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RESEARCH ARTICLE

Influence of cognitive, neuropsychiatric, and diagnostic factors on financial capacity: A longitudinal analysis of the ADNI cohort

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Abstract

Introduction: Financial capacity (FC) is the ability to independently manage finances in a manner consistent with one's self-interest. To investigate the relationship between FC, cognitive domains, neuropsychiatric symptoms, and transitions from normal cognition (cognitive normal [CN]) to mild cognitive impairment (MCI) or Alzheimer's disease (AD), we conducted a secondary analysis of the Alzheimer's Disease Neuroimaging Initiative (ADNI) cohort using the Financial Capacity Instrument short form (FCI-SF).

Methods: To examine these longitudinal relationships, we fit two models, a random effects (random intercept) "time-averaged" model and a "time since previous visit" model, where we regressed each of the five component financial scores on each of the cognitive composite scores. To examine the effect of baseline FCI-SF performance on conversion rates from normal to MCI or AD, we computed a survival model.

Results: A total of 874 participants (diagnostic group, *N*, mean age: CN: 501, 74.4; MCI: 319, 74.6; and AD 54, 74.9) were included in the analyses. In time since previous visit models, we found that lower executive function composite scores were related to decline in the complex checkbook score ($ß = 1.35$ (0.55), $p = 0.016$) and total completion time of the FCI-SF ($ß = 1.85$ (9.36), $p = 0.025$). In addition, lower composite visuospatial score was significantly related to poorer performance on financial conceptual knowledge, complex checkbook, and total completion time. Lower composite memory score was highly related to decline in financial conceptual knowledge, single checkbook, and bank statement subscale scores. ADNI participants in the lowest tertile of total completion time, at any point in time, were four times more likely to receive a diagnosis of MCI or AD compared to participants in the highest tertile with a hazard ratio of 4.22 ([2.29] $p = 008$).

Discussion: There is a multifaceted interaction between poorer cognition and everyday financial function where executive function, memory, and visuospatial cognition are related to FC. The strongest predictor of conversion from normal to either MCI or AD, appears to be time to completion.

KEYWORDS
cognition, depression, financial capacity

Highlights

- Decline in financial capacity (FC) is observed during transition to dementia and increases the risk of negative outcomes.
- Executive function, memory, and visuospatial cognition are related to FC.
- The strongest predictor of conversion from normal to either mild cognitive impairment (MCI) or Alzheimer's disease (AD) is time to completion or processing speed.

1 | INTRODUCTION

An estimated 6.2 million Americans have Alzheimer's disease (AD), and this number is projected to grow to 13.8 million by mid-century.[1] Impairment in performing everyday tasks such as driving, traveling, cooking, medication management, and financial affairs, collectively referred to as instrumental activities of daily living (IADLs), is a core diagnostic criterion for dementia along with cognitive decline. In addition, functional decline has a significant influence on the progression and conversion from mild forms of cognitive impairment (MCI) to dementia.[2] Specifically, impaired ability to make financial decisions disproportionately impacts older individuals, many of whom experience cognitive decline.[3]

Impaired financial decision-making specifically exposes older adults to an increased risk of exploitation and accounts for an estimated 30% of all elder abuse reports.[4] In 2010 alone, victims of financial elder abuse lost an estimated $2.9 billion (with some reports as high as $30 billion) in the United States, including claimed loss of money and goods to legitimate businesses, scams, and family and friends, and indirect losses through medical insurance fraud.[5] Moreover, the inability to manage finances is one of the strongest predictors of caregiver burden where the only available interventions involve the execution of legal mechanisms (guardianship, conservatorship) that restrict independent financial function.[6,7] Impaired financial function is an important area of public health concern as reviewed recently by the Institute of Medicine, which also sponsored an initiative with the Social Security Administration focused on financial function in older adults and their beneficiaries.[8]

Financial capacity (FC) refers to the ability to independently manage finances in a manner consistent with one's self-interest.[9] FC comprises a broad range of conceptual, pragmatic, and judgment abilities ranging from *basic skills*, such as counting coins and prioritizing bills, to more *complex skills*, such as using financial conceptual knowledge and investment decision-making in everyday life. Declines in one or both skills are first observed in individuals with MCI with progressive worsening in all aspects of FC observed during transition to dementia.[10–12] Standardized and well-validated instruments such as the Financial Capacity Instrument (FCI) have been developed to assess FC during aging.[10,13,14]

Cognitive correlates of impaired FC (in MCI) have been associated primarily with executive control and numerical calculation. More specifically, subdomains of executive control (selective attention, self-monitoring, and working memory) have been strongly correlated with FC.[15-18] In addition, the loss of executive functions accounts for the greatest proportion of variance of everyday functional ability,[19] and several studies, including our own previous work,[20,21] have shown specific associations between executive functions,[22,23] memory and psychomotor speed,[24,25] and FC suggesting a multifaceted interaction between cognition and everyday function. Relatedly, the high incidence of mood and behavior (neuropsychiatric) symptoms in MCI and AD has also been shown to be associated with cognitive and executive function impairment as well as IADL decline, but longitudinal analyses in large samples are sparse. Of particular and recent interest is the association of mood and motivational symptoms on IADLs including FC.[26-29]

To investigate the longitudinal interaction between FC, cognitive domains, mood symptoms, and transitions from normal cognition to MCI or AD, we conducted a secondary analysis of the Alzheimer's Disease Neuroimaging Initiative (ADNI) cohort focused on the FCI short form (FCI-SF) scores in cognitively normal (CN) older adults, persons with MCI, and AD ($N = 874$) over time. Our aims were to: (1) examine the association of cognitive composite scores and performance on the FCI-SF, hypothesizing that worse executive function composite scores would be associated with FCI-SF decline over time; (2) examine the influence of mood symptoms on FCI-SF performance in MCI and AD at baseline, expecting that increasing depression (Geriatric Depression Scale Short Form [GDS-15]) would correlate with FCI-SF decline over time; (3) examine the influence of baseline FCI-SF measures on conversion rates from normal to MCI or AD longitudinally where we hypothesized that worse FCI-SF scores would predict conversion from normal to MCI or AD.

RESEARCH IN CONTEXT

- **Systematic review**: The authors reviewed the current literature using traditional (e.g., PubMed) sources. Although this is not the first longitudinal analysis focused on financial capacity (FC), this is the first known longitudinal analysis examining the mediating effect of FC on diagnostic outcome in a large sample over a long follow-up period.
- **Interpretation**: Our findings indicate a multifaceted interaction between cognitive domains, and that processing speed may be an important factor in conversion from normal cognition to mild cognitive impairment (MCI) or Alzheimer's disease (AD).
- **Future directions**: In the absence of tolerable and effective disease-modifying treatments for AD and other dementias, targeted neurocognitive, behavioral, supportive, or compensatory interventions for declining instrumental activities of daily living (IADLs) are needed to help older adults stay independent longer. Given the public health significance of impaired FC on our aging society, expanded research in larger samples should provide further insights into ultimately developing effective interventions for patients and caregivers.

2 | METHODS

2.1 | Study design and participants

Data used in the present analyses were accessed (September 2021) from the ADNI data sharing resources (adni.loni.ucla.edu). ADNI is a longitudinal, multicenter study, the overarching goal of which is to develop clinical, imaging, genetic, and biochemical biomarkers for the early detection of AD. Here, all available longitudinal data from all four phases of the study (ADNI-1, ADNI-GO, ADNI-2, and ADNI-3) were utilized. ADNI was launched in 2004 and has received competitive renewals and extensions that have allowed the longitudinal collection of participant data involving 59 sites in the United States and Canada. To the extent possible, participants were carried forward from previous phases for continued monitoring, whereas new participants were added with each phase to further investigate the evolution of AD.

After obtaining informed consent, participants, between the ages of 55 and 90, were recruited and underwent a series of initial tests that were repeated at annual intervals for 3 years. The assessments included clinical, neuropsychological, and genetic testing as well as lumbar puncture, magnetic resonance imaging (MRI), and positron emission tomography (PET) scans. Participant cohorts included CN, early MCI (EMCI), late MCI (LMCI), and AD. English-speaking participants who completed the FCI-SF at baseline were retained for the current analysis. We also included participants who did not have visit 1 FCI-SF but completed it at subsequent visits, thereby shifting their baseline. Participants were excluded with any neurological diagnoses other than AD or any primary psychiatric diagnoses such as major depressive disorder, or substance abuse or dependence, as detailed by ADNI exclusionary criteria.[30] For the purposes of this analysis, we combined both EMCI and LMCI, as distinguished by ADNI, into MCI.

2.2 | Assessments

2.2.1 | Financial skills

The 37-item FCI Short Form (FCI-SF) is an abbreviated version of the 115-item FCI.[13] The FCI-SF was included in ADNI3 starting in 2016. The FCI-SF assesses four domains of everyday financial activity: monetary calculation skills, financial conceptual knowledge, understanding and using a checkbook and register (divided into single and complex tasks), and understanding and using a bank statement. Item scores are summed to establish a series of five component performance scores (Mental Calculation, Financial Conceptual Knowledge, Single Checkbook/Register, Complex Checkbook/register, and Using a Bank Statement), and also an FCI-SF Total Score (range 0–74), with higher scores indicating better financial skills. In addition to financial performance, the FCI-SF assesses task time to completion as a dimension of financial ability. Time to completion scores (in seconds) are obtained for four FCI-SF tasks and generate a composite time score for the two checkbook tasks, and a composite score for all timed tasks (range 0–670 s), with higher scores indicating slower performance.[10,13,14]

2.2.2 | Cognitive testing

Neuropsychological composite scores were developed for executive function, memory, language, and visuospatial domains derived from ADNI baseline and follow-up neuropsychological batteries. An iterative process involving confirmatory factor analysis to develop individual domain models was used, which was then subjected to model fitting methods.[31] The final composite model for the executive function (EF) domain included the following subtests: category fluency for animals and vegetables, Trail Making Test (TMT) A and B, Digit span backwards, Wechsler Adult Intelligence Scale Revised (WAIS-R) Digit Symbol, and 5 Clock Drawing items (circle, symbol, numbers, hands, time) and were selected as described in Gibbons, et al.[32] The final model for the memory domain included three Mini-Mental State Exam (MMSE)[33] items (recall of ball, flag, tree), Logical Memory I and II (immediate and delayed recall), three forms of the Alzheimer's Disease Assessment Scale-Cognitive Subscale (ADAS-Cog) word lists, and two forms of the Rey Auditory Verbal Learning Test (RAVLT) word lists, as described in Crane et al.[34] Finally, the visuospatial composite score included a clock copy task (a test of constructional praxis found on the ADAS-Cog), and the copy design task on the MMSE.[35] The language composite score was not included in this analysis because language skills have not been implicated in the study of FC in previous literature as briefly reviewed in the introduction.

2.2.3 | Mood and everyday function

The 15-item Geriatric Depression Scale (or GDS-15)[36] is a self-report measure of depression that was included to evaluate the effect of affective disturbance on FC. A score ≥ 5 suggests depression. The Functional Assessment Questionnaire (FAQ), a study partner–reported questionnaire, was used as a measure of everyday function, where higher scores (0–30) indicate better function and a cutpoint of 9 indicates dependent functioning.[37–39]

2.3 | Statistical approach

To examine the relationship between FCI-SF performance, cognitive domain composite scores, and mood symptoms scores, we fit two models: (1) a random effects (random intercept) "time-averaged" model (linear mixed-effects model), where we regressed each of the five component financial scores on each of the cognitive composite scores; and (2) a random effects (random intercept) model (similar to a lagged model) where at each visit, *change since the last visit* in outcome is regressed on the last visit change in the predictor. Predictors for mood symptoms included the GDS-15 total score. Both models were adjusted for the effects of age, sex, race, and years of education.

To examine the effect of baseline FCI-SF performance on conversion rates from normal to MCI or AD, we computed a survival model. We limited this to people who were CN at baseline. "Failure" was defined as either an MCI or dementia diagnosis (irrespective of which occurred first) and could occur at any time during enrollment in the study. Failure occurs at the first instance (even if the participant is adjudicated as CN again at a later visit). Nineteen participants were found to have a diagnosis of CN at a future visit even if they met our criteria for "failure." We used R package risksetROC, which can calculate survival-based area under the curve (AUC) up to a given time. In our study, the longest follow-up time is 15.14 years, so we used year 16 as the last AUC calculations. We also calculated their corresponding 95% confidence intervals (CIs) in 5, 8, and 10 years by using bootstrap approach resampling the data 1000 times. We fit individual Cox models for baseline total financial score, total time, and each of the FCI-SF subscales. For each model, we placed the predictor into tertiles and constructed Kaplan–Meier curves using those three tertiles. We also calculated Schoenfeld residuals to ensure that proportional hazards assumption and therefore the Cox model are appropriate.

On an exploratory basis, using the machine learning program KappaTree,[40] an R adaptation of ROC4, a public domain program (http://www.stanford.edu/~yesavage/ROC.html), we conducted receiver-operating characteristic (ROC) analyses and computed weighted Kappas to identify predictors of conversion to MCI or AD out of a list of 12 candidate predictors (below). The KappaTree program implements a form of recursive partitioning, in that it cycles through each possible cutoff of each candidate predictor variable and iteratively branches on the best cutoff for the best variable at each node as a function of weighted kappa.[41] In our application, sensitivity and specificity were equally weighted and the variables considered were age, sex, race, education, MMSE, TMT B, logical memory, mental calculation, financial conceptual knowledge, simple checkbook task, complex checkbook task, and bank statement management. Statistical analyses were performed with STATA 16 software and R package KappaTree.[40] Significance was set at two-sided $p < 0.05$.

3 | RESULTS

A total of 874 participants were included in the analyses: 501 CN, 319 MCI, and 54 AD based on the inclusion and exclusion criteria. Five hundred ten participants completed the FCI-SF at the baseline evaluation and the remainder completed it at a later time point, thereby shifting the baseline. Significant differences were observed between diagnostic groups for sex and education as shown in Table 1. All subcomponents of the FCI-SF (mental calculation, financial conceptual knowledge, single and complex check, and bank statement), cognitive composite scores (executive function, memory, visuospatial) and the MoCA and MMSE were found to be significantly different between groups (Table 1) with expected differences of CN > MCI > AD.

In the "time averaged" models adjusted for age, sex, and education, all associations between FCI-SF subcomponents were found to be significantly ($p < 0.001$) associated with all cognitive composite scores (Tables S1–S3). In the random-effects regression model for "change since the previous visit" for all diagnostic classes (adjusted for age, sex, and education), however, we found the following significant ($p < 0.01$) associations between FCI-SF subcomponents and cognitive composite scores: complex checkbook ($ß = 3.092$ (l.l63) $p = 0.002$) and time to completion ($ß = -62.747(-90.7l8)$ $p < 0.001$) in the visuospatial domain (Table S5); financial conceptual knowledge ($ß = 0.5ll$ (0.l82) $p = 0.002$), simple checkbook ($ß = l.335$ (0.452) $p = 0.003$), and bank statement ($ß = l.0l$ (0.297) $p = 0.006$) in the memory domain (Table S6). Significant associations in the executive function composite were not found at the $p < 0.01$ level (Table S4). Significant ($p < 0.01$) associations of FCI-SF total score change and total completion time change with the GDS-15 in the time-averaged model (Table S7) were both significant but neither were significant in the change since last visit model (Table S8) when applying $p < 0.01$.nd

In addition, we fit age, sex, race, and education-adjusted Cox regression MCI/AD free survival models to FCI-SF total completion time tertiles. Figure 1 shows Kaplan–Meier plots showing comparison of tertiles on conversion from CN to MCI or AD. Tertile ranges (in seconds) were established as follows: (1) first tertile 112–240 s; (2) second tertile 249–343 s; a(3) third tertile 344–670 s. Compared to the lowest (best) tertile, having a total completion time in the second tertile was associated with a hazard ratio of incident MCI or AD of 1.75 (0.56–5.47) $p = 0.334$), and having a total completion time in the third (worst) tertile was associated with a hazard ratio of 4.22 (1.46–12.23) $p = 008$). Thus, ADNI participants in the third tertile of total completion time, at

TABLE 1 Characteristics by cognition type.

	CN N = 501	MCI N = 319	AD N = 54	p-value
Mean age, years	74.44 (7.95)	74.65 (7.84)	74.90 (7.62)	.89
Female (%)	208 (41.5%)	192 (60.2%)	35 (64.8%)	<.001
White	445 (88.8%)	295 (92.5%)	48 (88.9%)	.22
Education, years	16.72 (2.41)	16.37 (2.51)	15.70 (2.53)	.005
Mental calculation score	3.58 (0.94)	3.20 (1.37)	2.15 (1.73)	<.001
Financial knowledge score	7.41 (1.00)	6.81 (1.54)	5.35 (1.81)	<.001
Single check score	18.47 (2.21)	16.48 (4.06)	11.56 (5.68)	<.001
Complex checkbook score	25.26 (4.26)	21.95 (7.05)	13.11 (9.00)	<.001
Bank statement score	12.51 (2.16)	11.26 (3.00)	8.15 (3.86)	<.001
Total completion time, seconds	314.80 (110.75)	370.60 (121.40)	492.85 (140.74)	<.001
Executive function composite score	0.75 (0.50)	0.34 (0.61)	−0.38 (0.84)	<.001
Language composite score	0.80 (0.52)	0.47 (0.57)	−0.18 (0.62)	<.001
Visuospatial composite score	0.06 (0.35)	−0.06 (0.44)	−0.40 (0.66)	<.001
Memory composite score	0.81 (0.55)	0.22 (0.67)	−0.79 (0.31)	<.001
GDS total score	1.34 (1.73)	1.93 (2.17)	3.00 (2.00)	.003
MoCA	25.95 (2.93)	22.90 (4.09)	16.94 (4.55)	<.001
MMSE	28.69 (1.71)	27.07 (3.51)	20.67 (4.50)	<.001

Note: Baseline characteristics ($N = 874$). Data are presented as mean (standard deviation (SD)) for continuous measures or *n* (%) for categorical measures. Analysis of variance (ANOVA) was used to measure of significance between groups.

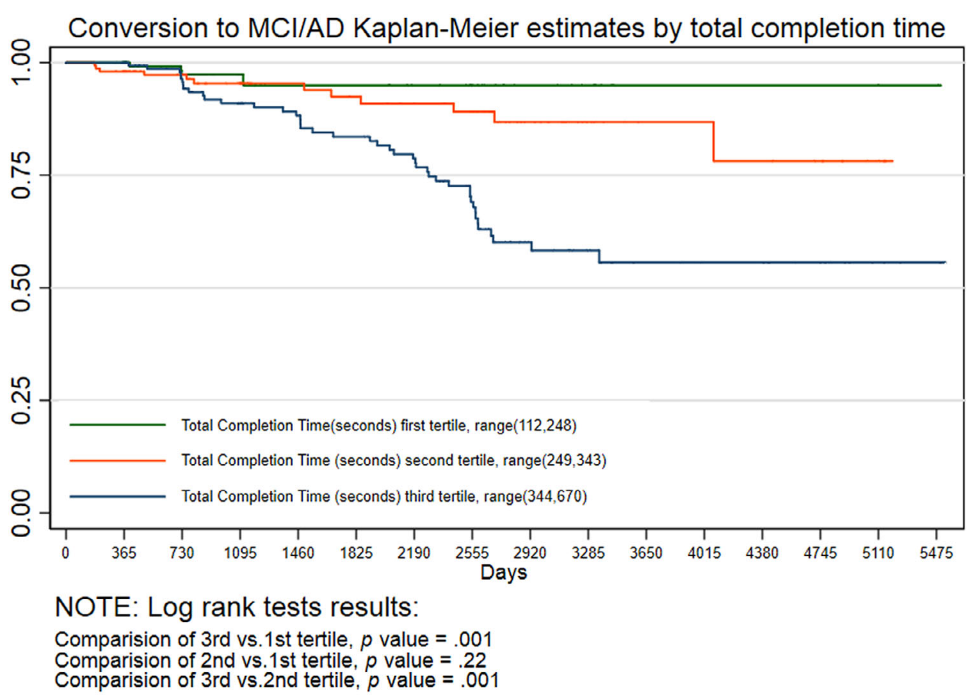

FIGURE 1 Kaplan–Meier survival curves to examine the effect of baseline FCI-SF performance on conversion rates from CN to MCI or AD at any time.

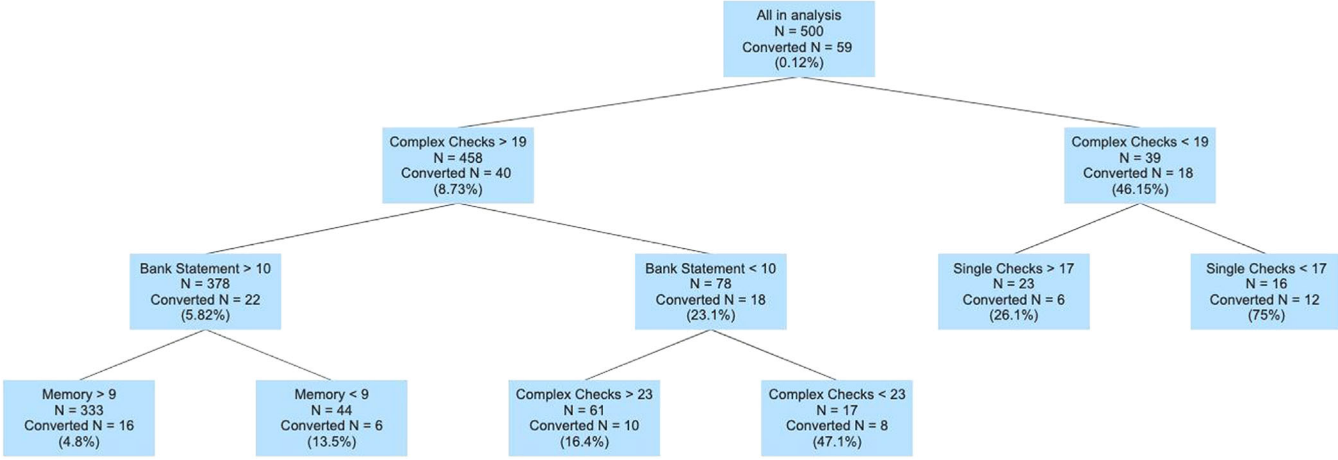

FIGURE 2 KappaTree Analysis. Exploratory KappaTree Analysis: receiver-operating characteristic (ROC) analyses and computed weighted Kappas to identify predictors of conversion from CN to MCI or AD out of a list of 12 candidate predictors: age, sex, race, education, MMSE, TMT B, logical memory, mental calculation, financial conceptual knowledge, simple checkbook task, complex checkbook task, and bank statement management.

any point in time, were 4× as likely to get an MCI or AD diagnosis as participants in the first tertile.

In the KappaTree analysis (Figure 2), of 12 candidate predictors, the complex checkbook task had the greatest effect on conversion (cutoff = 19; *kappa*: 0.306). Eighteen participants (46.1%) among those who converted had complex checkbook task score < 19. In this group, 12 (75%) scored less than 17 on the simple checkbook task. Scoring greater than 19 on the complex check task resulted in 40 participants (8.73%) converting to MCI or AD. For those scoring > 19 on the complex checkbook task, the next optimal branching was on the bank statement task, with a cutoff of 10. Among the 378 individuals who scored > 19 on complex checking and > 10 on banking statement, only 22 (5.8%) had a subsequent MCI or AD diagnosis. By contrast, among 78 individuals scoring greater than 19 on the complex check but ≤ 10 on the bank statement task, 18 (23.1%) had a later MCI or AD diagnosis. Among those scoring ≤ 19 on the complex check task, the next optimal branching was on the single check task, with a cutoff of 17. Of the 23 people who scored ≤ 19 on complex checks but > 17 on single checks, 6 (26.1%) had a subsequent MCI or AD diagnosis. By contrast, among the 16 people who scored ≤ 19 on complex checks and ≤ 17 on single check, 12 (75%) had a later MCI or AD diagnosis. The full branching structure is shown in Figure 2. Across all branches, efficiency (% correctly classified) was 81.7% and the weighted kappa was 0.29. Positive predictive value was 0.32 and negative predictive value was 0.93, suggesting that this task was particularly helpful in ruling out future MCI or AD for participants.

4 | DISCUSSION

In this secondary analysis of data available in ADNI, we examined the longitudinal relationship of cognition and mood symptoms on FC and the relationship of FC on conversion to MCI or dementia. Our main findings are that FC, as measured by specific tasks of the FCI-SF, is associated with executive, visuospatial, and memory over time. Furthermore, higher report of depressive symptoms, as measured by the GDS-15, was related to poorer FCI-SF performance and longer completion time. Finally, slower time to completion on the FCI-SF was significantly related to increased conversion from normal to either MCI or AD. Although this is not the first longitudinal analysis focused on FC,[42–44] this is the first known longitudinal analysis examining the effect of FC on diagnostic outcome in a large sample over a long follow-up period.

It has been systematically shown that impairment in FC is one of the earliest IADL changes seen in MCI.[10-12] Financial skills are known to require components of judgment and decision-making, and the cognitive correlates of impaired FC (in MCI) have been associated primarily with executive control and numerical calculation.[15-18] Early work by Boyle and colleagues[15] found that executive functioning and apathy accounted for significant functional decline in AD patients. Similarly, Duda et al.[19] found that loss of executive functions account for the greatest proportion of variance of functional ability and Earnst et al.[45] found that working memory difficulties were associated with diminished FC in AD. In MCI, inattention and difficulties with self-monitoring on cognitive tasks are thought to contribute to their slower and more error-prone performances on FC tasks.[17] More specifically, subdomains of executive control (selective attention, self-monitoring, and working memory) have been strongly correlated with FC.[15-18] Given these prior findings, we initially hypothesized that FC would be associated with executive function alone. However, we found that executive functioning composite was associated with FCI-SF subcomponents only in the time-averaged model but memory and visuospatial domains were differentially associated with FCI-SF tasks in both regression models at the $p < 0.01$ level. Specifically, in the change since last visit models, we found that complex checkbook and time to completion subcomponents were significantly associated with visuospatial functioning, whereas financial conceptual knowledge, simple checkbook, and bank statement were significantly associated with memory. Taken together, these results suggest that integration of other cognitive domains (visuospatial skills and memory) in addition to executive functioning are associated with successful completion of financial tasks that involve accessing accumulated knowledge, reading and writing, and task difficulty. In one longitudinal study by Niccolai et al.,[46] written arithmetic, visual confrontation naming, visuospatial memory, and visual attention showed the highest associations with declining FC. In sum, our findings are consistent with prior work showing associations between FC and executive functions,[22,23] memory, and psychomotor speed,[24,25] suggesting a multifaceted interaction between cognition and everyday financial function.

With regard to our finding of the timing component of the FCI-SF being a strong predictor of conversion to MCI or AD, we note surprisingly scant evidence from the previous literature referring to this variable on the FCI-SF. Most published work has reported associations of the total score rather than time to completion. As noted above, timing components are obtained for four FCI-SF tasks and generate a composite time score for the two checkbook tasks, and a composite score for all timed tasks. If a participant exceeds the allowable time limit on one of these tasks, they receive a 0 credit. Therefore, a "ceiling effect" on the total score for participants with slower time to completion may exist; however, this has not been examined directly to our knowledge. It would seem, then, that time to completion also ought to be considered as a significant factor in assessing FC overall and future analyses should include it as a variable of interest.

The presence of neuropsychiatric symptoms (NPS) such as depression, anxiety, and apathy is nearly universal (80%–90%) in AD[47] and the prodromal phases such as in MCI.[48–51] These syndromes affect cognitive performance including executive functions and have been shown to affect FC in patients with late-life depression,[52] vascular dementia,[53] and Parkinson's disease.[54] Furthermore, increased depression has been shown to affect FC in cross-sectional studies of older adults, and we have extended this observation to a longitudinal analysis, noting that higher report of depressive symptoms at baseline was associated with decline in FCI-SF over time. For example, two studies found that over twice as many older adults with major depression relative to non-depressed older adults demonstrated difficulty on performance-based tests of FC.[55] Executive control deficits also predict a subsequent diagnosis of dementia in depressed older adults.[56] Executive control alone, however, may not be sufficient to explain the association between depression and FC. Our KappaTree results, for example, did not find that the TMT-B was a significant predictor of conversion to MCI or AD. Moreover, the associations between cognition and FC might be different for depressed and non-depressed older adults. In samples that did not emphasize depression, Sherod et al.[18] found that executive functioning was not a predictor of the total FCI score (full version) in cognitively unimpaired individuals or mild AD participants and explained only ≈11% of the variance in persons with MCI. Likewise, Niccolai et al.[46] found no association between executive functioning and change in FCI-SF total score over 2 years. In both of these articles, FCI-SF was explained by a mix of cognitive processes, with strong contributions from basic arithmetic.

As such, the FCI-SF may be a useful marker of conversion, as it simultaneously taps into several cognitive constructs relevant to everyday living. Furthermore, depressed mood may also exacerbate functional weaknesses in the presence of neuropathology. Hybels et al.[57] found that the effect of baseline white matter hyperintensity volume on the change in IADL status over 16 years differed by depression status. Older adults who were both depressed and had a higher volume of hyperintensities at baseline were more at risk for IADL limitations compared to non-depressed older adults with similar hyperintensity volumes. From a biological standpoint, then, one might envision that the FCI engages a broader range of circuitry compared to EF, as it potentially engages frontostriatal pathways, as with EF, but also the parietal cortico-subcortical circuits mediating arithmetic including the angular gyrus where engagement may be higher in these latter regions.

Several studies have now shown that daily functioning becomes impaired in the early stages of cognitive decline before a diagnosis of dementia is warranted.[22,24,58–61] This observation is taken in the context that those with MCI are at increased risk of progressing to dementia.[62–65] As a result, the revised criteria for MCI as put forward by Albert et al.,[66] suggest that while those with MCI may have mild problems performing complex functional tasks, they are able to live independently. Similarly, several studies have shown that early impairment in ADLs increased risk of conversion from normal to MCI to dementia.[67–69] In the Sydney Memory and Ageing Study,[70] the authors showed that increased difficulty with participation in highly cognitively demanding activities specifically predicted amnestic MCI but not non-amnestic MCI, whereas those activities with low cognitive demand did not predict MCI or dementia.[70] Similarly, Peres et al.[59] and Di Carlo et al.[63] found that in those with normal cognition, self-reported IADL restrictions predicted progression to dementia after 2 and 4 years, respectively.

The results of this analysis underscore the importance of IADLs in the overall temporal trajectory of cognitive decline in old age. Although our primary findings are illustrative of FC as a key component associated with cognitive worsening or diagnostic conversion, they are not correlated with concurrent neurobiological changes such as the accumulation of amyloid or tau over time. Recently, however, a cross-sectional analysis by Tolbert et al.[71] showed that global cortical amyloid beta (Aß) deposition as measured by 18-F Florbetapir PET was associated with worse performance on FCI-SF, thus linking FC to AD pathology. Moreover, although the results of this analysis were adjusted for demographic variables, sex differences in performance on the FCI-SF were not addressed specifically but are an important area for further investigation. Finally, although our results seem to point to depression playing an important role in declining FC, we were not able to examine the role of other NPS, specifically apathy, which are strongly related to executive dysfunction. Apathy is increasingly reported in a variety of neuropsychiatric diseases and warrants further examination in relation to FC.

In the absence of tolerable and effective disease-modifying treatments for AD and other dementias, targeted neurocognitive, behavioral, supportive, or compensatory interventions for declining IADLs are needed to help older adults stay independent longer. Given the public health significance of impaired FC on our aging society, expanded research in larger samples should provide further insights into ultimately developing effective interventions for patients and caregivers. Our surprising finding that time to completion is the one significant predictor of diagnostic conversion may suggest that interventions such as computerized cognitive training,[72] which has shown improvements in time to completion, may be applied to improving FC and perhaps other IADL performance. Continued and expanded research in larger samples should provide further insights into ultimately developing effective interventions based on cognitive foundations of FC, with the eventual goal of stabilizing decline and maintaining independence.

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The authors have nothing to report.

CONFLICT OF INTEREST STATEMENT

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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