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2 **Alcohol intake and cognitive abilities in old age: the Lothian Birth Cohort**

3 **1936 study**

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23
24 **Tables:** 4

25 **Supplementary tables:** 2

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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.

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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, & Alperovitch, 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

1 between alcohol intake and memory. At present, it is unclear how different types of alcoholic
2 beverage are associated with cognitive function in late life. Few epidemiological studies have
3 looked further than overall alcohol intake. There is some suggestion that wine, but not spirits or
4 beer, is protective against cognitive decline (Luchsinger, Tang, Siddiqui, Shea, & Mayeux,
5 2004) and dementia (Truelsen, Thudium, & Grønbaek, 2002). The proposed explanation is
6 based on the antioxidant activity of the flavonoids found in wine. However, not all studies
7 report consistent results. According to The Nurses' Health Study, using data derived from
8 12,480 elderly women, no significant differences in risk of cognitive impairment or decline
9 were observed according to type of alcoholic beverage (Stampfer et al., 2005).

10 Typically, the direction of causation that is studied and assumed is from alcohol to
11 cognitive ability, especially in old age. The most widely accepted mechanism behind the
12 putatively protective role of alcohol on cognitive aging is an indirect benefit via a reduced risk
13 of vascular disease. A quantitative review of moderate alcohol intake and biological markers of
14 CHD risk, reported a causal association via alcohol induced changes in lipids and haemostatic
15 factors (Rimm, Williams, Fosher, Criqui, & Stampfer, 1999). Further support for an effect on
16 brain vasculature comes from Magnetic Resonance Imaging studies which reveal a lower
17 prevalence of white matter abnormalities and infarcts in older persons with moderate alcohol
18 intake than in non-drinkers (Mukamal, Longstreth, Mittleman, Crum, & Siscovick, 2001).
19 However, it is also possible that the observed relation between alcohol and cognitive health is
20 attributable to prior intelligence. Previous studies report that intelligence influences the amount
21 and/or type of alcohol intake. People with a higher IQ tend to drink regularly but moderately
22 (British Medical Association, 2008). Higher IQ scores have also been associated with a
23 preference for wine over other types of alcohol in later life (Mortensen, Sørensen, & Grønbaek,
24 2005). If moderate drinkers are, on average, more intelligent than non-drinkers, the reported
25 beneficial effect of moderate drinking on cognitive function in adulthood may be confounded

1 complete a Food Frequency Questionnaire. Of the 1091 participants interviewed, 922 (84.5%)
2 provided both alcohol consumption and cognitive data, and formed the present study sample.
3 Ethics permission for the Lothian Birth Cohort 1936 (LBC1936) study protocol was obtained
4 from the Multi-Centre Research Ethics Committee for Scotland (MREC/01/0/56) and from
5 Lothian Research Ethics Committee (LREC/2003/2/29). The research was carried out in
6 compliance with the Helsinki Declaration. All participants gave their written, informed
7 consent.

8

9 **Procedure**

10 **Measurement of alcohol intake.** Alcohol intake was assessed using the Scottish
11 Collaborative Group 165-item Food Frequency Questionnaire (FFQ) version 7.0
12 (<http://www.foodfrequency.org>). The FFQ has good repeatability (dietary intake in later life is
13 reasonably stable in the short term) and good validity for most nutrients in community
14 dwelling older populations (Jia, Craig, Aucott, Milne, & McNeill, 2008; McNeill, Winter, &
15 Jia, 2009). It is also a valid assessment tool for measuring alcohol intake; there is good
16 agreement between the FFQ and 4-day weighed diet records in men ($r = 0.83$) and women ($r =$
17 0.70) (Masson et al., 2003). This self-report questionnaire measures alcohol use over the
18 previous 2-3 month period from nine alcoholic beverages, namely: ‘low-alcohol lager or beer’;
19 ‘dark beer (export, bitter or stout)’; ‘light beer (lager or continental beer)’; ‘white wine’; ‘red
20 wine’; ‘sherry, port etc’; ‘spirits or liqueurs’; ‘alcopops (e.g. Bacardi Breezer)’ and ‘cider’.
21 Each item on the questionnaire refers to a standard measure, e.g., 1 half-pint (beer/lager/cider),
22 1 pub measure (spirits). Participants mark one of nine responses to indicate frequency of
23 consumption: rarely or never; 1-3 per month; 1 per week; 2-3 per week; 4-6 per week; 1 per
24 day; 2-3 per day; 4-6 per day; 7+ per day.

1 In the event of any missing responses, a letter was sent requesting the information.
2 Using standard FFQ protocol, incomplete questionnaires (with 10 or more missing items from
3 a total of 165) were excluded from the analyses. Thirty-nine questionnaires were ‘incomplete’,
4 26 were returned blank and 98 were not returned. A total of 928 (85%) completed FFQs were
5 returned. One was later excluded where the amount of alcohol consumed was a clear statistical
6 outlier and information collected at interview revealed a history of problem drinking. Five
7 further individuals were excluded because they were identified as having potential dementia
8 based on a score of < 24 on the Mini-Mental State Examination (Folstein, Folstein, &
9 McHugh, 1975). The final sample for analysis in the present study comprised 922 relatively
10 healthy participants (445 men, 477 women) aged about 70 ($M = 69.5$, $SD = 0.8$) years at time
11 of testing. Five of these participants each had one item of missing alcohol data. Therefore, total
12 alcohol intake could be calculated for 917 participants. We calculated the daily alcohol intake
13 in units derived from each beverage based on UK government guidelines¹ and a combined total
14 daily alcohol measure from all 9 sources.

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

22 *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.

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

8 *Processing speed factor*

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

21 *Memory factor*

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

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

4 *Verbal ability*

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

9 *Mini-Mental State Examination (MMSE)*

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

13 *The Moray House Test (MHT)*

14 Participants had previously taken part in the nationwide Scottish Mental Survey of
15 1947 (SMS1947) at age 11. All school children born in 1936 and attending Scottish schools on
16 the 4th of June 1947, took a version of the *Moray House Test (MHT)* No.12 (Scottish Council
17 for Research in Education; SCRE, 1933; 1949), a group administered mental test comprising
18 71 items and with a time limit of 45 minutes. Often referred to as a ‘verbal reasoning’ test, it
19 contains items, including: word classification; arithmetic; spatial items; cypher decoding;
20 same-opposites; reasoning; proverbs; practical items; analogies; and following directions. The
21 *MHT* was concurrently validated against the Terman-Merrill Revision of the Binet Scales
22 (Terman & Merrill, 1937) following the SMS1947. The correlation for both boys and girls was
23 .81 (SCRE, 1949). The test conducted at age 11 reflects cognitive functioning towards the end
24 of primary school education and is a valid measure of early-life ability. LBC1936 participants
25 repeated the same test about 60 years later, at ~age 70, as part of the cognitive assessment.

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

4 **Demographic and control variables.** Marital status, education (years of full time
5 education) and smoking status (current, ex or never smoker) were ascertained during interview.
6 A medical history was taken (including diagnoses of diabetes, high blood pressure, high
7 cholesterol, cardiovascular disease and stroke). Body mass index (BMI) was calculated from
8 height and weight measurements taken during the physical examination. A physical activity
9 measure (number of days per month of exercise) was obtained from a self-report questionnaire
10 booklet comprising various social and lifestyle questions. Adult social class was derived from
11 participants' highest reported occupation and consisted of 6 categories ranging from I
12 (professional occupations) to V (unskilled occupations), with III (skilled occupations) divided
13 into IIIN (non-manual) and IIIM (manual) (Office for Population Censuses and Surveys,
14 1980). Women were assigned a social class based on the highest occupation of the household.
15 Due to the small number of participants in class V, classes IV and V were combined.

16

17 **Statistical analyses**

18 Analyses were performed using SPSS v.14.0. Participants were categorised as non-
19 drinkers, low-level drinkers (≤ 2 units per day) or moderate-substantial drinkers (> 2 units per
20 day). This classification was used to illustrate any demographic and health differences between
21 alcohol intake groups, using analysis of variance and Chi-Square tests, as appropriate. The
22 main analyses examined the associations between alcohol intake (units/day) as a continuous
23 variable and cognitive outcome scores (separately for men and women) using general linear
24 models. Cognitive outcomes were: age 70 IQ; g factor; processing speed factor; memory
25 factor; NART and WTAR. Four models were fitted to the data, each including adjustment for

1 potential confounding factors. Model 1 tested the unadjusted effects of alcohol on each
2 outcome measure. Model 2 included age 11 IQ to control for early life ability. Model 3
3 included occupational social class. The final model adjusted for age 11 IQ and occupational
4 social class in combination. We present relevant estimates of effect size, reported here as
5 partial eta-squared (η_p^2), as well as p-values. Post-hoc, the Sobel Test (Sobel, 1982) was used
6 to test for mediating effects of occupational social class on the associations between childhood
7 IQ and alcohol consumption. An online resource was used
8 (<http://www.danielsoper.com/statcalc/calc31.aspx>) to calculate the Sobel Test Statistic and we
9 report regression coefficients, standard errors, Sobel statistic (z) and p-values.

10

11

Results

Descriptive

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[INSERT TABLE 1 APPROX. HERE]

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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 ($p = .020$).

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

1 (equivalent to one pint of beer or one glass of wine) per day compared to one in six women.
2 Apart from being male, those reporting a higher alcohol intake were significantly more likely
3 to belong to a professional occupational social class (67% of moderate-substantial drinkers
4 belonged to social class groups I and II, compared to 48% of the non-drinkers), have more
5 years of education, and were less likely to be smokers. Those with a higher alcohol intake were
6 significantly more likely to have a higher childhood IQ and a higher age 70 IQ (both $p < .001$).
7 Moderate-substantial drinkers had, on average, a 6.8 point higher age 11 IQ than non-drinkers,
8 and a 6.1 point higher age 70 IQ than non-drinkers. Non-drinkers were significantly more
9 likely to have had a diagnosis of cardiovascular disease than low or moderate-substantial
10 drinkers. Alcohol intake was not associated with marital status, MMSE score, BMI, level of
11 physical activity or history of hypertension, stroke, diabetes or high cholesterol.

12 **[INSERT TABLE 2 APPROX. HERE]**

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

14 Separate analyses of cognition-alcohol intake associations were conducted for men and
15 women (see table 2). Mean cognitive scores differed significantly between alcohol intake
16 categories for all cognitive outcome variables in men; and in women, with the exception of age
17 70 IQ scores (although the trend was in the same direction). The best cognitive scores for men
18 and women were among those drinking > 2 units per day; these moderate-substantial drinkers
19 did better on tests at age 11 and age 70 than both low-level and non-drinkers. The lowest
20 cognitive scores were associated, almost entirely, with the non-drinkers. In an additional
21 analysis, we re-classified drinkers into those drinking within current UK guidelines: 21 units
22 per week for men ($n = 270$); 14 units per week for women ($n = 303$) and those exceeding this
23 weekly upper limit (men $n = 132$, women $n = 78$). This did not appreciably change any of the
24 associations seen in table 2; the best cognitive scores were still found among those in the
25 highest consumption category. These results are available from the authors on request.

1 **[INSERT TABLE 3 APPROX. HERE]**

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

3 Table 3 presents mean intake of each type of alcohol for men and women. The women
4 in our sample were found to derive most of their alcohol units (80%) from wine, whereas men
5 consumed alcohol from a larger range of sources. The mean daily alcohol intake of men (2.63
6 units) was more than double that of women (1.14 units; $p < .001$). Compared to women, men
7 consumed significantly more wine, spirits and beer. Consumption of low-alcohol beer,
8 alcopops and cider were very low in this older cohort; therefore, no further analyses are
9 presented using these alcohol types. We examined the relationship between alcohol intake, age
10 11 IQ and social class. Intake of red wine, white wine, sherry/port and total alcohol intake were
11 associated with a higher childhood IQ and more professional social class ($p < .001$).

12 **[INSERT TABLE 4 APPROX. HERE]**

13 **General linear models**

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

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

3 In men, nearly half (48%) their total alcohol intake comes from wine, and the
4 remainder, from mainly beer and spirits. Table 4 presents the results for total alcohol intake
5 and wine intake (full results can be seen in supplementary table 2). In the initial unadjusted
6 model, total alcohol intake was associated with significantly better test performance in all
7 cognitive domains. The largest effect sizes were for memory ($\eta_p^2 = .035$) and age 70 IQ ($\eta_p^2 =$
8 $.032$). After full adjustment, the only remaining statistical effect of overall alcohol intake on
9 cognitive outcomes in men was a positive association with memory scores, which was also
10 found in women. Contrary to the results found for overall alcohol intake, wine consumption in
11 men was associated with significantly better performance on both verbal ability tests (NART, p
12 $= .004$, $\eta_p^2 = .020$; WTAR, $p = .031$ $\eta_p^2 = .011$) and statistical significance held throughout the
13 models. Again, substantial attenuation from age 11 IQ and social class was observed. The type
14 of alcohol consumed by men was an important factor in relation to cognitive performance (see
15 supplementary table 2). Notably, wine and sherry/port consumption was associated with better
16 cognitive performance, especially on both verbal ability tests, even after full adjustment. The
17 converse was true of beer consumption which was associated with poorer NART performance
18 after adjustments ($p = .041$, $\eta_p^2 = .010$). However, spirits intake was associated with a better
19 memory performance ($p = .004$, $\eta_p^2 = .021$).

20 Interaction terms were added in separate models (not presented in Tables) to examine
21 whether there were any interaction effects between childhood IQ and alcohol intake, or social class
22 and alcohol intake, on later cognitive outcomes in either sex. In women, we found no evidence of
23 any interaction effects of childhood IQ and alcohol. However, there was a social class-alcohol
24 interaction on age 70 IQ ($p < .001$, $\eta_p^2 = .050$) and processing speed ($p = .026$, $\eta_p^2 = .025$). Data
25 plots suggested that the only deleterious effects of alcohol consumption on age 70 IQ and

1 processing speed were found in the manual social classes (IIIM, IV, and V). In men, we found no
2 evidence of any interaction effects of social class on any of the cognitive outcomes. However,
3 there was a significant childhood IQ-alcohol interaction on age 70 IQ ($p < .001$, $\eta_p^2 = .044$); and
4 significant childhood IQ-wine interactions on age 70 IQ ($p < .001$; $\eta_p^2 = .043$), NART ($p < .002$;
5 $\eta_p^2 = .023$) and WTAR ($p < .037$; $\eta_p^2 = .010$). Data plots suggested that, in those drinking less
6 alcohol, there were stronger correlations between age 11 and age 70 IQ. That is, in those
7 participants drinking little or no alcohol, more of the variance in their age 70 IQ scores could be
8 accounted for by childhood ability when compared with those drinking more alcohol, among
9 whom causes other than childhood IQ contributed more to cognitive variation in old age.

10 We also examined the potentially mediating effects of social class on the link between
11 prior cognitive ability and alcohol consumption. Using the Sobel test, we identified a mediating
12 effect of social class, on both the association between childhood IQ and total alcohol
13 consumption ($A = -.024$, $SE_A = .002$; $z = 2.99$, $p < .001$), and between childhood IQ and wine
14 consumption ($B = -.303$, $SE_B = .098$; $z = 5.59$, $p < .001$)². The standardised beta of the direct
15 path (age 11 IQ-total alcohol) was .020, and .012 after social class was introduced as a
16 mediator. The amount of the relationship accounted for by social class was .008, representing
17 40% of the direct effect. For wine intake, the standardised beta of the direct path (age 11 IQ-
18 wine drinking) was .019, and .008 after social class was introduced as a mediator. Therefore,
19 the amount of the relationship between age 11 IQ and wine drinking accounted for by social
20 class was .011, representing 58% of the direct effect.

21

22

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

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

20 Many previous studies have concluded that alcohol consumption has a direct protective
21 effect on cognition, via vascular mechanisms or otherwise. The current study indicates that this
22 premature conclusion may be erroneous. Prior ability and SES were found to significantly
23 confound the relationship between alcohol intake and cognitive abilities in old age. These
24 findings are in keeping with the previous literature where higher intelligence, measured as
25 early as childhood, was related to a higher alcohol intake in adult life (Batty et al., 2008) but

1 less alcohol induced hangovers (Batty, Deary, & Macintyre, 2006) suggestive of moderate
2 consumption. One other study has attempted to examine the effects of prior ability on the
3 cognitive effects of alcohol use in old age (Cooper et al., 2009). However, it used only an
4 estimate, rather than an actual measure of prior ability. The authors concluded that cognitive
5 ability was no longer associated with overall alcohol use once estimated ‘premorbid IQ’
6 (NART) was controlled for. In the present study it was clear that in addition to having NART
7 scores, it was important to have a measure of early life intelligence, and also to analyse the data
8 according to type of alcohol-based drink.

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

15 Those with a higher IQ (even when measured in childhood) and more advantaged adult
16 SES are more likely to develop a preference for wine and sherry/port drinking. This is
17 consistent with findings from other studies, suggesting that these effects are not particular to
18 this cohort, or to Scottish culture. For example, in studies using large Danish samples,
19 preference for wine over beer and other alcoholic beverages was linked to a higher IQ
20 (Mortensen, Sørensen, & Grønbaek, 2005) and a higher social class (Nielsen, Schnor, Jensen &
21 Grønbaek, 2004; Osler, Godtfredsen & Prescott, 2008). In France, social and environment
22 factors have been linked to alcohol preference; wine drinking was associated with a more
23 favourable social environment whereas the converse was true for beer drinking (Ruidavets et
24 al., 2004). In the USA, wine preference was associated with significantly higher level of
25 education (Paschall & Lipton, 2005). We also found in women that the association between

1 overall alcohol intake and cognitive function was not the same for all social classes; there was
2 some evidence of relative cognitive disadvantage (in age 70 IQ and processing speed) with
3 alcohol, but only in those women drinking greater amounts and who belonged to the manual
4 occupational social class groups. In men, the effects of alcohol were less likely to be moderated
5 by social class but were, to some extent, by prior ability. There was a particularly ‘beneficial’
6 (modifying) effect of wine consumption on cognitive performance (age 70 IQ and verbal
7 ability) in those with a higher childhood IQ. Correspondingly, the association between
8 childhood IQ and cognitive ability in later life was significantly lower among people who
9 drank alcohol when compared with those who drank little or none.

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

20 **Study limitations**

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

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

5 The FFQ measures alcohol intake from the most recent 2-3 month period. Although this
6 short-term data cannot be assumed to reflect habitual patterns of alcohol consumption, there
7 are a number of reports supporting the validity of this form of measurement, given the
8 temporal stability of patterns of alcohol intake in later life. For example, Ruitenberg et al.
9 (2002) found that only 6% of older participants reported a change in drinking pattern in the
10 previous five years. In the present study, classification of alcohol intake into groups was used
11 for illustrative purposes, not for the key analyses. While this could lead to misclassification,
12 self-reports of alcohol consumption are assumed to be valid for the purpose of classifying
13 drinkers into broad consumption bands (Eren, 1995). Drinkers were classified into
14 consumption groups based on units of alcohol intake, as in previous literature (e.g., Huang,
15 Qiu, Winblad, & Fratiglioni, 2002; Stott et al., 2008). Our method was also consistent with
16 those studies using a three-tiered classification representing: non-drinkers; low-level/minimal
17 drinkers (equivalent to ≤ 1 drink/2 units per day); and moderate drinkers (equivalent to >1
18 drink/2 units per day (e.g. McGuire, Ajani, & Ford, 2007; Britton, Marmot, & Shipley, 2008;
19 Lang, Wallace, Huppert, & Melzer, 2007; Espeland et al., 2006).

20 **Generalisability**

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

1 **Study advantages**

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

18 **Conclusions**

19 Our results support the concept that the previously reported 'moderate alcohol
20 consumption-better cognition' association is, substantially, a consequence of confounding by
21 higher prior cognitive ability and adult SES. The exceptions were positive associations
22 between alcohol intake and memory performance, and verbal ability. However, the effects
23 were small, and the clinical significance of these findings is uncertain. It is not until we
24 examine mediating factors such as IQ and SES more fully across the lifespan that we can begin
25 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) | | <i>p</i> |
|--------------------------------------|-----------------|-----------|----------------|-----------|---|-----------|--|-----------|-----------------|
| | <i>n</i> = 917* | | <i>n</i> = 134 | | <i>n</i> = 497 | | <i>n</i> = 286 | | |
| | <i>M</i> | <i>SD</i> | <i>M</i> | <i>SD</i> | <i>M</i> | <i>SD</i> | <i>M</i> | <i>SD</i> | |
| 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/m ²) | 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 |

Running head: ALCOHOL INTAKE AND COGNITIVE ABILITIES

| | | | | | |
|---------------------------------|------|------|------|------|-------------|
| 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)

| Cognitive outcome | 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) | | | |
| | <i>n</i> = 40 | | <i>n</i> = 194 | | <i>n</i> = 208 | | <i>n</i> = 94 | | <i>n</i> = 303 | | <i>n</i> = 78 | | | |
| | <i>M</i> | (<i>SD</i>) | <i>M</i> | (<i>SD</i>) | <i>M</i> | (<i>SD</i>) | <i>p</i> | <i>M</i> | (<i>SD</i>) | <i>M</i> | (<i>SD</i>) | <i>M</i> | (<i>SD</i>) | <i>p</i> |
| 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 |
| <i>g</i> 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 | |
|---------------------|------------------|-------------|------------------|-------------|------------------|-------------|-----------------|-------------------|----------------------|-------------------|----------------------|-------------------|
| | <i>n</i> = 922* | | <i>n</i> = 445 | | <i>n</i> = 477 | | Mann-Whitney U | | Spearman rho | | Spearman rho | |
| Alcohol (units/day) | <i>M</i> (range) | % reporting | <i>M</i> (range) | % reporting | <i>M</i> (range) | % reporting | <i>U</i> | (<i>p</i>) | <i>r_s</i> | (<i>p</i>) | <i>r_s</i> | (<i>p</i>) |
| 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 | |
|---------------|-------|-----------------------------|------------|-----------------------------|------------|-------------------------|------------|-----------------------------|------------|-----------------------------|------------|-----------------------------|------------|
| | | <i>n</i> = 917 | η_p^2 | <i>n</i> = 898 | η_p^2 | <i>n</i> = 886 | η_p^2 | <i>n</i> = 891 | η_p^2 | <i>n</i> = 921 | η_p^2 | <i>n</i> = 921 | η_p^2 |
| units per day | | <i>p</i> | | <i>p</i> | | <i>p</i> | | <i>p</i> | | <i>p</i> | | <i>p</i> | |
| Total alcohol | | | | | | | | | | | | | |
| <i>Women</i> | | | | | | | | | | | | | |
| | 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 |
| <i>Men</i> | | | | | | | | | | | | | |
| | 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 | | | | | | | | | | | | | |
| <i>Men</i> | | | | | | | | | | | | | |
| | 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

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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 | |
|---------------|-------|-------------------------|------------|-------------------------|------------|-------------------------|------------|-----------------------------|------------|-----------------------------|------------|-----------------------------|------------|
| | | <i>n</i> = 917 | η_p^2 | <i>n</i> = 898 | η_p^2 | <i>n</i> = 886 | η_p^2 | <i>n</i> = 891 | η_p^2 | <i>n</i> = 921 | η_p^2 | <i>n</i> = 921 | η_p^2 |
| units per day | | <i>p</i> | | <i>p</i> | | <i>P</i> | | <i>P</i> | | <i>p</i> | | <i>p</i> | |
| 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 | 1 | .607 | .001 | .321 | .002 | .148 | .005 | .257 | .003 | .376 | .002 | .305 | .002 |
| (reg + dark) | 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

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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 | |
|----------------------|-------|-----------------------------|------------|-----------------------------|------------|-------------------------|------------|-----------------------------|------------|-----------------------------|------------|-----------------------------|------------|
| | | <i>n</i> = 917 | η_p^2 | <i>n</i> = 898 | η_p^2 | <i>n</i> = 886 | η_p^2 | <i>n</i> = 891 | η_p^2 | <i>n</i> = 921 | η_p^2 | <i>n</i> = 921 | η_p^2 |
| | | <i>P</i> | | <i>p</i> | | <i>P</i> | | <i>p</i> | | <i>P</i> | | <i>p</i> | |
| 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 (reg + dark) | 1 | .680 | .000 | .920 | .000 | .821 | .000 | .675 | .000 | .032^b | .011 | .172 | .004 |
| | 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