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Metamemory and Financial Decision Making in Older Adults Without Dementia

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Objective: Metamemory refers to self-awareness of one's memory function, and the extent to which metamemory deficit impacts financial decision making is unknown. This study tested the hypothesis that metamemory deficit is associated with poor financial decision making among older adults without dementia. ***Method:*** Data came from 502 community-dwelling older adults participating in the Rush Memory and Aging Project. Metamemory deficit was determined empirically by contrasting subjective memory ratings with performance on objective memory tests. Larger discrepancy of self-rated memory scores from performance-based testing scores indicates greater deficit. Financial decision making was assessed using a performance-based measure. Multivariable regression analyses examined the association of metamemory deficit with financial decision making. ***Results:*** Participants had a mean age of 83 years and a mean education of 15 years. Approximately 75% were female. On average, participants answered two thirds of the financial decision making questions correctly. Female sex, older age, lower education, and lower financial literacy were correlated with poorer financial decision making. In an ordinal logistic regression model controlled for demographics and financial literacy, an 1SD increase in metamemory deficit reduced the odds of having better financial decision making by approximately 15%, *OR*: 0.844, 95% CI [0.719–0.991]. This association persisted after further controlling for family income, early life socioeconomic status, depressive symptoms and executive function. ***Conclusions:*** Metamemory deficit in older adults is a potential indicator of impaired financial decision making.

Key Points

Question: What is the relationship between metamemory deficit and financial decision making in old age? ***Findings:*** Older adults free of dementia but with greater metamemory deficit performed more poorly on financial decision making. ***Importance:*** Many older people without overt cognitive impairment are actively engaged in their own financial matters, and metamemory deficit negatively impacts their financial decision making. ***Next Steps:*** To expand the investigation to people of color and explore the extent to which the result differs between race/ethnicity.

Keywords: metamemory, financial decision making, financial literacy, aging

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Older adults hold the vast majority of the nation's household wealth yet are highly vulnerable to poor financial decision making. Converging evidence across disciplines suggests that financial decision making deteriorates as people age (Chung et al., 2017; Denburg et al., 2005; Korniotis & Kumar, 2011; Tymula et al., 2013). Suboptimal financial behaviors among older adults include mismanagement of retirement funds, failure to optimize credit card balance transfers, borrowing at high interest rates (Agarwal et al., 2009), and susceptibility to financial fraud and scams (Burnes et al., 2017). Many older adults suffer irrecoverable losses due to financial mishaps, which poses an economic and public health challenge that will become ever more urgent as the landscape of the U.S. population shifts toward older age. The population of Americans aged 65 and older is projected to reach 95 million by 2060, almost double the number in 2016. On top of that, older adults are faced with increasingly complex modern financial products. Social security and pensions have largely been replaced by employee-funded investments such as 401(k), which rely heavily on individual financial literacy and financial decision making skills. Identifying factors associated with poor financial decision making is necessary to facilitate policies and strategies to safeguard the financial well-being of our aging population.

It is well documented that cognitive deficits are an important determinant of poor decision making in old age (Agarwal & Mazumder, 2013; Samanez-Larkin, 2013). Cognitive impairment compromises older persons' financial capabilities including reading bank statements, paying bills, and fulfilling complex financial tasks (Marson et al., 2000; Okonkwo et al., 2006). Studies have shown that, compared to cognitively intact older persons, those with mild cognitive impairment (MCI) perform worse in multiple domains of decision making abilities, including financial decision making (Han et al., 2015). Data from longitudinal studies also suggest that older persons with MCI experience significant decline in financial skills (Martin et al., 2019), and even subtle age-related changes in cognition are associated with poor decision making (Boyle, Yu, Wilson, et al., 2012).

Distinct from cognition, metacognition refers to self-awareness of one's cognitive ability; thus, it reflects the integrity of self-referential processing (Cosentino, Metcalfe, Holmes, et al., 2011). The duality of cognition and metacognition are tightly correlated in healthy individuals; however, some dissociation may occur in neurologic or psychiatric disorders. Metamemory is similarly defined as self-awareness of memory function (Flavell & Wellman, 1975). Current literature on metamemory largely focuses on unawareness of memory loss or anosognosia. Anosognosia is common in Alzheimer's dementia. Among MCIs, anosognosia represents an earlier indication of prodromal dementia (Bastin et al., 2021). A recent study reported that older adults who are unaware of their cognitive deficit are more likely to suffer wealth losses (Mazzonna & Peracchi, 2020). However, the study did not directly examine the relationship between unawareness and poor financial decision making. Memory unawareness also impairs daily decision making capacity about medication management (Cosentino, Metcalfe, Cary, et al., 2011). In a separate line of work, studies have shown that financial unawareness and memory unawareness share some similarity such that overconfidence in financial ability is associated with poor financial decision accuracy (Sunderaraman et al., 2020), and older adults with cognitive impairment often are unaware of declining financial ability (Gerstenecker et al., 2019). Taken together, this evidence suggests that the repercussions of anosognosia may extend to financial and other aspects of daily functioning. Of note, according to the definition of metamemory, misperception toward either end (i.e., under- or over-estimation of memory function) can be indicative of a deficit. While the current research largely hinges on anosognosia, the extent to which metamemory deficit in general is associated with financial decision making remains unclear.

To address this knowledge gap, in this work we investigated the association of metamemory deficit with financial decision making in over 500 community-dwelling older adults free of dementia. A focus on older adults without dementia is of particular importance because dementia-free older adults are typically functionally unimpaired in day to day activities and remain actively engaged in decision making, even though many struggle in the financial domain. Metamemory deficit was determined empirically by contrasting subjective memory ratings with history of change in objectively-assessed memory performance. Importantly, this definition is not restricted to anosognosia, but also encompasses underestimation of one's memory function. We hypothesized that older adults with greater metamemory deficit would perform more poorly on financial decision making.

Method

The Rush Memory and Aging Project

The Rush Memory and Aging Project (MAP) is a cohort study of Alzheimer's dementia and other common chronic conditions of aging (Bennett et al., 2012). The study, started in 1997 and ongoing, enrolls older adults from across northeastern Illinois who live in continuous care retirement communities, Section 8 and Section 202 subsidized housing and retirement homes. All participants were free of known dementia at enrollment and agreed to annual home visits that include detailed clinical evaluations. In 2010, a study on the causes and consequences of impaired decision making in old age was added to MAP. By embedding the decision making assessment into an ongoing cohort study, this unique design offers important analytic opportunities for investigations such as this one (eFigure 1). In particular, annual cognitive evaluations up until the first decision making assessment provide longitudinal data needed for a robust estimation of the prior history of change in memory performance which, coupled with subjective memory ratings at the decision making assessment, allows us to empirically derive a measure of metamemory deficit that can then be correlated with financial decision making ability. A total of 1,712 MAP participants were alive and active when the decision making substudy started, 217 were ineligible due to language barriers, severe sensory impairment, or moving out of the area. A total of 48 participants withdrew from the study and another 67 died before they were approached for decision making assessment. Of the remaining, 1,253 (91%) participants had completed baseline decision making assessment by the time of these analyses on March 25, 2021. To estimate prior history of change in memory, we restricted to 548 participants who had at least two memory assessments by the time of decision making assessment. A small number of participants were excluded from the analyses due to dementia ($N = 42$) or missing data in key variables ($N = 4$), resulting in an analytic sample of 502.

Both MAP and the decision making substudy were approved by a Rush University Medical Center institutional review board. Written informed consents were obtained from all the participants.

Dementia Diagnosis

Diagnosis of dementia follows standard decision rules, as previously described (Bennett et al., 2006). Briefly, at enrollment and annual follow-up visits, all participants underwent uniform detailed clinical evaluations that include neurological examination, cognitive assessment, and interview on medical history. After reviewing all available data, dementia was determined by the clinician at each evaluation. The diagnosis requires history of cognitive decline and evidence of impairment in multiple cognitive domains. Participants diagnosed with dementia by the time of decision making assessment were excluded from the analyses.

Objective Assessment of Memory

Memory was assessed annually using seven tests that include immediate and delayed recall of the East Boston Story, immediate and delayed recall of Story A from Logical Memory, Word List Memory, Word List Recall, and Word List Recognition (Wilson et al., 2002). To reduce the floor and ceiling effects, raw scores for each test were standardized using baseline mean and standard deviation, and the resulting z-scores were averaged across the tests to yield a composite score for memory. These annual memory scores up until the first decision making assessment were used to estimate prior history of change in objectively-assessed memory. Separately, a composite score for executive function were computed using eight tests that include category fluency, digits forward and backward, digit ordering, symbol digits modality, number comparison, Stroop color naming, and word reading.

Self-Assessment of Memory

At annual interviews, participants were asked two questions about their memory; whether they have trouble remembering things, and how they think their memory compares to 10 years ago. Participants rated each question on a 5-point scale and the ratings were summed to yield a score for subjective memory (Wilson et al., 2015). The scores range between 2 and 10, with higher scores indicating higher self-assessed memory. As detailed in the data analysis section, to establish a temporal relationship between change in memory and metamemory deficit, subjective memory ratings at the decision making assessment were contrasted with the history of change in memory performance before the decision making assessment.

Financial Decision Making

Financial decision making was assessed using six questions adapted from an established performance-based measure (Boyle, Yu, Buchman, et al., 2012). The measure mimics real-world financial materials and involves a series of questions on selecting mutual funds. Briefly, participants are presented with tables of information on different mutual funds and then asked three simple and three difficult questions. The simple questions assess the ability to understand and retrieve information from the tables (e.g., identify the account management fee), and the difficult questions require integration of multiple pieces of information to make a financial choice (e.g., choose a fund with management fee less than 1% and gross annual return over 6.5%). Correct responses to individual questions were tallied to obtain a total financial decision making score, which ranges between 0 and 6. Higher scores indicate higher financial decision making ability. Scores at the first decision making assessment were used as the outcome.

We note that the decision making measure used here involves a subset of items from a previously developed and validated decision making assessment tool that was designed for use in older adults and simulates materials used in real-world settings (Finucane et al., 2005; Finucane & Gullion, 2010). The measure was based on the person-task-fit conceptual framework that draws on characteristics of the decision maker (experience, relevant knowledge), the task at hand (complexity/difficulty), and fit (appropriateness of type of decision for the context). As such, it assesses multiple skills and abilities to comprehend basic information, integrate different pieces of information, temper impulsivity, and make an optimal choice. Our programmatic line of research on decision making has shown that performance on this measure is associated with abilities that are expected to be related to and that it is a good predictor of adverse health outcomes (Boyle et al., 2013; Stewart et al., 2018), thus providing additional support for its validity.

Financial Literacy

Financial literacy was assessed using a 23-item instrument adapted from the Health and Retirement Study (HRS; Han et al., 2014). Briefly, 12 of the 23 items assess financial knowledge about mutual funds, interest rates in relation to bond prices, riskiness of asset classes, risk and investing time horizons, credit card debt payment, stock trading, and the role of the Federal Deposit Insurance Corporation. Separately, eight items assess abilities of performing monetary calculations that include comparing percentages, converting percentages to numbers, calculating sale prices of merchandise, taking averages, and calculating returns given interest rates. The remaining three items assess skills of projecting investment returns. A financial literacy score was calculated as the percentage of the 23 items that were answered correctly, with higher scores indicating higher financial literacy. Financial literacy scores at the first decision making assessment were used as a covariate.

Other Covariates

Age was calculated using date of birth and date of the decision making assessment. Sex, race, and ethnicity, as well as years of education were reported by participants. Participants chose one of the 10 levels that represents their total family income ($0–$4,999, $5,000–$9,999, $10,000–$14,999, $15,000–$19,999, $20,000–$24,999, $25,000–$29,999, $30,000–$34,999, $35,000–$49,999, $50,000–$74,999, $75,000 and over). Early life socioeconomic status was determined based on information on parents' education as well as number of children in the family, as recently described (Weissberger et al., 2021). Participants also reported number of depressive symptoms they experienced during the week prior to the interview using a 10-item version of the Center for Epidemiologic Studies Depression scale (CES-D).

Data Analyses

We measured metamemory deficit as discrepancy between subjective memory ratings at the decision making assessment and objectively-assessed change in memory prior to the decision making assessment. First, we fit a linear mixed effects model, where annual composite scores for memory up until the decision making assessment was the longitudinal outcome, and time in years since the parent study baseline was the predictor. The resulting person-specific slopes measured the history of change in memory, such that more negative slopes indicate faster decline in memory and nonnegative slopes indicate no decline. Next, we regressed subjective memory ratings at the decision making assessment on these slopes of change in memory. The residuals capture the extent to which self-rated memory deviates from objectively assessed memory performance (eFigure 2). Positive (or negative) residuals suggest that participants overestimate (or underestimate) their memory performance. Absolute value of these residuals was used to score metamemory deficit. Higher scores indicate larger discrepancy, and thus greater deficit.

Bivariate correlations between variables of interest were examined using Wilcox rank sum test or Spearman correlation, as appropriate. Multivariable regression analyses examined the association of metamemory deficit with financial decision making. As financial decision making was measured as the total number of six questions that participants answered correctly, we chose logistic regression with the financial decision making scores as an ordinal discrete outcome. We hypothesized that greater metamemory deficit was associated with poorer financial decision making ability.

Considering the crucial role of financial literacy in financial decision making (Lusardi, 2012), we controlled for financial literacy in all the models, together with age, sex, and education. Socioeconomic background is an important determinant of financial decision making, and separately, negative affect and poor executive function may be implicated in metamemory deficit. To assess the robustness of our result, we repeated our primary model by further controlling for these factors. In addition, since the definition of metamemory deficit includes both over- and underestimation of one's memory function, we conducted a series of analyses to investigate whether the association of metamemory deficit with financial decision making differs between older adults who overestimated their memory function and those who underestimated.

Data were analyzed using SAS/STAT programs (version 9.4) on a LINUX machine. Statistical significance was determined at α level of 0.05.

Results

Study Participants

A total of 502 older adults were included in this study. The average age was 82.8 years at decision making assessment [Standard deviation (*SD*): 7.8, range: 59.4–100.8]. Over three quarters were female ($N = 384$, 76.5%) and the mean years of education was 15.2 ($SD = 3.1$, range 7–28). Additional characteristics of the study participants are reported in Table 1.

Table 1
Characteristics of the Study Participants

Characteristics	Descriptive statistics
Age (years), *M* (*SD*)	82.8 (7.8)
Male sex, *N* (%)	118 (23.5%)
Education (years), *M* (*SD*)	15.2 (3.1)
Race, *N* (%)	
Whites	455 (90.6%)
Blacks	46 (9.2%)
Asians	1 (0.2%)
Latino, *N* (%)	486 (96.8%)
Self-reported memory rating, *M* (*SD*)	4.8 (1.3)
Slopes of change in memory, *M* (*SD*)	0 (0.04)
Metamemory deficit, *M* (*SD*)	1.0 (0.86)
Financial literacy, *M* (*SD*)	72.2 (16.1)
Financial decision making, *Mdn* (IQR)	4 (2–4)
Household income, *Mdn* (IQR)	8 (5–9)
Early life socioeconomic status, *M* (*SD*)	0.02 (0.73)
Depressive symptoms, *Mdn* (IQR)	0 (0–2)
Executive function, *M* (*SD*)	0.08 (0.65)

Note. *M* = mean; *SD* = standard deviation; *Mdn* = median; IQR = interquartile range. Household income: 1: $0–$4,999, 2: $5,000–$9,999, 3: $10,000–$14,999, 4: $15,000–$19,999, 5: $20,000–$24,999, 6: $25,000–$29,999, 7: $30,000–$34,999, 8: $35,000–$49,999, 9: $50,000–$74,999, 10: $75,000 and over.

Metamemory Deficit

By the time of the decision making assessment, participants had undergone an average of six annual cognitive evaluations (*SD*: 3.1, range: 2–17) and all were free of dementia. Using longitudinal cognitive data, we estimated the history of change in memory prior to the decision making assessment. On average, we did not observe a decline in memory among these nondemented participants, and the mean slope of change was not statistically significant ($p = .580$). However, there was substantial person-to-person variation in the slopes of change (eFigure 3). Approximate 40% of the participants showed negative slopes of change, suggesting a memory decline.

Person-specific slopes of change in memory prior to the decision making assessment were positively correlated with subjective memory ratings at the decision making assessment (eFigure 4), such that older adults with slower memory decline rated their memory performance higher (Spearman's ρ: 0.2, $p < .001$). Next, we regressed self-rated memory scores on the slopes of change in objectively-assessed memory. Approximate 64% of the participants rated their memory higher than what was predicted by the memory testing scores (i.e., positive residuals), and the remaining 36% under-rated their memory (i.e., negative residuals). We estimated metamemory deficit by taking the absolute value of these residuals. The estimate was skewed slightly to the right with a mean of 1.00 ($SD = 0.86$) and a median of 0.78 [interquartile range (IQR): 0.25–1.68].

Metamemory Deficit and Financial Decision Making

On average, participants answered four out of the six financial decision making questions correctly (IQR: 2–4). Female sex (z: 3.49, $p < .001$), older age (Spearman's ρ: -0.29, $p < .001$), and lower education (Spearman's ρ: 0.29, $p < .001$) were correlated with poorer financial decision making. Higher financial literacy was correlated with better financial decision making (Spearman's ρ: 0.47, $p < .001$). Greater metamemory deficit was correlated with

poorer financial decision making (Spearman's ρ: −0.12, $p = .008$). Similar associations were observed in an ordinal logistic regression model that controlled for demographics and financial literacy (Figure 1). A 1SD increase in metamemory deficit reduced the odds of having better financial decision making by approximately 15% (Table 2 Model 1). In the same model, a 1SD improvement in the financial literacy score doubled the odds of having better financial decision making.

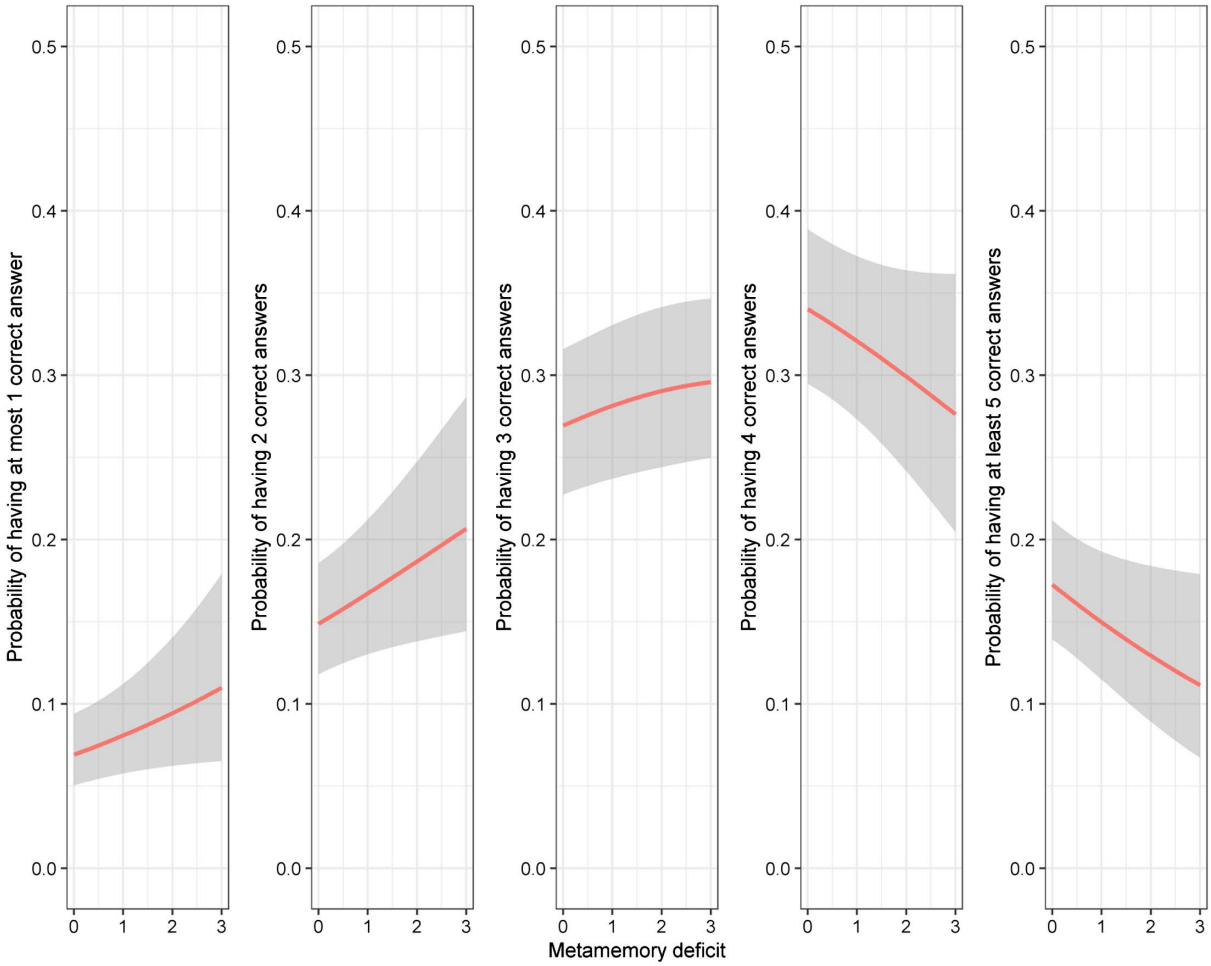
We repeated the analysis by further controlling for family incomes, early life socioeconomic status, depressive symptoms, and executive function. Income (Spearman's ρ: 0.31, $p < .001$) and early life socioeconomic status (Spearman's ρ: 0.19, $p < .001$) were correlated with financial decision making. Separately, more depression symptoms were correlated with greater metamemory deficit (Spearman's ρ: 0.16, $p < .001$), while higher executive function was correlated with less deficit (Spearman's ρ: −0.13, $p = .005$). In a regression model controlling for these factors, though income, depressive symptoms and executive function emerged as correlates of financial decision making, the effect size for metamemory remained essentially the same (Table 2 Models 2).

Over- Versus Underestimation of Memory and Financial Decision Making

By regressing subjective memory ratings on objectively assessed slopes of memory decline, the residuals capture the extent which

Figure 1

Metamemory Deficit and Financial Decision Making



Note. The figure illustrates the association of metamemory deficit with financial decision making for representative older female participants with mean age and mean years of education. Metamemory deficit was scored by regressing subjective memory ratings on slopes of change in objectively assessed memory. The score, computed as the absolute value of the residuals, captures the extent which self-rated memory deviates from the prediction by the memory performance tests. Higher scores indicate greater deficit. For illustration purpose, the range of the metamemory deficit score was set between 0 and 3, with each one unit representing 1SD difference in deficit. Each of the 5 panels, from left to right, reported the predicted probabilities (y-axis) of having at most 1 correct answer, 2, 3, 4, and finally at least 5 correct answers at the financial decision making assessment as a function of the metamemory deficit score (x-axis). Shaded areas represent the corresponding 95% confidence bands. It is evident that as the metamemory deficit becomes greater, the predicted probabilities of having more correct answers decrease. See the online article for the color version of this figure.

Table 2
Metamemory Deficit and Financial Decision Making

Independent variable	Model 1 (N = 501)	Model 2 (N = 482)
Age	0.639 (0.540–0.757), <.001	0.733 (0.611–0.878), <.001
Male sex	1.106 (0.738–1.656), 0.626	1.524 (0.992–2.339), 0.054
Education	1.323 (1.106–1.581). 0.002	1.164 (0.954–1.420). 0.135
Financial literacy	2.126 (1.745–2.591), <.001	1.684 (1.347–2.106), <.001
Metamemory deficit	0.844 (0.719–0.991), 0.039	0.835 (0.705–0.989), 0.036
Income	—	1.100 (1.017–1.191), 0.018
Socioeconomic status	—	1.053 (0.875–1.267), 0.585
Depressive symptoms	—	1.260 (1.053–1.508), 0.012
Executive function	—	1.961 (1.589–2.420), <.001

Note. Statistics reported are Odds Ratio (95% Confidence Interval), p value. Other than male sex and household income, the statistics are presented as the odds ratio of having better financial decision making with respect to 1SD increase in the independent variables.

self-rated memory deviates from the prediction by the memory performance tests. Positive (or negative) residuals suggest that participants rated their memory function higher (or lower) than what was reflected by objective memory testing scores. We created a binary indicator to differentiate individuals who had positive residuals (64%) from those who had negative residuals (36%). First, we added to the model a term for the interaction between the binary indicator and the metamemory deficit score. This interaction term was not significant (p = .961), suggesting that the association of metamemory deficit did not differ between older adults who overestimated and those who underestimated. Next, we performed a stratified analysis by examining the association separately for older persons with positive residuals and those with negative residuals. The odds ratio [*OR*] for the positive residuals group was 0.855, 95% CI [0.681–1.073], and the *OR* for the negative residuals group was 0.843, 95% CI [0.647–1.097]. These estimates, while statistically not significant, suggest that metamemory deficit tended to be associated with poor financial decision making regardless of grouping. Finally, we split the sample into three groups. Here, we classified an older person as an over-estimator if the self-reported memory rating is 1SD above the prediction by the memory testing score (N = 125, 25%), and an under-estimator if the self-reported memory rating is 1SD below the prediction (N = 115, 23%). We then directly examined the group difference in financial decision making with older persons who neither over- nor under-estimated as the reference group (N = 262, 52%). In this analysis, the estimates again suggest that, compared to the reference group, both under- (*OR*: 0.704, 95% CI [0.471–1.051]) and overestimating (*OR*: 0.849, 95% CI [0.575–1.254]) groups tended to perform more poorly in financial decision making. Overall, these results consistently suggest that older persons who lack awareness of their own memory (no matter whether they under- or overestimate it) are likely to have poor financial decision making performance.

Discussion

Anosognosia, unawareness of own memory deficit, is implicated in loss of household wealth and everyday decision making impairment. In this work, we applied a broader definition of metamemory deficit by bringing in together lack of awareness from both ends, i.e., over and underestimation of one's memory function, and we examined the association of metamemory deficit with financial decision making among community living older adults without dementia. Our findings revealed that older adults with greater metamemory deficit performed more poorly on an established, performance-based instrument of financial decision making that mimics the real-world task of selecting mutual funds.

The connection between cognitive function and financial decision making in old age is well recognized, however literature on metamemory and decision making is largely limited to anosognosia. One study reported that among persons with Alzheimer's disease, those with anosognosia show diminished everyday decision making capacity related to medication management (Cosentino, Metcalfe, Cary, et al., 2011). Specifically, they tend not to appreciate difficulties of managing medications by themselves or the potential benefits and harms of receiving assistance. Very little work has examined the financial consequences of memory unawareness. We found only one publication on unawareness of memory decline and financial performance (Mazzonna & Peracchi, 2020). The study leveraged data from HRS and showed that older adults who had severe memory loss but were unaware experienced significantly greater financial losses (i.e., on average about 6% of their mean wealth over a 2-year period). Since these losses primarily occur among individuals who were in charge of household finances and were largely concentrated in riskier assets such as stocks, the authors postulated that the association is attributable to poor financial decisions. Building on these results, we introduced a measure of metamemory deficit and examined its association with financial decision making in a community based cohort. Our findings expand the field in several important ways.

By specifically focusing on community living older adults who were free of dementia, our results suggest that metamemory deficit negatively impacts financial decision making among older people without overt cognitive impairment and who are likely actively engaged in their own financial matters. The implications of this finding are two-fold. First, it adds to an increasing literature (Boyle, Yu, Wilson, et al., 2012; Han et al., 2015; Marson et al., 2009) showing that many older adults are susceptible to poor decision making and lack adequate financial ability even in the absence of dementia. Older adults without dementia and especially those with mild memory deficit typically live independently and handle their own finances. Indeed, in our present study a large majority of the participants (~85%) reported that they were handling their money (e.g., paying bills, writing checks, and keeping track of income) completely by themselves. Failure to recognize a broader scope of

poor decision making among our aging population poses major economic and public health threats. Second, while prior studies have shown that memory function and cognition in general are associated with decision making (Del Missier et al., 2015; Stewart et al., 2018), the findings in this work further suggest that metamemory deficit is also an important indicator of poor decision making. Identifying early signs of impaired decision making is essential to facilitate interventions (e.g., improving financial literacy as discussed below, or seeking financial advice) to protect older adults from adverse financial consequences. Moreover, these findings may also inform regulatory agencies and guide policy efforts to address the growing challenge of poor financial decision making and vulnerability to fraud and scams among older adults.

Importantly, financial literacy plays a pivotal role in financial decision making, especially so among older adults (Lusardi, 2008; Lusardi & Mitchell, 2014). Here we show that the association between memory unawareness and financial decision making is independent of the association between financial literacy and financial decision making. With both predictors included in the same model, greater metamemory deficit was associated with poorer financial decision making and, conversely, higher financial literacy was associated with better financial decision making. Further, the regression coefficients suggest that the effect of financial literacy is much bigger than memory unawareness. Specifically, less than a quarter *SD* improvement in financial literacy would fully reverse the adverse "effect" of a 1SD increase in metamemory deficit. These results suggest that improving financial literacy may provide a powerful buffer against the impacts of metamemory deficit on financial decision making, and reaffirm the importance of educational programs that promote financial knowledge and numeracy skills among older adults.

The previous study on memory unawareness and wealth losses reported that the wealth losses were observed only in older adults who overestimated their memory deficits. The investigators attributed this to overconfidence. Interestingly, in the current work, we did not find a differential association of metamemory deficit between older adults who overestimated and those who underestimated their memory function (i.e., the interaction of the metamemory deficit score by group was not significant). Further analyses stratified by group showed consistent results. The regression coefficients for the association, while statistically not significant, are in the same direction for both participants who overestimated and those who underestimated and are of comparable effect size. This discrepancy warrants further investigation as it has important policy implications. The overconfidence interpretation led the investigators of the previous study to propose interventions focusing on moderating overconfidence instead of improving financial literacy. By contrast, we postulate that anosognosia likely reflects the accumulation of neuropathology in the brain that occurs in the years, or even decades, prior to the onset of overt cognitive impairment. Indeed, recent data from clinicopathologic cohorts suggest that anosognosia is common, increases with age, and is associated with multiple dementia-related brain lesions including Alzheimer's disease pathologies and infarcts (Wilson et al., 2015). Similar findings have been reported by others as well (Gagliardi et al., 2021; Hanseeuw et al., 2020). Notably, very little is known about factors associated with underestimation of one's memory function. While accumulating neuropathologies are implicated in anosognosia, likely there are different mechanisms that underlie underestimation of one's memory. For example, psychological factors such as depression or anxiety may play a role, and executive function may also be involved. We note, however, that the association of metamemory deficit with financial decision making persisted in a model that controlled for depressive symptoms and executive function. Future studies are necessary to identify potentially distinct mechanisms that drive over versus under-estimation of one's memory ability.

In this work, person-specific rates of change in objective memory performance were estimated using annual testing scores. Notably, repeated administration of memory tests likely leads to underestimation of memory decline in old age. Prior literature suggests that initial testing scores are most affected by retesting learning (Theisen et al., 1998; Wilson et al., 2018). In a sensitivity analysis, we reestimated the slopes of memory change by excluding data from the first two assessments. In this reduced sample ($N = 367$), both person-specific slopes of memory change and the resulting unawareness scores are highly correlated with the initial estimates in the full sample. Further, the association of unawareness with financial decision making was very similar, suggesting that the retest learning effect is small and unlikely to influence our findings in a meaningful way.

This is the first investigation of the relationship between metamemory and financial decision making in this cohort. The study has many strengths. Our analytic design is unique as we leveraged annual cognitive evaluations prior to the decision making assessment to characterize history of memory decline which, coupled with subjective memory ratings at the decision making assessment, allowed us to obtain an empirical estimate of metamemory deficit. The financial decision making instrument applied in this work has been validated and closely simulates real-world scenarios of choosing mutual funds, and thus are relevant for maintaining independence and wellbeing in old age. Notably, as the instrument assesses primarily investment decision making, it may not capture more basic financial decision making skills such as making purchases or household budgeting. Other limitations include that data came from older adults who volunteered to participate in a cohort that requires brain autopsies. We acknowledge that participants in this work are predominantly non-Latino Whites with high education and relatively high family income. Our findings may not be readily applicable to the general public, especially underrepresented groups.

An important next step is to expand the investigation to people of color, and examine the extent to which the result differs between race/ethnicity. With social and environmental experiences varying significantly between races/ethnicities, we recognize several analytic challenges in investigating ethnoracial difference in financial decision making as well as the association of metamemory deficit. The current measure of financial decision making may not reflect the same construct in people of color. The measurement invariance and ecological validity of the instrument needs to be assessed. Separately, it is equally important for any research on ethnoracial difference to properly address various confounding factors. Of note, our decision making battery has recently been implemented in a separate cohort that recruits exclusively older Black Americans. As sufficient data accumulate, they will allow us to properly investigate these important issues in the near future.

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