Fong, 2007). Moreover, these findings may reflect the tendency for individuals experiencing declines in executive functioning to disengage with these types of tasks due to impairments in their ability to regulate their engagement in health-promoting versus health-damaging behaviors. Hence, individuals declining in executive functioning may be less able to actively and effortfully engage in behaviors (e.g., stimulating cognitive activities) in the pursuit of long-term goals (e.g., sustained or improved cognitive performance). This may result in a lower sense of control over one's cognitive abilities, which could further exacerbate declines in executive functioning.

Limitations

Although the present study adds new findings, it has several limitations that should be considered by investigators seeking to expand on this work. Our analysis was limited in the number of waves of data available to examine the longitudinal associations between cognitive control beliefs and cognition. As a result of having two waves of data, we were unable to use a random-intercept cross-lagged panel model to separate between-subjects variance from within-subjects variance. Additional waves of data, with three or more assessments, will enable future investigators to further examine this dynamic relationship over time. Moreover, there was selective attrition and the current sample was highly educated with relatively high levels of self-reported health and cognitive control beliefs and consisted of a relatively small percentage of non-White individuals, which may affect the generalizability of the current findings to more diverse samples. Additionally, MIDUS does not have a formal measure of cognitive status, and so we are unable to discern if any members of our sample were experiencing some form of cognitive impairment or dementia. We also utilized the brief 9-item cognitive control beliefs measure that was available in MIDUS rather than the longer format of the PIC measure, which limited our ability to examine how cognition relates to different dimensions of cognitive control beliefs. Whereas we recognize that the effect sizes of M2 cognitive control beliefs on cognitive changes and M2 executive functioning on maintenance of cognitive control beliefs are considered small, these longitudinal effects are similar to previous work that examined the cross-sectional relationship between cognitive control beliefs and cognition (Raldiris et al., 2021). It is also possible that there are additional factors, such as subjective age, aging stereotypes, and fear of aging, that could reduce perceptions of control over cognition in addition to poor executive functioning (Stephan et al., 2021). Moreover, our measure of stimulating cognitive activities was by self-report rather than an objective measure and as such was subject to potential response bias. In addition, while frequency of engagement with stimulating cognitive activities represents one mechanism through which executive functioning affects cognitive control beliefs, it is likely that additional health behaviors, such as physical activity, represent others. For example, past work has shown that poor executive functioning is associated with less engagement in physical activity (Buckley et al., 2014), and physical activity is associated with greater maintenance of general control beliefs (Neupert et al., 2009). Given that both cognitive and physical activity have been associated with higher control beliefs (Neupert et al., 2009; Thana-Udom et al., 2021), future work should examine the unique and additive contributions of these types of activities on perceptions of control over time.

Implications and Future Directions

The present study has added to our understanding of the relationship between cognitive control beliefs and cognitive performance over time. The results have practical and theoretical implications despite some limitations. Those with a greater sense of control over cognitive aging were better able to maintain their memory and executive functioning over 10 years. The relationship between executive functioning and 10-year changes in cognitive control beliefs was mediated by the frequency of engaging in stimulating cognitive activities. This suggests that individuals with poor or declining executive functioning may be less likely to engage in these types of health-promoting behaviors. Lower executive functioning may lead to a lower sense of control over one's cognition due to reductions in stimulating cognitive activities. Moreover, disengagement from stimulating cognitive activities may precede declines in cognitive control beliefs, which in turn could then lead to further declines to cognitive functioning. Additional waves of data will be needed to extend the model to test this type of vicious cycle. Identifying other potential mechanisms to promote regimented engagement in health-promoting behaviors, such as engaging in stimulating cognitive activities, may help individuals maintain both their cognitive control beliefs and cognition into middle to late adulthood.

Conclusion

As individuals enter later adulthood, they experience a number of changes in their cognitive health. These changes do not follow a singular trajectory and may vary due to a number of individual differences, including one's cognitive control beliefs and engagement in health-promoting behaviors. However, many may disengage from health-promoting behaviors due to their views of age-related changes as largely inevitable, irreversible, and uncontrollable as well as due to poor executive functioning. Importantly, the present study adds to the body of work that has shown that sense of control represents a type of age-related belief that can help individuals adapt to and minimize age-related declines in health and cognition. Specifically, this study provides evidence to support the idea that individuals who feel more in control of their cognitive abilities are more likely to perform better and decline less over time than those who feel less in control and that those who perform better are more likely to have higher cognitive control beliefs over time than those who do not perform as well. Our results also show that those with better executive functioning engage more frequently in a health-promoting behavior, that is, cognitively stimulating activities, which benefits cognitive control beliefs over time.

Supplementary Material

Supplementary data are available at *The Journals of Gerontology, Series B: Psychological Sciences and Social Sciences* online.

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Conflict of Interest

None.

Data Availability

This study was not preregistered. Data are publicly available at the following website: (https://www.icpsr.umich.edu/web/ICPSR/series/203) and study analysis code may be made available for appropriate use upon email request to the corresponding author.

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