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The need to belong: A parallel process latent growth curve model of late life negative affect and cognitive function

Yuhan Ni[a], Jenn-Yun Tein[b], Minqiang Zhang[a,c,d,*], Fengquan Zhen[a], Feifei Huang[a], Yingshi Huang[a], Yiming Yao[a], Jiaqi Mei[a]

[a] School of Psychology, South China Normal University, Guangzhou, China
[b] Prevention Research Center, Department of Psychology, Arizona State University, Tempe, USA
[c] Center for Studies of Psychological Application, South China Normal University, Guangzhou, China
[d] Guangdong Key Laboratory of Mental Health and Cognitive Science, South China Normal University, Guangzhou, China

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ABSTRACT

Objective: Late life negative affect (NA) often co-occurs with poor cognitive function (CF); however, very little is known about the mechanism of the relationship between them. We examined the longitudinal relationship between NA and CF over a 12-year period and the effects of several related risk factors in a general sample.
Methods: Five waves of data on Chinese Longitudinal Healthy Longevity Survey (CLHLS) were collected from a total of 1,314 elderly Chinese, aged 60 and over. A parallel process latent growth curve model with two time-invariant covariates and seven time-varying covariates was used to demonstrate the joint trajectories of NA and CF to assess their related factors in the elderly during a 12-year period.
Results: Significant association of negative affect and cognitive decline was found at baseline and over time for our sample. Poorer initial cognitive performance predicted a faster increase in negative affect over time. Being female was associated with worse initial performance and a faster rate of deterioration of NA and CF. Regular exercise, married status, social activities, and Mahjong playing were associated with slower rates of negative affect increase and cognitive decline.
Conclusion: These findings demonstrated that the late life negative affect co-occurs with cognitive decline and negative affect might be a mutative mental reaction to cognitive dysfunction. Gender difference, exercise benefit, and the "need to belong" effect were observed over time, highlighting the importance of exercise and socialization for older females.

1. Introduction

Successful aging is a public health and research priority as the number of elderly people is increasing worldwide. China is one of the most rapidly aging societies in the world. According to Yearbook (2017), the number of elderly people over the age of 65 in China had reached 149 million in 2016; the Knoema World Data Atlas (2019) reported that population aged 65 years and above for China was 1.6 % in 2017. These data indicate China is becoming an ultra-aged society and the aging population in China currently and in the near future will definitely pose great challenges to the whole society. Consequently, the mental and psychological problems of the elderly are becoming increasingly prevalent.

Negative affect (NA) is a prevalent condition amongst older people, with a significant impact on the quality of late life (Wilson & Cleary, 1995). NA is a broad concept that can be summarized as feelings of emotional distress (Watson, Clark, & Tellegen, 1988); a construct defined by the common variance among anxiety, depression, sadness, fear, and other unpleasant emotions. Not only does it contribute to be an indicator of mental health and affective well-being, but it is also considered to be a major predictor of functional health and longevity. Elderly with high NA are more likely to report somatic complaints (Leventhal, Hansell, Diefenbach, Leventhal, & Glass, 1996), psychological stress, and physical problems (Watson & Pennebaker, 1989) than those with low NA. In addition, cognitions are strongly implicated in the etiology of emotional disorders (Alloy & Riskind, 2006).

A large and still growing literature has addressed the robust relations between NA and cognitive function (CF). Cognitive functioning is a well-known indicator of maintaining independence and survival in older adults (Ryan & Smith, 2009), referring to multiple mental

* Corresponding author at: School of Psychology, South China Normal University, Tianhe District, Guangzhou, China.
E-mail address: 2640726401@qq.com (M. Zhang).

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abilities, including thinking, reasoning, remembering, attention and so on. The most consistent findings suggest that NA is associated with cognitive decline for elderly (Beaudreau & O'Hara, 2008; Hammar & Årdal, 2009; Stein, Leventhal, & Trabasso, 2013). For example, Beaudreau and O'Hara (2008) critically reviewed evidence of more prevalent anxiety in cognitively impaired older adults, elevated anxiety related to poorer cognitive performance, and more severe anxiety symptoms predicting future cognitive decline.

A large number of studies suggest a longitudinal association between cognitive decline and negative affect, such as depression (Snowden et al., 2015), anxiety (Bierman, Comijs, Rijmen, Jonker, & Beekman, 2008; Breitve et al., 2016), and loneliness (Zhong, Chen, Tu, & Conwell, 2017). However, there has been considerably less investigation into the directionality or the mechanism linking NA and CF. It is yet unknown whether negative affect is a risk factor for cognitive deterioration or a mental reaction to age-related cognitive decline.

Recent studies have argued that the relationships between maladaptive cognitions and negative emotion are recursive and bidirectional such that negative affective states can reciprocally lead to increases in maladaptive cognitions and new negative life events in return (Hankin & Abramson, 2001; Masten & Cicchetti, 2010). It is plausible that the relationship between NA and CF is bidirectional, which is only verified in few recent studies. For example, Brailean et al. (2017) found that older adults may experience an increase in depressed affect in reaction to poor memory function. A 26-year period study showed that there are bidirectional associations between anxiety and cognitive performance among measures of processing speed, attention, and memory but not visuospatial abilities among older adults (Petkus, Reynolds, Wetherell, Kremen, & Gatz, 2017). To date, of these studies that focused on the reciprocal effects of emotional states on cognition, most has been limited to depression and anxiety. More longitudinal studies are necessary to support the causal relations between NA and CF.

When examining possible recursive relationships between NA and CF, a key issue concerns whether NA and CF are associated with different protective or risk factors. Identifying the protective and risk factors of NA and CF among older adults could be important for guiding the prevention and intervention strategies. Previous research has demonstrated that psychological and sociological factors, such as functional limitations, lifestyle, age-related health changes and so on, play significant roles on late life NA and CF (Mehta, Yaffe, & Covinsky, 2002; Plassman, Williams, Burke, Holsinger, & Benjamin, 2010). A more profound understanding of these and other factors is important for designing effective preventive interventions for ameliorating CF for elderly.

The purpose of this study is to address the following two questions: (1) Is the relation of late life negative affect and cognitive function bidirectional in elderly Chinese? and (2) What are the risk or protective factors affecting the bivariate trajectories of late life NA and CF? As illustrated in Fig. 1, using data obtained from a large sample over 12 years, we used a parallel process latent growth curve model (PP-LGCM) to examine the bidirectional relation of late life NA and CF over time as well as explore the association between the following factors and bivariate growth trajectories: *demographic factors, behavioral factors, social factors,* and *medical factors*. Some of demographic factors were treated as time-invariant covariates (TICs) because they had fixed values that did not change over time. On the other hand, some of the psychosocial factors (e.g., smoking and drinking) might co-vary with the healthy outcome over time (Sulander, Helakorpi, Rahkonen, Nissinen, & Uutela, 2004). To better modeled inter- and intra-individual variability, the time-varying covariates (TVCs) that generally accounted for the variance within individuals should be integrated to reflect their influence on the repeated outcome variable (Muthén, 2004).

2. Methods

2.1. Sample

Participants were drawn from the The Chinese Longitudinal Healthy Longevity Survey (CLHLS), a large multi-wave nationally representative longitudinal study concerning Chinese older adults in the general population (Yi, 2008) and the factors related to healthy human longevity. The CLHLS dataset are publicly available at the National Archive of Computerized Data on Aging (ICPSR 36179) (http://opendata.pku.edu.cn/dataverse/CHADS) after sending a data user agreement to the CLHLS team. CLHLS gathered information on quality of life (e.g., socioeconomic characteristics, health, lifestyle, family, and demographic profile) of elderly in 22 provinces in China in the period 1998–2014. The data used for this study were collected in five waves - 2002, 2005, 2008, 2011 and 2014. The original sample of 16,064 individuals was interviewed in 2002, and 1,679 elders retained for this cohort after losing elders due to death or lost to follow-up (Yi, 2008). Individuals were excluded if they had died, lost to follow-up, or failed to respond to the items comprising the outcome variable. Fig. 2 illustrated the structure of the analytic sample included in each measurement wave, the attrition rates and the reasons for dropout. Ultimately it contained a total of 1,314 respondents aged from 63 to 103 in 2002 (Wave 1; Mean = 68.7, SD = 6.4) with 639 (48.6 %) males and 675 (51.4 %) females.

2.2. Measurements

2.2.1. Cognitive function (CF)

The Mini-Mental State Examination (MMSE) questionnaire (Folstein, Folstein, & McHugh, 1975) was adopted and translated into Chinese in the CLHLS, which has been used in many studies with satisfactory reliability and validity (Katzman et al., 1988; Zhang, Gu, & Hayward, 2008). The MMSE assessed five domains of the elderly people' cognitive function: *Orientation* (e.g., "what time of day is it right now"), *Registration* (e.g., "repeat a sequence of objects"), *Attention and calculation* (e.g., mathematical problem), *Recall* (e.g., "repeat the name of specific words a while later"), and *Language* (e.g., "repeat a specific sentence"). MMSE score ranges from 0 (all answers are incorrect) to 30 (all answers are correct), with lower score indicating poorer cognition. Items included in the test are listed in the Appendix. Cronbach's alpha ranged from .78 to .90 across the five waves.

2.2.2. Negative affect (NA)

CLHLS administered several questions on affective experiences among Chinese elderly (Chen & Short, 2008; Luo & Waite, 2014). Negative affect was measured by three items with a 5-Likert scale (from "never" to "always"): *Neuroticism* ("feel fearful or anxious"), *Loneliness* ("feel lonely and isolated"), and *Perceived Loss of Self-worth* ("feel useless with age"), mainly derived from the Positive Affect and Negative Affect Schedule (Diener et al., 2010). The measure was calculated by summing scores on the three items with the values ranging from 3 to 15, with higher values indicating higher NA. Cronbach's alpha ranged from .62 to .67 across the five waves.

2.2.3. Covariates

The following covariates, which have been shown in previous studies to be associated with NA and CF, were considered. All covariates were dichotomized into two responses (1 = yes / male or 0 = no / female), including *demographic factors* (gender – "male / female"; marital status – "married / not" ; residential pattern – "co-resident with children / not"), *behavioral factors* (smoking status – "smoking regularly / not"; drinking status – "drinking regularly / not"; exercising status – "exercise regularly / not"), *social factors* (social activity – "conducting social activities with others / not"; Mahjong playing – "playing Mahjong with others in leisure time / not"), and *medical factors* (chronic

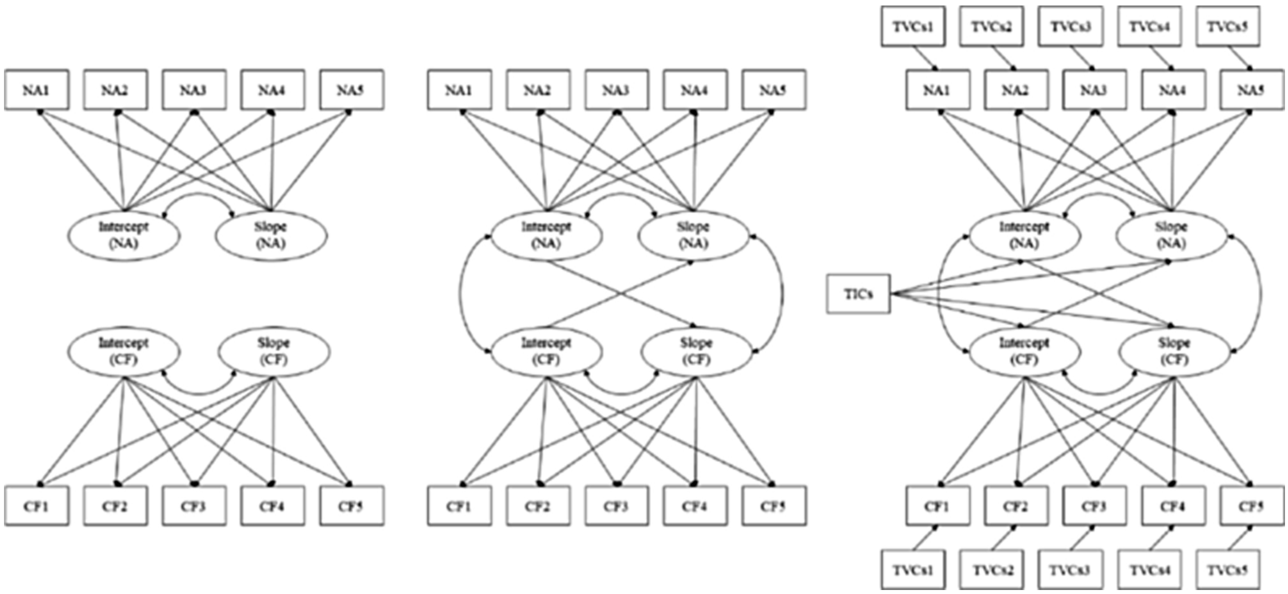

Fig. 1. Hypothesized model of the current study.
Note. NA: negative affect; CF: cognitive function; TICs: time-invariant covariates, including gender and chronic diseases; TVCs: time-varying covariates, including marital status, residential pattern, smoking status, drinking status, exercise status, social activity, and Mahjong playing.
Univariate LGCM: as a function of time in study.
Unconditional PP-LGCM: to observe the relationship between NA and CF.
Conditional PP-LGCM with covariates: to investigate the effect of covariates.

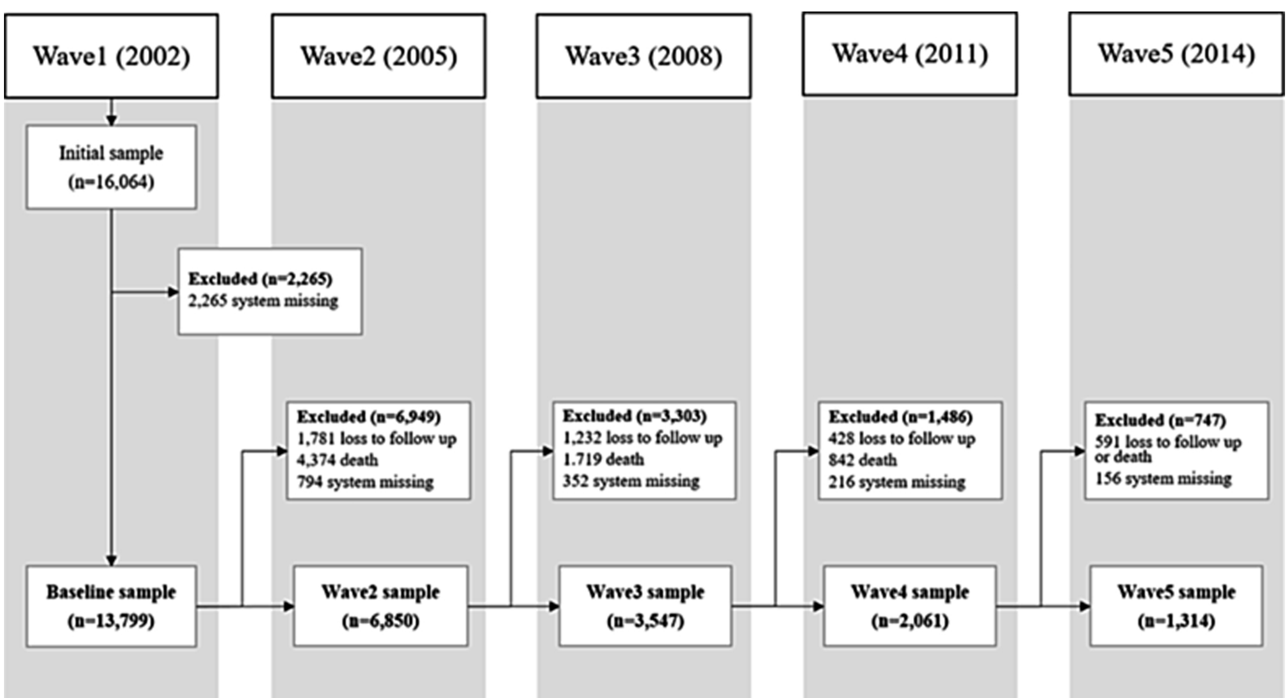

Fig. 2. Structure of the study sample.
Note. System missing: failed to respond to the items comprising the outcome variable.

disease, – "having any of 26 chronic diseases including hypertension, diabetes, stroke, cerebrovascular disease / not"). Gender and chronic disease were regarded as time-invariant covariates (TIC), only measured at baseline. The other seven variables were treated as time-varying covariates (TVC), measured at each time point.

2.3. Analysis procedure

Descriptive statistics were calculated for the individual demographic variables in each wave (see, Table 1) with continuous variables being expressed as means and standard deviation (*SD*) and categorical variables being presented as percentages.

Next, we fitted three latent growth curve models (LGCMs). *Step 1: Univariate LGCM.* A univariate LGCM was fitted to NA and CF,

Table 1
Characteristics of the study participants among 1,314 older adults in 5 waves.

	2002	2005	2008	2011	2014
Number of participants	1,314	–	–	–	–
Age, mean ± SD	68.7 ± 6.4	–	–	–	–
Time-invariant covariates					
Male, n (%)	639 (48.6)	–	–	–	–
Having chronic diseases, n (%)	1,001(76.2)	–	–	–	–
Time-varying covariates					
Married, n (%)	806(61.3)	735(55.9)	667(50.8)	584(44.4)	518(39.4)
Co-resident with children, n (%)	585(44.5)	597(45.4)	538(40.9)	538(40.9)	435(33.1)
Smoking, n (%)	327(24.9)	349(26.6)	290(22.1)	287(21.6)	250(19.0)
Drinking, n (%)	343(26.1)	359(27.3)	279(21.2)	280(21.3)	229(17.4)
Exercising. n (%)	507(38.6)	524(39.9)	557(42.4)	630(47.9)	494(37.6)
Having social activities, n (%)	297 (22.6)	296(22.5)	240(18.3)	289(22.0)	257(19.6)
Mahjong Playing, n (%)	334(25.4)	345(26.3)	314(23.9)	276(21.0)	264(20.1)
Main variables					
Negative affect, mean ± SD	6.25 ± 2.19	6.37 ± 2.28	6.26 ± 2.33	6.39 ± 2.29	6.57 ± 2.34
Cognitive function, mean ± SD	27.87 ± 2.73	26.56 ± 3.98	27.03 ± 3.63	26.64 ± 4.31	25.85 ± 5.07

respectively, as a function of time [see Fig. 1(a)]. Univariate LGCMs allow for an examination of (1) the initial level (i.e. intercept); (2) its rate of change (i.e. slope); (3) the association between the initial level of the outcome and its rate of change (Brailean et al., 2017). A linear form of the latent growth trajectory was tested in our models. *Step 2: Unconditional parallel process LGCM (PP-LGCM)*. In order to describe the concurrent relation (or co-development) between NA and CF, an unconditional PP-LGCM ((Duncan & Duncan, 2004; Preacher, Wichman, Briggs, & MacCallum, 2008) was applied by using respective total scores of NA and CF across all five waves [see Fig. 1(b)]. PP-LCGM analyses not only estimate the parameters of the growth factors (intercepts and slopes) of each variable, but also estimate the relations among the growth factors, permitting consideration of a wide range of hypotheses and tests for interrelations among "moving" constructs (Schulenberg & Maggs, 2001). In this study, PP-LCGMs estimate associations between: (1) baseline NA and baseline CF; (2) baseline NA and the rate of change in CF; (3) baseline CF and the rate of change in NA; (4) the rate of change in NA and the rate of change in CF. *Step 3: Conditional PP-LCGM.* To control for the confounder effects, a conditional PP-LCGM with covariates as depicted in Fig. 1(c) was also tested: the growth factors of NA and CF (i.e., intercept and slope factors) were regressed on TICs, while NA and CF scores at each time point were regressed on TVCs. Because there is no theoretical reason to expect the concurrent effects of the TVCs to change across waves, they were constrained to be equal across waves in our model.

All LGCMs were fit using Mplus version 8.0 (Muthen & Muthen, 2017) with Maximum Likelihood Robust (MLR) estimation. Model fit was evaluated based on the comparative fit index (*CFI*) (Bentler, 1990) and the Tucker–Lewis index (*TLI*) (Tucker & Lewis, 1973) with values > .95 representing good fit, the root mean square error of approximation (*RMSEA*) (Steiger, 1990) and standardized root mean square residual (*SRMR*) (Hu & Bentler, 1998) with values < .06 and < .08 reflecting good and marginal fit, respectively.

3. Results

3.1. Descriptive statistics

Table 1 showed the descriptive statistics for sample across five waves. Of the 1,314 respondents, at the first assessment (i.e., 2002), the mean age was 68.7 years (*SD* = 6.4; range = 63–103) and 638 (48.6 %) were males, 1,001 (76.2 %) had been diagnosed with chronic diseases.

Of the total sample over the 12 years, married elderly participants varied from 806 (61.3 %) to 518 (39.4 %), individuals reporting that they had co-residence with children varied from 585 (44.5 %) to 435 (33.1 %), 250 (19.0 %) to 327 (24.9 %) conducted regular smoking, 229 (17.4 %) to 343 (26.1 %) regular drinking, and 494 (37.6 %) to 507 (38.6 %) regular exercise. Elderly participants who reported having social activities with others varied from 257 (19.6 %) to 297 (22.6 %), and who played Mahjong ranged from 494 (37.6 %) and 507 (38.6 %) over the study period.

The mean NA of overall population across assessments ranged from 6.25 to 6.57, suggesting that participants had low initial negative well-beings but NA increased with a little fluctuation over time. The mean CF ranging from 27.87 to 25.85 indicates a normal cognition in the baseline and cognitive decline over time except in 2005.

3.2. Univariate LGCMs of NA and CF

Model fit for the univariate models of NA and CF was good (χ^2 = 34.369, *df* = 10, *CFI* = .95, *TLI* = .95, *RMSEA* = .04, and *SRMR* = .04 for NA; χ^2 = 33.06; *df* = 10, *CFI* = .94, *TLI* = .94, *RMSEA* = .04, and *SRMR* = .07 for CF). The mean of the intercept and slope was statistically significant for both NA and CF outcomes, suggesting a significant linear change in scores over time (see Table 2).

For NA, the model resulted in a mean initial value of 6.24 (t = 124.97, p < .001) and a significant mean slope with value of .02 (t = 3.75, p < .001), where the value of .02 could be interpreted as the average increase of NA per unit of time (i.e., wave). The variances for the intercept and slope were .91 (t = 5.80, p < .001) and .01 (t = 2.39, p < .05), indicating significant variation across individuals of initial NA and change rates for NA. There was no significant correlation between initial NA and change rates (t = .22, p = .824).

Likewise, mean initial value of CF was 27.88 (t = 377.12, p < .001) and mean slope of CF was statistically significant, showed a value of -.15 decline of CF per wave (t = −14.48, p < .001). The variances of the intercept and slope for CF outcomes were 2.80 (t = 6.57, p < .001), and .04 (t = 4.36, p < .001), respectively. There was no significant correlation between initial CF and change rates either (t = −.57, p = .571).

3.3. Unconditional parallel process LGCM of NA and CF

The unconditional parallel process linear model, which tested the concurrent relation between NA and CF from 2002 to 2014 as depicted in Fig. 1(b), indicated a good fit to the data (χ^2 = 114.25, *df* = 42, *CFI* = .93, *TLI* = .93, *RMSEA* = .04, and *SRMR* = .06). As Table 3 showed, a lower baseline level of NA was significantly associated with a higher

Table 2
Estimates for univariate latent growth curve models (LGCM).

		Estimate	*S.E.*	*t*	*p*
Negative affect	Mean				
	$I_{(NA)}$	6.24***	0.05	124.97	0.000
	$S_{(NA)}$	0.02***	0.01	3.75	0.000
	Variance				
	$I_{(NA)}$	0.91***	0.16	5.80	0.000
	$S_{(NA)}$	0.01*	0.00	2.39	0.017
	Covariance				
	$I_{(NA)} \leftrightarrow S_{(NA)}$	0.00	0.02	0.22	0.824
Cognitive function	Mean				
	$I_{(CF)}$	27.88***	0.07	377.12	0.000
	$S_{(CF)}$	−0.15***	0.01	−14.48	0.000
	Variance				
	$I_{(CF)}$	2.80***	0.43	6.57	0.000
	$S_{(CF)}$	0.04***	0.01	4.26	0.000
	Covariance				
	$I_{(CF)} \leftrightarrow S_{(CF)}$	−0.03	0.05	−0.57	0.571

Note. $I_{(NA)}$ = intercept of negative affect; $I_{(CF)}$ = intercept of cognitive function; $S_{(NA)}$ = slope of negative affect; $S_{(CF)}$ = slope of cognitive function.
* $p < 0.05$.
*** $p < 0.001$.

Table 3
Estimates for linear LGCM with parallel progress.

	β	*CI*(95 %)		*S.E.*	*t*	*p*
		Lower	Upper			
$I_{(NA)} \leftrightarrow I_{(CF)}$	−0.47**	−0.60	−0.34	0.07	−6.99	0.000
$S_{(NA)} \leftrightarrow S_{(CF)}$	−0.61***	−0.90	−0.33	0.15	−4.23	0.000
$I_{(NA)} \rightarrow S_{(CF)}$	−0.04	−0.23	0.16	0.10	−0.35	0.729
$I_{(CF)} \rightarrow S_{(NA)}$	0.22*	0.02	0.43	0.11	2.13	0.033

Note. Double headed arrows represent correlations, whereas single headed arrows represent regression effects; $I_{(NA)}$ = intercept of negative affect; $I_{(CF)}$ = intercept of cognitive function; $S_{(NA)}$ = slope of negative affect; $S_{(CF)}$ = slope of cognitive function. Values are standardized coefficients and standard errors (*S.E.*s).
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

baseline level of CF ($\beta = -.47$, $t = -6.99$, $p < .001$). There was also significant association between the growth trajectory of NA (slope $_{(NA)}$) and the growth trajectory of CF (slope $_{(CF)}$) ($\beta = -.61$, $t = -4.23$, $p < .001$), indicating that the elderly experiencing an accelerating increase in negative affect were often those with a rapid cognitive decline, and vise versa. Initial level of NA was not associated with the rate of change in CF over time ($\beta = -.04$, $t = -.35$ $p = .729$) while poor initial CF scores predicted a faster increase in NA over time ($\beta = .22$, $t = 2.13$, $p < .05$).

3.4. Conditional parallel process LGCM with covariates

Two time-invariant covariates (*gender* and *chronic disease*) and seven time-varying covariates *(marital status, residential pattern, smoking status, drinking status, exercising status, social activity,* and *Mahjong playing*) were added into this linear LGCM model to determine whether individual characteristics were predictive of bivariate trajectories of late life NA and CF. The conditional linear model fitted the data well: $\chi^2 = 453.58$, $df = 391$, $CFI = .96$, $TLI = .96$, $RMSEA = .01$, and $SRMR = .03$. Table 4 summarized the findings for these predictors of bivariate trajectories over time.

As to TICs, the associations between gender and NA growth factors and between gender and CF growth factors were significant but in opposite directions ($\beta = -.20$, $t = -2.82$, $p < .01$ for intercept$_{(NA)}$ and $\beta = -.18$, $t = -2.28$, $p < .05$ for slope$_{(NA)}$; $\beta = .20$, $t = 3.32$, $p < .01$ for intercept$_{(CF)}$ and $\beta = .30$, $t = 4.76$, $p < .001$ for slope$_{(CF)}$, respectively). Compared to females, males (1) reported lower NA and higher CF at baseline on average, and (2) had a faster rate of increase in NA and had a slower rate of decline in CF over time. Chronic disease essentially had no effects on the growth factors on NA and CF except for the initial factor of CF ($\beta = -.14$, $t = -2.91$, $p < .01$), suggesting that having chronic diseases was associated with a lower initial level of CF.

As to TVCs, exercising status, marital status, social activities, and Mahjong playing significantly related to trajectories of both NA and CF during five waves, while residential pattern and drinking status were only significantly related to the trajectory of NA (see Table 4). Particularly, elderly participants who were married, had regular exercise, were socially active, and played Mahjong through the subsequent period of time were more likely to report lower scores in NA and higher scores in CF. Co-residence with children and regular drinking had a positive effect on lowering NA. Smoking status did not significantly predict the change in NA and CF ($\beta = .01$, $t = .37$, $p = .71$ for NA; and $\beta = .02$, $t = .85$, $p = .39$ for CF, respectively).

Table 4
Covariates effect estimates for linear LGCM with parallel progress.

Predictors	*β*	*CI*(95 %)		*S.E.*	*t*	*p*
		Lower	Upper			
Time-invariant covariates						
Male → $I_{(NA)}$	−0.20**	−0.33	−0.06	0.07	−2.82	0.005
Male → $S_{(NA)}$	−0.18*	−0.34	−0.03	0.08	−2.28	0.022
Male → $I_{(CF)}$	0.20**	0.08	0.32	0.06	3.32	0.001
Male → $S_{(CF)}$	0.30***	0.18	0.42	0.06	4.76	0.000
Having chronic diseases → $I_{(NA)}$	0.11	−0.01	0.23	0.06	1.75	0.081
Having chronic diseases → $S_{(NA)}$	0.11	−0.04	0.27	0.08	1.44	0.150
Having chronic diseases → $I_{(CF)}$	−0.14**	−0.24	−0.05	0.05	−2.91	0.004
Having chronic diseases → $S_{(CF)}$	0.01	−0.11	0.13	0.06	0.17	0.868
Time-varying covariates						
On marital status → NA	−0.11***	−0.15	−0.08	0.02	−6.81	0.000
Co-resident with children → NA	−0.05***	−0.08	−0.02	0.02	−3.48	0.000
Smoking → NA	0.01	−0.03	0.04	0.02	0.37	0.711
Drinking → NA	−0.04*	−0.07	−0.01	0.02	−2.52	0.012
Exercising → NA	−0.13***	−0.16	−0.10	0.01	−9.04	0.000
Having social activities → NA	−0.04**	−0.07	−0.01	0.01	−2.80	0.005
Playing Mahjong → NA	−0.06***	−0.09	−0.13	0.02	−3.70	0.000
On marital status → CF	0.08***	0.04	0.12	0.02	3.67	0.000
Co-resident with children → CF	−0.02	−0.06	0.02	0.02	−0.98	0.329
Smoking → CF	0.02	−0.02	0.06	0.02	0.85	0.396
Drinking → CF	0.01	−0.03	0.05	0.02	0.52	0.602
Exercising → CF	0.09***	0.06	0.13	0.02	5.56	0.000
Having social activities → CF	0.11***	0.08	0.15	0.02	7.06	0.000
Playing Mahjong → CF	0.12***	0.09	0.16	0.02	7.43	0.000

Note. Single headed arrows represent regression effects; $I_{(NA)}$ = intercept of negative affect; $I_{(CF)}$ = intercept of cognitive function; $S_{(NA)}$ = slope of negative affect; $S_{(CF)}$ = slope of cognitive function. Values are standardized coefficients and standard errors (*S.E.*s). Coefficients of time-varying covariates were equal over time.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

4. Discussion

The current study examined longitudinal relationships among negative affect (NA) and cognitive function (CF) as well as investigated the effects of nine time-invariant and time-variant risk factors on NA and CF in a large sample of elderly, using parallel process latent growth curve models. Our longitudinal evidence suggests that elderly Chinese showed low initial negative well-beings and a gentle rise in negative affect over time. The current results are in line with previous research that has found higher rates of negative affect in very old age (i.e., 85+ years; e.g., Kessler, Foster, Webster, & House, 1992) and a meta-analysis from 1995 to 2011 regarding the increased loneliness trajectory among Chinese older adults (Li, Yu, & Wang, 2014). Negative affect was higher in late life, presumably when the skills needed to regulate emotion were compromised (Teachman, 2006). Elderly Chinese showed a general decline over time in cognitive function, corresponding to a large body of knowledge suggesting that cognitive decline is part of normal aging (e.g. Tilvis et al., 2004; Wilson, Beckett, Bennett, Albert, & Evans, 1999). Moreover, our findings supported the hypothesis that late-life negative affect (e.g. neuroticism, loneliness, and depression) co-occurs with cognitive dysfunction (Brailean et al., 2016; Shankar, Hamer, McMunn, & Steptoe, 2013; Waggel et al., 2015). As for the effect of initial CF on the change in NA, our findings showed that poorer cognitive function at baseline predicted long-term increasing negative affect, which is consistent with previous research concerning long-term depression (Jajodia & Borders, 2011; Nys et al., 2006). The increase in NA in persons with poor baseline CF might indicate a psychological reaction to cognitive dysfunction, implying that maintaining good cognitive functioning could help the elderly protect against negative emotion. Regarding the effect of baseline NA on change in CF, our findings suggested that the initial NA did not predict the change in CF. Thus, negative affect might not be a risk factor for cognitive decline in the general population, which is consistent with another general population study which indicated that baseline levels of depressed affect, positive affect, and somatic symptoms did not predict the rate of cognitive decline (Brailean et al., 2017). Our findings conflicted with previous studies such that they found higher initial NA predicted accelerated cognitive decline but we did not (Christodoulou et al., 2009; Geda et al., 2014). It is probably because there is a stronger prospective effect of NA on cognitive decline in studies with shorter follow-up durations, but could not be observed in a long-term period like our study.

To our knowledge, this is the first study to present an affect-cognition model with regard to both time-invariant and time-variant risk factors. Firstly, gender difference was observed in bivariate trajectories of late life NA and CF. Females experienced a slower rate of increase in NA and a faster rate of decline in CF over time. This gender effect is consistent with previous results (Isaacowitz & Smith, 2003; Koo, Rie, & Park, 2004). Compared with men, women's age-related changes in gene expression occur earlier, or occur faster, some of which have been linked to cognitive decline and neurodegenerative diseases (Yuan, Chen, Boyd-Kirkup, Khaitovich, & Somel, 2012). On the other hand, stress will make women more likely to show the decline of age-related cognitive ability. Specifically, women are more vulnerable to stress than men, especially in China. The dual pressures from family and work, especially the conflicts of multiple social roles (e.g., spouse, parent, employee) and the squeeze of gender culture in China, can also lead to a decline in Chinese women's mental health. Inconsistent with previous studies demonstrating that chronic disease was associated with cognitive decline (Harmand et al., 2014) and an increase in negative affect (Assari & Lankarani, 2016), there was little evidence to suggest that chronic disease operated as a predictor in this study. Perhaps because changes in NA and CF may only be related to specific chronic conditions (e.g. hypertension; see, Kilander, Nyman, Boberg, Hansson, & Lithell, 1998), but not to other chronic diseases (e.g. diabetes; see, González-Rivas et al., 2019).

Crucially, compared to other health-related factors, elderly Chinese seem to have more need of social interaction with others. Our findings showed that marital status, social activities, and Mahjong playing had an impact on both the negative affect and cognitive function of the elderly. Specifically, being married, participating in social activities, and playing mahjong in the leisure time were associated with improving cognitive function and reducing negative affect. Co-residing with children contributed to improved negative affect. Social relations are an important aspect of healthy aging. Over several decades, intense interest in social support has revealed its beneficial impact on social network, meaningful social bonds on well-being (Chen & Feeley, 2014; McAuley et al., 2000), mental health (Kawachi & Berkman, 2001; Kessler & McLeod, 1985), cognitive function (Seeman, Lusignolo, Albert, & Berkman, 2001), and even mortality (Lyyra & Heikkinen, 2006). Our study also suggests that the elderly establish social relationships with beneficial effects on affective and cognitive processes, which is consistent with the “the need to belong” hypothesis proposed by Baumeister and Leary (1995). The immediate family of the old individual is the major social support in time of illness, while the extended family represents the major tie to the community (Shanas, 1979). In this study, family support is significantly meaningful, including being accompanied or supported by spouse and children. In addition, regular social activities and Mahjong playing are also good ways to maintain frequent positive interactions to ensure enduring relationships. Therefore, our study suggests that both families and communities could help older people build intergenerational relationships and social networks to provide strong emotional support for the elderly, meanwhile the government should create a good environment for social adaptation of the elderly through the formulation of social policies and the development of community activities, which may help improve late life in elderly participants in China.

From the person-centered viewpoint, our findings supported an increasing body of literature showing that exercise has beneficial effects on a variety of quality of late life, including better health-related outcomes, better functional ability, and better affective states (Elward & Larson, 1992; Hogan, Mata, & Carstensen, 2013). Previous research concerning effects of smoking on cognitive outcome was inconclusive, with most longitudinal evidence showing weak or null associations (Chen et al., 2003; Peters et al., 2009). In this study, smoking was not associated with change in either negative emotions or cognitive decline. No associations between alcohol use and cognitive outcomes were observed over time, which also found in a meta-analysis of 23 longitudinal studies reporting no evidence of a protective effect of alcohol consumption against impaired cognitive function in older adults (Peters, Peters, Warner, Beckett, & Bulpitt, 2008). However, consistent with existing research (Holdsworth et al., 2016), our findings showing that drinking was negatively associated with negative affects also support the suggestion that regular drinking in elderly might signify good mental health. It may be explained by the widely recognized self-medication hypothesis that a person with high negative affect might turn to drinking as a means to treat their emotion. But the underlying etiological mechanism is yet to be clear. It also should be noted that does not at all suggest that alcohol should be viewed as an effective treatment for negative affect.

The strengths of the study include its longitudinal data; its representative large sample of the community-dwelling Chinese population aged 60 and over; the use of parallel process LGCM focusing on joint trajectories of late life negative affect and cognitive function; and our use of both time-invariant and time-varying covariates to provide more powerful evidence to demonstrate effects of risk factors. However, there are also a few limitations of this study. Firstly, we did not consider specific domains of both NA (e.g. anxiety, loneliness) and CF (e.g. calculation, recall), so it is not clear whether the bi-direction relation equally applies to all of the dimensions. Besides, the pattern of trajectories for the late life affect and cognitive performance might be heterogeneous, which means that there might be different typologies of parallel trajectories of negative affect and cognitive decline among elderly people and the effects and directions between negative affect and cognitive decline might be different among different typologies.

5. Conclusion

This study used a parallel process approach to examine a bivariate trajectory of late life negative affect and cognitive function in a 12-year period for a nationally representative sample. Our findings supported the hypothesis that late-life negative affect co-occurs with cognitive decline and negative affect might be a mutative mental reaction to cognitive dysfunction. The effects of gender, exercise, and conception of "need to belong" on cognitive decline and negative affect were observed over time, highlighting the importance having tailored interventions in improving late life negative affect and accelerated cognitive decline.

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None.

CRediT authorship contribution statement

Yuhan Ni: Conceptualization, Methodology, Software, Data curation, Writing - original draft. **Jenn-Yun Tein:** Writing - review & editing. **Minqiang Zhang:** Conceptualization, Resources, Supervision. **Fengquan Zhen:** Writing - review & editing, Visualization. **Feifei Huang:** Writing - review & editing. **Yingshi Huang:** Visualization, Investigation, Validation. **Yiming Yao:** Investigation. **Jiaqi Mei:** Writing - review & editing.

Declaration of Competing Interest

None of the authors have any conflicts of interest or financial ties to disclose.

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Appendix A. Supplementary data

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