Associations between social and intellectual activities with cognitive trajectories in Chinese middle-aged and older adults: a nationally representative cohort study

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Research

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Abstract

Background Associations between the frequency of social and intellectual activities and cognitive trajectories are understudied in Chinese middle-aged and older adults. We aimed to examine this association in a nationally representative longitudinal study.

Methods The China Health and Retirement Longitudinal Study (CHARLS) is a prospective cohort study conducted from 2011 to 2016, with a nationally representative sample of Chinese middle-aged and older participants. The frequency of social and intellectual activities was measured in 2011-2012. Interview-based cognitive assessments of orientation and attention, episodic memory, and visuospatial skills and the calculation of combined global scores were conducted in three waves (2011-2012, 2013-2014 and 2015-2016). Cognitive trajectories over the study period were analyzed using group-based trajectory models (GBTMs), and the associations of the trajectory memberships with social and intellectual activities were analyzed using multinomial logistic regression. Odds ratios (ORs) and 95% confidence intervals (CIs) were reported.

Results After excluding respondents with missing data on cognitive function, we ultimately included 7243 participants aged 50 years or older in the analysis. Three trajectory groups for global cognitive performance over time were identified: low (20.34%), intermediate (34.39%) and high (45.27%). After adjustment for sociodemographic variables, lifestyles and health conditions, more frequent intellectual activities (OR: 0.43, 95% CI: 0.32 - 0.58) and social activities (OR: 0.66, 95% CI: 0.56 - 0.78) were both associated with a lower likelihood of being in the low global cognitive trajectory group than in the high trajectory group in separate analyses. These associations persisted after mutually exclusive adjustment for social and intellectual activities.

Conclusions More frequent social and intellectual activities were associated with more favorable cognitive aging trajectories. Increasing the frequency of engagement in social and intellectual activities might help delay or prevent cognitive impairment in older people.

Introduction

Cognitive impairment and dementia are the most common geriatric symptoms in elderly individuals aged 60 years and older [1]. As the global population is aging, the number of individuals with cognitive impairment or dementia has dramatically increased both in China and internationally [2-4]. A recent meta-analysis and systematic review reported that an estimated 15% of the older Chinese population suffered from cognitive impairment [5]. A high prevalence of cognitive impairment translates into a very large economic burden [6]. There is no effective treatment for cognitive impairment or dementia [7]. Thus, early identification of potentially modifiable risk factors for cognitive decline is crucial to delay and prevent the occurrence of cognitive impairment and/or dementia [8].

A large body of studies has examined the association between leisure time activities and cognitive function in older adults [9-14]. The results have been mixed. Some studies found no association between

participation in social activities and cognitive function [13, 14], while many other studies demonstrated that frequent participation in social and/or intellectual activities was associated with reduced risk for cognitive decline and dementia [9-12]. Most of those studies used linear mixed-effects models to evaluate the impact of social or intellectual activities on cognitive function [15, 16] and did not consider the physiological trajectory of cognitive function. Group-based trajectory modeling using longitudinal data can capture not only cognitive function but also heterogeneities in changes in cognitive function over time at both the individual and subgroup levels [17]. However, very few studies have focused on the associations of social and intellectual activities with cognitive trajectories among older people.

Therefore, the current study aimed to identify different trajectories in cognitive function and to investigate the associations of social and intellectual activities with cognitive trajectories in a nationally representative sample of middle-aged and older Chinese adults.

Methods

Study population

The China Health and Retirement Longitudinal Study (CHARLS) is a nationally representative study of Chinese adults aged ≥ 45 years. The CHARLS is designed to describe the dynamics of retirement and its impact on health, health insurance, and economic well-being. The baseline survey was conducted in 2011-12 among 17,708 participants from 150 counties of China's 28 provinces [18], and data on socioeconomic status, lifestyles, medications, health status and functioning assessments were collected. Details on the study design, sampling procedure, and data collection have been described in previous publications [18]. Briefly, the CHARLS participants were recruited through a four-stage, stratified, cluster random sampling method. The CHARLS participants were followed biennially to obtain updated information. The CHARLS data are available for the baseline survey in 2011-2012, the first follow-up survey in 2013-2014, and the second follow-up survey in 2015-2016. The Biomedical Ethics Committee of Peking University approved this study, and all participants provided written informed consent.

The current analyses focused on individuals aged 50 years and older. As shown in supplementary **Figure S1**, a total of 7,011 participants lacked measurements of cognitive function (n=2,655) or health status and functioning (n=112), were younger than 50 (n=4,019), or had dementia or Parkinson's disease (n=225) at baseline. Those participants were excluded from the current analyses. In addition, a further 3,454 participants were excluded due to loss to follow-up (n=854), missing data on cognitive function during follow-up (n=1,642) or incident dementia or Parkinson's disease (n=129). Therefore, the current analyses were carried out among 7,243 participants aged ≥50 years who had complete cognitive tests assessed at baseline, the first follow-up, and the second follow-up survey.

Social and intellectual activities

The frequencies of leisure time activities in the past month were measured through self-reports. Leisure time activities included seven items and were classified as either social activities (interacting with friends; going dancing, exercising, or practicing Qigong; participating in community-related organizations; and doing voluntary charity work or assisting others) or intellectual activities (playing Mahjong, cards or chess; attending an educational or training course; investing in stock or surfing the internet) [10, 11]. The frequency of each activity was measured as “never”, “not regularly”, “almost every week” or “almost daily”. We coded each item as 1 = “almost every week” or “almost daily” and 0 = “never” or “not regularly”. The composite scores for social activities (ranging from 0 to 4) and intellectual activities (ranging from 0 to 3) were calculated as the sum of their corresponding activity scores.

Cognitive function

In accordance with previous studies using data from the CHALRS [19, 20], cognitive function, including episodic memory, orientation/attention and visuospatial skills, was assessed at baseline and during the two follow-up visits by three tests: word recall, the Telephone Interview of Cognitive Status (TICS), and figure drawing.

The word recall test evaluated episodic memory. Examiners read a list of 10 random words, and participants were instructed to recall as many words as possible immediately afterward (*immediate recall*). The number of correctly recalled words was scored and indicated the participant’s immediate recall. Ten minutes later, the participants were asked to recall the same list of words (*delayed recall*). Episodic memory scores were calculated as the average number of immediate and delayed word recalls and ranged from 0 to 10.

The original TICS measures an individual’s mental status. In the CHARLS, ten questions from the TICS were used, including questions on serial subtraction of 7 from 100 (up to five times), the date (month, day, and year), the day of the week, the season of the year, and figure drawing. The questions primarily measure orientation/attention; the total score was calculated as the sum of correct answers to the ten questions and ranged from 0 to 10.

The figure drawing test assessed visuospatial abilities. Participants were shown a picture of two overlapping pentagons and were asked to draw a similar picture. Participants who drew correctly received a score of 1, and those who did not correctly draw the picture received a score of 0.

Overall cognitive function was calculated as the sum of the scores of the three tests and ranged from 0 to 21. To make the cognitive function scores compatible across the surveys, the scores for the first and second follow-up surveys were standardized to the baseline scores using the mean and standard deviation (SD) of the cognitive scores at baseline. Specifically, the cognitive function scores from the follow-up surveys were transformed to *z* scores by subtracting the mean score at baseline and dividing by the SD at baseline. In addition, a composite global cognitive *z* score was calculated for each participant

by averaging the *z* scores of the three tests and re-standardizing them to baseline *z* scores using the mean and SD of the baseline global cognitive *z* score.

Covariates

Baseline measurements of age, sex, education level, marital status, location of residence, household income level, smoking, drinking, self-perceived health status, physician-diagnosed chronic diseases, disability, self-reported visual and hearing impairments, depressive symptoms, and body mass index (BMI) were included as covariates in the current analyses. Educational level was categorized as “no formal education”, “primary school”, “middle school”, or “high school or above”. Marital status included “married” and “others”. Location of residence was divided into “rural” and “urban”. Household income was categorized into tertiles and coded as “low”, “medium”, and “high”. Self-perceived health status was reported as “good”, “fair” or “poor”. Physician-diagnosed chronic diseases included hypertension, diabetes mellitus, dyslipidemia, heart diseases, stroke, lung disease, arthritis, and cancer. Disability was defined as having limitations in any of the five activities of daily living, including bathing, dressing, eating, getting into/out of bed, and toileting [21]. Depressive symptoms were assessed using the 10-item version of the Center for Epidemiologic Studies Depression Scale, and a score of ≥ 10 indicated the presence of depressive symptoms [22]. BMI was calculated as the weight in kilograms divided by the square of the height in meters. BMI was categorized as follows: <18.5, 18.5-23.9, 24.0-27.9, and ≥ 28.0 kg/m^2 [23].

Statistical analysis

Group-based trajectory models (GBTMs) implemented through the “traj” plugin procedure in Stata[24] were used to identify the trajectories of the global cognitive *z* scores during the 4 years of follow-up [17] based on the assumption of a censored normal distribution [25]. A maximum of five trajectory groups was set a priori. We fitted the models from one group trajectory to five group trajectories, and the follow-up time was used as a time scale. The Bayesian information criteria (BIC) and Akaike’s information criterion (AIC) were used to identify the best fitted model. Furthermore, an average posterior probability of assigning each participant to a group of approximately 70% or higher was indicative of a good fit, and models with greater than 5% membership in each trajectory group were selected. As shown in supplementary **Table S1**, the AIC and BIC were similar across models with 3, 4, and 5 trajectory groups. To be comparable with findings from the Whitehall II cohort study [26], in which three trajectory groups were identified for cognitive function, we decided to choose the three-group trajectory model. Then, we compared the model fit with different forms (i.e., linear, quadratic, and cubic). Because the CHALRS had 3 waves of data collection, the models were tested for linear and quadratic trends for each trajectory group. In the final model, the overall global cognitive z scores had 3 trajectory groups, which were in linear, quadratic, and quadratic forms. The mean probabilities of final group membership were above 83% for all cognitive function measures. The final three trajectory groups had low, intermediate, and high cognitive

function. We repeated the above analysis for the individual cognitive domains, including episodic memory, orientation/attention, and figure drawing.

The baseline characteristics of the study participants were described according to the three trajectory groups of overall cognitive function. Continuous variables were summarized as the mean (± SD), and categorical variables were expressed as frequencies and percentages. Continuous variables were checked for normality and log-transformed if necessary. Differences between groups were compared using one-way analysis of variance (ANOVA) for continuous variables and the χ^2 test for categorical variables.

A multinomial logistic regression model was used to estimate the association of social and intellectual activities with the trajectories of the cognitive function measures, including overall cognitive function, episodic memory, and orientation/attention. The high trajectory was set as the reference group for each cognitive outcome. Odds ratios (ORs) and the corresponding 95% confidence intervals (CIs) associated with a 1-unit increase in social and intellectual activities scores were reported. We built five sets of models for each cognitive outcome. Model 1 adjusted for age and sex. Model 2 additionally adjusted for socioeconomic status variables, including education, marital status, location of residence, and household income. Model 3 adjusted for all variables in model 2 plus health behaviors, including smoking, drinking, and BMI. Model 4 additionally adjusted for health conditions, including self-perceived health status, depressive symptoms, disability, visual and hearing impairment, hypertension, diabetes mellitus, dyslipidemia, heart disease, stroke, lung disease, arthritis, and cancer. Model 5 was the fully adjusted model, in which both social and intellectual activities were added.

We also investigate the joint associations of social and intellectual activities with cognitive trajectories by adding an interaction term between social and intellectual activities in model 5. To make the interpretation easier, we recoded both social and intellectual activity variables, with 1 = more than 1 activity, which was labeled “frequent”, and 0 = less than 1 activity, which was labeled “rare”. Then, we created a combined variable with four categories: rare intellectual and rare social activities, rare intellectual activities but frequent social activities, frequent intellectual activities but rare social activities, and frequent intellectual and frequent social activities. For each cognitive trajectory, the model was adjusted for socioeconomic status variables, health behaviors, and health conditions.

All analyses were performed with Stata version 15.1 (StataCorp, College Station, TX). A two-sided p-value less than 0.05 was considered statistically significant.

Results

As shown in **Figure 1**, three trajectory groups were identified for global cognitive function: low (20.34%, n = 1,473), intermediate (34.39%, n = 2,491) and high (45.27%, n = 3,279). Each trajectory had a slightly decreasing shape over time. Similar trajectories were identified for the cognitive function components (**Supplementary Figures S2-S4**).

The baseline characteristics of the participants in each trajectory group for global cognitive function are presented in **Table 1**. Participants in the low trajectory group were more likely than those in the high trajectory group to be older; be male; have lower levels of education and income; and have stroke, depressive symptoms, disability, and visual or hearing impairments.

The associations of intellectual activities and social activities with trajectories of global cognitive *z* scores are displayed in **Table 2**. Participants who often participated in intellectual or social activities were less likely to be in the low or intermediate trajectory groups for cognitive function. After accounting for age and sex, a 1-unit increase in the intellectual activity score was associated with a 75% (95% CI: 68%-81%) lower likelihood of being in the low trajectory group and a 52% (95% CI: 44%-59%) lower likelihood of being in the intermediate trajectory group. After further adjusting for socioeconomic status, health behaviors, chronic conditions, and social activities, the magnitudes of the associations were attenuated but still significant ($P < 0.001$). Similarly, participants with a 1-unit higher social activity score were 50% (95% CI: 43%-56%) and 32% (95% CI: 25%-39%) less likely to be in the low and intermediate trajectory groups, respectively. When further controlling for all other variables in the full model, the associations were weaker but still significant ($P < 0.02$). Intellectual and social activities were also associated with the trajectories of orientation/attention and episodic memory (**Table 3**).

Figure 2 shows the joint associations between intellectual and social activities and trajectories of cognitive function. A synergistic effect between social and intellectual activities was observed (*P* for interaction = 0.027). Compared to adults who reported less participation in both intellectual and social activities, adults who reported frequent participation in both intellectual and social activities had better cognitive trajectories, with multivariable-adjusted ORs (95% CI) for the low and intermediate trajectories of global cognitive function of 0.44 (0.30 - 0.65) and 0.66 (0.52 - 0.84), respectively.

Discussion

We identified three trajectory groups for global cognitive function over a 4-year follow-up period among a nationally representative sample of 7,243 middle-aged and older Chinese adults recruited from the CHALRS. Of these participants, 20.34% had low, 34.39% had intermediate, and 45.27% had high global cognitive function trajectories. We demonstrated that more frequent social and intellectual activities were both associated with a better cognitive performance trajectory over time. More importantly, the two types of activities worked synergistically to achieve better cognitive trajectories.

The membership and shape of cognitive trajectories varied across different populations of older people [26-29]. In this population-based longitudinal study, three cognitive trajectories were identified. Similar trajectories were also identified in the Whitehall II study [26]. Our findings showed that there were clear differences in the baseline levels of global cognitive function but relatively small differences in the slope between the three trajectory groups. Overall, 45% of older Chinese people had high cognitive function trajectories over the 4 years of follow-up.

Consistent with previous studies, we found that older people with high levels of engagement in social or intellectual activities had more favorable subsequent cognitive function than those with low levels of engagement [13, 30-33]. A cross-sectional analysis based on the CHARLS data also showed that participation in social or intellectual activities was associated with better cognitive function [34]. Similarly, in the Paquid cohort, engagement in social, physical, and intellectual activities was associated with a favorable cognitive trajectory over 20 years of follow-up [12, 35]. In the Health and Retirement Study, which used similar statistical methods, it was also shown that more social engagement in old age was associated with a lower risk of a declining cognitive trajectory [36]. As the first longitudinal study among Chinese older adults using trajectory analyses, our study contributed further knowledge of the association of social and intellectual activities with better cognitive trajectories over time in a Chinese population.

In the study population, we found that having higher education levels and being married were both associated with a better cognitive performance trajectory, which was consistent with a previous study [26]. Additionally, we found that people who were depressed had poor cognitive performance. In addition, people who were depressed also were less engaged in social and intellectual activities. The mediating effect of depression on these associations needs to be further examined.

The strengths of this study are that it used well-validated measures of cognitive function and different types of leisure time activities. We followed a relatively large nationally representative cohort of middle-aged and older Chinese adults for a 4-year follow-up period with complete assessment of cognitive function. We also used advanced statistical models (namely, GBTMs) to fit the cognitive aging trajectories. This approach helped identify groups of individuals who experienced similar levels and patterns of cognitive functions over time, while linear mixed models focus on mean population trajectories. There are several limitations. First, although the frequencies and types of leisure activities were measured using a well-validated questionnaire, recall bias still existed. However, recall bias was very likely nondifferential, which would bias the associations towards the null, which shows the robustness of our findings. Second, although the associations between social activities, intellectual activities, and cognitive aging trajectories were robust after adjustment for various demographic characteristics, socioeconomic status, health behaviors, and health conditions, residual confounding factors were not fully controlled, such as the *APOE* genotype [37]. Genotypes were not measured in the CHARLS. As such data will be available in the future, further analyses incorporating the *APOE* genotype are warranted. Finally, our findings were based on an observational study, and an interventional study is warranted to determine a causal relationship between social and intellectual activities and cognitive trajectories.

Conclusion

In conclusion, we found that participation in social activities and/or intellectual activities in midlife was independently associated with a favorable cognitive aging trajectory over time. To prevent or delay the onset of cognitive impairment, older adults are encouraged to engage in more social activities and/or intellectual activities.

Declarations

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Availability of data and materials

The CHARLS dataset is freely available to all bona fide researchers. Researchers can gain access to the data (http://charls.pku.edu.cn/en). Data can also be obtained on request (statguo@ccmu.edu.cn).

Ethics approval and consent to participate

Each participant included in this study signed a written informed consent form before taking the survey. Ethics approval for the data collection in CHARLS was obtained from the Biomedical Ethics Review Committee of Peking University (IRB00001052-11015).

Consent for publication

All authors approved the final manuscript for submission and gave consent for publication.

Competing interests

The authors declare that they have no competing interests.

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Tables

able 1. Baseline characteristics of the participants according to trajectories of global ɔgnitive function (n=7243)

haracteristic	Trajectory of global cognitive function			p-value
	Low (n=1473)	Intermediate (n=2491)	High (n=3279)	
ge (years)	63.8 ± 8.1	61.0 ± 7.1	59.4 ± 6.3	<0.001
emale sex (%)	1089 (73.9)	1281 (51.4)	1217 (37.1)	<0.001
ducational level (%)				<0.001
No formal education	1350 (91.6)	1475 (59.2)	651 (19.9)	
Primary school	103 (7.0)	654 (26.3)	923 (28.1)	
Middle school	16 (1.1)	283 (11.4)	995 (30.3)	
High school or above	4 (0.3)	79 (3.2)	710 (21.7)	
Iarried (%)	1165 (79.1)	2208 (88.6)	3027 (92.3)	<0.001
ural residence (%)	1164 (79.0)	1733 (69.6)	1708 (52.1)	<0.001
ousehold income level (%)				<0.001
Low	691 (46.9)	915 (36.7)	793 (24.2)	
Medium	481 (32.7)	861 (34.6)	1058 (32.3)	
High	291 (19.8)	702 (28.2)	1404 (42.8)	
Missing	10 (0.7)	13 (0.5)	24 (0.7)	
urrent smoker (%)	326 (22.1)	810 (32.5)	1231 (37.5)	<0.001
urrent drinker (%)	328 (22.3)	814 (32.7)	1340 (40.9)	<0.001
elf-report of health (%)				<0.001
Good	264 (17.9)	498 (20.0)	902 (27.5)	
Fair	654 (44.4)	1264 (50.7)	1751 (53.4)	
Poor	555 (37.7)	729 (29.3)	626 (19.1)	
epression (%)	766 (52.0)	1011 (40.6)	838 (25.6)	<0.001
isability (%)	373 (25.3)	417 (16.7)	324 (9.9)	<0.001
isual impairments (%)	164 (11.1)	164 (6.6)	133 (4.1)	<0.001
earing impairments (%)	184 (12.5)	214 (8.6)	181 (5.5)	<0.001
ypertension (%)	403 (27.4)	704 (28.3)	903 (27.5)	0.770
iabetes mellitus (%)	71 (4.8)	169 (6.8)	247 (7.5)	0.003
yslipidemia (%)	97 (6.6)	232 (9.3)	436 (13.3)	<0.001
eart diseases (%)	150 (10.2)	327 (13.1)	492 (15.0)	<0.001
troke (%)	39 (2.6)	72 (2.9)	55 (1.7)	0.006
ung disease (%)	184 (12.5)	301 (12.1)	332 (10.1)	0.017
rthritis (%)	621 (42.2)	1001 (40.2)	1043 (31.8)	<0.001
ancer (%)	13 (0.9)	18 (0.7)	35 (1.1)	0.390
ody mass index (%)				<0.001
<18.5 kg/m^2	153 (10.4)	163 (6.5)	114 (3.5)	
18.5-23.9 kg/m^2	759 (51.5)	1248 (50.1)	1458 (44.5)	
24.0-27.9 kg/m^2	299 (20.3)	612 (24.6)	911 (27.8)	
≥28.0 kg/m^2	128 (8.7)	235 (9.4)	353 (10.8)	
Missing	134 (9.1)	233 (9.4)	443 (13.5)	
ntellectual activities (points)	0.1 ± 0.2	0.1 ± 0.3	0.2 ± 0.4	<0.001
ocial activities (points)	0.3 ± 0.4	0.3 ± 0.5	0.4 ± 0.6	<0.001

*Numbers are mean (± SD) or number (%). SD, standard deviation.

Table 2. Multinomial logistic regression analysis for the associations of intellectual activities and social activities with trajectories of global cognitive function*

	Trajectory of global cognitive function			
	Low vs high		Intermediate vs high	
	ORs (95% CI)	p-value	ORs (95% CI)	p-value
Intellectual activities (1 point per increase)				
Model 1: Adjusted for age and sex	0.25 (0.19 - 0.32)	<0.001	0.48 (0.41 - 0.56)	<0.001
Model 2: Adjusted additionally for socioeconomic status [a]	0.37 (0.28 - 0.49)	<0.001	0.64 (0.54 - 0.76)	<0.001
Model 3: Adjusted additionally for health behaviors [b]	0.39 (0.29 - 0.52)	<0.001	0.65 (0.55 - 0.78)	<0.001
Model 4: Adjusted additionally for health conditions [c]	0.43 (0.32 - 0.58)	<0.001	0.69 (0.58 - 0.82)	<0.001
Model 5: Adjusted additionally for social activities	0.47 (0.35 - 0.64)	<0.001	0.72 (0.60 - 0.86)	<0.001
Social activities (1 point per increase)				
Model 1: Adjusted for age and sex	0.50 (0.44 - 0.57)	<0.001	0.68 (0.61 - 0.75)	<0.001
Model 2: Adjusted additionally for socioeconomic status [a]	0.60 (0.51 - 0.71)	<0.001	0.80 (0.71 - 0.90)	<0.001
Model 3: Adjusted additionally for health behaviors [b]	0.62 (0.53 - 0.73)	<0.001	0.81 (0.73 - 0.91)	<0.001
Model 4: Adjusted additionally for health conditions [c]	0.66 (0.56 - 0.78)	<0.001	0.84 (0.75 - 0.94)	0.002
Model 5: Adjusted additionally for intellectual activities	0.71 (0.60 - 0.84)	<0.001	0.87 (0.77 - 0.98)	0.020

*Data are reported as odd ratios (ORs) and 95% confidence intervals (CI).

[a] Socioeconomic status included education, marital status, residence, and household income.

[b] Health behaviors included smoking status, drinking status, and body mass index.

[c] Health conditions included self-report of health, depression, disability, visual problem, hearing problem, hypertension, diabetes mellitus, dyslipidemia, heart disease, stroke, lung disease, arthritis, and cancer.

Table 3. Multinomial logistic regression analysis for the associations of intellectual activities and social activities with individual trajectory of cognitive function tests*

	Trajectory of individual cognitive function			
	Low vs high		Intermediate vs high	
	OR (95% CI)	p-value	OR (95% CI)	p-value
	Orientation/attention			
Intellectual activities (1 point per increase)				
Model 1: Adjusted for age and sex	0.23 (0.17 - 0.31)	<0.001	0.52 (0.45 - 0.61)	<0.001
Model 2: Adjusted additionally for socioeconomic status [a]	0.35 (0.25 - 0.48)	<0.001	0.69 (0.58 - 0.82)	<0.001
Model 3: Adjusted additionally for health behaviors [b]	0.37 (0.27 - 0.51)	<0.001	0.70 (0.59 - 0.82)	<0.001
Model 4: Adjusted additionally for health conditions [c]	0.41 (0.29 - 0.57)	<0.001	0.73 (0.62 - 0.87)	<0.001
Model 5: Adjusted additionally for social activities	0.44 (0.31 - 0.61)	<0.001	0.75 (0.63 - 0.89)	0.001
Social activities (1 point per increase)				
Model 1: Adjusted for age and sex	0.54 (0.47 - 0.63)	<0.001	0.72 (0.66 - 0.80)	<0.001
Model 2: Adjusted additionally for socioeconomic status [a]	0.67 (0.57 - 0.79)	<0.001	0.85 (0.76 - 0.95)	0.004
Model 3: Adjusted additionally for health behaviors [b]	0.70 (0.59 - 0.82)	<0.001	0.86 (0.77 - 0.96)	0.009
Model 4: Adjusted additionally for health conditions [c]	0.74 (0.63 - 0.88)	0.001	0.89 (0.80 - 1.00)	0.047
Model 5: Adjusted additionally for intellectual activities	0.80 (0.68 - 0.92)	0.013	0.93 (0.83 - 1.04)	0.182
	Episodic memory			
Intellectual activities (1 point per increase)				
Model 1: Adjusted for age and sex	0.28 (0.23 - 0.35)	<0.001	0.48 (0.41 - 0.57)	<0.001
Model 2: Adjusted additionally for socioeconomic status [a]	0.50 (0.39 - 0.63)	<0.001	0.69 (0.58 - 0.82)	<0.001
Model 3: Adjusted additionally for health behaviors [b]	0.51 (0.40 - 0.65)	<0.001	0.69 (0.58 - 0.82)	<0.001
Model 4: Adjusted additionally for health conditions [c]	0.55 (0.43 - 0.70)	<0.001	0.72 (0.61 - 0.86)	<0.001
Model 5: Adjusted additionally for intellectual activities	0.63 (0.49 - 0.81)	<0.001	0.78 (0.65 - 0.94)	0.008
Social activities (1 point per increase)				
Model 1: Adjusted for age and sex	0.40 (0.35 - 0.46)	<0.001	0.59 (0.53 - 0.66)	<0.001
Model 2: Adjusted additionally for socioeconomic status [a]	0.52 (0.44 - 0.61)	<0.001	0.72 (0.64 - 0.81)	<0.001
Model 3: Adjusted additionally for health behaviors [b]	0.53 (0.45 - 0.63)	<0.001	0.72 (0.64 - 0.82)	<0.001
Model 4: Adjusted additionally for health conditions [c]	0.56 (0.48 - 0.66)	<0.001	0.75 (0.67 - 0.85)	<0.001
Model 5: Adjusted additionally for social activities	0.59 (0.50 - 0.70)	<0.001	0.78 (0.69 - 0.88)	<0.001
	Figure-drawing			
Intellectual activities (1 point per increase)				
Model 1: Adjusted for age and sex	0.27 (0.20 - 0.35)	<0.001	0.60 (0.52 - 0.69)	<0.001
Model 2: Adjusted additionally for	0.41 (0.30 -	<0.001	0.77 (0.66 -	0.001

socioeconomic status [a]	0.56)		0.90)	
Model 3: Adjusted additionally for health behaviors [b]	0.42 (0.31 - 0.57)	<0.001	0.79 (0.67 - 0.92)	0.003
Model 4: Adjusted additionally for health conditions [c]	0.46 (0.34 - 0.63)	<0.001	0.81 (0.70 - 0.95)	0.011
Model 5: Adjusted additionally for intellectual activities	0.50 (0.36 - 0.68)	<0.001	0.81 (0.69 - 0.95)	0.008
Social activities (1 point per increase)				
Model 1: Adjusted for age and sex	0.55 (0.48 - 0.64)	<0.001	0.83 (0.75 - 0.91)	<0.001
Model 2: Adjusted additionally for socioeconomic status [a]	0.68 (0.58 - 0.81)	<0.001	0.96 (0.87 - 1.07)	0.482
Model 3: Adjusted additionally for health behaviors [b]	0.70 (0.59 - 0.82)	<0.001	0.99 (0.89 - 1.09)	0.789
Model 4: Adjusted additionally for health conditions [c]	0.73 (0.62 - 0.86)	<0.001	1.01 (0.91 - 1.11)	0.907
Model 5: Adjusted additionally for intellectual activities	0.78 (0.66 - 0.93)	0.004	1.03 (0.93 - 1.15)	0.528

*Adjusted variables were similar to Table 2.

Figures

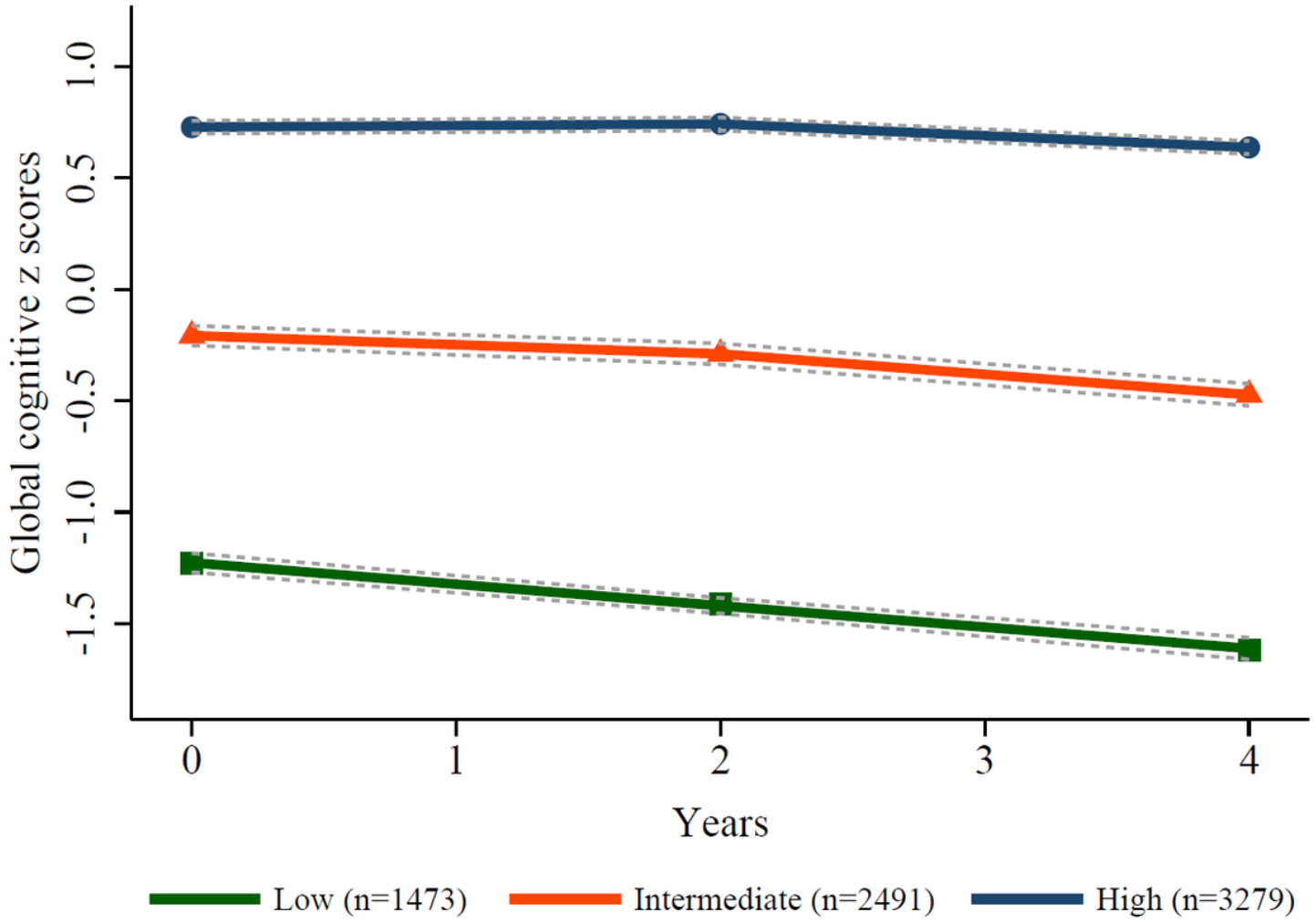

Figure 1

Trajectory of episodic global cognitive function

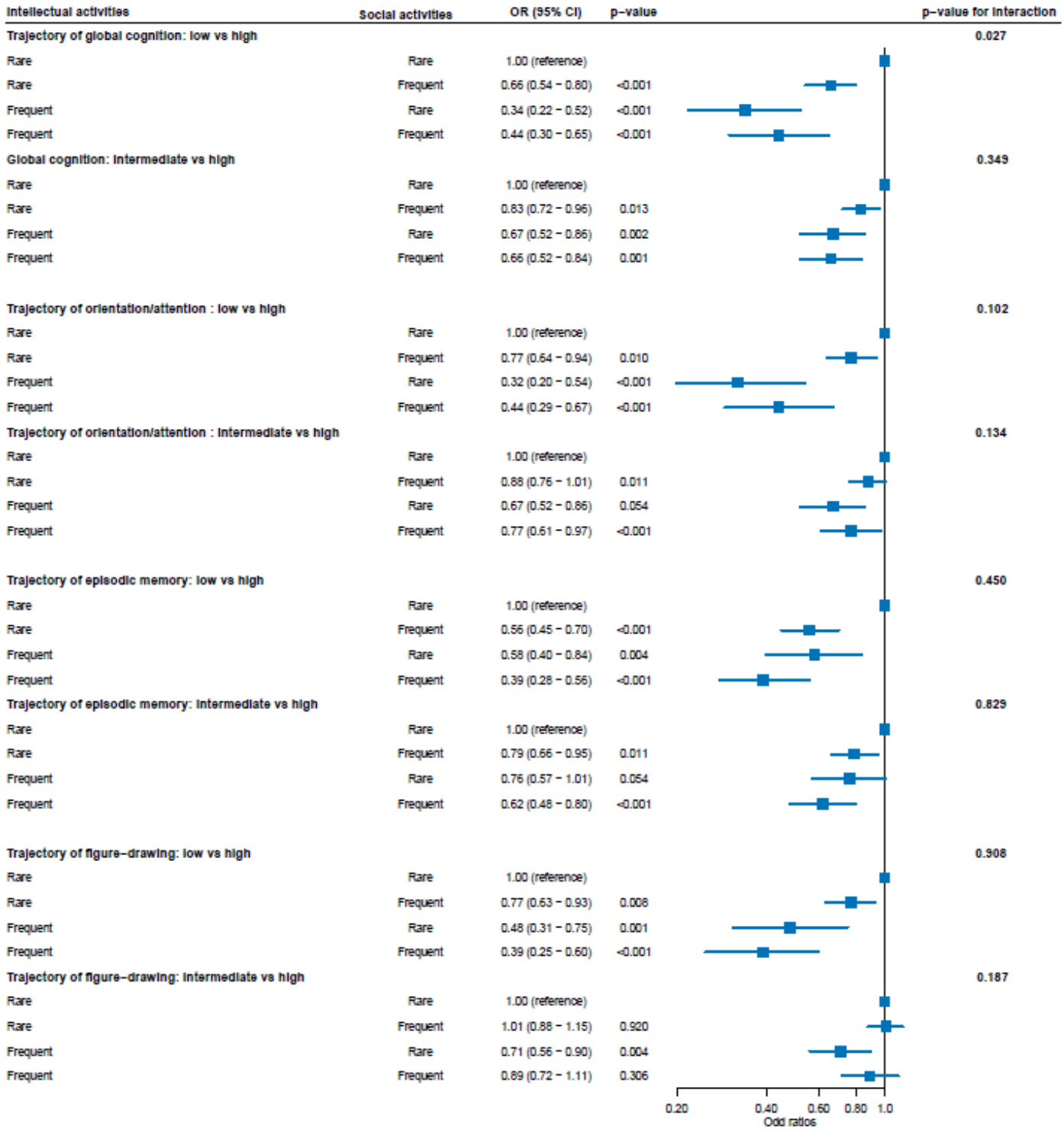

Figure 2

Joint associations of intellectual and social activities with cognitive function trajectories

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Supplementarymaterials20191106.pdf