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Association of big-5 Personality Traits with Cognitive Impairment and Dementia: A Longitudinal Study

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What is already known on this subject?

- Personality traits are thought to be associated with a range of health outcomes; neuroticism and conscientiousness have recently been suggested to be important risk factors for dementia.
- The role of depression in the association between personality traits and dementia remains unclear.

What this study adds?

- In a large cohort study of over 6,000 participants, conscientiousness was the only personality trait to have an association with dementia risk after control for the effects of sociodemographic characteristics, socioeconomic status, and depression.
- Increased risk of dementia associated with higher neuroticism was explained by depression history and depressive symptoms.
- Lack of progress in curative solutions for dementia highlights the need for identification of risk factors. Our results show that personality traits are unlikely to be important determinants of dementia.

ABSTRACT

Background Personality traits have been liked to cognitive outcomes such as dementia but whether these associations are robust to the effects of third variables remains the subject of debate. We examined the role of socioeconomic status, depression (history and depressive symptoms), health behaviors, and chronic conditions in the association of the big 5 personality traits with cognitive performance, cognitive impairment and incidence of dementia.

Methods Data on 6,135 persons (30% women), aged 60-83 years in 2012/13, are drawn from the Whitehall II study. Participants responded to the 26-item Midlife Development Inventory to assess personality traits (openness, conscientiousness, extraversion, agreeableness, and neuroticism), underwent cognitive testing in 2012/13 and 2015/16 and were followed for incidence of dementia (N=231) until 2019.

Results Logistic regression, adjusted for sociodemographic factors, suggested a cross-sectional association with cognitive impairment for four of the five traits but only neuroticism was associated with incident cognitive impairment. All associations were completely attenuated when the analyses were adjusted for depression. Cox regression (mean follow-up: 6.18 years) adjusted for sociodemographic variables showed higher conscientiousness (HR per SD increment=0.72; 95% CI: 0.65, 0.81) and extraversion (HR=0.85; 95% CI: 0.75, 0.97) to be associated with lower dementia risk; higher neuroticism (HR=1.32; 95% CI: 1.17, 1.49) was associated with increased risk. Further adjustment for depression led to only conscientiousness retaining an association with dementia (HR=0.81; 95% CI: 0.69, 0.96), which was robust to adjustment for all covariates (HR=0.84; 95% CI: 0.71, 0.91; p=0.001).

Conclusion Our results show that only conscientiousness has an association with incidence of dementia that is not attributable to socioeconomic status or depression. The association of neuroticism with dementia was explained by depression.

Personality is seen to reflect enduring dispositions in an individual's cognitive, emotional and behavioral tendencies. The "big 5" model, the most widely used theory of personality, includes five broad traits of openness, conscientiousness, extraversion, agreeableness and neuroticism.[1 2] There is a burgeoning research literature on their association with health,[3-5] also at older ages.[6-9] Research in the past ten years suggests personality traits to be associated with cognitive impairment[10-12] and dementia.[12-14] Neuroticism and conscientiousness are thought to be particularly important; a recent study used repeat data on the big-5 personality traits to show that the association of conscientiousness and neuroticism with cognitive dysfunction was not due to reverse causation, i.e. changes in mood and behavior in the preclinical phase of dementia.[12] Nevertheless, taken together the evidence is far from robust. Intriguingly, studies show conscientiousness[10] and neuroticism[11 13-15] to be associated with Alzheimer's disease and related dementias but not with their pathologic hallmarks such as plaques, tangles, infarcts or Lewy bodies in the brain.

A recent meta-analysis (total N=5,054) concluded that assessment of conscientiousness and neuroticism may help identify individuals at risk of Alzheimer's disease[16] but the role of third variables that might explain observed associations remains unclear. Recent guidelines on dementia prevention have either included a long list of risk and protective factors[17] or a smaller set, drawn from across the life course.[18] Personality factors are not yet included in these lists and whether they are independent risk factors for dementia remains unclear. Accordingly, the objective of our study is to examine the role of putative confounders (socioeconomic factors), depression that is likely to share variance with personality traits, and mediators (health behaviors, chronic conditions) in the association of the big 5 personality traits with cognitive outcomes. We examine cross-sectional associations with cognitive performance on a range of tests, and longitudinal associations with cognitive impairment and incidence of dementia.

Methods

Study Design and Participants

The Whitehall II study is an ongoing cohort study of 10,308 persons (6,895 men and 3,413 women), aged 35-55 years at study recruitment in 1985/88.[19] Follow-up assessments including postal questionnaire and clinical examinations have taken place approximately every 5 years. The baseline for the current analyses was the 2012/13 wave of data collection when big 5 personality traits were first included in the study. Participant (written, informed) consent and research ethics approvals (University College London (UCL) ethics committee) are renewed at each contact; the latest approval was by the NHS London - Harrow Research Ethics Committee, reference number 85/0938.

Personality (2012/13)

The Midlife Development Inventory (MIDI) Personality Scale was used to the big-5 personality traits.[20] It requires participants to rate themselves on how well an adjective described them on a 4-point Likert scale (1= not at all,… 4= a lot). Seven adjectives measure openness (creative, imaginative, intelligent, curious, broad-minded, sophisticated, adventurous), 5 adjectives each for conscientiousness (organized, responsible, hardworking, careless [reversed], thorough), extraversion (outgoing, friendly, lively, active, talkative), and agreeableness (helpful, warm, caring, softhearted, sympathetic) and 4 adjectives for neuroticism (moody, worrying, nervous, calm [reversed]). Raw scores were averaged for each trait and transformed into z-scores (Mean=0, Standard Deviation (SD)=1) in order to allow comparison between personality traits and results from other studies.[21]

Cognitive Test Battery (2007/09, 2012/13 and 2015/16)

In addition to the Mini-Mental State Examination (MMSE), a brief 30-point measure of global cognitive function,[22] we assessed four cognitive domains:

Memory, using 20 one-or-two syllable words.

Language/fluency, via two tests, words beginning with "S" and as many "animal" names; one minute was allowed for each test. A score was calculated as the mean of the two standardized scores.

Attention, using the Trail Making Test part A (TMT-A),[23] which requires participants to draw lines sequentially connecting 25 encircled numbers in ascending order; time to complete the task is recorded.

Executive function, using two tests: the Alice Heim 4-I (AH4-I), a time limited test composed of a series of 65 verbal and mathematical reasoning items of increasing difficulty[24]; and the time to perform Trail Making Test- part B (TMT-B),[23] which required the participant to identify numbers and letters in a specified sequence while shifting from number to letter sets. A score was calculated as the mean of the two standardized scores.

Poor cognitive performance was defined as score< -1.5 standard deviation using age, sex, and education specific thresholds; for the MMSE we used a threshold of 24.

Cognitive Impairment in 2015/16, using both measures of cognitive performance (2015/16) and cognitive decline (between 2012/13 and 2015/16) as in other studies,[25] was based on the following criteria:

1) MMSE scores < 24, or
2) Poor cognitive performance (below the -1.5 Z score) in any of the four cognitive domains at the 2015/16 assessment, and definite cognitive decline between 2012/13 and 2015/16, defined as falling below the worst 20th percentile of change on more than 1 domain or below the worst 10th percentile on at least 1 domain.

Cognitive impairment in 2012/13 was defined in a similar manner using data from 2007/09 and 2012/13.

Incident dementia (2012/13 to 2019)

We used comprehensive tracing of three electronic health record databases for dementia ascertainment (ICD-10 codes F00-F03, F05.1, G30, G31): the national hospital episode statistics (HES) database, the Mental Health Services Data Set (MHSDS) and the mortality register. All three are national databases in a system with universal health care; HES and MHSDS contain information on both in- and out-patient care, with the latter also including data on care in the community.

Covariates (2012/13)

Socio-demographic factors included age, sex, ethnicity (white, non-white), marital status (married/cohabiting vs. other), and education (no formal education, lower secondary school, higher secondary school, university, higher degree).

Adult socioeconomic-status (SES) was assessed using occupational position at age 50, a six- level variable related to salary, social status and level of responsibility at work.[19]

Depressive symptoms were assessed using the 20-item Center for Epidemiologic Studies Depression Scale (CES-D),[26] a 20-item inventory of the National Institute of Mental Health Center for Epidemiological Studies, to assess frequency and severity of depressive symptoms. Relative performance within the cohort of CES-D against the interviewer-administered revised Clinical Interview Schedule as criterion for detecting a depressive episode were similar; sensitivity and specificity 83% and 86%.[27]

History of depression was defined as reported use of anti-depressants between 1985/88 to 2012/13 or records of depression in electronic health records (ICD10 F32, F33) up to 2012/13.

Health behaviors included smoking (current-, ex-, and never-smoker), alcohol consumption (measures on frequency and number of alcoholic consumed, converted to units of alcohol consumed per week and categorized as none, 0-14 units, and >14 units), physical activity (modified Minnesota leisure-time physical activity questionnaire[28] containing 20 items on

frequency and duration of activities which were assigned a metabolic equivalent (MET) value by using a compendium of activity energy costs;[29] activities with MET<3 and ≥3 were coded as mild and moderate-and-vigorous physical activity, respectively[30]), and frequency of fruit and vegetable consumption (seldom or never, < once a month, 1-3 times a month, 1-2 times a week, 3-4 times a week, 5-6 times a week, once a day, 2-3 times a day, 4 or more times a day).

Chronic conditions were ascertained using data from clinical examinations in the study and linkage to electronic health records, combined into one measure of the number of chronic conditions. They included diabetes (fasting glucose ≥ 7·0 mmol/l, reported doctor-diagnosed diabetes, use of diabetes medication, ICD10: E10-E14), coronary heart disease (12-lead resting ECG recording, ICD10: I20-I25, procedures K40-K49, K50, K75, U19), stroke (MONICA-Ausburg stroke questionnaire, ICD10: I60-I64), chronic obstructive pulmonary disease (ICD10: J41-J44), arthritis, cancer (cancer registry with malignant cancer ICD10: C00–C97) and Parkinson's disease (ICD10: G20).

Statistical Analysis

Descriptive characteristics of the study population in 2012/13 as a function of cognitive impairment in 2012/13 and incidence of dementia (between 2012/13 and 31st March 2019) were examined using Student's t-test and Chi-squared test. The analyses of poor cognitive performance or cognitive impairment were undertaken using logistic regression. As there were no sex differences in effect estimates men and women were combined in the analyses. Each personality trait was examined in separate models, with results of associations expressed per 1 SD increase in the trait. The basic analyses (Model 1) were adjusted for age, sex, marital status, ethnicity, and education. We then included adult SES (Model 2), measures of depressive symptoms and depression history (Model 3), and finally health behaviors and chronic conditions (Model 4) in successive models. All covariates were assessed concurrent to the measure of personality traits.

The analyses where dementia was the outcome were undertaken using Cox proportional hazards regression. In these analyses participants were followed from the date of their assessment at the 2012/13 wave of the study until the date of recorded dementia, death, or March 31st 2019, whichever came first. This allowed the analyses to take into account the competing risk of death in the association of personality traits with dementia. The covariates were included in the Cox regression in a similar fashion as in the logistic regression. All analyses were undertaken using STATA 15, two-sided p-value < 0.05 was considered statistically significant.

Sensitivity analysis: As in a recent paper,[12] we repeated the analysis by comparing personality traits using linear regression. The adjustment for covariates was identical to that in the main analyses. We also examined the association of personality with cognitive impairment and dementia without adjustment for current depressive symptoms, assessed by the CES-D. Finally, we examined the association of depression history and CES-D score (standardized to a z-score) with dementia after adjustment for personality traits (separately for each trait) and all other covariates.

Results

Of the 6,318 participants who were alive and attended the 2012/13 clinical screening, 6,135 had data on personality, covariates, and dementia follow-up. The cross-sectional analyses with cognitive data were based on 5,278 participants; missing data were more common in participants who were older, female, single, and had lower SES (p<0.001).The analysis of incident cognitive impairment in 2015/16 was based on 4,167 participants; flow-chart in **eFigure 1** presents the sample selection.

Cronbach's alpha suggested reasonable internal consistency for openness (α=0.79), conscientiousness (α=0.61), extraversion (α=0.79), agreeableness (α=0.81), and neuroticism

(α=0.73). The correlation between the five traits (**eTable 1**) showed extraversion to be strongly associated with openness (Pearson r=0.54, p<0.0001) and agreeableness (r=0.56, p<0.0001). Of the five personality traits, CESD score was most strongly associated with neuroticism (Pearson r=0.52, p<0.0001). The characteristics of participants, as a function of cognitive status in 2012/13 and dementia status at the end of the follow-up, are shown in **Table 1**. Participants with poor cognitive status at baseline or dementia at the end of the follow-up were older, and had a poorer sociodemographic, behavioral, and health profile. The association of personality traits with low SES, depression history and high CESD score is shown in **eTable 2**; conscientiousness was associated with all three covariates and neuroticism with both measures of depression.

The cross-sectional associations of personality traits with poor cognitive performance are shown in **Table 2**. Adjustment for SES (Model 2) to the minimally adjusted model did not substantially alter associations but additional inclusion of depression history and current depressive symptoms considerably attenuated associations (Model 3). In fully adjusted models (Model 4), higher openness was associated with lower odds of poor language/fluency (odds ratio (OR) per 1 SD increase in openness=0.79; 95% Confidence Interval (CI): 0.69, 0.89). Higher conscientiousness was associated with lower odds of poor attention (OR=0.82; 95% CI: 0.71, 0.94), and higher neuroticism was associated with lower odds of poor MMSE scores (OR=0.72; 95% CI: 0.52, 0.98).

Table 3 shows results for cognitive impairment, the upper panel results are on impairment status concurrent to the assessment of personality traits and lower panel using data on incidence of impairment at the 5 year follow-up. All personality traits except agreeableness were associated with cognitive impairment in the minimally adjusted cross-sectional analyses (Model 1) but not when analyses were adjusted for depression history and depressive symptoms (Model 3). Only

neuroticism was associated with increased OR of incidence of impairment at follow-up (Model 1: 1.15; 95% CI: 1.01, 1.30) but further adjustment for covariates attenuated this association.

The validity of dementia cases in the Whitehall II study has been demonstrated by showing differences in cognitive decline trajectories between dementia cases and those free from dementia (**eFigure 2**). We recorded 231 incident dementia cases over a mean follow-up of 6.18 ((SD=1.07); range: 0.05 to 7.17 years) in the total population, corresponding data in dementia cases alone was 3.68 (SD=1.77), Range: 0.05 to 6.90 years. Results of the Cox regression to examine the association of personality traits with incidence of dementia are shown in **Table 4**. In the minimally adjusted analyses (Model 1), conscientiousness and extraversion were associated with lower hazard ratio (HR) of dementia; 0.72 and 0.85, respectively per one standard deviation increase in personality traits, and greater neuroticism was associated with greater HR of dementia (1.32; 95% CI: 1.16, 1.49). Adjustment for SES (Model 2) did not affect associations but further adjustment for depressive symptoms and history of depression attenuated associations except that with conscientiousness (Model 3). In the fully adjusted model one standard deviation higher conscientiousness score was associated with a lower risk of dementia (HR=0.83; 95% CI: 0.73, 0.93; Model 4).

The results of sensitivity analysis using linear regression to compare personality scores in those with and without cognitive impairment (**eTable 3**) and then those with dementia diagnosis to those free of dementia at the end of follow-up (**eTable 4**) were similar to results reported in the main analyses in that no associations were present for cognitive impairment and only conscientiousness score (difference in z score= -0.25 (-0.37, -0.12); $p<0.001$) was lower in those who later developed dementia. The analyses of personality with cognitive impairment and dementia without adjustment for depression symptoms concurrent to the assessment of

personality are shown in **eTable 5**. These analyses show stronger associations of conscientiousness (HR=0.77; 95% CI: 0.69, 0.87) and neuroticism (HR=1.25; 95% CI: 1.10, 1.41) with dementia compared to analyses that also adjust for CESD (Table 4) but no association with cognitive impairment in cross-sectional or prospective analyses. The final sensitivity analysis (**eTable 6)** shows that in mutually adjusted models, undertaken separately for each personality trait, depression history and CES-D depression were associated with increased risk of dementia.

Discussion

Recent studies have suggested that neuroticism and conscientiousness are important predictors of the risk of dementia.[12 16] Our objective was to examine whether the association between personality traits and cognitive outcomes was due to residual confounding by sociodemographic factors and depression, and independent of potential mediators such as health behaviors and chronic health conditions. In this large population based study of the big five personality traits, there was some evidence of an association between conscientiousness and lower risk of dementia; conscientiousness was also associated with better attention but not cognitive impairment. There was no evidence of an association between the other personality traits (openness, extraversion, agreeableness, neuroticism) and cognitive outcomes. In relation to the importance of "third" variables, our results suggest a strong role for depression but not for adult SES.

As current guidelines on risk and protective factors for dementia[17 18] do not include personality dimensions, careful consideration of the role of confounding factors and overlapping constructs such as depression is important. Evidence on the association of neuroticism and cognitive outcomes in previous studies [12 21 31 32] and meta-analyses [16 33] is far from robust. In one study

neuroticism was associated with the MMSE but not the Mattis Dementia Rating Scale or the Trail-making tests A and B.[32] Some studies examined components of the neuroticism trait using the longer format of the 5 factor personality scale. In these studies, the "proneness to distress" component was associated with more rapid cognitive decline ,[34] increased risk of cognitive impairment,[11] and Alzheimer's disease.[13-15] The use of components of the neuroticism scale without correction for multiple testing and the fact that proneness to distress was associated with Alzheimer's disease but not its pathologic hallmarks in these studies [13-15] raises questions about the nature of reported associations although the pathological hallmarks of Alzheimer's disease are not consistently associated with clinical symptoms or acknowledged risk factors.[17]

One study on 800 Swedish women, using a 38 years follow-up, showed the association between neuroticism measured in midlife and dementia to be completely attenuated after adjustment for a one-item measure of distress.[31] Our results on dementia, albeit with a shorter follow-up, are similar, with an attenuation in hazard ratio associated with neuroticism from 1.32 ($p<0.001$) to 1.10 ($p=0.24$) after controlling for depressive symptoms and history of depression. There is consistent evidence of an association between neuroticism and depressive illness,[35] suggesting that depression may be an important confounder of the association between neuroticism and health. The sensitivity analysis with adjustment for all covariates besides current depressive symptoms showed stronger associations between neuroticism and dementia. However, in these analyses (eTable 5) neuroticism was not associated with cognitive impairment in cross-sectional or longitudinal analyses. Given the lack of a consistent association with cognitive outcomes, and the strong role of depressive symptoms, it is unlikely that neuroticism is a risk factor for cognitive dysfunction.

A recent paper argued for the importance of neuroticism and conscientiousness for dementia with "effect sizes similar to those of well-established clinical and lifestyle risk factors".[16] These conclusions were based on a meta-analysis (N=5,054) and analysis of data from the Baltimore Longitudinal Study of Aging (BLSA); it is worth noting that the covariates used included only age, sex, ethnicity and education. Furthermore, findings from BLSA are comparable to our results with this limited set of confounders (our results in Model 1, Table 4): for openness (HR of 0.89 compared to 0.94 in our data), conscientiousness (0.69 compared to 0.72), extraversion (0.86 compared to 0.85), agreeableness (0.86 compared to 1.08) and neuroticism (1.37 compared to 1.32). However, further adjustment for depression, listed as a putative risk factor for dementia,[17] [18] completely attenuated the association between neuroticism and dementia in our study.

The association of conscientiousness with dementia in our data was robust to adjustment for SES, depression, health behaviors, and chronic conditions. However, conscientiousness was not associated with incidence of cognitive impairment in models adjusted for socio-demographic factors (Model 2, Table 3), not allowing firm conclusions to be drawn on its role in cognitive dysfunction. A recent meta-analysis which compared personality trait profile of AD patients (N=603) to healthy subjects (N=679) found no differences in self-reported conscientiousness although informant-rated conscientiousness was lower in dementia patients, albeit in studies with high heterogeneity (I^2 96.62).[33] In the Religious Orders Study conscientiousness was not associated with neurodegeneration markers in those who died and underwent brain autopsy,[10] but a recent study reported widespread positive associations between conscientiousness and cortical thickness.[36] Large scale individual-participant meta-analyses also show conscientiousness to be the only personality trait from the big five model that is associated with obesity (N=78,931)[5] and mortality (N=76,150).[3] Further research using larger numbers is needed before firm conclusions can be drawn on the association between conscientiousness and dementia and how it compares

with other risk factors for dementia. It is possible that persistence, self-control, and long-term planning that characterize conscientiousness involve health self-care that has a protective effect on cognitive outcomes.

Our results need to be considered in light of some limitations. The ascertainment of dementia was based on linkage to electronic health records. In the UK, dementia ascertainment via HES records only has been shown to have high specificity but only moderate (78%) sensitivity missing milder cases of dementia.[37] Our use of two other databases is likely to have greater sensitivity.[38] There might be some underestimation of dementia incidence but any effects on associations are likely to be small if missingness is not related to personality. The advantage of record linkage method is that it allows analysis on everyone recruited to the study rather than only on those who continue to participate in the study and are available for an in-person ascertainment of dementia. As dementia is a progressive disease, the precise date of onset is almost impossible to determine and all estimates lack precision. A further limitation is use of an occupational cohort study where participants tend to be healthier than those in the general population; however, this is an unlikely source of bias in risk factor-disease associations as we have previously shown estimates from our study to be similar to those reported in general population-based studies.[39] Finally, the short follow-up used in the analyses makes it difficult to rule out reverse causation as a potential explanation for our findings. We used a brief personality inventory; it is possible that more elaborate personality scales will allow better assessment of the association of personality with cognitive outcomes.

The psychometric properties of the personality scales used in our study are sound. Alpha reliabilities in our study were comparable to those reported in studies such as the National Social Life, Health, and Aging Project (NSHAP), Midlife in the United States (MIDUS) and Health and

Retirement Study (HRS) studies[40] and the Religious Orders Study which used the 60-item version of the scale. The correlation between the personality traits was also similar to that observed in the NSHAP study;[40] for example the correlation of openness with conscientiousness (0.36 in our study compared to 0.48), extraversion (0.54 compared to 0.53), agreeableness (0.39 compared to 0.36) and neuroticism (-0.20 compared to -0.13) were similar.[40] Finally, the 240-item scale in BLSA yielded associations between personality traits and dementia adjusted for sociodemographic factors that were similar to ours in analysis using Cox [16] and linear regression (our results in **eTable 4**).[12]

The burden of dementia will continue to grow with population ageing. The lack of curative solutions highlights the importance of primary prevention, which is underpinned by identification of modifiable risk factors and better knowledge of non-modifiable risk factors. Neuroticism and conscientiousness have been suggested as personality traits that are associated with cognitive impairment and dementia. Our results show that the association of neuroticism with cognitive dysfunction was explained by depressive symptoms. Only conscientiousness was associated with dementia, and the magnitude of this association was modest, suggesting that benefits from interventions targeting personality, if any, are likely to be small.

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Competing Interest: None declared.

Authors Contribution

ASM & MSY undertook the analyses and the paper was drafted by ASM. ASM, MSY, SS, MK, AF, AD, and JD contributed to planning, conduct, interpretation of results, and critical revisions of the manuscript. ASM is guarantor.

Table 1. Sample characteristics at baseline (2012/13) as a function of cognitive status at the end of the follow-up.*

	Cognitive Impairment (N=5278)			Dementia (N=6135)		
	No CI	**CI**	**P**	**No Dementia**	**Dementia**	**P**
N	**4875**	**403**		**5904**	**231**	
Age, M(SD)	69.26 (5.66)	71.54 (6.41)	<0.0001	69.59 (5.78)	75.38 (4.97)	<0.0001
Male	3552 (72.86)	272 (67.49)	<0.001	4199 (71.12)	150 (64.94)	0.04
White	4594 (94.24)	319 (79.16)	<0.001	5488 (92.95)	207 (89.61)	0.05
Married/cohabitating	3665 (75.18)	263 (65.26)	<0.001	4388 (74.32)	142 (61.47)	<0.001
No academic qualifications	426 (8.74)	62 (15.38)	<0.001	594 (10.06)	43 (18.61)	<0.001
Lower occupational position	452 (9.27)	101 (25.06)	<0.001	703 (11.91)	52 (22.51)	<0.001
CES-D score, M(SD)	6.91 (7.22)	10.03 (9.07)	<0.0001	7.24 (7.59)	11.03 (8.97)	<0.0001
Depression history	518 (10.63)	60 (14.89)	0.008	638 (10.81)	44 (19.05)	<0.001
Health Behaviours						
Current smokers	158 (3.24)	20 (4.96)	0.07	224 (3.79)	10 (4.33)	0.62
Alcohol, M(SD)	10.20 (11.22)	7.06 (9.50)	<0.0001	9.83 (11.35)	7.59 (10.28)	0.003
Less than daily fruit & veg	961 (19.71)	130 (32.26)	<0.001	1267 (21.46)	63 (27.27)	0.04
Hours of mod-vig physical activity per week, M(SD)	3.59 (3.57)	2.34 (2.84)	<0.0001	3.43 (3.52)	2.33 (2.95)	<0.0001
≥ 2 Chronic conditions	564 (11.57)	85 (21.09)	<0.001	750 (12.70)	64 (27.71)	<0.001
Big 5 personality, M(SD)						
Openness	2.98 (0.48)	2.91 (0.54)	0.009	2.98 (0.49)	2.92 (0.58)	0.12
Conscientiousness	3.37 (0.45)	3.28 (0.51)	<0.001	3.37 (0.45)	3.16 (0.53)	<0.0001
Extraversion	3.04 (0.55)	2.97 (0.60)	0.03	3.04 (0.56)	2.97 (0.58)	0.04
Agreeableness	3.31 (0.49)	3.32 (0.52)	0.61	3.31 (0.50)	3.83 (0.49)	0.04
Neuroticism	1.87 (0.57)	1.95 (0.64)	0.02	1.88 (0.59)	2.01 (0.63)	0.002

*Numbers are N (percentage), otherwise stated.

Abbreviations: M: Mean, SD: standard deviation, CI: cognitive impairment, CES-D: Center for Epidemiologic Studies-Depression scale

Table 2. Association between personality traits and poor cognitive performance: cross sectional analyses (N=5278).

	Model 1		Model 2: Model 1 + SES		Model 3: Model 2 + depression		Model 4: Model 1 + all covariates	
	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Memory (N cases/N total: 275/5278)								
Openness	0.96 (0.85, 1.09)	0.51	0.99 (0.87, 1.12)	0.84	1.04 (0.91, 1.18)	0.57	1.05 (0.92, 1.19)	0.46
Conscientiousness	0.87 (0.77, 0.98)	0.02	0.90 (0.80, 1.01)	0.08	0.96 (0.85, 1.10)	0.58	0.99 (0.87, 1.12)	0.83
Extraversion	0.90 (0.79, 1.02)	0.09	0.91 (0.80, 1.03)	0.14	0.98 (0.86, 1.12)	0.79	1.00 (0.88, 1.15)	0.95
Agreeableness	1.01 (0.89, 1.15)	0.87	1.00 (0.88, 1.14)	0.98	1.04 (0.91, 1.18)	0.59	1.03 (0.91, 1.18)	0.61
Neuroticism	1.20 (1.06, 1.35)	0.003	1.18 (1.05, 1.33)	0.007	1.05 (0.91, 1.22)	0.49	1.06 (0.92, 1.23)	0.43
Language/Fluency (N cases/N total: 292/5278)								
Openness	0.70 (0.62, 0.80)	<0.001	0.75 (0.66, 0.85)	<0.001	0.77 (0.68, 0.87)	<0.001	0.79 (0.69, 0.89)	<0.001
Conscientiousness	0.89 (0.80, 1.01)	0.06	0.97 (0.86, 1.09)	0.59	1.03 (0.91, 1.17)	0.63	1.05 (0.92, 1.19)	0.47
Extraversion	0.85 (0.75, 0.96)	0.008	0.86 (0.76, 0.98)	0.02	0.91 (0.80, 1.04)	0.15	0.93 (0.81, 1.06)	0.28
Agreeableness	0.98 (0.86, 1.11)	0.72	0.96 (0.85, 1.09)	0.52	0.99 (0.87, 1.13)	0.89	0.98 (0.86, 1.12)	0.81
Neuroticism	1.10 (0.97, 1.24)	0.13	1.05 (0.93, 1.19)	0.43	0.94 (0.81, 1.09)	0.42	0.96 (0.82, 1.11)	0.56
Attention (N cases/N total: 201 /5278)								
Openness	0.83 (0.72, 0.95)	0.008	0.86 (0.75, 1.00)	0.04	0.91 (0.78, 1.05)	0.19	0.92 (0.79, 1.06)	0.23
Conscientiousness	0.73 (0.64, 0.83)	<0.001	0.76 (0.67, 0.87)	<0.001	0.81 (0.70, 0.93)	0.003	0.82 (0.71, 0.94)	0.01
Extraversion	0.84 (0.73, 0.97)	0.02	0.85 (0.74, 0.99)	0.03	0.92 (0.79, 1.07)	0.29	0.93 (0.80, 1.09)	0.39
Agreeableness	0.96 (0.83, 1.11)	0.61	0.95 (0.82, 1.11)	0.54	0.99 (0.86, 1.15)	0.92	0.98 (0.86, 1.12)	0.81
Neuroticism	1.10 (0.97, 1.24)	0.13	1.05 (0.93, 1.19)	0.43	0.94 (0.81, 1.09)	0.42	1.13 (0.95, 1.34)	0.16
Executive Function (N cases/N total: 335/5278)								
Openness	0.83 (0.74, 0.93)	<0.001	0.88 (0.78, 0.98)	0.02	0.94 (0.84, 1.06)	0.30	0.95 (0.85, 1.07)	0.43
Conscientiousness	0.75 (0.67, 0.83)	<0.001	0.79 (0.71, 0.89)	<0.001	0.87 (0.78, 0.98)	0.03	0.89 (0.79, 1.01)	0.06
Extraversion	0.91 (0.81, 1.02)	0.11	0.93 (0.82, 1.04)	0.20	1.05 (0.92, 1.19)	0.48	1.07 (0.94, 1.22)	0.30
Agreeableness	0.99 (0.88, 1.11)	0.84	0.98 (0.87, 1.10)	0.69	1.03 (0.91, 1.16)	0.67	1.02 (0.90, 1.15)	0.78
Neuroticism	1.21 (1.08, 1.35)	<0.001	1.17 (1.04, 1.31)	0.01	0.96 (0.83, 1.10)	0.54	0.97 (0.84, 1.11)	0.64
MMSE (N cases/N total: 66/5206)*								
Openness	0.92 (0.73, 1.18)	0.52	0.99 (0.78, 1.26)	0.92	1.03 (0.81, 1.32)	0.80	1.04 (0.81, 1.33)	0.76
Conscientiousness	0.93 (0.73, 1.18)	0.54	1.00 (0.78, 1.27)	0.97	1.07 (0.83, 1.38)	0.61	1.12 (0.87, 1.46)	0.38
Extraversion	1.12 (0.86, 1.46)	0.40	1.12 (0.86, 1.46)	0.41	1.22 (0.92, 1.61)	0.17	1.23 (0.93, 1.64)	0.15
Agreeableness	1.04 (0.80, 1.35)	0.78	1.03 (0.79, 1.3)	0.85	1.06 (0.82, 1.39)	0.65	1.04 (0.80, 1.35)	0.77
Neuroticism	0.89 (0.69, 1.17)	0.41	0.85 (0.65, 1.12)	0.25	0.71 (0.52, 0.97)	0.03	0.72 (0.52, 0.98)	0.04

Abbreviations: OR: Odds Ratio, CI: Confidence Interval, SES: socio-economic status, CES-D: Center for Epidemiologic Studies-Depression scale, MMSE: Mini–Mental State Examination test; *MMSE outcome variable has 72 missing values.

Model 1: adjusted for age, sex, ethnicity, marital status, education; Model 2: Model 1 + SES using occupation position; Model 3: Model 2 + depression history, CES-D score

Model 4: Model 3 + health behaviours (physical activity, smoking status, fruits and vegetable consumption, alcohol consumption), and chronic conditions (coronary heart disease, stroke, diabetes, cancer, chronic obstructive pulmonary disease, Parkinson's disease, and arthritis).

Table 3. Association of personality traits with Cognitive Impairment.

	Model 1		Model 2: Model 1 + SES		Model 3: Model 2 + depression		Model 4: Model 1 + all covariates	
	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Cross-sectional analysis (N cases/N total: 403/5278)								
Openness	0.87 (0.78, 0.96)	0.008	0.90 (0.82, 1.00)	0.06	0.96 (0.86, 1.06)	0.42	0.98 (0.88, 1.09)	0.66
Conscientiousness	0.84 (0.76, 0.92)	<0.001	0.87 (0.79, 0.97)	0.008	0.95 (0.86, 1.06)	0.37	0.98 (0.88, 1.09)	0.70
Extraversion	0.87 (0.78, 0.96)	0.008	0.88 (0.79, 0.98)	0.02	0.96 (0.86, 1.08)	0.54	0.99 (0.88, 1.11)	0.88
Agreeableness	0.94 (0.84, 1.04)	0.24	0.93 (0.83, 1.03)	0.17	0.97 (0.87, 1.08)	0.55	0.96 (0.87, 1.07)	0.51
Neuroticism	1.17 (1.06, 1.30)	0.003	1.15 (1.04, 1.28)	0.009	0.98 (0.87, 1.11)	0.80	1.00 (0.88, 1.13)	0.97
Longitudinal analyses/Incident cases (N cases/N total: 291/4167)								
Openness	1.01 (0.89, 1.15)	0.83	1.05 (0.92, 1.19)	0.47	1.09 (0.96, 1.24)	0.20	1.10 (0.97, 1.26)	0.14
Conscientiousness	0.90 (0.80, 1.01)	0.09	0.94 (0.83, 1.06)	0.29	0.99 (0.87, 1.12)	0.85	0.99 (0.87, 1.13)	0.90
Extraversion	0.96 (0.84, 1.09)	0.50	0.98 (0.86, 1.11)	0.70	1.03 (0.91, 1.18)	0.61	1.05 (0.92, 1.20)	0.47
Agreeableness	1.01 (0.89, 1.14)	0.91	1.00 (0.88, 1.14)	0.97	1.03 (0.91, 1.17)	0.65	1.02 (0.90, 1.16)	0.71
Neuroticism	1.15 (1.01, 1.30)	0.03	1.13 (1.00, 1.28)	0.05	1.04 (0.90, 1.21)	0.59	1.05 (0.91, 1.22)	0.49

Abbreviations: OR: Odds Ratio, CI: Confidence Interval, SES: socio-economic status, CES-D: Center for Epidemiologic Studies-Depression scale, MMSE: Mini–Mental State Examination test; *MMSE outcome variable has 72 missing values.

Model 1: adjusted for age, sex, ethnicity, marital status, education; Model 2: Model 1 + SES using occupation position; Model 3: Model 2 + depression history, CES-D score

Model 4: Model 3 + health behaviours (physical activity, smoking status, fruits and vegetable consumption, alcohol consumption), and chronic conditions (coronary heart disease, stroke, diabetes, cancer, chronic obstructive pulmonary disease, Parkinson's disease, and arthritis).

Table 4. Association between personality traits and incidence of dementia (N=6135).

	Model 1		Model 2: Model 1 + SES		Model 3: Model 2 + depression		Model 4: Model 1 + all covariates	
	HR (95% CI)	**P**	**HR (95% CI)**	**P**	**HR (95% CI)**	**P**	**HR (95% CI)**	**P**
N cases/N total= 231/6135; mean follow-up 6.18 years (SD=1.07)								
Openness	0.94 (0.83, 1.07)	0.38	0.95 (0.84, 1.08)	0.43	1.02 (0.90, 1.16)	0.76	1.03 (0.91, 1.18)	0.63
Conscientiousness	0.72 (0.64, 0.81)	<0.001	0.72 (0.65, 0.81)	<0.001	0.80 (0.71, 0.90)	0.001	0.83 (0.73, 0.93)	0.002
Extraversion	0.85 (0.75, 0.97)	0.02	0.85 (0.75, 0.97)	0.02	0.97 (0.84, 1.11)	0.63	1.00 (0.87, 1.15)	0.98
Agreeableness	1.08 (0.94, 1.25)	0.43	1.08 (0.94, 1.24)	0.28	1.12 (0.98, 1.29)	0.09	1.13 (0.99, 1.30)	0.07
Neuroticism	1.32 (1.16, 1.49)	<0.001	1.32 (1.17, 1.49)	<0.001	1.08 (0.93, 1.26)	0.29	1.10 (0.94, 1.27)	0.24

Abbreviations: HR: Hazard Ratio, SD: Standard Deviation SES: socio-economic status, CES-D: Center for Epidemiologic Studies-Depression scale, MMSE: Mini–Mental State Examination test; *MMSE outcome variable has 72 missing values.

Model 1: adjusted for age, sex, ethnicity, marital status, education; Model 2: Model 1 + SES using occupation position; Model 3: Model 2 + depression history, CES-D score

Model 4: Model 3 + health behaviours (physical activity, smoking status, fruits and vegetable consumption, alcohol consumption), and chronic conditions (coronary heart disease, stroke, diabetes, cancer, chronic obstructive pulmonary disease, Parkinson's disease, and arthritis).

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