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Original Article

Stress internalization is a top risk for age-associated cognitive decline among older Chinese in the U.S

Michelle H Chen^{a,b,*} , Yiming Ma^{a,c} , Charu Verma^a , Stephanie Bergren^a , William T Hu^{a,b,**} ^a Institute for Health, Health Care Policy and Aging Research, Rutgers University, 112 Paterson St., New Brunswick, NJ 08901, USA^b Department of Neurology, Robert Wood Johnson Medical School, Rutgers University, 125 Paterson St., New Brunswick, NJ 08901, USA^c Children's Hospital of Philadelphia, 3401 Civic Center Blvd., Philadelphia, PA 19104, USA

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ABSTRACT

Background: Behavioral and sociocultural factors are often examined in population-based studies as independent variables, yet latent factors often influence multiple behaviors all at once. This may be especially true in immigrant populations living in or near ethnic enclaves. Better characterization of internal or external factors underlying multiple behaviors is critical to modify the root causes of health-related behaviors.

Objectives: To identify inter-relatedness of multiple internal (acculturation, behavior, well-being) and external (neighborhood & community) characteristics, as well as their influence on age-associated cognitive decline in a large group of non-demented older Chinese Americans living in the Chicago metropolitan area.

Setting: Secondary data analysis of the Population Study of ChInese Elderly (PINE).

Participants: 1528 non-demented older Chinese Americans (aged 60+) who attended three waves of PINE.

Design: Longitudinal cohort study.

Intervention(s): Not applicable.

Measurements: Three psychobehavioral and 3 sociocultural factors were included in factor analysis for independent variables; Chinese versions of the Mini-Mental State Examination, East Boston Memory Test, Digit Span Backward, and oral Symbol Digit Modalities Test were included in principal component analysis to derive dependent variables.

Results: Factor analysis identified three main behavioral/sociocultural constructs: stress internalization, neighborhood/community cohesion, and external stress alleviation. Among these, only stress internalization – consisting of greater perceived stress, greater hopelessness, and lower conscientiousness – was associated with longitudinal decline in memory, while none with decline in executive functioning. Neither acculturation nor activity engagement was related to longitudinal decline in memory or executive functioning, even though participants with greater acculturation or activity engagement had better baseline cognitive performance.

Conclusions: Only the factor underlying stress processing, hopelessness, and conscientiousness was associated with rates of longitudinal memory decline in this older non-demented Chinese American cohort. These maladaptive traits have been linked to the Asian model minority stereotype but all the same potentially modifiable. Limitations include potential selection bias, potential cultural inappropriateness of the measures, and limited cognitive test battery and clinical information.

1. Introduction

The number of older Asian Americans is expected to grow 93 % by 2040 [1]. Among ethnic Asian groups, Chinese Americans represent the largest subgroup and constitute 24 % of all Asian Americans [2]. Older

Chinese Americans are consistently underrepresented in memory and aging studies [3]. According to a recent meta-analysis, there is a systematic underrepresentation of Asian Americans in Alzheimer's disease and related dementias (AD/ADRD) research [4]. AD/ADRD prevalence estimates for Chinese Americans specifically were highly heterogeneous

* Corresponding author at: Rutgers University; 112 Paterson St., New Brunswick, New Jersey 08901, USA.

** Co-Corresponding author at: Rutgers University; 125 Paterson St., New Brunswick, New Jersey 08901, USA.

E-mail addresses: michelle.chen2@rutgers.edu (M.H. Chen), william.hu@rutgers.edu (W.T. Hu).<https://doi.org/10.1016/j.tjpad.2025.100270>

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across studies, ranging between $<1\%$ and 33% , and incidence rates were not broken down from the pan-Asian category [4]. Available studies suggest older Chinese Americans face increased risk of delayed diagnosis and treatment of dementia [5]. This can result from reduced knowledge of dementia as an illness rather than an inevitable aspect of aging [6], cultural stigma associated dementia and other mental illnesses [7], and stronger dyadic or family interdependence which can mask functional decline [8]. The largely immigrant (69%) [9] Chinese American population may also have health-related knowledge which has remained stagnant from their time of immigration, and their access to lay [10] or professional [11] sources of information could be made worse by 67% of older Chinese Americans speaking English very poorly or not at all [9]. Even though some health prevention approaches may provide cognitive benefits across racial/ethnic groups, there is a paucity of direct evidence linking factors targeted by these approaches to rates of longitudinal cognitive decline among Chinese Americans.

The Chicago-based Population Study of Chinese Elderly (PINE) is the largest community-based cohort study on older Chinese Americans. Unlike earlier studies on cognition among Asian Americans such as the Honolulu-Asia Aging Study (HAAS) [12] and the Multi-Ethnic Study of Atherosclerosis (MESA) [13], PINE participants represented a numerically smaller minority ethnic group (Chinese Americans representing 1–1.5% of the Chicago Metropolitan Area in PINE vs. Japanese Americans representing 25–45% of the Hawaii population in HAAS [14]), were more likely to live in an ethnic enclave (60% of PINE participants live in Chinatown), and had lower socioeconomic status (SES; 23% of PINE participants vs. 64% of Chinese MESA participants had at least some college education). These distinctions make PINE a unique resource to examine the impact of sociobehavioral factors on cognition.

Prior PINE studies – often examining a select number of risk or resilience factor and a single mean cognitive score – correlated multiple measures of healthier living (e.g., social engagement, cognitive leisure activities) with better cognition [15–17]. However, there are several limitations for this approach. Repeatedly examining only subsets of factors increases cohort-level Type I errors. Multiple sociobehavioral variables in immigrant populations can also be jointly influenced by internal (e.g., acculturation) or external (e.g., access to transportation) factors, and thus are not truly independent. For outcomes, prior PINE studies operationalized cognitive decline as a one-way crossing beyond a threshold (Z-score of -1.5) of a participant's average performance in five short tests relative to the entire cohort [18]. The potential inclusion of people with mild baseline impairment during derivation of this threshold risks underestimating the proportion of people experiencing meaningful cognitive decline, and the threshold approach overlooks common fluctuations in cognitive performance in population studies.

To best prioritize actionable risk and resilience factors in age-associated cognitive decline among older Chinese Americans, the current paper will address limitations of prior PINE studies by identifying participants with normal cognition at baseline, assessing longitudinal cognitive trajectories, and accounting for interdependence among sociobehavioral risk factors. The overall objective is to identify *longitudinal* sociobehavioral risk and resilience factors associated with cognitive decline in non-demented older U.S. dwelling Chinese adults. We hypothesize that after taking into account of interdependence among predictors, most sociobehavioral predictors previously linked to cognitive decline in existing PINE studies will not be significantly linked to cognitive changes longitudinally. The few risk factors that are identified as significant longitudinal predictors in this study will critically inform future interventions.

2. Methods

2.1. Ethics in human research

This study was approved by the Institutional Review Boards of Rush University Medical Center and Rutgers University. The study was

performed in accordance with ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments, and signed informed consents were obtained from all participants.

2.2. Participants

Study sample was drawn from waves 1–3 of PINE. Study design and participant characteristics were previously detailed [19,20]. Briefly, PINE is a community-based epidemiological study of older adults of Chinese descent (aged 60 and older) living in the greater Chicago, Illinois area (midwestern U.S.). In-person interviews were conducted in 2011–2013, 2013–2015, and 2015–2017 for the three waves. 1528 subjects who were non-demented at baseline and attended all three waves were included in this study (see Fig. 1 for participant selection). Mean actual time between waves is 25.5 months.

2.3. Measures

All study measures have been forward and backward translated to and from Chinese by a bilingual and bicultural research team, and iteratively refined with the input of a bilingual and bicultural community advisory board.

2.3.1. Cognitive functioning

Five cognitive measures were collected in PINE. Global cognitive functioning was assessed using the Chinese version of the Mini-Mental State Examination (C-MMSE) [21]. Episodic memory was further evaluated with the East Boston Memory Test [22], which included immediate (EBMT-immediate) and delayed (EBMT-delayed) recall. Working memory was measured by the Wechsler Memory Scale-Revised (WMS-R) [23] Digit Span Backward subtest total score. Processing speed was assessed using the oral version of the Symbol Digit Modalities Test (SDMT) [24]. Tests were administered in the Chinese dialect of the participant's choice (e.g., Mandarin, Cantonese).

MMSE is one of the most commonly used cognitive screening measures. The Chinese version has been shown to be sensitive to detect

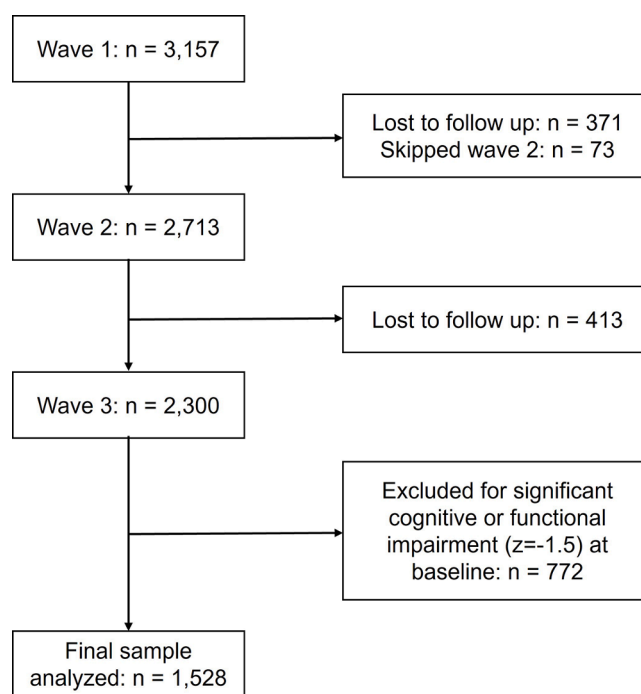


Fig. 1. CONSORT diagram. Reasons for dropouts or skipping a wave include death ($n = 361$), no contact ($n = 289$), reluctance to continue participation ($n = 89$); reasons were unknown for $n = 118$.

cognitive impairment among older Chinese adults [25], and demographically-adjusted normative data have been established [26]. C-MMSE has been utilized by other large-scale community-based cohort studies in older Chinese adults such as the China Health and Retirement Longitudinal Study (CHARLS) [27] and the Chinese Longitudinal Healthy Longevity Survey (CLHLS) [28]. Digit Span Backward and SDMT are also well-established and commonly used neuropsychological measures that have been validated in the older Chinese population [29, 30]. Convergent validity has been established between Digit Span and SDMT such that these measures were found to load onto the same attention/executive functioning component [29], similar to results of the current study (see below). While the EBMT has not been validated in the Chinese population before PINE, the English version has shown convergent validity with other memory measures (e.g., word lists) [31] and demonstrated adequate sensitivity in detecting cognitive impairment in older adults [32]. In PINE, performance on the cognitive measures were negatively associated with age and positively linked to education [18], consistent with findings in other Chinese and non-Chinese samples.

2.3.2. Predictors of cognitive functioning

Demographic variables included age at wave 1, sex, years of formal education, marital status, and annual income.

Acculturation was measured by the 12-item PINE Study Acculturation Scale [33] adapted from a short acculturation scale developed for Hispanics that surveyed language use (proficiency and preference in speaking English and Chinese), media (preference of English and Chinese media), and ethnic social relations (socialization with Chinese and non-Chinese individuals) [34].

Health conditions were evaluated by asking participants to self-report whether they were diagnosed by a medical professional for certain conditions, including heart disease, stroke, cancer, high cholesterol, diabetes, high blood pressure, hip fracture, thyroid disease, and osteoporosis. We additionally created a semi-quantitative sum of the total number of cardiovascular risk factors (heart disease, stroke, high blood pressure, and diabetes). Additional symptoms not necessarily associated with a certain condition were monitored using a review of systems (ROS), which included 15 organ systems in which participants selected all symptoms for each system that they were currently being treated or had been treated in the past. Systems assessed included general, skin, head, ears, eyes, nose, throat, breasts, respiratory, cardiovascular, gastrointestinal, urinary, vascular, musculoskeletal, and neurologic. Participants were also asked whether and how much they smoked cigarettes. Smoking history in terms of pack years (number of packs of cigarettes smoked per year multiplied by number of years smoked) at wave 1 were calculated from their responses.

Depression was assessed by Patient Health Questionnaire (PHQ-9 [35]), and anxiety was assessed by the Anxiety Subscale of the Hospital Anxiety and Depression Scale (HADS [36]). The NEO Five-Factor Inventory [37] was used to assess traits of conscientiousness (12 items) and neuroticism (6 items). Only the conscientiousness score was included in this study because it retained all items from the original inventory, and the shorter version of the neuroticism scale showed lower levels of internal reliability than the conscientiousness scale in the PINE sample [38]. The extent of stress (unpredictability, uncontrollability, and overloading) experienced was assessed using the 10-item Perceived Stress Scale (PSS-10) [39]. The 7-item short form for the Beck Hopelessness Scale [40] was used to measure pessimistic cognitions. The short form was developed and validated among patients with terminal cancer [41]. Neighborhood cohesion (interactions among neighbors) was assessed using questions from the Chicago Health and Aging Project [42]. Perception of belonging, influence, commitment, and connection to one's community were measured by the 12-item Sense of Community Index [43]. Levels of perceived social support from family and friends were evaluated by questions from the National Social Life, Health & Aging Project (NSHAP) [44]. Activity engagement was assessed with 16

questions regarding frequency of engagement in various activities (e.g., reading, playing mahjong, visiting relatives, friends, or neighbors) [45]. Content and a summary of participants' responses to the psychosocial questionnaires are detailed in Supplementary Material 1.

2.4. Statistical analyses

Data analyses were conducted using IBM SPSS version 28 and R version 4.3.1. Data analysis was conducted within the Rutgers Asian Resource Center for Minority Aging Research (RCMAR) measurement and analysis core.

2.4.1. Cognitive outcomes

To address the potential inclusion of participants with baseline cognitive impairment in the derivation of Z-scores, we established a normative subgroup within PINE. We first identified participants with C-MMSE > 28 at wave 3 which excluded incident dementia while allowing for practice effects during early waves. To additionally account for the possibility that some cognitively impaired individuals had high C-MMSE, we reduced heterogeneity in this normative cohort by removing individuals who had Lawton-Brody Instrumental Activities of Daily Living (IADL) < 7 (equivalent to Z-score of -1.5 as there was no difference between men and women in this cohort) during any wave. The resultant subgroup's performance at wave 1 ($n = 724$) formed the normative curve for each cognitive measure. Raw performance also underwent linear regression analysis to adjust for age, sex, and education before Z-transformation to produce adjusted Z-scores. All participants' Z-scores across the five measures at wave 1 were then analyzed using principal component analysis (PCA; Varimax rotation), arriving at two principal components (PC) which were used as cognitive outcomes. PCs for subsequent waves were generated based on formulas from wave 1. This agnostic approach (instead of pre-specifying which measure should go into which domain) allowed for the additional possibility that an English subtest associated with memory can load onto executive function or both domains when conducted in Chinese. Because C-MMSE is a global cognitive screening measure and does not measure a specific cognitive domain, it was not included in the PCA derivation beyond the identification of a non-demented group.

2.4.2. Predictors

All variables with skewed distributions were transformed for subsequent analyses. Demographic predictors included age, sex (male or female), years of formal education, marital status (married or not married), and income (low, medium, or high). The majority of the sample reported lower income ranges, so reported income was divided into tertiles (<\$5000, \$5000-\$10,000, and >\$10,000). Given the sample largely reported low acculturation, a median split was performed to dichotomize the variable into low acculturation (≤ 13 ; preferring mostly Chinese language, media, and friends; 36 %) and some acculturation (> 13 ; 64 %). There was a survivorship bias such that those who immigrated earlier were older than those who immigrated more recently at study entry. Moreover, due to recruitment strategies focused on more recent immigrants, there was a significant association between age at baseline and age at immigration. Therefore, age at immigration was not included as an independent predictor. Health predictors included presence or absence of various health conditions or symptoms (for depression, it is low, medium, or high levels). Neighborhood cohesion was normalized by log-transformation and further transformed into Z-scores for comparison. Other psychosocial variables including sense of community, conscientiousness, perceived stress, feelings of hopelessness, perceived social support, and activity engagement, were also Z-transformed. Due to the large number of psychosocial predictors, we conducted an exploratory factor analysis (EFA) to identify latent constructs. Because we expected correlations between variables, principal axis factoring using oblique (Equamax) rotation was used. These factor scores were included as psychosocial predictors in subsequent models.

Activity engagement did not load onto a factor, so it was included as a standalone predictor. Activity engagement, feelings of hopelessness, social support, perceived stress, and depression were used as time-varying variables. All other predictors were treated as time-invariant and wave 1 values were used. Spearman correlation was conducted to evaluate collinearity among predictors.

2.4.3. Associations between predictors and cognitive outcomes

Linear mixed-effects models (LMM) were performed to identify factors influencing baseline or longitudinal (interaction term with time) cognition. Because we were mostly concerned with intra-individual changes over time, use of PC scores in LMM also reduces influence from one or more cognitive tests having greater fluctuation. All demographic, immigration-related, health, and psychosocial predictors were entered into the models as fixed effect factors or covariates. Time in months since the baseline visit was entered both as fixed and random effects, and subject's random intercept was included to account for within-person clustering. A first-order autoregressive covariance structure, commonly used in longitudinal analyses, was used to model the random effects. Models were built stepwise, such that *all* predictors (as well as their interaction with time) were included in the initial model, but any predictors or interaction terms that had $p > 0.15$ were iteratively removed. The Akaike information criterion ($\Delta AIC > 2$) was used to decide if a model iteration was better than the previous with a preference for simpler model for $\Delta AIC \leq 2$. Only variables that remained in the final models, *after step-wise removal*, are reported in the Results section. Due the large number of dropouts (including both individuals who were lost to follow up and individuals who were not included in this manuscript due to incomplete waves), we conducted an attrition sensitivity analysis to evaluate the effects of dropout on predictors and outcomes of interest.

3. Results

PINE participants had relatively low SES, with average education of 9 years and 83.73 % making less than \$10,000 per year (Table 1). Most immigrated to the U.S. during middle age after 1980, and on average have been U.S. residents for almost two decades. C-MMSE scores were moderately correlated with performance on the EBMT, digit span backward, and SDMT ($r = 0.44 - 0.53$; $p < 0.001$). Up to 20 % of participants' cognitive scores fluctuated by one standard deviation (S.D.) or more between time points (Supplementary Material 3), reinforcing the need for more rigorous analysis of cognition beyond threshold-based conversion.

Table 1
Demographic characteristics of the sample.

Variable	Value
N: number	1528
Age at wave 1: mean years (sd)	71.05 (7.44)
Education: mean years (sd)	9.10 (4.92)
Female sex: number (proportion)	881 (57.66)
Married: number (proportion)	1155 (75.64)
Income: number (proportion)	
Low: <\$5000/year	529 (34.71)
Medium: \$5000–10,000/year	747 (49.02)
High: >\$10,000/year	248 (16.27)
Immigration period: number (proportion)	
1970 or before	86 (5.63)
1971 – 1980	131 (8.57)
1981 – 1990	379 (24.80)
1991 – 2000	479 (31.35)
2001 or later	453 (29.65)
Age at immigration: mean (sd)	52.19 (11.84)
Number of years in the U.S.: mean (sd)	18.94 (12.33)

Note. sd: standard deviation.

3.1. PCA of cognitive outcomes

PCA of the five adjusted cognitive Z-scores showed Kaiser-Meyer-Olkin (KMO) sampling adequacy of 0.396 and Barlett's test of sphericity at $p < 0.001$. These modest correlations among the cognitive measures thus supported our selection of PCA over factor analysis for cognitive outcomes. Two PCs were extracted (eigenvalues > 1.0 , Fig. 2 Panel C): EBMT-immediate recall, EBMT-delayed recall, and EBMT-percent retention loaded onto the memory PC; digit span backward and SDMT loaded onto the executive functioning PC.

3.2. EFA of psychosocial constructs

As predicted in this cohort consisting mostly of Chinese immigrants living in and around an ethnic enclave, bi-variate analysis showed multiple correlations among sociobehavioral variables (Fig. 2 Panel A). This supported the non-independent nature of participants' sociobehavioral variables. EFA identified three factors (scree plot, two with eigenvalues > 1.0 ; KMO of 0.624, Barlett's test of sphericity $p < 0.001$; Fig. 2 Panel B). One factor (stress internalization) loaded onto measures of hopelessness, perceived stress, and low conscientiousness; a second factor (neighborhood/community cohesion) loaded onto neighborhood cohesion and sense of community. The third factor (external stress alleviation) loaded onto higher perceived social support and lower levels of perceived stress. No factor loaded onto activity engagement and acculturation, and they were subsequently analyzed as independent variables.

3.3. Identifying significant predictors of cognitive outcomes

Only predictors included in the final model after iterative removal (see Statistical Analyses section for more details) are presented here. Greater baseline memory PC scores were associated with older age, fewer years of formal education, higher annual income, higher level of acculturation, and absence of strokes. Some of these differences dissipated over time (i.e., regression towards the mean), including effects from education and acculturation (Table 2, Fig. 3, and Supplementary Material 2). In contrast, higher stress internalization and stroke were each associated with greater rates of memory decline over time. For 1 S. D. of increase in stress internalization, we observed a 0.024 S.D. greater annualized decline in memory function ($p = 0.015$). This compares with a history of stroke associating with a 0.084 S.D. greater annualized decline in memory ($p = 0.036$), although the overall frequency of stroke diagnosis ($n = 50$) was low so interpretation may be limited.

We next examined factors associated with change in executive functioning over time. Multiple factors affecting baseline memory PC score also influenced executive functioning PC score, including age, formal education, annual income, and acculturation. Depressive symptoms, stroke, heart disease, low activity engagement, and greater neighborhood/community cohesion factor were additionally associated with worse baseline executive function (Supplementary Material 2). None of the clinical or sociobehavioral factors examined influenced longitudinal executive functioning, and only greater formal education was associated with greater decline in executive function (Supplementary Material 2). However, there was no difference in slope of unadjusted executive function scores over time among PINE participants (Supplementary Material 4), so we suspect the effect of education on adjusted executive functioning to result from education-adjustment during Z-transformation. As this relationship was not observed for memory, we made the conservative conclusion that greater education in older Chinese Americans was not protective against longitudinal decline in executive functioning.

Regarding the effects of attrition, older age, higher acculturation, higher stress internalization, lower neighborhood/community cohesion, lower external stress alleviation, and lower cognitive scores were associated with dropout (see Supplementary Material 5).

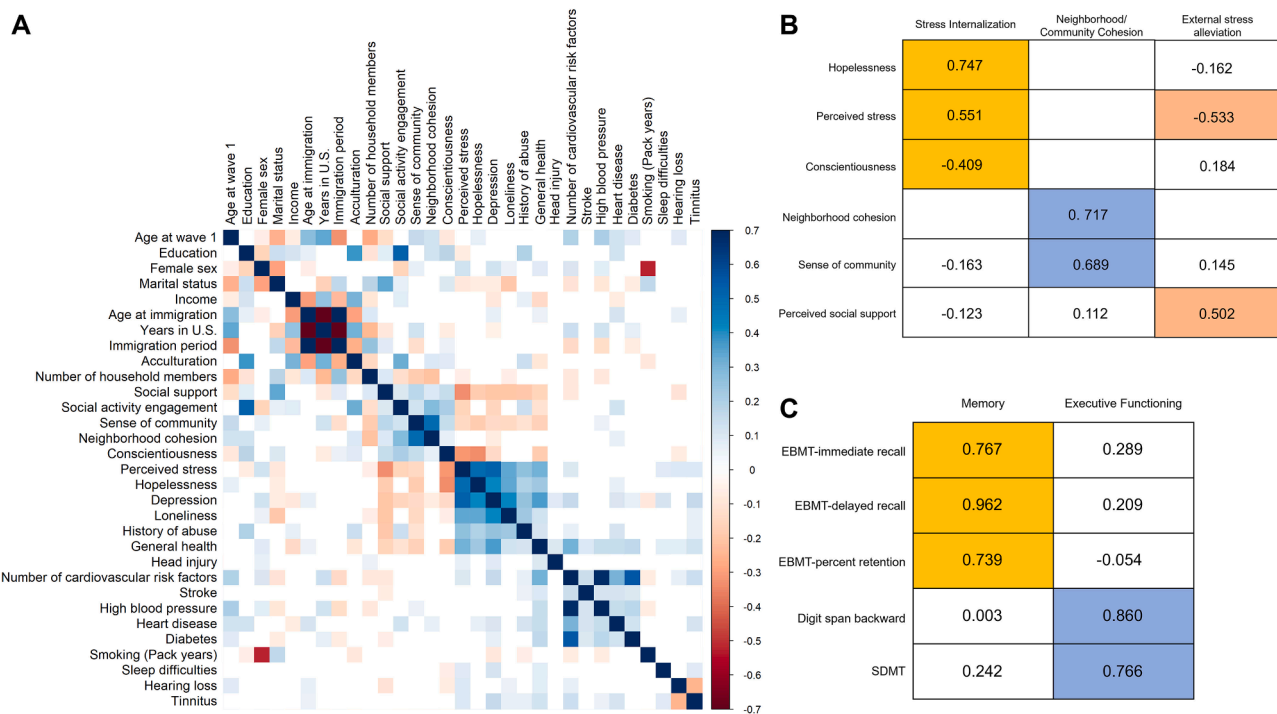


Fig. 2. Correlations among predictors, and loadings for factor and principal component analyses. Note. Panel A illustrates the correlations among predictors. P values are adjusted using the Benjamini-Hochberg correction, with the false discovery rate set at 0.05. Only significant correlations are shown in colors, insignificant correlations are depicted as blank cells. Panel B illustrates the strength of the factor loadings for the psychosocial variables from the rotated factor matrix. Panel C illustrates the strength of the component loadings for the cognitive variables from the rotated component matrix. EBMT: East Boston Memory Test; SDMT: Symbol Digit Modalities Test.

4. Discussion

Among sociobehavioral factors examined in PINE, we identified three intrinsic constructs linking multiple survey outcomes: stress internalization, neighborhood/community cohesion, and external stress alleviation. Even when compared alongside demographic and clinical risk factors, stress internalization showed strong association with memory decline over three consecutive waves in PINE. In contrast, none influenced change in executive functioning over time.

Most studies focused on cognitive aging in Asian Americans using HAAS and MESA have focused on biological predictors of cognitive decline. Participants in these studies either represent one of the most populous minority ethnic groups in the region (HAAS) or had high SES (MESA), and generalizability of these studies to U.S. mainland Asian Americans or Asians with lower SES is unknown. To our knowledge, only one previous PINE study examined cognitive trajectories in more than two waves [15], as at least three time points is required to identify longitudinal trajectory. It identified a strong relationship between baseline function and rates of decline (e.g., those with the worst baseline function had the fastest cognitive decline). As we discussed, the group with the worst baseline function and fastest temporal decline likely included participants with undiagnosed cognitive impairment. Socio-behavioral factors associated with their cognitive change may have more to do with behaviors during early stages of dementia than risk-associated behaviors predisposing to dementia onset. Conversely, some factors (e.g., education, acculturation) may improve performance on baseline neuropsychological testing [46] without altering longitudinal rates of change (which has been observed in parallel in U.S. Latino immigrants [47]). It may thus come as no surprise that factors previously associated with cognition in cross-sectional studies of PINE largely failed to influence longitudinal cognition in our analysis. This could result from fallacy of reverse causality, regression towards the mean, or both. Our study thus underscores the importance of leveraging longitudinal cognitive and functional assessment to retrospectively identify a

baseline group with normal cognition.

The identification of multiple latent sociobehavioral constructs has conceptual and practical implications. It is not known if there exists more prominent clustering of sociobehavioral factors in older immigrants or minority adults than in older White adults. The former two groups' neighborhood-level factors were better known to result from race relations in the U.S. (e.g., redlining) than choice [48]. However, sociobehavioral clustering within individuals has been shown beyond segregated minority populations to manifest in geographically dispersed research participants according to income and cultural factors [49]. The novel construct we observed to consist of hopelessness, perceived stress, and low conscientiousness in PINE deserves follow-up investigation for its association with longitudinal memory decline. While we conceptualized this factor as stress internalization, these traits could also represent a culturally specific phenotype for depression or another mood disorder. In keeping with this, older Asian immigrants in North America – especially among those with lower levels of acculturation and English proficiency – face increased depression risks [50]. Higher perceived stress itself is linked to lower baseline cognitive scores, faster cognitive decline, increased risk of dementia, and reduced brain volume [51,52]. Hopelessness and low conscientiousness have also been respectively linked to cognitive impairment in the Finland-based Cardiovascular Risk Factors, Aging, and Dementia Study [53] and the U.S.-based Religious Order Study [54]. Whether these traits herald more severe depression [53] or pre-symptomatic neurodegeneration [54] remains to be determined, yet their replication across three very distinct cohorts deserves further mechanistic exploration. Because these traits correspond more to stress perception and processing than mere presence of stressors, their potentially modifiable nature can be a unique focus of future socio-behavioral intervention.

One potentially unique aspect of stress internalization among older Chinese adults involves the model minority stereotype. Asian Americans are often monolithically seen as being spared by health disparities [55], and this erroneous assumption is underscored by significantly lower

Table 2
Estimates of fixed effects for the memory component.

	Estimate	T	p	CI
Months since baseline	-0.003	-0.683	0.495	-0.011 to 0.005
Age	0.012	5.081	<0.001**	0.008 to 0.017
Male vs. female	-0.045	-1.280	0.201	-0.114 to 0.024
Years of formal education	-0.027	-5.967	<0.001**	-0.036 to -0.018
Education × time since baseline	0.0004	2.808	0.005**	0.0001 to 0.001
Unmarried vs. married	0.002	0.049	0.961	-0.098 to 0.103
Marital status × time since baseline	-0.003	-1.780	0.075	-0.005 to 0.0003
Annual income: low vs. high	-0.118	-2.400	0.017**	-0.215 to -0.022
Annual income: medium vs. high	-0.094	-1.941	0.052*	-0.189 to 0.001
Low acculturation vs. some acculturation	-0.257	-5.723	<0.001**	-0.345 to -0.169
Acculturation × time since baseline	0.003	2.198	0.028*	0.0003 to 0.006
Absence vs. presence of stroke	0.190	1.662	0.097	-0.034 to 0.414
Stroke × time since baseline	-0.007	-2.104	0.036*	-0.014 to -0.0005
Absence of tinnitus vs. presence of tinnitus	0.085	1.373	0.170	-0.036 to 0.206
Tinnitus × time since baseline	0.002	1.325	0.185	-0.001 to 0.006
Stress internalization factor	0.017	0.655	0.512	-0.034 to 0.068
Stress internalization × time since baseline	-0.002	-2.447	0.015**	-0.003 to -0.0004

Note. CI: confidence interval.

* Significant at $p \leq 0.05$.

** Significant at $p \leq 0.01$.

education in Chinese Americans' education in PINE than MESA. Older Chinese Americans may thus feel the need to silently endure various psychosocial stressors such as lower English proficiency and acculturation, reduced participation in mainstream American society and healthcare, and discrimination. In the context of low SES, high-effort coping have been associated with worse health outcomes – a phenomenon known as John Henryism, originally posited to explain the high prevalence of hypertension among low resourced Southern Black men [56]. While John Henryism has been primarily studied in Black Americans [57], the notion of high effort coping beyond available resources may similarly explain a maladaptive response to the model minority stereotype among PINE participants, especially if they regularly deal with greater stress than HAAS participants and with fewer resources than Chinese MESA participants. If this relationship is validated, efforts to alleviate the model minority stress may be more fruitful in preventing longitudinal cognitive decline in older Chinese Americans than nebulous public health efforts focused on the built environment or community dynamics. Culturally-adapted programs aimed to reduce mental health stigma and normalize discussions about mental health, training healthcare providers on recognizing internalized distress among older Asian patients and making appropriate mental health referrals, and community education campaigns to challenge harmful stereotypes (e.g., model minority) and promote culturally inclusive narratives around aging and mental health are all potential interventions informed by these findings.

Limited benefits of potentially protective sociobehavioral factors in diverse populations also deserve a closer examination. For example, studies on the beneficial role of social engagement on cognition have been more convincing in older White [58] than older Black [59,60] and Japanese [61] Americans. A methodological concern is the cultural

generalizability of scales used to assess these sociobehavioral traits. Similar to the possibility that stress internalization may alternatively reflect depression in PINE participants, a stronger belief in the value of community may underestimate their protective effects in minority participants when using a scale developed for mid-20th Century American lifestyles. For example, Chinese Americans' affirmative responses to social engagement questionnaires may be limited by feasibility and affordability of overnight trips, eating out, or attending a concert for immigrants who do not drive. In keeping with this, we did not find a difference in men and women's IADL scores in PINE when the scale's original interpretation scheme accounted for outdated gender roles. However, until more culturally-relevant scales for social engagement or support can validate their protective effects against cognitive decline in Chinese Americans, these factors should be reserved more for promotion of general well-being than evidence-based prevention of cognitive aging.

Results from this study should be interpreted with the following limitations. While this was the largest community-based study of older Chinese Americans, participants were all recruited from the Chicago metropolitan area and nearly 1000 individuals were lost to follow-up between waves 1 and 3 or not included in the current manuscript due to incomplete waves. We decided to include only individuals with 3 complete waves in order to prioritize accurate modeling of intra-individual cognitive change over time, especially in a population with limited normative data on cognitive aging. However, this approach may introduce selection bias. Based on our attrition analysis, dropout was associated with older age, lower cognitive scores, higher stress internalization, and lower levels of neighborhood/community cohesion and external stress alleviation. While our analytic sample thus represents a relatively healthier subgroup, the consistency of our positive finding on stress internalization and memory with other large non-Asian cohorts was reassuring. Future research should explore more inclusive modeling approaches to incorporate partial data and more fully capture the impact of attrition. We did not include the area deprivation index, since we already included income levels and the majority of participants live in or near Chinatown, in order to avoid collinearity. However, future research may investigate additional sociocultural constructs such as environmental influences. Typical for community-based studies, our small cognitive battery may lack sufficient sensitivity for subtle cognitive decline. The brain-behavior relationships for memory and executive function components also have not been directly validated in a Chinese-speaking population, although we were successful in deriving two distinct cognitive PCs in keeping with their English originals. While many study instruments were commonly used in China-based cohorts and others and were forward/backward translated with the input of a community advisory board, their cultural appropriateness may lag behind linguistic accuracy. Future research should further explore their cultural appropriateness. Many sociobehavioral variables were based on self-reports which can be subject to response or recall bias. Similarly, a diagnosis-based derivation of medical co-morbidities risks reverse causality related to health care access. Nevertheless, we present a novel yet robust finding in line with other large population-based non-Asian cohorts which should broaden its generalizability and should further prioritize it in future prevention studies.

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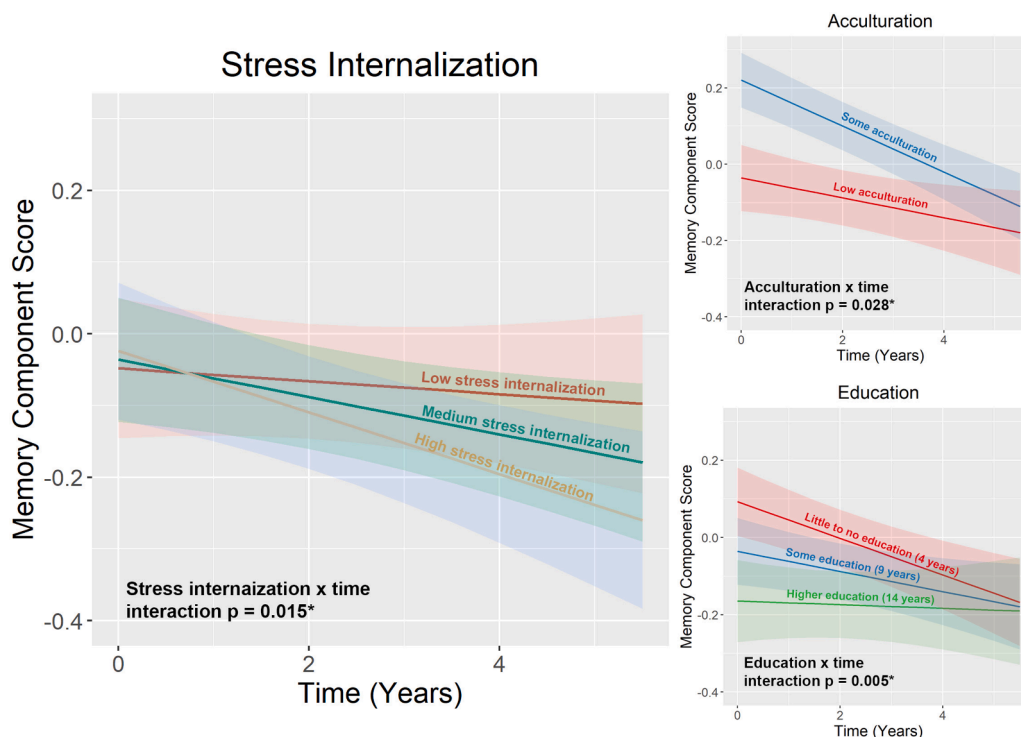


Fig. 3. Significant longitudinal predictors of memory component scores.

Note. Moderating effects of longitudinal predictors on decline on memory component score over time. Shaded regions represent 95 % confidence intervals for the predicted values.

*Continuous moderators (stress internationalization and education) are stratified at the mean as well as one standard deviation above and below the mean for demonstration purposes, but they were analyzed as continuous variables in the models.

of the manuscript.

AI disclosures

No artificial intelligence software has been used in preparation of this manuscript.

CRediT authorship contribution statement

Michelle H Chen: Writing – original draft, Funding acquisition, Formal analysis, Conceptualization. **Yiming Ma:** Writing – review & editing, Formal analysis. **Charu Verma:** Writing – review & editing, Formal analysis. **Stephanie Bergren:** Writing – review & editing, Project administration. **William T Hu:** Writing – review & editing, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

Dr. Chen reports grants from NIH/NIA during the conduct of the study. Dr. Hu reports grants from NIH/NIA during the conduct of the study; personal fees from Apellis Pharmaceuticals, personal fees from Beckman-Coulter Diagnostics, personal fees from Biogen, grants and personal fees from Fujirebio Diagnostics, outside the submitted work. Ms. Ma has nothing to disclose. Ms. Verma has nothing to disclose. Ms. Bergren has nothing to disclose.

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Supplementary materials

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