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How Well Does Subjective Cognitive Decline Correspond to Objectively Measured Cognitive Decline? Assessment of 10–12 Year Change

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Abstract

Background: Although not strongly correlated with current objective cognitive ability, subjective cognitive decline (SCD) is a risk factor for Alzheimer's dementia. Most studies focus on SCD in relation to future decline rather than objective prior decline that it purportedly measures.

Objective: We evaluated whether self-report of cognitive decline—as a continuous measure—corresponds to objectively-assessed episodic memory and executive function decline across the same period.

Methods: 1170 men completed the Everyday Cognition Questionnaire (ECog) at mean age 68 assessing subjective changes in cognitive ability relative to 10 years prior. A subset had mild cognitive impairment (MCI), but MCI was diagnosed without regard to subjective decline. Participants completed up to 3 objective assessments of memory and executive function (*M*=56,

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62, and 68 years). Informant-reported ECogs were completed for 1045 individuals. Analyses controlled for depression and anxiety symptoms assessed at mean age 68.

Results: Participant-reported ECog scores were modestly associated with objective decline for memory (β=−.23, 95% CI [−.37,−.10]) and executive function (β=−.19, 95% CI [−.33,−.05]) over the same time period. However, these associations were nonsignificant after excluding MCI cases. Results were similar for informant ratings. Participant-rated ECog scores were more strongly associated with concurrent depression and anxiety symptoms, (β=.44, 95% CI [.36,.53]).

Conclusion: Continuous SCD scores are correlated with prior objective cognitive changes in non-demented individuals, though this association appears driven by individuals with current MCI. However, participants' current depression and anxiety ratings tend to be strongly associated with their SCD ratings. Thus, what primarily drives SCD ratings remains unclear.

Keywords

aging; cognitive decline; cognitive function; memory; executive function; latent growth model

Introduction

Greater subjective cognitive decline (SCD) – the self-reported experience of worsening cognitive ability – is a risk factor for Alzheimer's disease (AD) [1]. Individuals who endorse more cognitive changes progress to AD at higher rates [2]. However, subjective ratings of cognitive decline often correspond poorly with concurrent objective cognitive testing [3,4] and vary in their association with AD pathology [5,6]. Thus, the perception of cognitive decline may represent an early marker of dementia when individuals note cognitive changes, but symptoms have not yet manifested broadly. On the other hand, a large proportion of individuals who report more cognitive decline will ultimately not evidence objective/progressive cognitive decline [7].

Methodological challenges may contribute to the varying predictive power of measures of SCD. These include sample being studied (e.g., clinic vs. community) [8–10] and operationalization and measurement of SCD (e.g., questionnaire level of detail, self vs. informant) [11]. Self- and informant reports are often discordant from one another or concurrent objective cognitive assessments [12,13]. Moreover, the timeframe that participants are asked to rate their cognitive changes also varies greatly across studies and measures of SCD [11].

It is noteworthy that most studies have been concurrent or future-oriented, without consideration of associations between subjective and objective cognitive *decline* over the same timeframe, which it purportedly assesses. How subjective ratings of cognitive decline correspond to objective cognitive changes in the corresponding interval has not been rigorously examined. One investigation demonstrated that changes in responses to a single question ("How would you rate your memory at the present time?") over up to 4 assessments corresponded to changes in episodic memory, but participants did not rate their memory change directly [14]. Another study demonstrated only weak correspondence between self-reported decline in memory and actual memory decline over a 2-year time period with 20%

reporting memory decline with no objective change, 12% with objective memory decline but no subjective decline, and only 4% with both subjective and objective memory decline [15]. Of note, both studies considered only a single question to measure one aspect of SCD (memory) and a single cognitive domain (episodic memory). Therefore, it will be important to examine these associations with more rigorous assessments of both subjective and objective cognitive decline.

We examined the relationship between self- and informant-reported perceptions of SCD (measured continuously) and objective cognitive change assessed within the past 12 years in a community-dwelling sample. Cognitive changes across 3 waves of assessment in this 12-year interval were assessed with latent growth curve models that allow us to simultaneously model baseline cognitive ability (i.e., intercept) and objective cognitive change (i.e., slope) in relation to SCD ratings, leveraging data from 6–7 tests/subtests per cognitive domain. We predicted that subjective ratings of cognitive decline by both participants and informants would correspond to actual cognitive changes in the domains of episodic memory and executive function, but that these associations would be moderate in magnitude given previous findings. We focused on episodic memory and executive function because they are the most characteristically impaired cognitive abilities in mild cognitive impairment (MCI) and Alzheimer's disease [16–19] and most well-represented on the measure of SCD used in the current study (the Everyday Cognition scale; ECog) [20]. Additionally, we have already demonstrated that both memory and executive function are declining across midlife within the sample investigated here [21,22].

Beyond objective function, SCD ratings are often related to mood symptoms [12,23–26] including depression ratings. For example, one recent cross-sectional study of 519 adults aged 60–95 demonstrated that SCD ratings were no longer associated with current objective cognition after adjusting for depression and demographic variables [26]. However, for SCD, respondents are asked to rate change from prior function, not current function. Here we also explored the role of depression and anxiety symptoms impact on the relationship between subject and objective cognitive decline. Because SCD ratings should correspond to objectively measured cognitive decline even after accounting for mood at the SCD assessment, we predicted that both objective cognitive change and mood would be independently associated with SCD ratings. However, we expected that the association between objective cognitive change and SCD ratings may weaken after accounting for depression and anxiety symptoms.

Materials and Methods

Participants

Participants were adult male twins in the Vietnam Era Twin Study of Aging (VETSA) [27]. They were recruited from the Vietnam Era Twin Registry, and were randomly selected from Registry twins who participated in a previous study [28]. All individuals served in the United States military at some point between 1965 and 1975, but are representative of American males of their age with respect to health and lifestyle factors; nearly 80% did not serve in combat or Vietnam [29–31]. Rates of post-traumatic stress disorder (PTSD) and other psychiatric diagnoses in VETSA are not elevated compared to other population studies

[32]. For example, at wave 2, only 5.0% of subjects had PTSD checklist (civilian version) scores greater than 49, a good predictor of PTSD [33], and at least half of the participants who experienced trauma reported non-military experiences as their most significant trauma. Rates of alcohol/drug dependence are not available, but alcohol consumption in VETSA does not appear elevated compared to other community samples (e.g., at baseline, only 14.6% of the sample reported drinking >2 drinks per day) [34].

VETSA included 3 assessment waves across an approximate 12-year period. The ECog was introduced at the final assessment, and a total of 1170 participants completed it. However, analyses were informed by all N=1608 individuals who completed at least one VETSA assessment for the most precise estimation of cognitive change (see Data Analysis). Table 1 displays demographic characteristics of the full sample, including N and mean age at each assessment. A total of 822 participants completed all of the VETSA assessments, with some subjects who did not complete all 3 assessments because they initially enrolled in the study at wave 2 (N=245) or wave 3 (N=123). Participants identified as White (92.8%), Black or African American (5.5%), American Indian (0.3%), Pacific Islander (0.1%), or more than one race (1.3%). Hispanic individuals comprised 2.7% of the sample.

All participants provided informed consent, and all procedures were approved by the Institutional Review Board of participating institutions. To ensure the study was a representative community sample for this age range, the only inclusion criteria for wave 1 were that twins must be between ages 51 and 59 at the time of recruitment, and that both twins in a pair agreed to participate. All wave 1 participants were invited to complete wave 2 and 3 regardless of participation of their co-twin. There were no additional inclusion or exclusion criteria at any wave.

Measures

At each wave, participants completed assessments over the course of one day (~7 hours). Each assessment included a medical history interview, neuropsychological and functional assessments, and some other activities (e.g., blood draw, additional questionnaires).

Subjective cognitive decline.—Participants completed the ECog [20] on the day of the wave 3 assessment. For all items, individuals were asked to rate how their current level of everyday cognitive functioning compares with how they functioned 10 years earlier. The ECog has 6 subscales: memory (8 items), language (9 items), visuospatial and perceptual abilities (7 items), and executive function: planning (5 items), organization (6 items), and divided attention (4 items). Analyses in the current study focus on the ECog total score (the average of all 39 items), thus reflecting continuous variability in self-perceived cognitive decline (rather than SCD and non-SCD groups). Higher scores on the ECog indicate greater decline. Participants and informants were required to respond to at least 20 items (>50% of the total items) to receive a score (“I don’t know” responses were coded as missing). Zero participant and 6 informant ECogs were excluded for missing too many items. Of the remaining data, the proportion of missing items was low (M=0.5%, SD=2.8% for participants, M=0.9%, SD=4.2% for informants). For example, only 6 participants and 13 of the remaining informants missed more than 20% of items.

Participants also identified an informant (anyone who knew them well except their twin brother, though in one instance a twin was allowed to be an informant). Questionnaires were mailed to the informant up to 3 times (3 weeks apart), then informants were called directly up to 3 times (3 weeks apart) until their questionnaire data were returned or they declined to participate. In total, 1045 informants (89.3% of all individuals who have participant-report ECog data) responded to the survey. The majority of informants were the twin's spouse (73.0%) or adult child (12.5%).

Objective episodic memory and executive function.—Memory and executive function factor score composites were created from previous latent variable analyses in VETSA [21,22,35–37]. Factor loadings at wave 1 were used to calculate factor scores at all waves and factor scores from all waves were standardized with respect to wave 1 means and standard deviations (i.e., assuming longitudinal measurement invariance). Additionally, prior to computing factor scores, all cognitive measures at the second and third waves of testing were adjusted to account for the fact that many of the subjects had encountered the tasks before [38]. These practice effect calculations leverage data from attrition replacement subjects who completed the task battery for the first time at wave 2 or 3 to estimate the increase in performance in returnees who completed the tests multiple times.

Episodic memory was assessed with the Logical Memory (LM) and Visual Reproductions (VR) subtests of the Wechsler Memory Scale-III [39], using both the immediate and delayed recall measures. We also used the California Verbal Learning Test-II (CVLT) [40] short delay free recall, long delay free recall, and the total score for the learning trials. Executive function was assessed with 6 tests spanning inhibition, shifting, and working memory span subdomains, consistent with theoretical models that emphasize the "common executive function" variance that underlies performance across this array of abilities [41,42]. Prepotent response inhibition was assessed with the Golden and Freshwater [43] verson of the Stroop task [44]. Task-set shifting was assessed using the Trail Making Test switching trial and category switching trial of the verbal fluency test, both from the Delis-Kaplan Executive Function System (D-KEFS) [45]. Working memory span was assessed with the letter-number sequencing and digit span (forward and backward) subtest of the Wechsler Memory Scale-III [46], and a reading span task [47]. Inhibition and shifting measures were appropriately adjusted for performance on baseline conditions (e.g., letter only and number only trails on the Trail Making Test) [21,35].

Mild cognitive impairment (MCI).—MCI was diagnosed using the Jak-Bondi actuarial/neuropsychological approach [48–50]. Impairment in a cognitive domain was defined as having at least two tests >1.5 SDs below the age- and education-adjusted normative means after accounting for "premorbid" cognitive ability by adjusting neuropsychological scores for performance on a test of general cognitive ability that was taken at a mean age of 20 years [50–52]. Importantly, subjective decline ratings were not used as a criterion for the actuarial VETSA MCI diagnosis. MCI diagnoses are available at all waves, but we focus on MCI diagnoses at the wave 3 assessment when individuals completed the ECog assessment.

Covariates.—Depression and anxiety symptoms were assessed with 3 measures: the 20-item Center for Epidemiologic Studies–Depression scale (CES-D) [53], the 20-item trait

form of the State-Trait Anxiety Inventory (STAI) [54], and the 5-item Mental Health subscale of the Short-Form Health Survey (SF-36) [55] which assesses both depression and anxiety symptoms. These measures were completed as part of a questionnaire mailed to subjects shortly prior to the wave 3 assessment, which they returned at the wave 3 assessment. Although latent growth curve models of cognitive ability factor age into estimates of intercept and slope, age at wave 3 was also included in regression analyses involving ECog ratings as older individuals are more likely to endorse SCD.

Table 2 describes the correlations among all measures of the study, which includes some additional potential covariates: participant's total years of education, their total number of health problems (e.g., summing chronic health problems from the Charlson comorbidity index) [56], and *ApoE* status (ε4+ alleles vs. ε4−). *ApoE* status was excluded from further analyses because it was not associated with any key study measures. Health problems were variably (and weakly) associated with SCD and cognitive tests, and including health problems and education as covariates did not result in any substantial changes to the primary regression results (see Supplemental Table S1). In these models, education was also no longer associated with SCD ratings after controlling for objective cognitive ability. Therefore, both measures were excluded from additional analyses.

Data Analysis

Although all participants were twins, the unit of analysis was at the level individuals (rather than twin pairs), as questions of genetics were outside the scope of this investigation. Analyses were conducted using Mplus version 8.3 [57], which accounts for missing observations using full-information maximum likelihood. Cognitive latent growth curve models were estimated by treating age as a time-varying variable. Factor loadings on the intercept factors were fixed to 1.0 at all waves. Factor loadings on the slope factor were based on the age of each participants at that wave of assessment (see Figure 1). Latent growth curve models were informed by all 1608 individuals who completed at least one VETSA assessment for the most precise estimation of cognitive change. Age was based on decades because this corresponds well with the ECog instructions to rate cognitive decline in the past 10 years.

Model fit was evaluated based on −2 log-likelihood (−2LL), Akaike's Information Criteria (AIC), and Bayesian Information Criteria (BIC). Significance of individual parameter estimates were established with standard error-based 95% confidence intervals and confirmed with χ^2 difference tests by fixing that parameter to zero. Standard errors were adjusted for clustering within families (i.e., using a sandwich estimator), and the χ^2 difference tests were appropriately scaled [58].

Regression analyses involving subjective decline were also conducted in the context of the latent growth curve model. In the first model, informant and participant ECog ratings were simultaneously regressed on memory intercept and slope factors, the depression/anxiety symptoms factor, and age at the final assessment (i.e., participant- and informant-rated decline were both dependent measures in the same structural equation model). A second model was fit replacing memory factors with executive function factors. In these models, because depression and anxiety symptoms measures are highly correlated, they were

combined to create a Depression/Anxiety Symptom latent factor (see supplement Figure S1 for standardized factor loadings). The depression/anxiety symptoms latent factor and age at ECog were also regressed on subjective decline ratings and allowed to correlate with cognitive intercept and slope factors (and each another). Thus, associations between SCD ratings and cognitive change, depression/anxiety symptoms, and age can be interpreted as controlling for one another. We also included a residual correlation between dependent variables (i.e., participant-rated and informant-rated ECog ratings).

Our first set of analyses included individuals with MCI. We then conducted the same analyses after excluding 181 individuals (15.7%) at wave 3 who were diagnosed with MCI. The latter test whether subjective ratings of cognitive decline still correspond to objective cognitive changes after excluding individuals who may have had the greatest objective change.

Data Availability

VETSA data are publicly available, with restrictions. Information regarding data access can be found at our website: https://medschool.ucsd.edu/som/psychiatry/research/VETSA/Pages/default.aspx

Results

Sample Characteristics and Descriptive Statistics

Characteristics of the sample and descriptive statistics for all study measures are displayed in Table 1. Table 2 displays the correlations among all variables. Of note, the association between participant-rated and informant-rated ECog scores was moderate (r = .39, 95% CI [.29, .50]).

Latent growth curve models of episodic memory and executive function data alone in the full sample are displayed in Figure 1 (model fit for memory: −2LL=−4067.10, AIC=8146, BIC=8159; model fit for executive function: −2LL=−4067.10, AIC=8146, BIC=8159). Slope variances were significant for both memory ($\chi^2(2)=44.75$, $p<.001$) and executive function ($\chi^2(2)=20.64$, $p<.001$), confirming that there was significant variability in cognitive change across the 3 waves of assessment. Intercept factors (which capture baseline cognitive ability) and slope factors (which capture cognitive change) were allowed to correlate with each other in the models, but this correlation was only significant for executive function (r=−.36, 95% CI [−.54, −.19]). Variance in the slope factors was considerably smaller than variance in the intercept factors, suggesting there was little variance in cognitive change per 10 years across middle age (i.e., variances in cognitive change were .12 for memory and .09 for executive function compared to intercept variances of .75 for memory and .77 for executive function). A small portion of the variance was also explained by unique variance in each cognitive factor score at each separate wave (residual variances .20 to .21).

After removing individuals diagnosed with MCI, latent growth curve models indicated that there was still significant variance in cognitive change for memory (.063, $\chi2(2)=8.17$, p=.017) and executive function (.059, $\chi2(2)=17.11$, p<.001). These findings confirm that even cognitively normal individuals varied in their objective decline across this 12 year

timeframe, and justify examining how these objective changes relate to subjective decline in stratified analyses. Hereafter, all associations are reported based on standardized estimates.

Table 3 displays the intercorrelations among the memory and executive function latent variable intercepts and slopes, including their association with the depression/anxiety symptoms latent factor and ECog ratings, after all variables were included in a full correlational model. The depression/anxiety symptoms latent factor was associated with baseline memory (r= −.15, 95% CI [−.23, −.08]) and executive function abilities (r= −.17, 95% CI [−.24, −.10]), as well as change in memory (r= −.15, 95% CI [−.29, −.01]) and change in executive function (r= −.21, 95% CI [−.34, −.07]). Additionally, baseline memory and executive function were correlated at r= .56, 95% CI [.48, .64] whereas change in memory and executive function were correlated at r= .93, 95% CI [.63, 1.0].

Associations Between Subjective and Objective Cognitive Change in the Full Sample

The primary study findings are displayed in Table 4 in which participant- and informant-rated ECog scores were regressed on cognitive intercept and slope factors, depression/anxiety symptoms, and age at the ECog assessment. Results from these models can be compared with the correlations in Table 3 to see the impact of controlling for covariates on the associations between subjective and objective cognitive decline. Supplemental Figure S1 depicts the full path models for the multiple regressions summarized in Table 4. Model fit for memory: −2LL=−12980.74, AIC=26031, BIC=26220. Model fit for executive function: −2LL=−12758.57, AIC=25587, BIC=25775.

As shown in Table 4a, participant-rated subjective reports of cognitive decline were associated with objective change in episodic memory (β= −.23, 95% CI [−.36, −.10]), such that individuals who had sharper declines in cognitive performance prior to ECog assessment reported greater subjective decline. Similar associations were observed for informant-rated decline (β= −.24, 95% CI [−.40, −.08]). Additionally, ECog scores were associated with baseline memory performance (i.e., Memory Intercept) for participant but not informant ratings (β= −.12, 95% CI [−.19, −.04]). Participant-rated ECog scores were most strongly associated with concurrent depression/anxiety symptoms (β= .44, 95% CI [.36, .53]), with more depression/anxiety symptoms associated with more perceived decline. This association with depression/anxiety ratings was significantly stronger in magnitude than the association between participant-rated ECog scores and their objective decline in memory, $\chi^2(1)=16.40$, $p<.001$. Informant-rated ECog score was also associated with participant depression/anxiety ratings (β= .25, 95% CI [.16, .33]), but not more strongly than objective memory change, $\chi^2(1)=0.00$, $p=.970$. Finally, older individuals reported more perceived decline than younger individuals (β= .08, 95% CI [.01, .14]), and their informants reported that they declined more (β= .06, 95% CI [−.01, .13]), though effects were small and significant for participant ratings only.

Similar results were obtained for executive function (Table 4b). ECog scores were associated with executive function decline for both participant ratings (β= −.19, 95% CI [−.33, −.05]) and informant ratings (β= −.27, 95% CI [−.47, −.07]). The executive function intercept was also associated with participant-rated ECog (β= −.17, 95% CI [−.25, −.10]) and informant-rated ECog (β= −.18, 95% CI [−.27, −.08]), suggesting individuals with lower

objective scores at baseline also reported more subjective decline at the final time-point. Finally, depression/anxiety symptoms were associated with participant-rated (β= .43, 95% CI [.36, .53]) and informant-rated ECog scores(β= .22, 95% CI [.11, .32]) to a similar degree as in the model with memory. Again, participant-rated ECog scores were more strongly associated with concurrent depression/anxiety symptoms than with their actual decline in executive function, $\chi^2(1)=9.91$, p=.002. These associations were similar in magnitude for informant-rated decline, $\chi^2(1)=0.17$, p=.683.

Associations Between Subjective and Objective Change After Excluding MCI

We replicated the previous set of analyses after excluding individuals who met criteria for MCI at the ECog assessment (N=181). Results are displayed in Table 5. In these models, objective memory and executive function change were no longer associated with ECog scores (for participant- or informant-rated decline), though trends were observed in the same direction and within the 95% CIs of the initial estimate (β=−.06 to −.20). Associations with other study variables remained largely unchanged. Baseline objective cognitive ability was still weakly associated with ECog scores for all comparisons except memory intercept with informant-rated decline (β=−.08 to −.20). Depression and anxiety symptoms were still strongly associated with participant-rated (βs=.46 to .47), as well as informant-rated ECog scores (βs=.26 to .28), to essentially the same degree as observed in the full sample. Associations with age were also nearly identical as in the corresponding analyses with the full sample (β=.06 to .11).

Discussion

In this large community sample of men transitioning from middle to early old age, we found that objective baseline memory and executive functioning performances were modestly related to participant- and informant-reports of subjective cognitive decline 12 years later. However, these associations appeared to be driven by the 15.7% of the sample who were diagnosed with MCI at the time of the ECog assessment. Rather, subjective ratings of cognitive decline were associated with mood symptoms. These findings suggest that subjective assessment of cognitive decline, whether from the individual or an informant, lack consistency with actual cognitive changes, especially those individuals whose cognitive ability lies within the normal range.

In total, with or without MCI cases included, only about 30% of the variance in participant-rated decline and about 15% of the variance in informant-rated decline was explained jointly by all predictors. This pattern suggests there is considerable variance in SCD ratings with underlying features due to other factors unexamined here.

Participant-rated ECog scores were most strongly associated with depression and anxiety symptoms at average age 68 rather than with objective decline. However, that was not the case for informant-ratings. These findings are consistent with the broader literature that finds SCD ratings are often related to mood symptoms [12,23–26] and more so than informant ratings, although it is in contrast to some other population-based studies that have not found a unique relationship between subjective cognitive ratings and depressive symptoms [59].

Prior studies, however, have not simultaneously examined objective cognitive *decline* across the same period when examining associations between mood and SCD ratings. The logic of assessing current depression/anxiety together with SCD is generally that subjective ratings of cognitive decline might really reflect the mood disturbances rather than actual cognitive decline, which is supported by the current findings. Specifically, individuals in the present study who were experiencing more current depression/anxiety symptoms had significantly poorer cognitive ability 12 years earlier (r= −.15 for baseline memory, r= −.17 for baseline executive function), and significantly sharper objective cognitive decline (r= −.15 for memory slope, r= −.21 for executive function slope). Therefore, there may be a bi-directional relationship between mood and actual cognitive decline with both independently impacting perceived decline [60]. These findings highlight that SCD may present as a risk factor for dementia in part due to mood and objective cognitive status, two factors that should be taken into account when assessing the relevance of SCD in clinical settings.

One reason for our discrepant findings with previous literature could be related to our novel methodology, examining how these mood and subjective cognitive measures were related to previous cognitive performance. Actual prior cognitive performance is not often examined in studies of SCD [14,15,61], and never with a comprehensive assessment of memory and executive function tests. The current results represent a novel understanding of the complex interplay between mood and subjective cognitive decline. What drives the association between SCD or depression/anxiety and *future* cognitive decline or dementia may not be the same as what drives associations with prior decline.

Another important finding was that the variance in both memory change and executive function change was quite small (i.e., the variance of cognitive change across 10 years was about $1/7^{th}$ the size of the variance for the intercept). Our latent factor score approach, which integrated across 6–7 measures in each domain, allowed us to meaningfully examine even this small variability in change and show that it corresponds to SCD ratings. The lack of strong variance in change suggests that individuals in the sample declined at a relatively similar rate. Moreover, change in memory was highly correlated with change in executive function, suggesting the small variability in change is similar across both domains.

The association between participant-rated and informant-rated subjective decline was also only r=.39, suggesting that informant reports likely capture distinct processes or different aspects of subjective cognitive functioning. In a cross-sectional study, Slavin et al found that informant reports of subjective cognitive complaints were more accurate than self-reports when current cognitive impairment was objectively present [12]. Our results contribute further, suggesting that informant reports may be less influenced by participants' depression and anxiety symptoms than are self-reports. However, despite the differences in participant-rated and informant-rated subjective decline in the present study, their degree of association with actual prior cognitive decline was very similar, and small in magnitude. Overall, this finding highlights the complexity of subjective reports of cognitive decline and the need to better understand the underlying drivers and mechanisms of this construct. In the next wave of the study, with both repeated objective testing and ECog ratings, we will be able to examine whether or not the accuracy of ECog ratings remains stable over time.

It is also worth noting again that our sample at the ECog assessment was 68 years and the oldest participant was only 73 years old. It may be that in older adults there would be greater variance in cognitive change over the period being rated, which might allow for stronger correlations between subjective ratings and actual cognitive decline. Additionally, the present sample also comprised a community-dwelling, non-patient sample. It might also be the case that there would be greater variance in objective cognitive decline, and possibly stronger correlations with SCD ratings and objective decline in individuals coming to a memory clinic. Finally, although the ECog specifically asked participants to rate whether their cognition has changed over the past decade, another possible explanation for these results is that participants' SCD judgments were influenced by their perception of their current ability. Indeed, correlations between ECog ratings and wave 3 factor scores (*r*s= −.28 for memory, −.25 for executive function) were similar to the associations with cognitive change from the latent growth model (*r*s= −.23 and −.19, respectively), lending some weight to this idea.

There are limitations of this study that should be considered. The sample included only men. Although previous work suggests that the association between SCD and current objective cognition does not differ across sex [12], it will be important to examine these associations in women as there may be sex differences in the ability of SCD to predict incident dementia [62]. Our results indicating that depression/anxiety symptoms are associated with SCD ratings generally more strongly than objective cognitive decline is consistent with Zlatar et al. who showed similar associations between SCD, depression symptoms, and current cognition in a sample of older Hispanics [24,26]. Given that our sample was predominantly non-Hispanic White, further replication in more diverse samples is needed. Another explanation for the stronger association between depression/anxiety symptoms and SCD ratings was that they were simply assessed with similar methods (i.e., self-reported questionnaires). In addition, other risk factors such as hypertension [63] or measures of Alzheimer's pathology (e.g., amyloid, tau) [5] may interact with SCD and should be explored in future studies.

This work also sought to address a gap in the literature by examining how SCD ratings compared to objective cognitive changes over the same interval using continuous measures. This approach preserved individual differences in both subjective and objective change, which should improve power. Most work in this field focuses on dichotomous scores for both SCD and cognitive change, so it is possible that the results observed here would differ if we had used dichotomous scores. However, earlier work suggests the correspondence may remain low even with such approaches [15,64]. Our findings align with another previous study that used continuous scores of subjective memory change (based on a single questionnaire item) that demonstrated only a weak relationship with objective memory change after accounting for current memory complaints and current memory performance [61]. Relatedly, although cognitive complaints/concern are not required in the research framework of the SCD-initiative [7], it is possible that objective and subjective ratings may correspond more strongly in the presence of cognitive concern than in their absence, but we were unable to examine this here. Finally, our latent growth model fitting strategy was by no means exhaustive, but it would require more timepoints to estimate more complex models of cognitive change (e.g., non-linear slopes) and when comparing objective cognitive

trajectories with subjective reports of cognitive decline a linear slope is likely sufficient (i.e., participants only rated how much they declined, not whether their decline appears to be accelerating).

In sum, the current study shows that objective prior cognitive change accounts for little variance in self-reported cognitive decline, but depression and anxiety symptom ratings are also associated with SCD ratings to a similar or greater degree. SCD is assessed in many studies, but the clinical meaning of these evaluations remains equivocal. Similarly, the validity of SCD as an early predictor of dementia is complicated by the non-specificity of SCD given that numerous factors may contribute to subjective ratings of cognitive decline. Despite substantial investigation of SCD, little is still known about how well it is associated with actual prior decline, which is what it was intended to measure. The findings highlight the importance of understanding subjective cognitive ratings in the context of the broader symptom presentation and the value of obtaining collateral information about prior cognitive functioning. Having shed light on the weak association between current subjective and actual prior cognitive decline, what accounts for SCD's ability to predict actual future decline remains to be elucidated.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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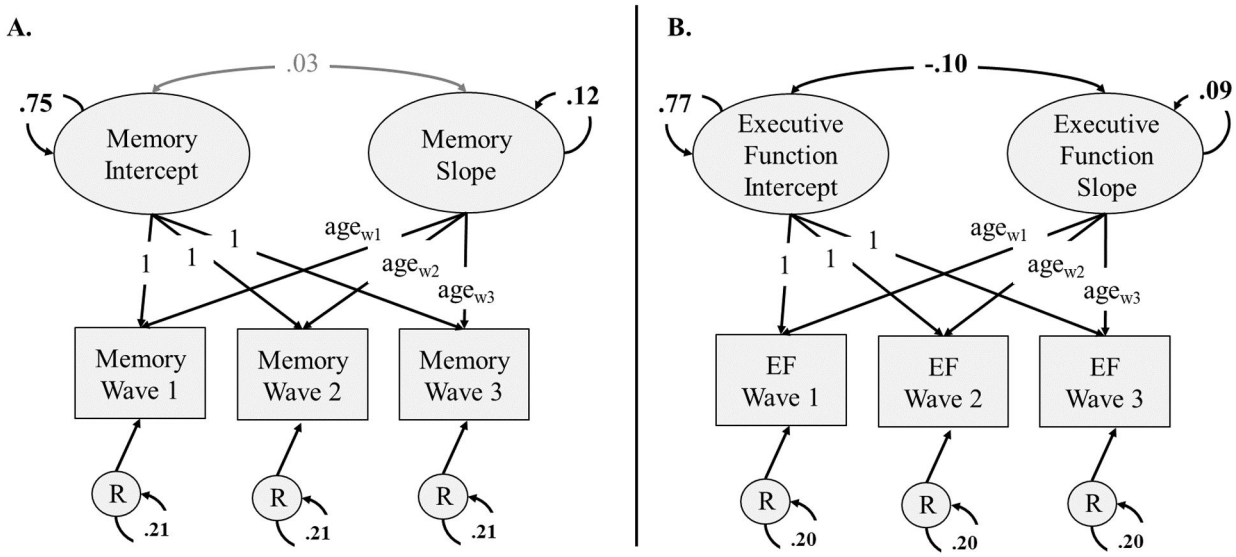

Figure 1:

Latent growth curve models of (A) episodic memory and (B) executive function. Ellipses indicate latent variables and rectangles indicate measured variables. Unstandardized parameter estimates are displayed. Factor loadings on the intercept factors were fixed to 1.0 at all waves. Factor loadings on the slope factors were based on the age of each participants at that wave of assessment (age_{w1}, age_{w2}, age_{w3}). Significant factor loadings are displayed in bold (i.e., 95% CI's do not include 0).

Table 1

Demographic Characteristics of the Sample and Descriptive Statistics for Key Study Measures

Measure	N	M	SD	Range	Skewness	Kurtosis
Demographic Characteristics						
Age (Wave 1)	1291	55.94	2.43	51.1, 60.69	0.06	−1.71
Age (Wave 2)	1207	61.72	2.45	55.96, 66.96	−0.17	−1.42
Age (Wave 3)	1196	67.56	2.53	61.37, 73.25	−0.39	−1.02
Yrs between Wave 1 and 3	918	11.44	1.39	5.58, 14.44	−1.52	4.04
Years of Education	1608	13.85	2.09	8, 20	0.59	−0.18
Health Problems (Wave 3)	1196	1.95	1.49	0, 8	0.86	0.79
ApoE E4 positive (%)	1471	29.3%	-	-	-	-
Depression/Anxiety Symptoms						
CES - Depression (Wave 3)	1191	7.11	7.61	0, 47	1.78	3.82
Trait Anxiety (Wave 3)	1190	30.79	9.29	20, 72	1.15	1.14
SF36 Mental Health (Wave 3)	1192	25.17	3.98	8, 30	−1.30	1.48
Everyday Cognition Questionnaire						
Participant-Rated	1170	1.54	0.44	1, 4	1.48	3.07
Informant-Rated	1045	1.39	0.46	1, 4	2.01	4.54
Cognitive Factor Scores						
Memory (Wave 1)	1284	0.00	1.00	−3.42, 2.96	−0.10	−0.05
Memory (Wave 2)	1202	−0.28	1.03	−4.27, 2.51	−0.20	0.07
Memory (Wave 3)	1168	−0.49	1.08	−4.79, 2.60	−0.11	0.11
Executive Function (Wave 1)	1285	0.00	1.00	−3.88, 2.85	−0.21	0.18
Executive Function (Wave 2)	1202	−0.45	0.92	−4.22, 2.60	−0.20	0.43
Executive Function (Wave 3)	1167	−0.83	0.93	−4.37, 2.00	−0.20	0.17

Note: Center for Epidemiologic Studies – Depression scale was log transformed for analyses. The Short-Form Health Survey – Mental Health scale (SF36) was reverse scored for analyses. 143 individuals (12.0%) scored above the cutoff for depression symptoms (16 or greater) that are potentially clinically relevant.

Table 2

Intercorrelations Among All Measures of the Study

Measure	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. ECog - Participant-Rated	1															
2. ECog - Informant-Rated	**.39**	1														
3. Memory Factor Score (Wave 1)	**−.17**	**−.14**	1													
4. Memory Factor Score (Wave 2)	**−.24**	**−.19**	**.77**	1												
5. Memory Factor Score (Wave 3)	**−.28**	**−.23**	**.74**	**.80**	1											
6. EF Factor Score (Wave 1)	**−.15**	**−.12**	**.45**	**.41**	**.38**	1										
7. EF Factor Score (Wave 2)	**−.23**	**−.17**	**.44**	**.47**	**.42**	**.76**	1									
8. EF Factor Score (Wave 3)	**−.25**	**−.21**	**.46**	**.50**	**.48**	**.73**	**.78**	1								
9. CES - Depression (Wave 3)	**.40**	**.24**	**−.12**	**−.18**	**−.19**	**−.12**	**−.20**	**−.22**	1							
10. Trait STAI (Wave 3)	**.45**	**.25**	**−.11**	**−.15**	**−.14**	**−.11**	**−.19**	**−.20**	**.71**	1						
11. SF36 - Mental Health (Wave 3)	**−.38**	**−.27**	.05	**.09**	**.09**	**.09**	**.16**	**.16**	**−.63**	**−.74**	1					
12. Age (Wave 1)	.06	**.08**	**−.11**	**−.13**	**−.15**	**−.05**	**−.11**	**−.09**	−.04	−.05	.06	1				
13. Age (Wave 2)	**.07**	**.09**	**−.09**	**−.12**	**−.14**	**−.06**	**−.11**	**−.10**	−.02	−.04	.05	**.95**	1			
14. Age (Wave 3)	**.08**	**.08**	**−.08**	**−.10**	**−.14**	**−.06**	**−.09**	**−.10**	−.02	−.03	.05	**.85**	**.93**	1		
15. Years of Education	**−.17**	**−.07**	**.24**	**.24**	**.23**	**.24**	**.25**	**.27**	**−.13**	**−.16**	**.12**	**.07**	**.09**	**.09**	1	
16. Health Problems (Wave 3)	**.17**	**.18**	−.05	**−.11**	**−.09**	−.05	**−.11**	−.11	**.23**	**.22**	**−.22**	.05	.04	.06	−.05	1
17. ApoE E4 positive	−.04	−.01	.03	.01	.01	.03	.03	−.01	−.01	−.02	.02	−.04	**−.05**	−.05	.00	.00

Note: Significant correlations are displayed in bold (i.e., 95% CI's do not include 0). ECog = Everyday Cognition Questionnaire; EF = Executive Function; CES – Depression = Center for Epidemiologic Studies–Depression Scale; STAI = State-Trait Anxiety Inventory.

Table 3

Intercorrelations Among Measures of Subjective Decline, Objective Memory and Executive Function Factors, and the Depression/Anxiety Symptoms Factor

Measure	1	2	3	4	5	6	7	8
1. ECog - Participant-Rated	1							
2. ECog - Informant-Rated	**0.39**	1						
3. Memory Intercept	**−0.21**	**−0.15**	1					
4. Memory Slope	**−0.30**	**−0.29**	0.11	1				
5. Executive Function Intercept	**−0.18**	**−0.11**	**0.56**	**−0.15**	1			
6. Executive Function Slope	**−0.24**	**−0.28**	−0.04	**0.93**	**−0.34**	1		
7. Depression/Anxiety Symptoms	**0.49**	**0.29**	**−0.15**	**−0.15**	**−0.17**	**−0.21**	1	
8. Age at ECog	**0.09**	**0.08**	-	-	-	-	−0.03	1

Note: Significant correlations are displayed in bold (i.e., 95% CI's do not include 0). ECog = Everyday Cognition Questionnaire.

Table 4

Standardized Regression Coefficients for Analyses Involving Objective Cognition, Cognitive Change and Subjective Cognitive Decline (at Age 67)

Measure	Participant-Rated Decline		Informant-Rated Decline	
	β	**95% CI**	***β***	**95% CI**
A. Model with Objective Episodic Memory				
Memory Intercept	−0.12	[−.19, −.04]	−0.08	[−.17, .00]
Memory Slope	−0.23	[−.36, −.10]	−0.24	[−.40, −.09]
Depression/Anxiety Symptoms	0.44	[.36, .53]	0.25	[.16, .33]
Age at ECog	0.08	[.01, .14]	0.06	[−.01, .13]
R^2	0.31		0.15	
B. Model with Objective Executive Function (EF)				
EF Intercept	−0.17	[−.25, −.10]	−0.18	[−.27, −.08]
EF Slope	−0.19	[−.33, −.05]	−0.27	[−.47, −.07]
Depression/Anxiety Symptoms	0.43	[.36, .53]	0.22	[.11, 32]
Age at ECog	0.11	[.05, .17]	0.10	[.04, .16]
R^2	0.29		0.15	

Note: The Intercept and Slope factors refer to the latent growth curve model of episodic memory (A) or executive function (B). Estimates for participant- and informant-rated decline were estimated in the same model, but their associations with memory and executive function were estimated in separate models because memory and executive function abilities were too highly correlated to be included in the same model. All estimates are standardized.

Table 5

Associations Between Objective and Subjective Cognitive Decline After Excluding Individuals With Mild Cognitive Impairment at Wave 3

Measure	Participant-Rated Decline		Informant-Rated Decline	
	β	**95% CI**	***β***	**95% CI**
A. Model with Episodic Memory				
Memory Intercept	−0.11	[−.18, −.04]	−0.08	[−.17, .00]
Memory Slope	−0.18	[−.37, .01]	−0.20	[−.42, .03]
Depression/Anxiety Symptoms	0.46	[.35, .56]	0.28	[.17, .38]
Age at ECog	0.09	[.02, .15]	0.06	[−.01, .14]
R^2	0.30		0.14	
B. Model with Executive Function (EF)				
EF Intercept	−0.13	[−.22, −.04]	−0.20	[−.32, −.08]
EF Slope	−0.06	[−.25, .13]	−0.20	[−.44, .04]
Depression/Anxiety Symptoms	0.47	[.37, .58]	0.26	[.14, 37]
Age at ECog	0.11	[.06, .17]	0.10	[.03, .18]
R^2	0.27		0.14	

Note: Analyses are identical to Table 4 except all individuals with MCI at the ECog assessment were excluded from analyses. The Intercept and Slope factors refer to the latent growth curve model of episodic memory (A) or executive function (B). Estimates for participant- and informant-rated decline were estimated in the same model, but their associations with memory and executive function were estimated in separate models because memory and executive function abilities were too highly correlated to be included in the same model. All estimates are standardized. N=1427