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Disaggregating between- and within-person associations of mastery and cognitive function: age as a moderator

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Abstract

Background Mastery may shape the way individuals cope with life challenges and influence cognitive function in later life. Mastery grows out of traumatic experience and could change over the life course. This study examined the within-person and between-person associations of mastery and cognitive function, and if these associations were moderated by age in the United States.

Method Data were derived from three time points (2006–2008, 2010–2012, and 2014–2016) of the *Health and Retirement Study,* with 14,461 adults (aged 51 or above). Cognitive function was measured through a 27-point Telephone Interview Cognitive Screen (TICS). Mastery was measured by a modified Pearlin Mastery Scale. Multilevel modeling was employed to analyze the data.

Results Both within-person (β=0.124, SE = 0.023, p < 0.001) and between-person (β=0.089, SE = 0.029, p = 0.002) mastery were significantly associated with cognitive function. Older adults with higher between-person mastery tended to have slower cognitive decline (β=0.063, SE = 0.021, p < 0.001). Moreover, age moderated the within-person (β=0.013, SE = 0.003, p < 0.001) associations between mastery and cognition with a stronger association observed among individuals with older age.

Conclusions The current study provides evidence for within-person and between-person associations between mastery and global cognition in the United States as well as the moderating role of age. The design of the current study did not directly assess the causal direction between mastery and cognitive function. Future studies could test the directionality of associations between mastery and cognitive function.

Keywords Mastery, Cognitive function, Multilevel modeling, Longitudinal study

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Background

With the rapid growth of older populations around the world, examining the potential psycho-social resources that may protect against cognitive decline in older adults becomes increasingly important for successful aging [1, 2]. It is critical to highlight these psycho-social predictors for cognitive decline, as they may shape how older adults cope with life challenges, and consequently influence to what extent older adults engage in behaviors related to cognitive health [3, 4]. In addition, these predictors may represent modified factors to target interventions aimed at maintaining cognitive function in older age [2, 5, 6]. One such promising factor is one's sense of mastery, which is considered an important resource for cognitive health among older adults.

Mastery, one component of perceived control, broadly defined as the ability to perform actions aimed at attaining desired outcomes [7, 8], evolves and changes over the life course and is likely to decrease in later life due to declining health and increased prevalence of adverse life events [9]. Mastery is instrumental in facilitating positive aging-related outcomes across adulthood and old age [10]. Constraints, as the other component of perceived control, refer to perceived obstacles or deterrents for achieving one's desired outcomes [11, 12]. However, investigations of the relationship of both within-person differences and between-person changes in mastery and cognitive function are sparse. It also remains largely unknown whether the association between mastery and cognitive function varies by age. Although one study identified age groups (60–64 vs. 20–24) as a significant moderator in the relationship between mastery and cognitive domains among Australians [2], this has largely been unexplored in diverse ethnic groups or other geographic areas. This study seeks to address the gap in the literature by examining the moderating effect of age and longitudinal associations between inter- and intra-individual mastery and cognitive function among a sample of US middle-aged and older adults as well as the moderating effect of age using three waves of data.

Intra- and inter-individual mastery and cognitive function

Lachman's integrative model of perceived control has been frequently used to outline the relationship between perceived control and cognitive function in middle and late adulthood [13, 14]. The model suggests that adults with higher perceived control may be more likely to perceive these declines as changeable and thus actively adopt positive strategies, engage in health-promoting behaviors, seek and receive social support, and reduce stress reactivity to compensate for cognitive decline [15]. Mastery is one component of perceived control [12] and its association with memory has been well documented in the literature. For example, a study in the Netherlands found that older adults with lower levels of mastery were likely to have memory complaints extending over a period of six years [16]. Similarly, another study revealed that higher mastery assessed at baseline was associated with less subjective memory complaints in the follow-up measurement [17]. Using data from the *Longitudinal Aging Study Amsterdam*, Klaming and colleagues found that a higher level of mastery was associated with better memory function, but not the rate of decline [18].

Although prior longitudinal studies consistently demonstrated a positive association between mastery and cognitive outcomes, they are still problematic due to statistical methods that confounded the within- and between-person effects. In longitudinal studies, time-varying predictors are those that are measured at each occasion, which usually consist of both within-person and between-person variations [19]. Thus, methods to distinguish within-person effects from between-person effects are warranted to investigate relationships between mastery and cognitive function. As discussed in prior work that failure to separate the within-person and between-person source of variations when using data with repeated measures may lead to biased results and incorrect conclusions about within-person relationships over time [20]. Researchers are not likely to quantify either within-person or between-person processes accurately without using appropriate methodology to unpack the complex structure of variability inherent in multivariate longitudinal data by distinguishing the impacts of within-person variation from between-person variation. The between-person effects reflect the inter-individual differences indicating the overall differences between individuals across all occasions. Within-person effects allowed respondents to act as their own controls, partially accounting for unobserved time-invariant confounders. Within a large body of research concerning mastery and cognition, exploring their correlation simultaneously from both within-person and between-person levels represents a relatively new trend in this area.

Evidence is mixed regarding the impacts of within-person and between-person mastery on cognitive function [2, 20, 21]. One study found a significant impact of both between-person and within-person mastery on processing speed [20]. However, Neupert's study found that the association between mastery and inductive reasoning or perceptual speed could be only explained by a within-person process rather than a between-person effect [22]. Another study reported that between-person mastery was positively related to memory, verbal intelligence, and processing speed, while within-person changes in mastery were not significantly associated with changes in cognitive domains [2]. Given that there are individual differences in mastery even under the same circumstance and the changes in mastery within persons under different circumstances, failure to explicitly consider separating between- and within-person sources of variation when modeling repeated measures data can lead to biased results. Prior studies mainly focused on cognitive domains and the results were mixed. This study aims to explore the within-person and between-person effects of mastery on overall cognition.

Age as a moderator

Lachman and colleagues (2011) indicated that the age trends for perceived control typically show an increase in early adulthood, with a peak in midlife, and a leveling off with a subsequent decline in later life. Older adults are more likely than the young to believe that their memory is poor, and decline is inevitable. Such concerns about memory emerge in middle age and may serve as a risk factor for accelerated cognitive decline, suggesting potential age differences in the control-cognition link [23]. Specifically, functional abilities and health may become progressively more delicate with aging. Social networks may also become more constricted due to the loss of close relatives and friends, increasing the risk for loneliness or social isolation [24, 25]. Increasing mastery skills can assist older adults to adapt the challenges that accompany aging [26]. Examining potential age-related variations in the impact of mastery on cognitive function can offer valuable insights for policymakers and healthcare providers. This knowledge can facilitate the development and implementation of tailored interventions aimed at addressing the needs of an aging population. In addition, age is strongly associated with cognitive function. Thus, we would expect that age will moderate the relationship between mastery and cognitive function.

Existing research has shown differentiated effects of mastery on cognitive domains across age groups. Prior research reported that the between-person effect of control belief on memory was only significant for midlife and older adults, but not younger adults [27]. Additionally, the discrepancy in prior findings regarding within-person mastery and cognitive domains can be explained by age. For example, Windsor's study analyzed a combined age group of young, midlife, and older adults and found that within-person mastery was not significantly associated with cognitive function [2]. However, Sargent-Cox' study reported that within-person mastery was significantly associated with cognitive function in older adults [20]. Therefore, whether the level of mastery or variability in mastery had greater salutary effects on cognitive outcomes may depend on age. Together, this literature highlighted the importance of exploring age differences in the relationship between mastery and cognitive function, suggesting that both between-person and within-person effects might differ by age.

The present study

The objectives of this study are to examine the longitudinal association between mastery and cognitive outcomes among older adults as well as the moderating effect of age. Specifically, we tested the following hypotheses:

> H1: Individuals with overall greater mastery have better cognitive function (a between-person effect), and on measurement occasions when individuals have higher mastery scores, they exhibit better cognitive performance (a within-person effect).
> H2: Mastery is associated with the rate of cognitive change at the between-person level. Individuals with greater mastery would experience a relatively slow rate of cognitive decline compared to those with lower mastery.
> H3: Age moderates the association between mastery and cognitive function at both within-person and between-person levels.
> H4: Age moderates the association between mastery and cognitive decline at the between-person level.

Methods

Study sample and data

This study used three-wave longitudinal data (2006–2008, 2010–2012, 2014–2016) from the *Health and Retirement Study* (HRS). HRS has been approved by several ethics' committees, including University of Michigan IRB (IRB protocol HUM00061128). In 1992, HRS collected a sample of 12,652 US residents who were born between 1931 and 1941 through biennial surveys that focus on various information (e.g., sociodemographic status, economic resource, and physical health). The HRS sample was drawn at the household financial unit level using a multistage, national area-clustered probability sample frame with the first wave of the community-dwelling (non-institutionalized) respondents in the contiguous United States born between 1931 and 1941.

Starting from 2006, about half of the 15,000 HRS (subsample A) respondents were randomly selected to complete the Psychosocial Leave-Behind Questionnaire (LBQ), including the mastery scale. This subsample participated in the LBQ every four years (e.g. 2006, 2010, and 2014), whereas the other half of the respondents (subsample B) participated in the LBQ starting from 2008 and was followed by the same 4-year circle (e.g. 2008, 2012, and 2016).

In order to fully leverage the sample size and examine the relationship between change of mastery and cognitive decline, we merged subsample A and subsample B by restructuring the dataset and aligning both samples' starting points (2006/2008) as Time 1. Then the follow-up data in 2010 (subsample A) and 2012 (subsample B) were merged and denoted as Time 2. Finally, the data in 2014 (subsample A) and 2016 (subsample B) were combined to form Time 3. We did not include the dataset in 2018 and 2020 because web-based interviews were conducted since 2018, which could introduce additional bias in the cognitive measurement [28].

We included respondents who participated at baseline (Time 1) and merged them with the RAND HRS longitudinal data file (V1) [29]. The RAND data file is a clean and easy-to-use data product that contains fourteen waves of Core Interview data from HRS with derived variables covering a large range of topics. At Time 1, 14,803 non-proxies completed both LBQ and a cognitive assessment. We further excluded participants ($n = 342$) who were under 51 and restricted our analytical sample to participants aged 51 or above at Time 1. This yielded a final analytical sample of 14,461 with 44,409 observations.

Key measures and study variables

Cognitive function

A modified Telephone Interview Cognitive Screen (TICS-m) was used to measure participants' cognitive function [30]. TICS-m assessed short-term memory, working memory, and speed of processing through (a) an immediate and delayed word recall (range = 0–20); (b) a serial seven subtraction task (range = 0–5); and (c) a backward counting task (range = 0–2 points). This measurement was administered at each wave for all participants. TICS-m was often used to measure the general status of cognitive function [30, 31]. It was a widely used telephone assessment instrument with good reliability and validity for screening dementia [30]. A composite score using all the items created a measure of cognitive function (range = 0–27), with a higher score indicating better cognition. The TICS-m scores from 2006–2008, 2010–2012 and 2014–2016 were used in the current study.

Mastery

Perceived mastery was measured using a 5-item scale modified from the Pearlin Mastery Scale [8]. The participants were asked to rate the following items on a 6-point Likert scale (1 = strongly disagree; 6 = strongly agree): "I can do just about anything I really set my mind to"; "When I really want to do something, I usually find a way to succeed at it"; and "What happens to me in the future mostly depends on me". The average score was taken from the five items to indicate participants' average level of perceived mastery, with higher scores indicating higher perceived mastery. The Cronbach's alphas were 0.89 in Time 1, 0.90 in Time 2, and 0.91 in Time 3.

Covariates

Demographic, socioeconomic, and health related factors were controlled as they may have confounded the association between mastery and cognitive function in previous studies [2, 11, 18]. Time-invariant variables included participants' baseline age (range = 51–104), race (1 = Hispanic; 2 = Non-Hispanic White; 3 = Non-Hispanic Black; 4 = other race), gender (0 = male; 1 = female), and education (years of schooling).

The time-varying variables included total wealth, calculated as total wealth components minus all debt, depression, and chronic conditions. The inverse hyperbolic sine (IHS) was used to handle the issue of skewness for total wealth [32]. The number of depressive symptoms were measured using a sum score of 8 items (range = 0–8) from the *Center for Epidemiologic Studies Depression scale* (CES-D; 0 = no, 1 = yes). The Cronbach's alphas for the depression scale were 0.77, 0.77, and 0.79 for Time 1, Time 2, and Time 3, respectively. Chronic conditions, evaluated by the number of 8 chronic diseases (i.e., high blood pressure, stroke, cancer or a malignant tumor, chronic lung disease, arthritis, cardiovascular disease, diabetes, emotional or psychiatric diagnoses, and sleep disorders; range = 0–8), were also controlled.

Data analysis

First, descriptive statistics were calculated for each variable. Second, multilevel modeling was employed to examine the association between mastery and cognitive function. The repeated measure of mastery, as a time-varying variable, was decomposed into within-person and between-person components [19]. In multilevel analysis, the two sources of variation are likely to have different effects on the outcome—a within-person effect and a between-person effect, respectively [33]. The between-person effects represent interindividual differences, whereas the within-person effects refer to intraindividual differences that are fluctuating within persons [34]. We used time to model trajectories rather than using age as the sole time metric to model trajectories as this approach provides a more accurate modeling approach. Early work suggested that using age as a time metric to model trajectories often relies on the inaccurate assumption that cross-sectional and longitudinal effects of aging are equivalent [35, 36]. Thus, we used time (assessed with time form baseline) to capture longitudinal changes in cognitive function while accounting for cross-sectional differences in cognitive function between those with different ages (assessed with age at baseline) [35, 36]; this is especially important when the study sample includes a wide range of age cohorts, such as HRS. We also included a quadratic term for age to capture its possible curvilinear association with cognitive function and created an interaction term between age at baseline and time to capture potential age-differences in longitudinal changes in cognitive decline.

To disaggregate within-person and between-person effects of mastery on cognitive function, we used a group-mean centering approach to examine whether intraindividual changes and interindividual differences in mastery are associated with the level of cognitive function and rate of cognitive decline [19, 37]. To be more specific, the within-person effect of mastery was modeled based on the difference of observed value x_{it} from the person's mean $\overline{x}_{i.}$ The person's mean value $\overline{x}_i$ which represented a person's average level of mastery across time, was added in the level-2 model as the between-person component. Using the same approach, we also decomposed time-varying covariates in the model to keep the interpretation of each coefficient more consistent.

By adopting the centering approach, the multilevel model with all covariates could be expressed as:

Level 1: $Cognition_{it} = \beta_{0i} + \beta_{1i}$ $\text{Time}_{\text{i}} + \beta_{2i}Condition\_WP_{it}$ $+\beta_{3i}Depression\_WP_{it} + \beta_{4i}Wealth\_WP_{it} + \beta_{5i}Mastery\_WP_{it} + \epsilon_{it}$, $\epsilon_{it} \sim N(0, \sigma^2)$

Level 2: $\beta_{0i} = \gamma_{00} + \gamma_{01}Age_i + \gamma_{02}Age_i^2 + \gamma_{03}Female_i +$ $r_{04}Education_i + \gamma_{05}Conditon_{BP_i} + \gamma_{06}Depression_{BP_i} +$ $\gamma_{07}\text{Non\_Hispanic\_White}_i + \gamma_{08}\text{Non\_Hispanic\_Black}_i +$ $\gamma_{09}\text{Other\_Race}_i + \gamma_{10}Wealth\_BP_i + \gamma_{11}Mastery\_BP_i{*}Age_i + \zeta_{0i}$,

$$\zeta_{0i} \sim N(0, u_0^2)$$

$$\beta_{1i} = \gamma_{10} + Age_i + \gamma_{11}Mastery\_BP_i + \gamma_{12}Age_i * Master\_BP_I + \zeta_{1i}, \quad \zeta_{1i} \sim N(0, u_1^2)$$

$$\beta_{2i} = \gamma_{20}$$

$$\beta_{3i} = \gamma_{30}$$

$$\beta_{4i} = \gamma_{40}$$

$$\beta_{5i} = \gamma_{50} + \gamma_{51}Age_i + \zeta_{5i}, \zeta_{5i} \sim N(0, u_5^2)$$

β_{0i} presents the level of cognitive function at the initial time point for person i, and β_{1i} presents the same person's rate of cognitive decline. β_{2i}-β_{5i} represent the coefficients of each time-varying covariate on the cognition. γ_{01}- γ_{51} represent the fixed effect of each covariate. The time variable was coded as (0, 1, 2), with one unit indicating a four-year time interval. Missingness was handled by full information maximum likelihood estimation (FIML). FIML was often used to handle data that are missing completely at random (MCAR) and missing at random (MAR) [38]. In the context of longitudinal studies of older adults, selective attrition may occur, where healthier older adults are more likely to remain at the end of the study. In this case, MAR is a plausible assumption to make. Based on Okpara's suggestions [39], we also compared baseline characteristics of those with and without complete data, which could help examine whether missingness is dependent on the observed variable (MAR). We conducted an additional logistic regression, where the dependent variable is a binary variable indicating whether a respondent completed all three waves of the survey (0 = not loss to the follow-up, 1 = loss to the follow-up). The predictors include all the covariates used in the current study. All analyses were completed using R package "lme4". The significance level was set at 0.01 in the current study.

Results

Sample characteristics

The descriptive information of each variable is shown in Table 1. The average baseline age was 68.93 (SD = 9.99). Female participants accounted for 58.81% (n = 8,505) of the total sample. The average education attainment among participants was 12.55 years (SD = 3.13). Most of them (76.92%) are Non-Hispanic Whites (n = 33,405). The average number of chronic conditions increased over time from 2.07 to 2.61. In contrast, both average mastery and cognitive function tended to decrease over time, with a more markedly changed on cognition than mastery. Finally, respondents' depression tended to slightly decrease over time. This might be caused by the drop-out of more depressed individuals or those experiencing an increase in depression over time.

Associations between mastery and cognitive function

Results for the association of mastery with cognitive function at the within-person and between-person levels are shown in Table 2. The intra-class correlation (ICC) was 0.446, indicating that 44.6% of total variance in cognitive function could be attributed to between-person variation across the sample. The first hypothesis was tested by Model 1. Participants had a linear decline in cognitive function ($\beta = -0.674, p < 0.001$) across time. Both within-person ($\beta = 0.124$, SE= $0.023, p < 0.001$) mastery and between-person (β = 0.089, SE= $0.029, p = 0.002$) mastery were significantly and positively associated with the level of cognitive function after controlling covariates. In order to test our second hypothesis that people with different mastery levels may differ in the rate of cognitive decline, we added the interaction terms between mastery (between-person) and time based on Model 1. In

Table 1 Descriptive statistics for study variables across waves ($N = 14{,}461$)

Variables	Time 1		Time 2		Time 3	
	N (%)		N (%)		N (%)	
Gender						
Male	5,956 (41.19%)					
Female	8,505 (58.81%)					
Race						
Hispanic	2619 (6.03%)					
Non_Hispanic_Black	5,544 (12.77%)					
Non_Hispanic_White	33,405 (76.92%)					
Other Race	1863 (4.28%)					
	Mean (SD)	(Min, Max)		(Min, Max)		(Min, Max)
Education (Years)	12.55 (3.13)	(0, 17)				
Baseline Age	68.93 (9.99)	(51, 104)				
Wealth	516,334 (1,196,975)	(-2199,392, 41,633,420)	462,301 (899,279)	(-1495,000, 27,992,000)	535,516 (1,086,222)	(-497,840, 30,850,000)
Chronic Conditions	2.07 (1.44)	(0, 8)	2.39 (1.48)	(0, 8)	2.61 (1.50)	(0, 8)
Depression	1.42 (1.94)	(0, 8)	1.38 (1.92)	(0, 8)	1.34 (1.88)	(0, 8)
Mastery	4.74 (1.13)	(1, 6)	4.68 (1.15)	(1, 6)	4.69 (1.13)	(1, 6)
Cognitive Function	14.79 (4.89)	(0, 27)	11.62 (7.17)	(0, 27)	9.06 (7.86)	(0, 27)

SD Standard deviation

Model 2, the results indicated that the interaction effect between mastery (between-person) and time was significant ($\beta = 0.063$, $SE = 0.021, p < 0.001$). Figure 1 shows that older adults who maintained a high mastery level over time tended to have slightly slower cognitive decline.

The third hypothesis was addressed by Model 3 from Table 2. We included interaction terms between age and mastery (within- and between-person components) to examine how age could moderate the association between mastery and cognition. The results showed that only the interaction effect between age and mastery at the within-person level ($\beta = 0.013$, $SE = 0.003$, $p < 0.001$) was significant, while its interaction at the between-person level was not significant ($\beta = 0.005$, $SE = 0.003$, $p = 0.080$). Figure 2 presents an illustration of the empirical finding about the interaction effect of within-person mastery and age on cognitive function. For a respondent from the youngest group (age 51–59), an increase in mastery does not relate to a change in cognitive function. In contrast, mastery and cognitive function tend to be strongly related for a respondent from the oldest group (age 80 and above), with higher mastery associated with a higher level of cognition.

In Model 4, we added a three-way interaction term of age, time, and between-person mastery to examine our fourth hypothesis. However, the interaction term was not statistically significant ($\beta = 0.003$, $SE = 0.002$, $p = 0.214$), implying that age did not moderate the association between mastery (between-person) level and cognitive decline.

All covariates except total wealth were significantly associated with cognitive function at both the between-person and within-person levels across four models. For example, in model 3, being female and higher level of education were associated with higher levels of cognitive function ($\beta_{female} = 0.859$, $SE = 0.054, p < 0.001$; $\beta_{education} = 0.456$, $SE = 0.010, p < 0.001$). Being a Non-Hispanic White has higher cognitive function than being a Hispanic ($\beta_{Non-Hispanic White} = 0.598$, $SE = 0.120, p < 0.001$). More chronic conditions and higher levels of depressive symptoms were associated with lower levels of cognitive function ($\beta_{condition_{bp}} = -0.110$, $SE = 0.021, p < 0.001$; $\beta_{depressionn_{bp}} = -0.267$, $SE = 0.018, p < 0.001$).

Appendix shows the results of sample attrition analysis. The logistic regression demonstrated that individuals who are older ($\beta = 0.043$, $SE = 0.002$, $OR = 1.044, p < 0.001$), male ($\beta = -0.125, SE = 0.037, OR = 0.882, p < 0.001$), more depressive symptoms ($\beta = 0.078$, $SE = 0.010$, $OR = 1.082$, $p < 0.001$), more chronic conditions ($\beta = 0.137$, $SE = 0.014$, $OR = 1.147$, $p < 0.001$), lower mastery ($\beta = -0.060$, $SE = 0.017$, $OR = 0.942$, $p < 0.001$) and cognitive function ($\beta = -0.077$, $SE = 0.005$, $OR = 0.926$, $p < 0.001$) are more likely to drop out in the study.

Discussion

The current study examined the association between mastery and cognitive function over 8 years in a national sample of midlife and older adults in the

Table 2 Association between mastery and cognitive function

Variables	Model 1			Model 2			Model 3			Model 4		
Terms	B	SE	P	B	SE	P	B	SE	P	B	SE	P
Intercept	8.385	0.221	< 0.001	8.550	0.227	< 0.001	8.579	0.229	< 0.001	8.529	0.229	< 0.001
Age	-0.148	0.003	< 0.001	-0.148	0.003	< 0.001	-0.170	0.013	< 0.001	-0.142	0.014	< 0.001
Age^2	-0.002	0.000	< 0.001	-0.002	0.000	< 0.001	-0.002	0.000	< 0.001	-0.003	0.000	< 0.001
Female	0.857	0.054	< 0.001	0.857	0.054	< 0.001	0.859	0.054	< 0.001	0.864	0.054	< 0.001
Education	0.456	0.010	< 0.001	0.456	0.010	< 0.001	0.456	0.010	< 0.001	0.458	0.010	< 0.001
Non_Hispanic_Black	-1.761	0.135	< 0.001	-1.760	0.135	< 0.001	-1.757	0.135	< 0.001	-1.762	0.136	< 0.001
Non_Hispanic_White	0.600	0.120	< 0.001	0.600	0.120	< 0.001	0.598	0.120	< 0.001	0.601	0.121	< 0.001
Other Race	-0.944	0.169	< 0.001	-0.943	0.169	< 0.001	-0.944	0.169	< 0.001	-0.932	0.169	< 0.001
Condition_BP	-0.109	0.021	< 0.001	-0.109	0.021	< 0.001	-0.110	0.021	< 0.001	-0.116	0.021	< 0.001
Condition_WP	-0.120	0.035	< 0.001	-0.116	0.035	0.001	-0.113	0.035	0.001	-0.119	0.034	< 0.001
Depression_BP	-0.266	0.018	< 0.001	-0.265	0.018	< 0.001	-0.267	0.018	< 0.001	-0.267	0.018	< 0.001
Depression_WP	-0.060	0.014	< 0.001	-0.059	0.014	< 0.001	-0.060	0.014	< 0.001	-0.044	0.014	< 0.001
Wealth_BP	0.070	0.006	< 0.001	0.070	0.006	< 0.001	0.071	0.006	< 0.001	0.071	0.006	< 0.001
Wealth_WP	0.012	0.005	0.024	0.012	0.005	0.026	0.012	0.005	0.020	0.008	0.005	0.125
Mastery_WP	0.124	0.023	< 0.001	0.120	0.023	< 0.001	0.127	0.023	< 0.001	0.089	0.023	< 0.001
Mastery_BP	0.089	0.029	0.002	0.055	0.031	0.081	0.048	0.032	0.134	0.069	0.032	0.030
Time	-0.674	0.023	< 0.001	-0.979	0.102	< 0.001	-0.971	0.103	< 0.001	-0.888	0.102	< 0.001
Interaction Effects												
Mastery_BP×Time				0.063	0.021	< 0.001	0.063	0.021	< 0.001	0.031	0.021	0.134
Age×Mastery_WP							0.013	0.003	< 0.001	0.007	0.002	< 0.001
Age×Mastery_BP							0.005	0.003	0.080	0.004	0.003	0.163
Age×Time										-0.055	0.011	< 0.001
Age×Mastery_BP×Time										0.003	0.002	0.214
Random Effects												
Residual variance (Level 1)	5.301	0.014	< 0.001	5.299	0.014	< 0.001	5.303	0.014	< 0.001	5.305	0.014	< 0.001
Intercept variance (Level 2)	6.879	0.221	< 0.001	6.880	0.227	< 0.001	6.870	0.229	< 0.001	6.870	0.228	< 0.001
Time (slope)	0.312	0.023	< 0.001	0.309	0.102	< 0.001	0.300	0.103	< 0.001	0.300	0.103	< 0.001
Mastery (slope)	0.174	0.023	< 0.001	0.171	0.023	< 0.001	0.162	0.023	< 0.001	0.162	0.023	< 0.001
Model R^2	0.721			0.722			0.725			0.732		

B Coefficient, *SE* Standard error, *wp* Within-person component, *bp* Between-person component, *Age^2* is the quadratic term for age variable

Time (slope) The slope of time, *Mastery (slope)* The slope of mastery, *Hispanic* is the reference group

United States. At both between-person and within-person levels, mastery was significantly and positively associated with the level of cognitive function. In addition, between-person mastery was significantly associated with less cognitive decline over time. Regarding the moderating role of age, the association between mastery and the level of cognitive function was more salient for individuals with older age.

The results were in line with previous research showing that both within-person mastery and between-person mastery were positively associated with the level of cognitive function [16, 40]. Our first hypothesis was supported. The significant association of between-person mastery and cognitive function indicated that individuals perceiving higher levels of mastery tended to have better cognitive performance compared with their counterparts who had lower levels of mastery. In addition, the significant association of within-person mastery and cognitive function suggested that intraindividual variability in mastery was associated with changes in cognitive function.

Our findings showed that between-person mastery was associated with cognitive decline. Our second hypothesis was also supported. The group with higher levels of mastery tended to show a slower rate of cognitive decline than the group with lower levels of mastery. This finding addressed a gap in knowledge by providing direct evidence that maintaining a high level of mastery over the life course could consistently benefit cognitive health. Although both Windsor [2] and Sargent-Cox [20] utilized

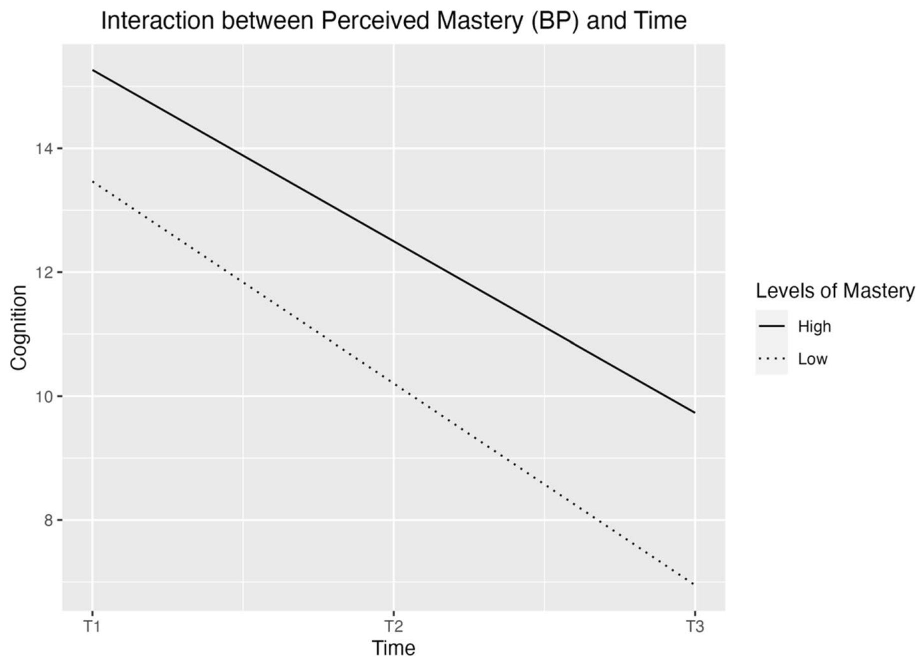

Fig. 1 Cognitive decline rate among adults with different mastery levels over time (Between-person Effect). *Note*: the between-person mastery was split into two groups based on one standard deviation below or above the mean

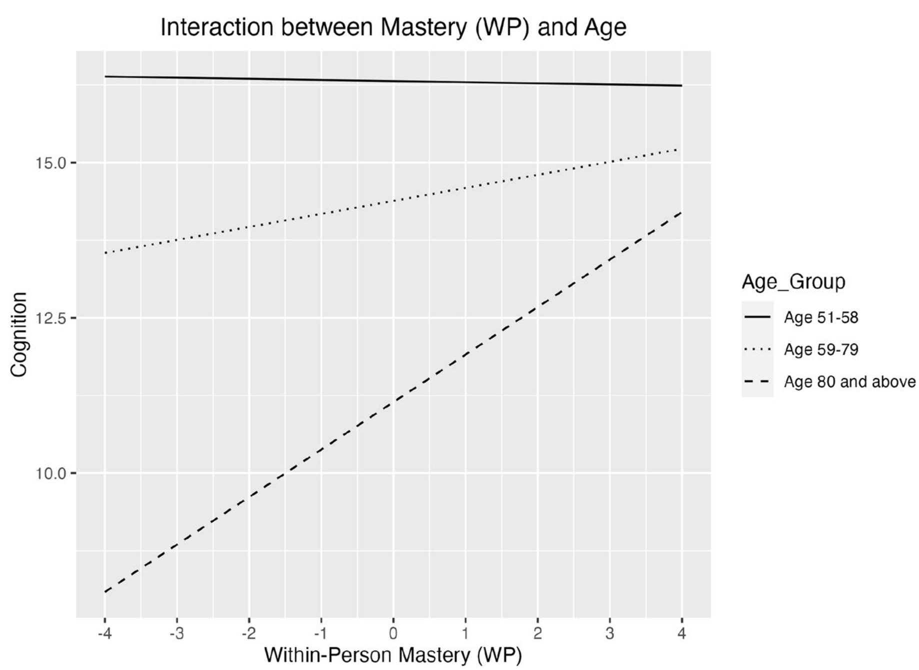

Fig. 2 Fluctuations in mastery (within-person) and cognitive trajectory by age. Note. Age was split into three groups based on mean and standard deviation of age. The mean age is about 69, and the standard deviation is around 10

similar analytical methods, their studies did not reveal the potential differences in cognitive decline among adults with different levels of mastery. The inconsistent results between Windsor [2] and Sargent-Cox [20] and our study might be due to the different study populations (age 20 and above vs. age 51 and above) and different measures for the cognitive outcomes (cognitive domains vs. global cognitive function). However, other research consistently showed that individuals with higher mastery level were more likely to engage in cognitively stimulating activities [41] and fostered an enriched lifestyle to help sustain cognitive stability [18].

The significant interaction effects between age and within-person mastery suggested that mastery would be more important for individuals with increasing age to maintain cognitive function; our third hypothesis was partially supported. The findings were consistent with previous studies that demonstrated the significant moderating role of age in the relationship between control belief and the level of cognitive function [2, 27, 42]. As depicted in Fig. 2, the association of within-person mastery and cognition was stronger in the older age group (age 80 and above) than the younger age groups. The decline of mastery may alter the physiological state of individuals with advanced age resulting in an increased cognitive vulnerability. Another possible reason is that individuals with higher levels of mastery utilized more compensatory strategies to help maintain their cognitive performance than their counterparts [43, 44].

Our fourth hypothesis was not supported given we did not find a significant moderation effect of age in the association of between-level mastery and cognitive decline. This may resonate to the Lachman's conceptual model that, in some situations, perceived control may not interact with aging effects. Promoting the level of mastery may be more important for those with cognitive impairment. Given our study was among the first to explore the moderating effect of age for the within-level and between-level of mastery and cognitive function, we suggest more studies to verify our findings.

Limitations and implications

This study has several limitations. First, although the attritional analysis comparing completers and attritional cases may suggest that the missing data may be MAR, we could not fully rule out the existence of MNAR. The estimation bias may still exist even though the FIML method was utilized. Thus, our results may not be generalized to older, less educated, male participants, or those with poorer health outcomes. Second, mastery was a subjective measure and was self-reported by respondents. This reporting bias cannot be avoided. Third, this study examined the association between mastery and cognitive function and decline. However, the decline could also undermine individuals' mastery beliefs [23]. The design of the current study did not directly assess the causal direction between mastery and cognitive function. Fourth, at least three waves of data are needed to estimate within-person effects. Stronger within-person effects might have been observed with more data collection points. Future studies could use more waves of data to examine the relationship between within-person mastery and cognitive function. Finally, survey weights were not applied in the analysis due to model-based inference [45]. Nevertheless, unweighted regression models still offer unbiased estimates of standard errors [46, 47].

Despite these limitations, this study has theoretical and practical implications. This study extended the line of research by examining within-person trajectory in mastery in addition to between-person component. We found that older adults who maintained a higher level of mastery over time tended to have higher cognitive function. Future studies could further test Lachman's conceptual model of mediational processes [14] and identify the possible behavioral, motivational, affective, and psychological mechanisms that link mastery to cognitive function. Our findings emphasized the construct of mastery may be an important psychological resource to preserve overall cognitive function, especially for older adults, which could inform cognitive interventions. The potential impacts of within-person and between-person mastery on cognitive function could operate at different timescales. Between-person mastery could be more stable than within-person mastery. These processes may be associated with different interventions operating at different timescales targeting within-person and between-person mastery [48].

Conclusion

In conclusion, the current study added to existing knowledge by examining the longitudinal association between within- and between-person mastery and cognitive function among a national representative sample of US middle-aged and older adults. We also explored the moderating role of age in the above associations. Overall, our findings demonstrated that mastery was positively associated with cognitive function at both within-person and between-person levels. Our results also suggested that the association of between-person and within-person mastery and cognitive function was stronger for individuals with older age. Future research could further explore the mechanisms through which mastery and cognitive function are interrelated.

Appendix

Table 3 Logistic Regression of attrition sample (*N*=14,461)

Terms	Estimate	SE	OR	*P* Value
Intercept	-1.472	0.215	0.230	< 0.001
Age	0.043	0.002	1.044	< 0.001
Female	-0.125	0.037	0.882	0.001
Education	-0.007	0.007	0.993	0.295
Non_Hispanic_Black	-0.031	0.092	0.970	0.739
Non_Hispanic_White	-0.174	0.082	0.840	0.033
Other Race	0.053	0.114	1.055	0.638
Depression_T1	0.078	0.010	1.082	< 0.001
Wealth_T1	0.000	0.000	1.000	0.819
Chronic Conditions_T1	0.137	0.014	1.147	< 0.001
Mastery_T1	-0.060	0.017	0.942	< 0.001
Cognition_T1	-0.077	0.005	0.926	< 0.001

OR Odds ratio, *SE* Standard error, *Hispanic* is the reference group

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Du, Li, and Peng analyzed data and wrote the main manuscript text. Wu, Pernice, Dong, and Wang reviewed and revised the manuscript.

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Availability of data and materials
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
The HRS has been approved by the Institutional Review Board at the University of Michigan. The HRS obtains informed verbal consent from voluntary participants and follows strict procedures to protect study participants from disclosure (including maintaining a Federal Certificate of Confidentiality).

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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References

1. Kim G, Shin SH, Scicolone MA, Parmelee P. Purpose in life protects against cognitive decline among older adults. Am J Geriatr Psychiatry. 2019;27(6):593–601.
2. Windsor TD, Anstey KJ. A longitudinal investigation of perceived control and cognitive performance in young, midlife and older adults. Aging Neuropsychol Cogn. 2008;15(6):744–63.
3. Zahodne LB, Nowinski CJ, Gershon RC, Manly JJ. Which psychosocial factors best predict cognitive performance in older adults? J Int Neuropsychol Soc. 2014;20(5):487–95.
4. Curtis RG, Windsor TD, Soubelet A. The relationship between Big-5 personality traits and cognitive ability in older adults - a review. Neuropsychol Dev Cogn B Aging Neuropsychol Cogn. 2015;22(1):42–71.
5. Seeman T, McAvay G, Merrill S, Albert M, Rodin J. Self-efficacy beliefs and change in cognitive performance: MacArthur studies on successful aging. Psychol Aging. 1996;11(3):538–51.
6. Wight RG, Aneshensel CS, Seeman M, Seeman TE. Late life cognition among men: a life course perspective on psychosocial experience. Arch Gerontol Geriatr. 2003;37(2):173–93.
7. Bandura A. Self-efficacy: the exercise of control. New York: W.H. Freeman; 1997.
8. Pearlin LI, Schooler C. The structure of coping. J Health Soc Behav. 1978;19(1):2–21.
9. Pearlin LI, Nguyen KB, Schieman S, Milkie MA. The life-course origins of mastery among older people. J Health Soc Behav. 2007;48(2):164–79.
10. Infurna FJ, Gerstorf D. Linking perceived control, physical activity, and biological health to memory change. Psychol Aging. 2013;28(4):1147–63.
11. Infurna FJ, Kappes C, Fraire N. Long-term antecedents of constraints and mastery: findings from the health and retirement study. Psychol Aging. 2018;33(6):965–74.
12. Infurna FJ, Mayer A. The effects of constraints and mastery on mental and physical health: conceptual and methodological considerations. Psychol Aging. 2015;30(2):432–48.
13. Miller LMS, Lachman ME. The sense of control and cognitive aging: toward a model of mediational processes. In: Hess TM, Blanchard-Fields F. (Eds.). Social cognition and aging. San Diego: Academic Press; 1999. p. 17–41.
14. Lachman ME. Perceived control over aging-related declines: adaptive beliefs and behaviors. Curr Dir Psychol Sci. 2006;15(6):282–6.
15. Robinson SA, Lachman ME. Perceived control and aging: a mini-review and directions for future research. Gerontology. 2017;63(5):435–42.
16. Comijs HC, Deeg DJH, Dik MG, Twisk JWR, Jonker C. Memory complaints; the association with psycho-affective and health problems and the role of personality characteristics. A 6-year follow-up study. J Affect Disord. 2002;72(2):157–65.
17. Lee P-L. Control beliefs level and change as predictors of subjective memory complaints. Aging Ment Health. 2016;20(3):329–35.
18. Klaming R, Veltman DJ, Comijs HC. The impact of personality on memory function in older adults—results from the Longitudinal Aging Study Amsterdam. Int J Geriatr Psychiatry. 2017;32(7):798–804.
19. Curran PJ, Bauer DJ. The disaggregation of within-person and between-person effects in longitudinal models of change. Annu Rev Psychol. 2011;62(1):583–619.
20. Sargent-Cox KA, Butterworth P, Anstey KJ. Role of physical activity in the relationship between mastery and functional health. Gerontologist. 2015;55(1):120–31.
21. Eizenman DR, Nesselroade JR, Featherman DL, Rowe JW. Intraindividual variability in perceived control in a older sample: the MacArthur successful aging studies. Psychol Aging. 1997;12(3): 489.
22. Neupert SD, Allaire JC. I think I can, I think I can: examining the within-person coupling of control beliefs and cognition in older adults. Psychol Aging. 2012;27(3):742–9.
23. Lachman ME, Neupert SD, Agrigoroaei S. The relevance of control beliefs for health and aging. In: Handbook of the psychology of aging. Elsevier; 2011. p. 175–90.
24. Li M, Dong X. Is social network a protective factor for cognitive impairment in US Chinese older adults? Findings from the PINE study. Gerontology. 2018;64(3):246–56.
25. Du C, Dong X, Katz B, Li M. Source of perceived social support and cognitive change: an 8-year prospective cohort study. Aging Ment Health. 2022;27(8):1496–505.
26. Cairney J, Krause N. Negative life events and age-related decline in mastery: are older adults more vulnerable to the control-eroding effect of stress? J Gerontol B Psychol Sci Soc Sci. 2008;63(3):S162–70.

27. Lachman ME, Andreoletti C. Strategy use mediates the relationship between control beliefs and memory performance for middle-aged and older adults. J Gerontol: Soc Sci. 2006;61(2):P88–94.
28. Domingue BW, McCammon RJ, West BT, Langa KM, Weir DR, Faul J. The mode effect of web-based surveying on the 2018 U.S. Health and retirement study measure of cognitive functioning. J Gerontol B Psychol Sci Soc Sci. 2023;78(9):1466–73.
29. RAND HRS Longitudinal File 2020 (V2). Produced by the RAND Center for the Study of Aging, with funding from the National Institute on Aging and the Social Security Administration. Santa Monica: 2024.
30. Crimmins EM, Kim JK, Langa KM, Weir DR. Assessment of cognition using surveys and neuropsychological assessment: the health and retirement study and the aging, demographics, and memory study. J Gerontol B Psychol Sci Soc Sci. 2011;66(suppl_1):i162–71.
31. Wu B, Luo H, Tan C, Qi X, Sloan F, Kamer A, Schwartz M, Martinez M, Plassman B. Diabetes, edentulism, and cognitive decline: a 12-year prospective analysis. J Dent Res. 2023;102(8):879–86.
32. Friedline T, Masa RD, Chowa GAN. Transforming wealth: using the inverse hyperbolic sine (IHS) and splines to predict youth's math achievement. Soc Sci Res. 2015;49:264–87.
33. Hoffman L, Stawski RS. Persons as contexts: evaluating between-person and within-person effects in longitudinal analysis. Res Hum Dev. 2009;6(2–3):97–120.
34. Maciejewski D, van Sprang E, Spinhoven P, Penninx B. Longitudinal associations between negative life events and depressive symptoms—a 9-year longitudinal study on between-person and within-person effects and the role of family history. J Pers Soc Psychol. 2021;121(3):707.
35. Mendes de Leon CF. Aging and the elapse of time: a comment on the analysis of change. J Gerontol B Psychol Sci Soc Sci. 2007;62(3):S198–202.
36. Morrell CH, Brant LJ, Ferrucci L. Model choice can obscure results in longitudinal studies. J Gerontol Series A: Biomedical Sci Med Sci. 2009;64(2):215–22.
37. Hülür G. Structural and functional aspects of social relationships and episodic memory: between-person and within-person associations in middle-aged and older adults. Gerontology. 2022;68(1):86-97.
38. Enders CK. The performance of the full information maximum likelihood estimator in multiple regression models with missing data. Educ Psychol Measur. 2001;61(5):713–40.
39. Okpara C, Edokwe C, Ioannidis G, Papaioannou A, Adachi JD, Thabane L. The reporting and handling of missing data in longitudinal studies of older adults is suboptimal: a methodological survey of geriatric journals. BMC Med Res Methodol. 2022;22(1):122.
40. Lee W-J, Chen L-K, Peng L-N, Chiou S-T, Chou P. Personal mastery attenuates the adverse effect of frailty on declines in physical function of older people: a 6-year population-based cohort study. Medicine. 2016;95(34):e4661.
41. Hertzog C, Kramer AF, Wilson RS, Lindenberger U. Enrichment effects on adult cognitive development: can the functional capacity of older adults be preserved and enhanced? Psychological Science in the Public Interest. 2008;9(1):1–65.
42. Miller LMS, Gagne DD. Effects of age and control beliefs on resource allocation during reading. Aging Neuropsychol Cogn. 2005;12(1):129–48.
43. Lachman ME, Andreoletti C. Strategy use mediates the relationship between control beliefs and memory performance for middle-aged and older adults. J Gerontol: Series B. 2006;61(2):P88–94.
44. Soederberg Miller LM, Gagne DD. Effects of age and control beliefs on resource allocation during reading abstract. Aging Neuropsychol Cogn. 2005;12(1):129–48.
45. Snijders TAB, Bosker RJ. Multilevel analysis: An introduction to basic and advanced multilevel modeling. London: SAGE Publications; 2011.
46. Gelman A. Struggles with survey weighting and regression modeling. Stat Sci. 2007;22(2):153–64.
47. Winship C, Radbill L. Sampling weights and regression analysis. Sociol Methods Rese. 1994;23(2):230–57.
48. Hamaker EL. The within-between dispute in cross-lagged panel research and how to move forward. Psychological Methods. 2023.

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