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Citation for published version:
Corley, J, Jia, X, Brett, CE, Gow, AJ, Starr, J, Kyle, JAM, Mcneill, G & Deary, IJ 2011, 'Alcohol intake and cognitive abilities in old age: The Lothian Birth Cohort 1936 study.' Cognitive Neuropsychology, vol. 25, no. 2, pp. 166-175. DOI: 10.1037/a0021571

Digital Object Identifier (DOI):
10.1037/a0021571

Link:
Link to publication record in Edinburgh Research Explorer

Document Version:
Peer reviewed version

Published In:
Cognitive Neuropsychology

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Janie Corley and Alan J. Gow are funded by the Sidney De Haan Award, part of the Disconnected Mind project funding from Help The Aged to Ian Deary and John Starr. A Research Into Ageing programme grant to Ian Deary and John Starr supported Alan Gow, Janie Corley and Caroline Brett. We thank the Scottish Council for Research in Education for allowing access to the SMS1947. We thank the LBC1936 Study participants. The work was undertaken by The University of Edinburgh Centre for Cognitive Ageing and Cognitive Epidemiology, part of the cross council Lifelong Health and Wellbeing Initiative (G0700704/84698). Funding from the Biotechnology and Biological Sciences Research Council (BBSRC), Engineering and Physical Sciences Research Council (EPSRC), Economic and Social Research Council (ESRC) and Medical Research Council (MRC) is gratefully acknowledged.

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Tables: 4

Supplementary tables: 2

Abstract

Objective: Moderate alcohol consumption has been associated with better cognitive performance in late adulthood, possibly via improving vascular health. Few studies have examined the potentially confounding roles of prior cognitive ability and social class in this relationship. **Method**: Participants were 922 healthy adults aged about 70 years in the Lothian Birth Cohort 1936 Study, on whom there are IQ data from age 11 years. Alcohol consumption was obtained by self-report questionnaire. Cognitive outcome measures included general cognitive ability, speed of information processing, memory and verbal ability. **Results**: Moderate-substantial drinking (> 2 units/day) was associated with better performance on cognitive tests than low-level drinking (≤ 2 units/day) or non-drinking in men and women. After adjusting for childhood IQ and adult social class, most of these associations were removed or substantially attenuated. After full adjustment, there remained a small, positive association between overall alcohol intake and memory (in women and men) and verbal ability (in women only). Womens' overall alcohol intake was derived almost exclusively from wine. In men, effects differed according to beverage type: wine and sherry/port consumption was associated with better verbal ability, but beer with a poorer verbal ability, and; spirits intake was associated with better memory. **Conclusions**: Prior intelligence and socioeconomic status influence both amount and/or type of alcohol intake, and may partly explain the link between alcohol intake and improved cognitive performance at age 70. Alcohol consumption was found to make a small, independent contribution to memory performance and verbal ability, but the clinical significance of these findings is uncertain.

Key words: alcohol, cognitive function, childhood IQ, aging.

Introduction

Moderate alcohol intake in middle-aged and older adults is associated with reduced all-cause mortality and a lower risk of cardiovascular disease (Naimi et al., 2005). Population-based studies have found that moderate drinking, compared to abstinence, can also benefit cognitive function (Espeland et al., 2005; Lang, Wallace, Huppert, & Melzer, 2007; Stampfer, Kang, Chen, Cherry, & Grodstein, 2005). Evidence from longitudinal assessments of older people suggests that light to moderate drinking has a protective effect against cognitive decline over time (Ganguli, Vander Bilt, Saxton, Shen, & Dodge, 2005; Wright, Elkind, Luo, Paik, & Sacco, 2006). Stampfer et al. (2005) reported that those who drank up to 15 mg of alcohol per day (not more than about one drink), had a 20% decreased risk of cognitive impairment at baseline, compared with non-drinkers, and these ‘moderate’ drinkers experienced less cognitive decline over a two-year period. Some studies have reported a positive association between moderate alcohol intake and improved cognitive performance in women, but not men (Dufouil, Ducimetiere, & Alpérovitch, 1997; Leroi, Sheppard, & Lyketsos, 2002; McGuire, Ajani, & Ford, 2007; Stott et al., 2008), and others, a significant effect in both sexes but a larger effect size in women (Britton, Singh-Manoux, & Marmot, 2004). A few studies have failed to find any positive cognitive benefit of non-excessive alcohol consumption (Cervilla, Prince, & Mann, 2000; Elwood et al., 1999). Inconsistencies may be attributable to methodological issues; a meta-analysis found that definitions of ‘moderate’ drinking vary widely across studies (Peters, Peters, Warner, Beckett, & Bulpitt, 2008).

The ‘beneficial’ cognitive effects of moderate alcohol intake are reportedly heterogenous, concentrated in areas of learning, executive functions and psychomotor speed (Ganguli et al., 2005); verbal knowledge and phonemic fluency (Britton et al., 2004); and in a women-only study, verbal knowledge, phonemic fluency and fine motor speed (Espeland et al., 2006). These, and many other studies, have failed to find strong evidence of an association between alcohol intake and memory. At present, it is unclear how different types of alcoholic beverage are associated with cognitive function in late life. Few epidemiological studies have looked further than overall alcohol intake. There is some suggestion that wine, but not spirits or beer, is protective against cognitive decline (Luchsinger, Tang, Siddiqui, Shea, & Mayeux, 2004) and dementia (Truelsen, Thudium, & Grønbæk, 2002). The proposed explanation is based on the antioxidant activity of the flavonoids found in wine. However, not all studies report consistent results. According to The Nurses' Health Study, using data derived from 12,480 elderly women, no significant differences in risk of cognitive impairment or decline were observed according to type of alcoholic beverage (Stampfer et al., 2005).

Typically, the direction of causation that is studied and assumed is from alcohol to cognitive ability, especially in old age. The most widely accepted mechanism behind the putatively protective role of alcohol on cognitive aging is an indirect benefit via a reduced risk of vascular disease. A quantitative review of moderate alcohol intake and biological markers of CHD risk, reported a causal association via alcohol induced changes in lipids and haemostatic factors (Rimm, Williams, Fosher, Criqui, & Stampfer, 1999). Further support for an effect on brain vasculature comes from Magnetic Resonance Imaging studies which reveal a lower prevalence of white matter abnormalities and infarcts in older persons with moderate alcohol intake than in non-drinkers (Mukamal, Longstreth, Mittleman, Crum, & Siscovick, 2001). However, it is also possible that the observed relation between alcohol and cognitive health is attributable to prior intelligence. Previous studies report that intelligence influences the amount and/or type of alcohol intake. People with a higher IQ tend to drink regularly but moderately (British Medical Association, 2008). Higher IQ scores have also been associated with a preference for wine over other types of alcohol in later life (Mortensen, Sørenson, & Grønbæk, 2005). If moderate drinkers are, on average, more intelligent than non-drinkers, the reported beneficial effect of moderate drinking on cognitive function in adulthood may be confounded by prior ability. Similarly, there appear to be social gradients in drinking. In the Whitehall study, some of the association between alcohol consumption and cognitive function could be explained by social position, as measured by employment grade (Britton et al., 2004). Variations in both IQ and SES may play important confounding roles in the alcohol-cognition relationship, yet many studies attribute causal effects of alcohol intake to improved cognition in the absence of this kind of data.

The sample in the present study is unusual in having validated measures of cognitive ability from childhood and old age as well as a range of sociodemographic and health data. The objectives of the present study were to examine whether: (1) a pattern of light to moderate drinking is associated with better cognitive outcomes in old age than non-drinking; (2) the effects on cognitive outcomes vary by type of alcoholic beverage; and (3) specifically, whether these relationships could be attributed to confounding by prior cognitive ability (age 11 IQ) and/or SES.

Methods

Participants and general methods

Participants were enrolled on the Lothian Birth Cohort 1936 (LBC1936) Study which comprises 1091 men and women. These individuals are surviving participants of the Scottish Mental Survey of 1947 (SMS1947: see Deary, Whalley, & Starr, 2009). Full details of the recruitment and testing of the LBC1936 are given in a free-access protocol paper (Deary et al., 2007). At the time of recruitment, LBC1936 members mostly resided in Edinburgh and its surrounding area (Lothian) in Scotland. They were relatively healthy and lived independently. Between 2004 and 2007, at a mean age of ~70 years, LBC1936 participants attended the Wellcome Trust Clinical Research Facility in Edinburgh to undergo cognitive testing, a clinical assessment and an interview. As a part of their general assessment, participants were asked to complete a Food Frequency Questionnaire. Of the 1091 participants interviewed, 922 (84.5%) provided both alcohol consumption and cognitive data, and formed the present study sample. Ethics permission for the Lothian Birth Cohort 1936 (LBC1936) study protocol was obtained from the Multi-Centre Research Ethics Committee for Scotland (MREC/01/0/56) and from Lothian Research Ethics Committee (LREC/2003/2/29). The research was carried out in compliance with the Helsinki Declaration. All participants gave their written, informed consent.

Procedure

Measurement of alcohol intake. Alcohol intake was assessed using the Scottish Collaborative Group 165-item Food Frequency Questionnaire (FFQ) version 7.0 (http://www.foodfrequency.org). The FFQ has good repeatability (dietary intake in later life is reasonably stable in the short term) and good validity for most nutrients in community dwelling older populations (Jia, Craig, Aucott, Milne, & McNeill, 2008; McNeill, Winter, & Jia, 2009). It is also a valid assessment tool for measuring alcohol intake; there is good agreement between the FFQ and 4-day weighed diet records in men (r = 0.83) and women (r = 0.70) (Masson et al., 2003). This self-report questionnaire measures alcohol use over the previous 2-3 month period from nine alcoholic beverages, namely: ‘low-alcohol lager or beer’; ‘dark beer (export, bitter or stout)’; ‘light beer (lager or continental beer)’; ‘white wine’; ‘red wine’; ‘sherry, port etc’; ‘spirits or liqueurs’; ‘alcopops (e.g. Bacardi Breezer)’ and ‘cider’. Each item on the questionnaire refers to a standard measure, e.g., 1 half-pint (beer/lager/cider), 1 pub measure (spirits). Participants mark one of nine responses to indicate frequency of consumption: rarely or never; 1-3 per month; 1 per week; 2-3 per week; 4-6 per week; 1 per day; 2-3 per day; 4-6 per day; 7+ per day.

In the event of any missing responses, a letter was sent requesting the information. Using standard FFQ protocol, incomplete questionnaires (with 10 or more missing items from a total of 165) were excluded from the analyses. Thirty-nine questionnaires were 'incomplete', 26 were returned blank and 98 were not returned. A total of 928 (85%) completed FFQs were returned. One was later excluded where the amount of alcohol consumed was a clear statistical outlier and information collected at interview revealed a history of problem drinking. Five further individuals were excluded because they were identified as having potential dementia based on a score of < 24 on the Mini-Mental State Examination (Folstein, Folstein, & McHugh, 1975). The final sample for analysis in the present study comprised 922 relatively healthy participants (445 men, 477 women) aged about 70 (M = 69.5, SD = 0.8) years at time of testing. Five of these participants each had one item of missing alcohol data. Therefore, total alcohol intake could be calculated for 917 participants. We calculated the daily alcohol intake in units derived from each beverage based on UK government guidelines[1] and a combined total daily alcohol measure from all 9 sources.

Measurement of cognitive performance at age 70. Cognitive function was assessed using a battery of neuropsychological tests. See the free-access LBC1936 protocol article for a full description of tests (Deary et al., 2007). In the present study, we used three composite cognitive scores derived from principal components analyses (PCA), to represent three distinct cognitive domains. Regression scores were calculated for the first unrotated principal component of the tests in each domain. In each case the scree slopes and eigenvalues suggested that a single component could be extracted.

g factor (general cognitive ability)

[1] Alcohol unit calculations were based on UK Government guidelines (http://www.direct.gov.uk/en/HealthandWellbeing/DG_10036434) as follows: half pint of lager or beer = 1 unit; half pint of low alcohol lager or beer = 0.5 units; standard glass of wine = 2 units; half pint/1 bottle of cider = 1 unit; standard glass of sherry or port = 1 unit; 1 pub measure of spirits or liqueurs = 1 unit; 1 bottle of alcopops = 1.5 units.

A *g* factor score, representing general cognitive ability, was derived from a PCA of scores on six Wechsler Adult Intelligence Scale-III^{UK} (WAIS-III; Wechsler, 1998a) subtests, namely: *Letter-Number Sequencing* (working memory); *Matrix Reasoning* (non-verbal reasoning); *Block Design* (constructional ability); *Digit Symbol* (speed of information processing); *Digit Span Backwards* (working memory); *Symbol Search* (speed of information processing). The first unrotated principal component explained 53% of the variance and all subtests had high loadings.

Processing speed factor

A processing speed factor was derived from a PCA of scores on a set of speed of processing measures, namely: *Symbol Search* (WAIS-III); *Digit Symbol* (WAIS-III); *Inspection Time* (computer-based task used to assess speed of elementary visual processing with no requirement for speeded reactions; Deary et al., 2004a); *Simple (SRT) and Choice Reaction Time (CRT)* (speed and variability of simple information processing; Cox, Huppert & Whichelow, 1993; Deary, Der, & Ford, 2001). The reaction time tasks were administered using a purpose built portable machine with five response keys (1, 2, 0, 3, 4). In *SRT*, the participant pressed the 0 key as quickly as possible after each 0 was shown on the LED screen (20 trials). In *CRT (four-choice)*, the participant pressed the appropriate key (1, 2, 3, or 4) according to the number which appeared on the LED screen, as quickly as possible (40 trials). Mean SRT and CRT response time and standard deviation were calculated. The first unrotated principal component for the speed factor explained 51% of the variance and all tests had high loadings.

Memory factor

A memory factor was derived from a PCA of scores on a set of memory measures from Wechsler Memory Scale-III^{UK} (WMS-III; Wechsler, 1998b), namely: *Logical Memory I Immediate and II Delayed Recall* (verbal declarative memory); *Spatial Span Forwards* and *Spatial Span Backwards* (non-verbal spatial learning and memory); *Verbal Paired Associates I*

Immediate Recall and II Delayed Recall (verbal learning and memory; immediate and delayed recall). The first unrotated principal component explained 43% of the variance and all tests had high loadings.

Verbal ability

Verbal ability was assessed using the *National Adult Reading Test* (NART: Nelson & Willison, 1991) and the *Wechsler Test of Adult Reading* (WTAR: Holdnack, 2001). These tests are widely used to estimate prior cognitive ability and each requires the pronunciation of a list of 50 irregular words.

Mini-Mental State Examination (MMSE)

The *MMSE* is a standardised brief screening measure for cognitive pathology (Folstein et al., 1975). Scores range from 0-30, with a score of less than 24 often used to indicate possible dementia.

The Moray House Test (MHT)

Participants had previously taken part in the nationwide Scottish Mental Survey of 1947 (SMS1947) at age 11. All school children born in 1936 and attending Scottish schools on the 4th of June 1947, took a version of the *Moray House Test (MHT)* No.12 (Scottish Council for Research in Education; SCRE, 1933; 1949), a group administered mental test comprising 71 items and with a time limit of 45 minutes. Often referred to as a 'verbal reasoning' test, it contains items, including: word classification; arithmetic; spatial items; cypher decoding; same-opposites; reasoning; proverbs; practical items; analogies; and following directions. The *MHT* was concurrently validated against the Terman-Merrill Revision of the Binet Scales (Terman & Merrill, 1937) following the SMS1947. The correlation for both boys and girls was .81 (SCRE, 1949). The test conducted at age 11 reflects cognitive functioning towards the end of primary school education and is a valid measure of early-life ability. LBC1936 participants repeated the same test about 60 years later, at ~age 70, as part of the cognitive assessment.

MHT scores at age 11 and 70 were corrected for age in days at time of testing and converted to an IQ scale where $M = 100$ and $SD = 15$. In this sample, the correlation between age 11 and age 70 IQ is .67 ($p < .001$).

Demographic and control variables. Marital status, education (years of full time education) and smoking status (current, ex or never smoker) were ascertained during interview. A medical history was taken (including diagnoses of diabetes, high blood pressure, high cholesterol, cardiovascular disease and stroke). Body mass index (BMI) was calculated from height and weight measurements taken during the physical examination. A physical activity measure (number of days per month of exercise) was obtained from a self-report questionnaire booklet comprising various social and lifestyle questions. Adult social class was derived from participants' highest reported occupation and consisted of 6 categories ranging from I (professional occupations) to V (unskilled occupations), with III (skilled occupations) divided into IIIN (non-manual) and IIIM (manual) (Office for Population Censuses and Surveys, 1980). Women were assigned a social class based on the highest occupation of the household. Due to the small number of participants in class V, classes IV and V were combined.

Statistical analyses

Analyses were performed using SPSS v.14.0. Participants were categorised as non-drinkers, low-level drinkers (≤ 2 units per day) or moderate-substantial drinkers (> 2 units per day). This classification was used to illustrate any demographic and health differences between alcohol intake groups, using analysis of variance and Chi-Square tests, as appropriate. The main analyses examined the associations between alcohol intake (units/day) as a continuous variable and cognitive outcome scores (separately for men and women) using general linear models. Cognitive outcomes were: age 70 IQ; *g* factor; processing speed factor; memory factor; NART and WTAR. Four models were fitted to the data, each including adjustment for potential confounding factors. Model 1 tested the unadjusted effects of alcohol on each outcome measure. Model 2 included age 11 IQ to control for early life ability. Model 3 included occupational social class. The final model adjusted for age 11 IQ and occupational social class in combination. We present relevant estimates of effect size, reported here as partial eta-squared (η_p^2), as well as p-values. Post-hoc, the Sobel Test (Sobel, 1982) was used to test for mediating effects of occupational social class on the associations between childhood IQ and alcohol consumption. An online resource was used (http://www.danielsoper.com/statcalc/calc31.aspx) to calculate the Sobel Test Statistic and we report regression coefficients, standard errors, Sobel statistic (*z*) and p-values.

Results

Descriptive

Characteristics of non-responders. Compared to those who completed the FFQ, non-responders (n = 163) were significantly more likely to: be older (p = .002), male (p = .006), belong to a less professional occupational social class, have fewer years of education, have a lower MMSE, have lower age 11 and age 70 IQ (all p <.001), and a higher BMI (p = .002); and were more likely to have had a diagnosis of diabetes (p = .049) or stroke (p = .020).

[INSERT TABLE 1 APPROX. HERE]

Characteristics of alcohol intake categories. The characteristics of alcohol intake categories are shown in table 1. 15% (134) reported no current alcohol intake (non-drinkers), 54% (497) drank 2 units or less per day (low-level drinkers; M = 0.8, SD = 0.6), and 31% (286) reported a daily intake of greater than 2 units a day (moderate-substantial drinkers; range 2.02 - 20.88, M = 4.6, SD = 2.7). There were significant gender differences between intake groups. More women than men were non- and low-level drinkers, and more men than women were in the moderate-substantial drinking category. Nearly half the men consumed more than 2 units (equivalent to one pint of beer or one glass of wine) per day compared to one in six women. Apart from being male, those reporting a higher alcohol intake were significantly more likely to belong to a professional occupational social class (67% of moderate-substantial drinkers belonged to social class groups I and II, compared to 48% of the non-drinkers), have more years of education, and were less likely to be smokers. Those with a higher alcohol intake were significantly more likely to have a higher childhood IQ and a higher age 70 IQ (both $p <.001$). Moderate-substantial drinkers had, on average, a 6.8 point higher age 11 IQ than non-drinkers, and a 6.1 point higher age 70 IQ than non-drinkers. Non-drinkers were significantly more likely to have had a diagnosis of cardiovascular disease than low or moderate-substantial drinkers. Alcohol intake was not associated with marital status, MMSE score, BMI, level of physical activity or history of hypertension, stroke, diabetes or high cholesterol.

[INSERT TABLE 2 APPROX. HERE]

Alcohol intake category and cognitive outcomes at age 11 and age 70

Separate analyses of cognition-alcohol intake associations were conducted for men and women (see table 2). Mean cognitive scores differed significantly between alcohol intake categories for all cognitive outcome variables in men; and in women, with the exception of age 70 IQ scores (although the trend was in the same direction). The best cognitive scores for men and women were among those drinking > 2 units per day; these moderate-substantial drinkers did better on tests at age 11 and age 70 than both low-level and non-drinkers. The lowest cognitive scores were associated, almost entirely, with the non-drinkers. In an additional analysis, we re-classified drinkers into those drinking within current UK guidelines: 21 units per week for men (n = 270); 14 units per week for women (n = 303) and those exceeding this weekly upper limit (men n = 132, women n = 78). This did not appreciably change any of the associations seen in table 2; the best cognitive scores were still found among those in the highest consumption category. These results are available from the authors on request.

[INSERT TABLE 3 APPROX. HERE]

Type of alcohol, and associations with childhood IQ and social class

Table 3 presents mean intake of each type of alcohol for men and women. The women in our sample were found to derive most of their alcohol units (80%) from wine, whereas men consumed alcohol from a larger range of sources. The mean daily alcohol intake of men (2.63 units) was more than double that of women (1.14 units; p <.001). Compared to women, men consumed significantly more wine, spirits and beer. Consumption of low-alcohol beer, alcopops and cider were very low in this older cohort; therefore, no further analyses are presented using these alcohol types. We examined the relationship between alcohol intake, age 11 IQ and social class. Intake of red wine, white wine, sherry/port and total alcohol intake were associated with a higher childhood IQ and more professional social class (p <.001).

[INSERT TABLE 4 APPROX. HERE]

General linear models

Four stages of general linear model (GLM) were fitted to the data to examine the contribution of alcohol (total and by type) and potentially confounding variables to age 70 cognitive function. Table 4 presents the main GLM results, by gender. For women, we present the effects of total alcohol intake only, as associations were found to reflect the predominant influence of wine intake on cognitive function (full results can be seen in supplementary table 1). Model 1 (unadjusted) showed a positive association between total alcohol (wine) intake and performance across all cognitive domains; the largest effect sizes were seen for verbal ability (NART, η_p^2 = .050; WTAR, η_p^2 = .042). When age 11 IQ and social class were added (independently) to the models, the associations with age 70 IQ, g factor and processing speed became non-significant. The positive associations with memory and NART (but not WTAR) scores remain significant, even after controlling for age 11 IQ and social class in combination.

However, effect sizes were markedly reduced. Overall, the attenuating effects of childhood IQ and social class on these positive associations are very substantial.

In men, nearly half (48%) their total alcohol intake comes from wine, and the remainder, from mainly beer and spirits. Table 4 presents the results for total alcohol intake and wine intake (full results can be seen in supplementary table 2). In the initial unadjusted model, total alcohol intake was associated with significantly better test performance in all cognitive domains. The largest effect sizes were for memory (η_p^2 = .035) and age 70 IQ (η_p^2 = .032). After full adjustment, the only remaining statistical effect of overall alcohol intake on cognitive outcomes in men was a positive association with memory scores, which was also found in women. Contrary to the results found for overall alcohol intake, wine consumption in men was associated with significantly better performance on both verbal ability tests (NART, p = .004, η_p^2 = .020; WTAR, p = .031 η_p^2 = .011) and statistical significance held throughout the models. Again, substantial attenuation from age 11 IQ and social class was observed. The type of alcohol consumed by men was an important factor in relation to cognitive performance (see supplementary table 2). Notably, wine and sherry/port consumption was associated with better cognitive performance, especially on both verbal ability tests, even after full adjustment. The converse was true of beer consumption which was associated with poorer NART performance after adjustments (p = .041, η_p^2= .010). However, spirits intake was associated with a better memory performance (p = .004, η_p^2= .021).

Interaction terms were added in separate models (not presented in Tables) to examine whether there were any interaction effects between childhood IQ and alcohol intake, or social class and alcohol intake, on later cognitive outcomes in either sex. In women, we found no evidence of any interaction effects of childhood IQ and alcohol. However, there was a social class-alcohol interaction on age 70 IQ (p < .001, η_p^2 = .050) and processing speed (p = .026, η_p^2 =.025). Data plots suggested that the only deleterious effects of alcohol consumption on age 70 IQ and processing speed were found in the manual social classes (IIIM, IV, and V). In men, we found no evidence of any interaction effects of social class on any of the cognitive outcomes. However, there was a significant childhood IQ-alcohol interaction on age 70 IQ (p <.001, η_p^2 = .044); and significant childhood IQ-wine interactions on age 70 IQ (p < .001; η_p^2 =.043), NART (p < .002; η_p^2 =.023) and WTAR (p < .037; η_p^2 =.010). Data plots suggested that, in those drinking less alcohol, there were stronger correlations between age 11 and age 70 IQ. That is, in those participants drinking little or no alcohol, more of the variance in their age 70 IQ scores could be accounted for by childhood ability when compared with those drinking more alcohol, among whom causes other than childhood IQ contributed more to cognitive variation in old age.

We also examined the potentially mediating effects of social class on the link between prior cognitive ability and alcohol consumption. Using the Sobel test, we identified a mediating effect of social class, on both the association between childhood IQ and total alcohol consumption (A = -.024, SE_A = .002; z = 2.99, p <.001), and between childhood IQ and wine consumption (B = -.303, SE_B = .098; z = 5.59, p <.001)[2]. The standardised beta of the direct path (age 11 IQ-total alcohol) was .020, and .012 after social class was introduced as a mediator. The amount of the relationship accounted for by social class was .008, representing 40% of the direct effect. For wine intake, the standardised beta of the direct path (age 11 IQ-wine drinking) was .019, and .008 after social class was introduced as a mediator. Therefore, the amount of the relationship between age 11 IQ and wine drinking accounted for by social class was .011, representing 58% of the direct effect.

Discussion

[2] A = the unstandardized regression coefficient for the relationship between the IV and mediator; SE_A = standard error of the relationship between the IV and mediator; B = the regression coefficient for the relationship between the mediator and the DV; SE_B = the standard error of the relationship between the mediator and the DV; z = Sobel Test Statistic

In the present study, drinking more alcohol was associated with better cognitive performance at age 70, by comparison with low-level drinking and no drinking. Moderate-substantial drinkers had better cognitive scores across all cognitive domains tested, with the exception of age 70 IQ scores in women (although this association did not reach significance level, it followed the same positive trend). In line with previous research, abstainers performed more poorly than light and moderate drinkers. However, after controlling for childhood IQ and SES, there remained little evidence of a relationship between alcohol intake and current cognitive function. Where significant effects remained, the reductions in effect sizes were striking. The apparent ‘benefits’ (after controlling for IQ and SES) of a higher overall alcohol intake were confined to memory performance in both men and women. Male drinkers of wine and sherry/port also appeared to have a better verbal ability (crystallized intelligence). However, these effect sizes were modest. It is plausible that the positive alcohol-crystallized IQ associations were still significant after controlling for age 11 IQ because crystallized IQ tests measure ‘peak’ ability and capture variance related to the accumulated intellectual development, and the associated lifestyle and education choices, that take place between childhood and adulthood. However, these ‘positive’ effects did not extend to drinking beer. Beer intake was associated with a poorer crystallized IQ (based on the NART score). Women with a higher wine intake performed better on tests of crystallized IQ and memory, and those consuming spirits performed better on one of the tests of crystallized IQ (NART).

Many previous studies have concluded that alcohol consumption has a direct protective effect on cognition, via vascular mechanisms or otherwise. The current study indicates that this premature conclusion may be erroneous. Prior ability and SES were found to significantly confound the relationship between alcohol intake and cognitive abilities in old age. These findings are in keeping with the previous literature where higher intelligence, measured as early as childhood, was related to a higher alcohol intake in adult life (Batty et al., 2008) but less alcohol induced hangovers (Batty, Deary, & Macintyre, 2006) suggestive of moderate consumption. One other study has attempted to examine the effects of prior ability on the cognitive effects of alcohol use in old age (Cooper et al., 2009). However, it used only an estimate, rather than an actual measure of prior ability. The authors concluded that cognitive ability was no longer associated with overall alcohol use once estimated 'premorbid IQ' (NART) was controlled for. In the present study it was clear that in addition to having NART scores, it was important to have a measure of early life intelligence, and also to analyse the data according to type of alcohol-based drink.

Moderate drinking has previously been reported to be more prevalent in educated, affluent classes and non-drinking more concentrated in the least educated, deprived groups (Jefferis, Manor, & Power, 2007). Our findings support those of a prior study linking alcohol intake, SES and cognitive function, whereby a pattern of higher SES and cognitive scores was found in men consuming light-moderate levels of alcohol than in abstainers or heavy drinkers, and in women drinkers, irrespective of level consumed (Richards, Hardy & Wadsworth, 2005).

Those with a higher IQ (even when measured in childhood) and more advantaged adult SES are more likely to develop a preference for wine and sherry/port drinking. This is consistent with findings from other studies, suggesting that these effects are not particular to this cohort, or to Scottish culture. For example, in studies using large Danish samples, preference for wine over beer and other alcoholic beverages was linked to a higher IQ (Mortensen, Sørensen, & Grønbæk, 2005) and a higher social class (Nielsen, Schnor, Jensen & Grønbæk, 2004; Osler, Godtfredsen & Prescott, 2008). In France, social and environment factors have been linked to alcohol preference; wine drinking was associated with a more favourable social environment whereas the converse was true for beer drinking (Ruidavets et al., 2004). In the USA, wine preference was associated with significantly higher level of education (Paschall & Lipton, 2005). We also found in women that the association between overall alcohol intake and cognitive function was not the same for all social classes; there was some evidence of relative cognitive disadvantage (in age 70 IQ and processing speed) with alcohol, but only in those women drinking greater amounts and who belonged to the manual occupational social class groups. In men, the effects of alcohol were less likely to be moderated by social class but were, to some extent, by prior ability. There was a particularly ‘beneficial’ (modifying) effect of wine consumption on cognitive performance (age 70 IQ and verbal ability) in those with a higher childhood IQ. Correspondingly, the association between childhood IQ and cognitive ability in later life was significantly lower among people who drank alcohol when compared with those who drank little or none.

Moderate alcohol consumption and a preference for wine, in those who are more cognitively able in later life, may be due to the influence of prior ability and social circumstances, on lifestyle factors. Wine drinkers tend to have more favourable health and lifestyle characteristics (e.g. a healthier diet) than that of predominantly beer and spirits drinkers (Paschall & Lipton, 2005). Given the literature documenting the association between a higher IQ and a healthier lifestyle in large, population-representative samples (Batty, Deary, Schoon, & Gale, 2007), it may be that people with higher cognitive ability engage in a lifestyle that protects against cognitive decline. Here, we found no differences between alcohol consumption groups in the markers of lifestyle that were measured, i.e. physical activity and BMI. Further research, perhaps incorporating dietary measures, could evaluate this further.

Study limitations

Information regarding longer-term history of drinking was not available for this dataset. This allowed for previous drinking in the non-drinking group. Ex-drinkers may have very different characteristics from ‘never drinkers’ (Wannamethee & Shaper, 2002). Compared to lifelong teetotallers, ex-drinkers show higher mortality rates (De Dabry et al., 1992, Shaper & Wannamethee, 2000) and cardiovascular risk factors (Shaper & Wannamethee, 2000). In the

LBC1936, non-drinkers have a higher incidence of hypertension, diabetes, high cholesterol, stroke and cardiovascular disease than moderate-substantial drinkers. Rather than reflecting a health benefit to moderate drinking, these data may reflect ex-drinkers having given up alcohol due to poor physical health.

The FFQ measures alcohol intake from the most recent 2-3 month period. Although this short-term data cannot be assumed to reflect habitual patterns of alcohol consumption, there are a number of reports supporting the validity of this form of measurement, given the temporal stability of patterns of alcohol intake in later life. For example, Ruitenberg et al. (2002) found that only 6% of older participants reported a change in drinking pattern in the previous five years. In the present study, classification of alcohol intake into groups was used for illustrative purposes, not for the key analyses. While this could lead to misclassification, self-reports of alcohol consumption are assumed to be valid for the purpose of classifying drinkers into broad consumption bands (Eren, 1995). Drinkers were classified into consumption groups based on units of alcohol intake, as in previous literature (e.g., Huang, Qiu, Winblad, & Fratiglioni, 2002; Stott et al., 2008). Our method was also consistent with those studies using a three-tiered classification representing: non-drinkers; low-level/minimal drinkers (equivalent to ≤1 drink/2 units per day); and moderate drinkers (equivalent to >1 drink/2 units per day (e.g. McGuire, Ajani, & Ford, 2007; Britton, Marmot, & Shipley, 2008; Lang, Wallace, Huppert, & Melzer, 2007; Espeland et al., 2006).

Generalisability

The LBC1936 are a somewhat self-selected sample. The sample represents a healthier and more cognitively able subgroup of the original SMS1947 cohort. This healthy survivor effect may have restricted the range of cognitive outcome scores in the present study. However, the range of cognitive abilities (and IQ scores) was still large and a restriction in range of abilities would likely lead to a modest underestimation of the effect sizes.

Study advantages

All of the participants were born in the same year (1936), thereby eliminating cohort effects and the effects of chronological age. Other studies have been hampered by inadequate cognitive test batteries, limited alcohol measures and inadequate control for confounders. The LBC1936 Study employs a comprehensive battery of cognitive tests. Studies using early life IQ data are rare and given the stability of IQ across the lifespan (Deary, Whalley, Lemmon, Crawford, & Starr, 2000; Deary, Whiteman, Starr, Whalley, & Fox, 2004b), the availability of such data offers a unique advantage in the investigation of factors affecting cognition with aging. The FFQ has advantages in terms of ascertaining detailed information on frequency and amount of different sources of alcohol intake, which is often lacking in studies which only ask about overall alcohol intake. Using FFQ data allowed us to look at the associations between different types of alcohol consumption on cognitive abilities. This proved to be important. The associations between alcohol consumption and cognitive domains are not uniform, and highlight the importance of making a distinction between alcoholic beverage types during data collection. The cross-sectional nature of this study is a potential limitation, but the LBC1936 Study is ongoing. There will be opportunities for follow-ups of this cohort, offering the potential to investigate alcohol’s effects, if any, on cognitive decline.

Conclusions

Our results support the concept that the previously reported ‘moderate alcohol consumption-better cognition’ association is, substantially, a consequence of confounding by higher prior cognitive ability and adult SES. The exceptions were positive associations between alcohol intake and memory performance, and verbal ability. However, the effects were small, and the clinical significance of these findings is uncertain. It is not until we examine mediating factors such as IQ and SES more fully across the lifespan that we can begin to examine the two-way nature of the alcohol-cognition relationship.

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Table 1

Characteristics of the population by alcohol intake category, with reported mean and p-values

	Total sample		Non-drinkers		Low-level drinkers (≤ 2 units/day)		Moderate-substantial drinkers (> 2 units/day)		
	n = 917*		*n* = 134		*n* = 497		*n* = 286		
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*p*
Alcohol intake (units/day)	1.9	*2.4*			0.8	*0.6*	4.6	*2.7*	n/a
Age (in years)	69.5	*0.8*	69.6	*0.9*	69.5	*0.8*	69.4	*0.9*	**.002**
Sex									**<.001**
Male (%)	48.3		29.9		39.0		72.7		
Female (%)	51.7		70.1		61.0		27.3		
Marital status									.062
Married (%)	72.7		64.2		71.8		78.3		
Widowed (%)	13.2		15.0		15.1		9.1		
Unmarried/divorced (%)	14.1		21.0		13.1		12.6		
Social class (%)									**.001**
I	18.9		12.4		17.3		25.1		
II	38.4		35.6		36.9		41.9		
IIIN	23.6		29.5		27.1		14.7		
IIIM	15.9		17.0		16.1		15.1		
IV+V	3.3		5.4		2.6		3.3		
Education (yrs f/t)	10.8	*1.1*	10.5	*0.9*	10.7	*1.1*	11.0	*1.2*	**<.001**
MMSE	28.9	*1.2*	28.9	*1.3*	28.9	*1.3*	29.0	*1.2*	.712
Age 11 IQ	101.4	*14.0*	97.6	*14.8*	100.6	*14.1*	104.4	*13.0*	**<.001**
Age 70 IQ	101.7	*13.2*	99.0	*13.3*	100.4	*14.2*	105.1	*10.3*	**<.001**
Body Mass Index (kg/m2)	27.6	*4.3*	27.7	*4.7*	27.6	*4.3*	27.7	*4.1*	.926
Physical activity (days/mth)	7.6	*8.1*	6.9	*8.6*	8.0	*8.4*	7.3	*7.1*	.286
Smoking status									**<.001**

Non-smokers (%)	44.4	45.5	49.5	35.0	
Ex-smokers (%)	43.3	36.5	38.8	54.2	
Current smokers (%)	12.3	18.0	11.7	10.8	
Hypertension, yes (%)	39.5	46.3	37.6	39.5	.193
Diabetes, yes (%)	7.5	11.9	6.4	7.3	.100
Cholesterol, yes (%)	35.1	39.5	32.4	37.8	.155
Stroke, yes (%)	4.0	6.7	3.8	3.1	.210
Cardiovascular disease, yes (%)	23.8	33.6	20.5	24.8	**.006**

Note.

*5 subjects had some missing alcohol data – unable to calculate total alcohol intake.

Table 2

Alcohol intake category and cognitive outcomes for men and women, with reported mean and p-values (ANOVA)

	Men							Women						
	Non-drinkers		Low-level drinkers (≤ 2 units day)		Moderate-substantial drinkers (> 2 units/day)			Non-drinkers		Low-level drinkers (≤ 2 units/day)		Moderate-substantial drinkers (> 2 units/day)		
	n = 40		*n* = 194		*n* = 208			*n* = 94		*n* = 303		*n* = 78		
Cognitive outcome	*M*	*(SD)*	*M*	*(SD)*	*M*	*(SD)*	*p*	*M*	*(SD)*	*M*	*(SD)*	*M*	*(SD)*	*p*
Age 11 IQ	96.2	(18.3)	98.3	(15.0)	103.7	(13.1)	**<.001**	98.2	(13.0)	102.2	(13.3)	106.3	(12.3)	**<.001**
Age 70 IQ	99.8	(13.6)	100.1	(15.2)	106.0	(9.7)	**<.001**	98.6	(13.2)	100.7	(13.5)	102.9	(11.6)	.103
g factor	-0.10	(1.00)	0.02	(0.98)	0.40	(0.90)	**<.001**	-0.12	(0.91)	0.01	(0.92)	0.34	(0.91)	**.003**
Processing speed	-0.02	(0.97)	-0.03	(1.00)	0.31	(0.88)	**.001**	-0.22	(0.88)	0.08	(0.88)	0.34	(0.92)	**<.001**
Memory	-0.11	(1.00)	-0.12	(0.93)	0.24	(0.93)	**<.001**	-0.02	(0.94)	0.04	(0.98)	0.46	(0.88)	**.002**
NART	34.7	(9.2)	33.2	(7.7)	36.5	(7.5)	**<.001**	32.8	(7.1)	35.2	(7.7)	39.0	(6.1)	**<.001**
WTAR	40.9	(7.8)	40.0	(6.7)	43.2	(6.2)	**<.001**	40.2	(6.5)	41.5	(6.7)	44.5	(4.7)	**<.001**

Table 3

Alcohol intake (units/day) by gender (Mann-Whitney U and p-values) and correlations between alcohol (total sample), age 11 IQ and occupational social class

	Total		Men		Women		Sex differences		Age 11 IQ		Social class	
	n = 922*		*n* = 445		*n* = 477		Mann-Whitney U		Spearman rho		Spearman rho	
Alcohol (units/day)	*M (range)*	*% reporting*	*M (range)*	*% reporting*	*M (range)*	*% reporting*	*U*	*(p)*	r_s	*(p)*	r_s	*(p)*
Total alcohol	1.86 (0-20.9)		2.63 (0-20.9)		1.14 (0-15.1)		**64413.5**	**(<.001)**	**.194**	**(<.001)**	**-.158**	**(<.001)**
Red wine	0.64	54.8	0.83	60.6	0.47	49.5	**88969.0**	**(<.001)**	**.249**	**(<.001)**	**-.291**	**(<.001)**
White wine	0.44	56.1	0.44	51.7	0.44	60.2	**98023.5**	**(.034)**	**.169**	**(<.001)**	**-.256**	**(<.001)**
Sherry/port etc	0.53	26.3	0.61	25.2	0.04	27.5	104318.5	(.561)	**.168**	**(<.001)**	**-.168**	**(<.001)**
Spirits/liqueurs	0.42	54.7	0.69	66.3	0.16	43.8	**70256.0**	**(<.001)**	.053	(.117)	.015	(.643)
Beer (reg+dark)	0.28	36.8	0.56	65.4	0.01	10.1	**43129.50**	**(<.001)**	.018	(.589)	.058	(.082)

Note.
*****total sample = 922; total sample with total alcohol units/day = 917

Table 4

Relationship between alcohol (units/day) and cognitive outcomes at age 70, by gender. General linear models, p values and measure of effect size (partial eta squared values). Model 1: unadjusted; Model 2: age 11 IQ; Model 3: social class; Model 4: age 11 IQ + social class

Predictor	Model	Age 70 IQ		*g* factor		processing speed		Memory		NART		WTAR	
		n = 917		*n* = 898		*n* = 886		*n* = 891		*n* = 921		*n* = 921	
units per day		*p*	η_p^2	*p*	η_p^2	*p*	η_p^2	*p*	η_p^2	*p*	η_p^2	*p*	η_p^2
Total alcohol													
Women	1	**.027**[a]	.010	**.002**[a]	.021	**.006**[a]	.017	**<.001**[a]	.034	**<.001**[a]	.050	**<.001**[a]	.042
	2	.523	.001	.156	.005	.093	.007	**.024**[a]	.012	**.006**[a]	.017	**.007**[a]	.016
	3	.399	.002	.054	.008	.062	.008	**.002**[a]	.021	**.000**[a]	.028	**.003**[a]	.019
	4	.228	.003	.123	.006	.170	.005	**.043**[a]	.010	**.048**[a]	.009	.084	.007
Men	1	**<.001**[a]	.032	**.001**[a]	.028	**.028**[a]	.011	**<.001**[a]	.035	**.002**[a]	.021	**<.001**[a]	.030
	2	**.020**[a]	.013	**.030**[a]	.011	.292	.003	**.010**[a]	.016	.138	.005	**.020**[a]	.013
	3	**.015**[a]	.014	**.040**[a]	.010	.360	.002	**.006**[a]	.018	.178	.004	**.037**[a]	.010
	4	.062	.009	.370	.002	.648	.001	**.030**[a]	.012	.537	.001	.125	.006
Total wine													
Men	1	**<.001**[a]	.034	**<.001**[a]	.032	.088	.007	**<.001**[a]	.031	**<.001**[a]	.060	**<.001**[a]	.047
	2	**.035**[a]	.011	**.022**[a]	.013	.771	.000	**.037**[a]	.011	**<.001**[a]	.042	**.001**[a]	.028
	3	.101	.006	.188	.004	.616	.001	.076	.008	**.008**[a]	.016	**.032**[a]	.011
	4	.208	.004	.345	.002	.349	.002	.212	.004	**.004**[a]	.020	**.031**[a]	.011

Note.
[a] denotes a positive model correlation coefficient; [b] denotes a negative model correlation coefficient

Supplementary table 1

In women, the relationship between alcohol (units/day) and cognitive outcomes at age 70. General linear models, p values and associated partial eta squared values. Model 1: unadjusted; Model 2: age 11 IQ; Model 3: social class; Model 4: age 11 IQ + social class

Predictor	Model	Age 70 IQ		*g* factor		processing speed		Memory		NART		WTAR	
		n = 917		*n* = 898		*n* = 886		*n* = 891		*n* = 921		*n* = 921	
units per day		*p*	η_p^2	*p*	η_p^2	*P*	η_p^2	*P*	η_p^2	*p*	η_p^2	*p*	η_p^2
Total alcohol	1	**.027**[a]	.010	**.002**[a]	.021	**.006**[a]	.017	**<.001**[a]	.034	**<.001**[a]	.050	**<.001**[a]	.042
	2	.523	.001	.156	.005	.093	.007	**.024**[a]	.012	**.006**[a]	.017	**.007**[a]	.016
	3	.399	.002	.054	.008	.062	.008	**.002**[a]	.021	**.000**[a]	.028	**.003**[a]	.019
	4	.228	.003	.123	.006	.170	.005	**.043**[a]	.010	**.048**[a]	.009	.084	.007
Wine	1	**.036**[a]	.009	**.002**[a]	.021	**.019**[a]	.012	**<.001**[a]	.032	**<.001**[a]	.044	**<.001**[a]	.039
	2	.419	.001	.108	.006	.160	.005	**.024**[a]	.012	**.019**[a]	.012	**.010**[a]	.015
	3	.445	.001	.063	.008	.161	.004	**.004**[a]	.019	**.001**[a]	.022	**.005**[a]	.017
	4	.188	.004	.289	.003	.295	.003	**.043**[a]	.010	.121	.006	.116	.006
Spirits	1	.786	.000	.659	.000	.254	.003	.304	.002	.100	.006	.280	.002
	2	.749	.000	.958	.000	.393	.002	.439	.001	**.041**[a]	.009	.212	.003
	3	.888	.000	.579	.001	.194	.004	.321	.002	.062	.008	.235	.003
	4	.869	.000	.850	.000	.305	.003	.468	.001	**.028**[a]	.011	.198	.004
Sherry/port	1	.300	.002	.201	.003	.088	.006	.611	.001	.079	.007	.194	.004
	2	.538	.001	.737	.000	.616	.001	.450	.001	.570	.001	.814	.000
	3	.772	.000	.578	.001	.242	.003	.991	.000	.310	.002	.601	.001
	4	.298	.003	.452	.001	.858	.000	.395	.002	.954	.000	.440	.001
Beer (reg + dark)	1	.607	.001	.321	.002	.148	.005	.257	.003	.376	.002	.305	.002
	2	.704	.000	.806	.000	.500	.001	.608	.001	.423	.001	.269	.003
	3	.931	.000	.541	.001	.272	.003	.378	.002	.584	.001	.494	.001
	4	.938	.000	.599	.001	.661	.000	.668	.000	.605	.001	.408	.002

Note.
[a] denotes a positive model correlation coefficient; [b] denotes a negative model correlation coefficient

Supplementary table 2

In men, the relationship between alcohol (units/day) and cognitive outcomes at age 70. General linear models, p values and associated partial eta squared values. Model 1: unadjusted; Model 2: age 11 IQ; Model 3: social class; Model 4: age 11 IQ + social class

Predictor	Model	Age 70 IQ		*g* factor		processing speed		Memory		NART		WTAR	
		n = 917		*n* = 898		*n* = 886		*n* = 891		*n* = 921		*n* = 921	
units per day		*P*	η_p^2	*p*	η_p^2	*P*	η_p^2	*p*	η_p^2	*P*	η_p^2	*p*	η_p^2
Total alcohol	1	**<.001**[a]	.032	**.001**[a]	.028	**.028**[a]	.011	**<.001**[a]	.035	**.002**[a]	.021	**<.001**[a]	.030
	2	**.020**[a]	.013	**.030**[a]	.011	.292	.003	**.010**[a]	.016	.138	.005	**.020**[a]	.013
	3	**.015**[a]	.014	**.040**[a]	.010	.360	.002	**.006**[a]	.018	.178	.004	**.037**[a]	.010
	4	.062	.009	.370	.002	.648	.001	**.030**[a]	.012	.537	.001	.125	.006
Wine	1	**<.001**[a]	.034	**<.001**[a]	.032	.088	.007	**<.001**[a]	.031	**<.001**[a]	.060	**<.001**[a]	.047
	2	**.035**[a]	.011	**.022**[a]	.013	.771	.000	**.037**[a]	.011	**<.001**[a]	.042	**.001**[a]	.028
	3	.101	.006	.188	.004	.616	.001	.076	.008	**.008**[a]	.016	**.032**[a]	.011
	4	.208	.004	.345	.002	.349	.002	.212	.004	**.004**[a]	.020	**.031**[a]	.011
Spirits	1	.179	.000	.103	.006	.065	.008	**.002**[a]	.021	.827	.000	.154	.005
	2	.482	.001	.307	.003	.175	.004	**.006**[a]	.018	.095	.038	.573	.001
	3	.399	.002	.190	.004	.096	.007	**.004**[a]	.019	.297	.003	.477	.001
	4	.582	.001	.290	.003	.148	.005	**.004**[a]	.021	**.039**[b]	.010	.855	.000
Sherry/port	1	**.013**[a]	.014	**.019**[a]	.013	.121	.006	**.023**[a]	.012	**.004**[a]	.019	**.003**[a]	.020
	2	.057	.009	.065	.008	.261	.003	.081	.007	**.012**[a]	.015	**.010**[a]	.016
	3	**.025**[a]	.012	**.034**[a]	.011	.210	.004	**.033**[a]	.011	**.005**[a]	.018	**.004**[a]	.019
	4	.062	.009	.071	.008	.311	.003	.073	.008	**.009**[a]	.017	**.008**[a]	.017
Beer	1	.680	.000	.920	.000	.821	.000	.675	.000	**.032**[b]	.011	.172	.004
(reg + dark)	2	.469	.001	.837	.000	.550	.001	.714	.000	**.007**[b]	.003	.098	.006
	3	.101	.006	.261	.003	.233	.003	.755	.000	.269	.018	.866	.000
	4	.184	.004	.327	.002	.233	.004	.943	.000	**.041**[b]	.010	.356	.002

Note.
[a] denotes a positive model correlation coefficient; [b] denotes a negative model correlation coefficient