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Personality traits and facets linked with self-reported alcohol consumption and biomarkers of liver health

Martina Luchetti, PhD[1], **Angelina R. Sutin, PhD**[1], **Alessandro Delitala, MD, PhD**[2], **Yannick Stephan, PhD**[3], **Edoardo Fiorillo, PhD**[4], **Michele Marongiu**[4], **Marco Masala**[4], **David Schlessinger, PhD**[5], and **Antonio Terracciano, PhD**[1]

[1]Florida State University College of Medicine, 1115 W. Call Street, Tallahassee, FL 32306-4300, USA

[2]Azienda Ospedaliero-Universitaria di Sassari, Via Michele Coppino 26a, 07100 Sassari, Italy

[3]EuroMov, University of Montpellier, 700 Avenue du Pic Saint Loup, 34090 Montpellier, France

[4]Institute for Genetic and Biomedical Research (IRGB), National Research Council, Cittadella Universitaria di Cagliari, 09042 Monserrato, Italy

[5]National Institute on Aging (NIA), National Institute of Health, 251 Bayview Boulevard, Baltimore, MD 21224, USA

Abstract

Introduction—This study examines whether the association between Five Factor Model personality traits and alcohol consumption extends beyond self-report to biomarkers of alcohol consumption.

Methods—Community-dwelling adults from Sardinia (*N*=5,380), Italy, completed the revised NEO Personality Inventory and reported on alcohol consumption, while traditional biomarkers of heavy drinking, such as gamma-glutamyl transferase (GGT), were assayed from blood samples.

Results—Associations between self-report measures were modest but consistent with previous findings on the link between personality and alcohol use. For instance, higher scores on the order and self-discipline facets of conscientiousness were associated with reduced risk of heavy alcohol consumption. Personality was also associated with GGT, though effects were small. Personality was unrelated to other biomarkers of liver health.

Martina Luchetti, PhD (Corresponding Author), Florida State University College of Medicine, 1115 W. Call Street, Tallahassee, FL 32306-4300, USA, Phone: +1 850 645 8151; martina.luchetti@med.fsu.edu.

Contributors

Martina Luchetti, Angelina R. Sutin and Antonio Terracciano formulated study questions and hypotheses. Martina Luchetti conducted literature searches and the statistical analyses, and wrote the first draft of the manuscript. Alessandro Delitala, Yannick Stephan, Edoardo Fiorillo, Michele Marongiu, Marco Masala, and David Schlessinger contributed to writing and editing select sections of the paper. All authors contributed to and have approved the final manuscript.

Conflicts of interest

All authors declare that they have no conflicts of interest.

Conclusions—This study adds multi-method evidence in support of a link between personality and health behaviors.

Keywords

alcohol consumption; gamma-glutamyl transferase; liver heath biomarkers; NEO-PIR; personality traits and facets

1. Introduction

Alcohol consumption is prevalent worldwide (SAMHSA, 2016; WHO, 2016). Excessive alcohol intake has harmful consequences on health by increasing risk for diseases such as certain cancers, cardiovascular and liver dysfunctions (Shield, Parry, & Rehm, 2014), and leads to disability and premature death (Lim et al., 2012–2013; WHO, 2014a). Increasing efforts have been directed to identify bio-psycho-social determinants of alcohol use and abuse. In particular, evidence suggests that individuals' characteristic way of thinking, feeling and behaving (personality) is associated with the level of alcohol consumed (Hakulinen et al., 2015; Malouff, Thorsteinsson, Rooke, & Schutte, 2007). Existing research on the link between personality and alcohol relies almost exclusively on self-reports of alcohol consumption. The purpose of the present study is to replicate previous findings and extend this association to biochemical measures of excessive alcohol use.

Personality functioning can be summarized along five broad dimensions, known as the Five-Factor Model (FFM) or Big Five (McCrae & Costa, 1999): neuroticism, the tendency to experience negative emotions; extraversion, an inclination toward being outgoing and sociable; openness, the tendency to be creative and open-minded; agreeableness, the tendency to be trusting and compassionate; and conscientiousness, the tendency to be organized and disciplined. These dimensions have been associated with various alcohol-related outcomes. In particular, high neuroticism, low agreeableness, and low conscientiousness show significant cross-sectional associations with greater alcohol consumption and dependence (Malouff et al., 2007 and Kotov, Gamez, Schmidt, & Watson, 2010 for meta-analyses; e.g., Atherton, Robins, Rentfrow, & Lamb, 2014; Martin & Sher, 1994; Ruiz, Pincus, & Dickinson, 2003). Of the other traits, extraversion tends to positively correlate with alcohol drinking (e.g., Atherton et al., 2014; Cheng & Furnham, 2013; Hong & Paunonen, 2009), whereas the evidence is mixed for openness (e.g., Atherton et al., 2014; Mezquita et al., 2015). More recently, Hakulinen and colleagues (2015) pooled data from eight cohorts and confirmed the association between personality and alcohol consumption concurrently and over time (up to >10 years). In their cross-sectional analyses, they found higher neuroticism and extraversion, and lower agreeableness and conscientiousness were associated with increased risk of heavy vs. moderate alcohol consumption, whereas higher agreeableness and lower extraversion and openness were associated with increased odds of abstinence. Higher extraversion and lower conscientiousness also predicted increased likelihood of transitioning from moderate to heavy consumption during follow-up. In another prospective study, Turiano and colleagues (2012) showed that higher neuroticism and extraversion predicted consumption of more alcoholic drinks, while higher

conscientiousness decreased the probability of alcohol use after accounting for socio-demographic variables.

These findings support the value of FFM in predicting potentially harmful drinking habits. In addition to self-report data, which usually refers to the number of drinks consumed over a given period of time (per week), it would be useful to know whether these associations extend to objective measures of alcohol use. If independent and dependent variables are measured in the same way, such as through self-report, the correlation may be high because of shared method variance. In contrast, when variables are not measured with the same method, their correlation, while likely reduced, reflects an association independent of shared method variance. For example, there is evidence that personality traits, as measured through self-report, are associated with both subjective and objective measures of health behaviors (e.g., self-reported and actigraphy-measured physical activity; Artese, Ehley, Sutin, & Terracciano, 2017; Sutin et al., 2016) and outcomes (e.g., body weight and adiposity; Sutin & Terracciano, 2016; Terracciano et al., 2009). The present study extends the relation between self-reports of personality and alcohol to blood markers of alcohol consumption.

A number of tests can detect alcohol-induced alterations of organ systems or body chemistry and identify hazardous drinking (Allen, Sillanaukee, Strid, & Litten, 2004; Jastrzębska et al., 2016; Niemelä, 2007, 2016; SAMHSA, 2012). Conventional alcohol biomarkers include blood-based measures of gamma-glutamyl transferase (GGT), aspartate amino transferase (AST) and alanine amino transferase (ALT), and mean corpuscular volume (MCV). GGT is an enzyme found in endothelial cell membranes of various organs, primarily in the liver, that mediates peptide transport and glutathione metabolism. GGT is known to rise in response to prolonged excessive alcohol intake. For example, levels of GGT were found to be elevated (on average 65 U/L) among individuals who report drinking ≥5drinks per occasion and repeat this pattern of drinking weekly (Åberg, Helenius-Hietala, Puukka, & Jula, 2017). AST and ALT are serum liver enzymes that also increase with heavy drinking and are markers of liver damage. MCV refers to the average size of red blood cells; elevated MCV may reflect long-lasting hematotoxic effects of alcohol. These biomarkers have been widely used as indirect indices of heavy alcohol consumption, lasting up to several weeks (SAMHSA, 2012), and provide complementary information to self-reports of alcohol intake.

Most research on personality and alcohol also focused solely on the five broad personality domains. Using the revised NEO Personality Inventory (NEO-PI-R; Costa & McCrae, 1992), this study proposes a trait- and facet-level analysis with the goal of providing a more detailed understanding of the relation between personality and alcohol consumption. Relative to the broad five traits, facets are less heterogeneous constructs and often have greater predictive power for specific behaviors and outcomes (Terracciano, Löckenhoff, Crum, Bienvenu, & Costa, 2008; Terracciano et al., 2009; Trobst, Herbst, Masters, & Costa, 2002). We expect excitement-seeking (an extraversion facet) and impulsiveness (a neuroticism facet) to be related to heavy alcohol drinking, as these facets reflect a lack of impulse control, while self-discipline and deliberation (conscientiousness facets that indicate perseverance and premeditation) may prevent excess alcohol consumption (McAdams & Donnellan, 2009; Ruiz et al., 2003).

The purpose of this study is twofold. First, we aim to replicate Hakulinen and colleagues' (2015) findings on the link between FFM personality traits and alcohol consumption and extend the analyses to the facets. We expect neuroticism and extraversion to be associated with increased risk of heavy alcohol consumption, while conscientiousness and agreeableness will be protective. Second, in addition to self-report measures, we also consider biomarkers of heavy drinking and examine their associations with personality among alcohol drinkers; we expected the associations to be similar to the self-reported alcohol consumption. Such an in-depth, multi-method approach can provide further insight into the role personality plays in alcohol drinking.

2. Methods

2.1. Participants

Data were drawn from the SardiNIA project, a large multidisciplinary study in a population-based cohort from Sardinia, Italy (Costa et al., 2007; Pilia et al., 2006). About 62% (N=6,162) of the population aged from 14 to 102 years, from a cluster of four towns in the Ogliastra region was enrolled in the project. After informed consent, blood samples were collected from each participant, along with their medical history, and other physical and self-report measures. From this total sample, 230 participants (3.7%) did not complete the NEO-PI-R due to scheduling conflicts, disinterest, or inability to understand items. Non-respondents tended to be older (M_{age}=67.7, SD=17.0) with lower levels of education (5th grade or below). An additional 263 participants (4.4%) had invalid personality scores according to NEO-PI-R manual (Costa & McCrae, 1992). The analyses in this article are based on 5,380 participants aged over 18 years that had data on personality and alcohol consumption (Table 1). All methods and procedures were approved by local institutional review boards in Italy and USA, and aligned with the Declaration of Helsinki.

2.2. Measures

2.2.1. Personality—Participants completed the Italian version of the NEO-PI-R, which measures five factor traits of personality and 30 facets (Terracciano, 2003). The 240 items were answered on a five-point Likert scale, from *strongly disagree* to *strongly agree*. Participants filled out the questionnaire (87.4%) or chose to have the questionnaire read by a trained psychologist (12.6%); administration mode was controlled in the analyses. Raw scores were standardized as T scores (M=5, SD=1) using combined-sex norms reported in the manual (Costa & McCrae, 1992).

2.2.2. Self-reported alcohol consumption—Participants were asked "Do you drink alcoholic beverages?" If participants responded yes, they were asked how many drinks per week they had, reporting the numbers of beers, wine glasses and spirits. Weekly alcohol consumption was calculated by summing the total number of drinks for each beverage. As in Hakulinen and colleagues' work, participants were then grouped into three categories: no consumption (0 drink/week), moderate consumption (1–20 drink/week for women; 1–27 drinks/week for men), and heavy consumption (≥21 drink/week for women; ≥28 drink/week for men).

2.2.3. Biomarkers of heavy alcohol drinking—Blood samples were collected in the early morning after an overnight fast and serum isolation was subsequently performed following standard centrifugation protocol. Liver function was measured by concentrations of GGT, AST, and ALT (U/L) using an automatic dry chemistry analyzer (A25 analyzer, BioSystems). Markers assessment was performed within two hours after serum isolation. MCV (fL) was quantified through a scatter-sensitive automated blood cell counter (Beckman Coulter).

2.2.4. Covariates—Age, age squared, sex, education (from *elementary school or lower* to *university degree*) and marital status (married/non-married) were included as covariates (Kashdan, Vetter, & Collins, 2005; Turiano et al., 2012), in addition to NEO-PI-R administration mode. Given that alcohol consumption and biomarkers are influenced by factors such as smoking and body weight (Miller & Gold, 1998; Sansone & Sansone, 2013; see also Breitling, Raum, Müller, Rothenbacher, & Brenner, 2009 and Danielsson, Kangastupa, Laatikainen, Aalto, & Niemelä, 2014), we further accounted for self-reported smoking status (i.e.“Do you smoke now?” yes/no) and body mass index (BMI) derived from staff-assessed weight and height (kg/m^2). Participants also reported the presence (yes/no) of liver or biliary diseases (cirrhosis, hepatitis, etc.). For the analysis predicting MCV, we further controlled for hemoglobin disorders (Galanello, 2013; Steinberg & Adams, 1991); a yes/no variable was created based on self-reports of thalassemia, beta heterozygote, beta homozygote, or alfa form, and levels of HbA2 (≥3.5%) and HbF (≥1%).

2.3. Analytic Strategy

To examine the association between personality and self-reported alcohol consumption, multinomial logistic regression was used to estimate the odds ratio of being a heavy drinker or abstainer, compared to being a moderate drinker (reference category; as in Hakulinen et al., 2015) for each trait and facet, controlling for age, age squared, sex, education, marital status, and administration mode. We repeated the analysis using linear regression for alcohol consumption as a continuous variable.

We tested the association between personality and biomarkers of liver health among drinkers (≥1drink/week) using linear regression. To normalize GGT, AST, ALT and MCV distributions, values were natural log-transformed. Each personality trait and facet was tested as a predictor of GGT, AST, ALT and MCV, controlling for the covariates; for the MCV analysis, we also controlled for the presence of thalassemia.

In sensitivity analyses, we further adjusted for participants’ smoking status and BMI, and excluded participants with liver or biliary diseases to examine whether the effects were driven by the presence of liver dysfunctions.

3. Results

Descriptive statistics for the sample are given in Table 1; bivariate correlations between personality, self-reported alcohol consumption and alcohol biomarkers are in supplementary material (Appendix A).

3.1 Personality associations with self-reported alcohol consumption

Multinomial regressions showed significant associations between the five major personality traits and self-reported alcohol consumption: higher conscientiousness and openness were associated with reduced risk of heavy vs. moderate alcohol drinking (Table 2). In particular, for every one standard deviation increase in conscientiousness, the risk of heavy consumption was reduced by >20%. Higher conscientiousness and agreeableness, and lower extraversion and openness were related to higher probability of no alcohol consumption. The associations held controlling for current smoking and BMI and excluding participants with liver diseases. Results were also similar when alcohol consumption was considered as a continuous variable.

Table 2 also reports the facet-level results. Compared to moderate consumption, the impulsiveness facet of neuroticism was associated with increased risk of heavy alcohol consumption, whereas all facets of conscientiousness (except for deliberation), the ideas facet of openness, and the assertiveness facet of extraversion reduced the probability of heavy drinking. The order, self-discipline and deliberation facets of conscientiousness were also associated with increased likelihood of abstinence, along with lower scores on impulsiveness, excitement-seeking, positive emotions, and most facets of openness (except for ideas and values). Notably, some of these facets (e.g., order) were more strongly related to alcohol drinking than their corresponding trait score. With a few exceptions (Table 2), the associations remained significant when controlling for smoking status and BMI, and when excluding participants with liver dysfunctions.

3.2 Personality associations with biomarkers of liver health among drinkers

Linear regressions showed FFM personality to be associated with levels of GGT among drinkers (Table 3): those higher in neuroticism and lower in openness and agreeableness had higher GGT values, controlling for demographics and administration mode[1]. Except for agreeableness, these effects held when accounting for smoking and BMI and excluding participants with liver diseases. No significant associations emerged for the other biomarkers.

Table 3 also reports the results for the facets. Of the neuroticism facets, self-consciousness, impulsiveness, and vulnerability were positively associated with GGT. The order and dutifulness facets of conscientiousness were negatively associated with GGT, along with the fantasy, feelings, and values facets of openness, the straightforwardness and modesty facets of agreeableness, and the activity facet of extraversion. Most associations remained significant when controlling for smoking and BMI and when excluding participants with liver dysfunction. AST, ALT and MCV were generally unrelated to the facets.

[1]In supplemental analyses, we examined whether age and sex moderated the associations between personality and the alcohol variables. There was not a consistent pattern across the alcohol measures. Results for these analyses are in the online supplementary material (Appendix A).

4. Discussion

Using a large sample from Sardinia, Italy, we examined the association between a comprehensive FFM personality measure and self-reports and biochemical indices of alcohol consumption. Except for neuroticism, our results replicated previous meta-analytic findings on the link between personality and self-reported alcohol drinking (Hakulinen et al., 2015; Malouff et al., 2007) and extended the associations to one biomarker of liver function, GGT. Personality traits and facets were generally unrelated with the other three biomarkers of liver health.

Consistent with Hakulinen et al.'s findings, high conscientiousness reduced risk for heavy alcohol drinking. In particular, within this domain, self-discipline and order were the facets more strongly associated with self-reported alcohol use. Individuals who score high on these facets are more methodical or organized, capable of self-control and long-term planning, and thus they are more able to avoid excessive alcohol use. They may also be more concerned about negative effects of alcohol and more motivated to limit consumption (Loukas, Krull, Chassin, & Carle, 2000). As suggested by Weiss and Costa (2005), individuals with high self-discipline may be 'more proactive in engaging in a variety of health-promoting behaviors while avoiding or minimizing health-damaging behaviors' (p. 731; see also Hall, Fong, & Epp, 2014 and Hagger-Johnson & Whiteman, 2007). Of note, in the current sample, more conscientious participants were more likely to be abstainers than moderate or heavy consumers. Abstention from drinking alcohol might be one of the pathways through which conscientiousness is linked to health and longevity (Bogg & Roberts, 2004; Kern & Friedman, 2008; Hill, Turiano, Hurd, Mroczek, & Roberts, 2011).

Contrary to our expectation, neuroticism trait was not associated with heavy alcohol consumption. As suggested in previous studies, this trait might be more strongly related to alcohol abuse/dependence symptoms than to normative levels of alcohol drinking (Malouff et al., 2007; see also Mezquita et al., 2015 and Ruiz et al., 2003). One possibility is that individuals with high neuroticism use alcohol to alleviate tension, depression/anxiety or loneliness (i.e. tension-reduction theories, Cappell & Herman, 1972), and for this reason are more likely to manifest problematic drinking patterns and dependence (Ibáñez et al., 2015; Mezquita et al., 2015; Read & O'Connor, 2006). We note that even though the overall effect of neuroticism was not significant, the facet of impulsiveness was a robust predictor of self-reports of alcohol drinking. Impulsive individuals may be predisposed to drink alcohol, even if not experiencing clinically relevant alcohol-related problems. This result is consistent with the literature on impulsivity-related traits and alcohol use (see Dick et al., 2010 review) and with studies that related the impulsiveness facet to other risk behaviors (Terracciano et al., 2008) and health outcomes (Mõttus et al., 2012; Sutin, Ferrucci, Zonderman, & Terracciano, 2011).

In the current sample, extraversion and openness also predicted alcohol drinking. Extroverts are more likely than introverts to engage in social activities that involve alcohol and derive more reward (e.g., mood enhancement) from this type of social interaction (Fairbairn et al., 2015). Indeed, participants with low scores on excitement-seeking and positive emotions were more likely to be abstainers. Similar to extraversion, openness may also be associated

with how individuals select recreational activities and situations, and thus the accessibility and exposure to alcohol. We found that openness attenuates the risk of heavy (vs. moderate) consumption but also reduces the odds of being an abstainer, which is consistent with a preference for variety, and the search for alcohol-related sensations and experiences.

Agreeableness was associated with abstinence from alcohol, a finding consistent with the Hakulinen et al. study. Agreeable individuals may be more attentive to social norms and avoid behaviors that are not socially approved, such as the use of psychoactive substance (Terracciano et al., 2008). Turiano and colleagues (2012) found that higher agreeableness decreases the odds of alcohol-related problems. Alcohol may indeed encourage hostility toward others and aggressive and delinquent behaviors (e.g., Miller et al., 2016). Heavy drinkers, however, did not differ from moderate drinkers in term of (dis)agreeableness in our sample.

Notably, most published studies rely on self-report measures of alcohol use. In fact, there is some concern that individuals may underreport their true level of alcohol consumption or be inaccurate in quantifying their alcohol intake. In addition to self-reported number of drinks, we considered biomarkers of liver health as indices of heavy drinking. For GGT, results were generally consistent with self-reports of alcohol consumption: GGT levels were primarily associated with low scores on openness, agreeableness, and specific facets of conscientiousness (i.e. low order), and with high neuroticism, though the regression coefficients were small in size. This pattern of associations did not extend to AST, ALT or MCV. A variety of factors modulate levels of these biomarkers, including weight gain and changes in lifestyle (Danielsson et al., 2014; Niemelä, 2016). Consequently, psychosocial factors, such as personality, are likely to have only a modest effect. Despite this, the present research provides preliminary evidence for an association between personality and one of the most widely used biomarkers of heavy drinking, GGT.

Future work can consider a broader panel of alcohol biomarkers to better characterize and monitor alcohol drinking over time. For instance, combinations of GGT with other blood constituents, such as carbohydrate-deficient transferase (CDT), have shown stronger correlations with actual alcohol intake than either GGT or CDT alone (e.g., Hietala, Koivisto, Anttila, & Niemelä, 2006). Compared to GGT or CDT, AST, ALT and MCV are somewhat less sensitive to detect excessive drinking (SAMHSA, 2012), and this issue may explain the null findings we observed for these indices in our sample. These conventional biomarkers should be examined in combination with newer direct blood markers of alcohol drinking (e.g., phosphatidyl ethanol, PEth; Wurst et al., 2010) and other physiological tests to detect alcohol abuse (e.g., hair tests; Crunelle et al., 2016).

The strengths of this study include the use of a large community sample, the assessment of both traits and facets of personality, and the examination of multiple indices of alcohol consumption. Few considerations are nonetheless needed. First, we performed multiple statistical tests to address the research questions. Even though this may increase risk of a Type I error, we chose to not correct level of significance for multiple testing because such corrections can be overly conservative and inflate Type II error (Perneger, 1998). We pinpoint that findings were consistent with theory and previous research on personality and

alcohol use. Second, our sample was from Sardinia, Italy, while previous studies were mostly from the US and the UK. According to the WHO online database, Italy is identifiable as a low-risk country for alcohol-attributable disease burden (WHO, 2014b). Alcohol consumption is closely linked to eating and mealtimes among Italians, who are more likely to engage in regular moderate drinking than risky binge drinking, which may attenuate consequences on liver function and health in this population. Perissinotto and colleagues (2010) found wine drinking to be a lifelong habit among elderly Italian men, with moderate levels of consumption associated with more favorable health profiles compared to abstinence. Even among younger Italians, reaching intoxication remains a rare motive for drinking (Allamani, Beccaria, & Voller, 2010).

While this study was cross-sectional, past research has shown that personality traits contribute to changes in drinking rates over time (Hakulinen et al., 2015). Even though potential reciprocal relations could not be assessed, this research represents a step toward understanding the factors that contribute to alcohol use and excessive drinking by identifying personality traits and specific facets associated with biochemical indices of alcohol use in addition to self-reports. This study adds multi-method evidence in support of a link between personality and health behaviors.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Highlights

- We examined Five Factor Model personality in relation to self-report and biomarkers of alcohol use
- Results confirmed the link of personality traits and facets with self-reported alcohol drinking
- Neuroticism, lower openness and agreeableness predicted elevated gamma-glutamyl transferase
- Personality traits and facets were unrelated to other biomarkers of liver health

Table 1

Characteristics of the sample

	Total	Self-reported Alcohol Consumption			
		No Consumption	Moderate Consumption	Heavy Consumption	*p*-value (chi-square or ANOVA)
	N = 5,380	N = 2,859	N = 2,017	N = 480	
Age	44.4 (16.2)	41.2 (15.9)	47.3 (15.9)	51.8 (13.9)	<.001
Females	58.2 %	76.7 %	44.2 %	7.5 %	<.001
Married	59.9 %	54.0 %	64.1 %	79.2 %	<.001
High school or higher education	33.5 %	39.2 %	30.4 %	11.7 %	<.001
Biomarkers of liver health					
GGT (U/L)	28.2 (39.0)	20.8 (25.1)	30.4 (35.8)	62.9 (78.8)	<.001
AST (U/L)	21.6 (14.2)	20.3 (11.8)	22.0 (13.7)	28.0 (23.8)	<.001
ALT (U/L)	25.4 (22.1)	22.9 (21.1)	26.3 (21.5)	36.1 (27.1)	<.001
MCV (fL)	86.6 (9.3)	85.8 (9.1)	87.0 (9.4)	89.3 (10.0)	<.001
Smokers	20.9 %	18.5 %	22.0 %	28.3 %	<.001
BMI (kg/m^2)	25.5 (4.6)	24.9 (4.9)	25.9 (4.2)	27.4 (4.1)	<.001
Liver Diseases (Yes)	6.9%	7.1 %	6.7 %	6.3 %	.706

Note. Mean (unadjusted) and standard deviations are reported if not otherwise specified. 47.6 % of the total sample reported to drink alcohol beverages; drinking categories: no consumption; moderate consumption (1–20 drink/week for women; 1–27 drinks/week for men); and heavy consumption (≥21 drink/week for women; ≥28 drink/week for men).

GGT = gamma-glutamyl transferase; AST = aspartate aminotransferase; ALT = alanine aminotransferase; MCV = mean corpuscular volume of erythrocytes.

Table 2

Associations between personality and self-reported alcohol consumption

	Self-reported Alcohol Consumption			Multinomial Logistic Regressions ORs (95% CI)		Linear Regressions (*β*s)
	No consumption	**Moderate consumption**	**Heavy consumption**	**Heavy vs. moderate consumption**	**No consumption vs. moderate consumption**	**Number of drinks/week**
Neuroticism	**5.49 (.02)**	**5.51 (.02)**	**5.61 (.04)**	**1.13 (0.99–1.29)**	**0.98 (0.91–1.05)**	**.02**
N1: Anxiety	5.72 (.02)	5.70 (.02)	5.69 (.04)	1.00 (0.87–1.14)	1.03 (0.96–1.11)	−.01
N2: Angry Hostility	5.36 (.02)	5.37 (.02)	5.42 (.04)	1.02 (0.91–1.15)	0.98 (0.92–1.05)	.02
N3: Depression	5.45 (.02)	5.47 (.02)	5.56 (.04)	1.09 (0.96–1.24)	0.98 (0.92–1.05)	.02
N4: Self-consciousness	5.25 (.02)	5.21 (.02)	5.30 (.05)	1.10 (0.98–1.23)	1.04 (0.97–1.10)	.00
N5: Impulsiveness	4.70 (.02)	4.79 (.02)	4.95 (.04)	1.21 (1.06–1.37) **	0.89 (0.83–0.96) **	.05 **
N6: Vulnerability	5.68 (.02)	5.70 (.02)	5.80 (.05)	1.09 (0.98–1.22)	0.98 (0.92–1.04)	.02
Extraversion	**4.82 (.02)**	**4.90 (.02)**	**4.90 (.04)**	**0.99 (0.87–1.14)**	**0.89 (0.83–0.96)** **	**.03** *
E1: Warmth	4.80 (.02)	4.84 (.02)	4.86 (.05)	1.02 (0.91–1.15)	0.95 (0.89–1.02)	.01
E2: Gregariousness	5.41 (.02)	5.45 (.02)	5.50 (.05)	1.04 (0.92–1.17)	0.96 (0.90–1.02)	.02
E3: Assertiveness	4.73 (.02)	4.77 (.02)	4.68 (.04)	0.87 (0.77–1.00) *a	0.94 (0.87–1.02)	.00
E4: Activity	5.23 (.02)	5.25 (.02)	5.17 (.04)	0.93 (0.81–1.06)	0.97 (0.90–1.04)	.00
E5: Excitement-seeking	4.63 (.02)	4.73 (.02)	4.76 (.04)	1.03 (0.90–1.18)	0.87 (0.81–0.93) **	.04 **
E6: Positive emotions	4.47 (.02)	4.55 (.02)	4.60 (.05)	1.06 (0.94–1.20)	0.93 (0.87–0.99) *	.02 *
Openness	**4.58 (.02)**	**4.69 (.02)**	**4.62 (.04)**	**0.85 (0.74–0.97)** *	**0.87 (0.81–0.93)** **	**.03** *
O1: Fantasy	5.06 (.02)	5.12 (.02)	5.10 (.04)	0.92 (0.81–1.04)	0.93 (0.86–0.99) *	.01
O2: Aesthetics	5.17 (.02)	5.26 (.02)	5.27 (.04)	0.93 (0.81–1.06)	0.88 (0.81–0.95) **	.04 **
O3: Feelings	4.58 (.02)	4.66 (.02)	4.60 (.04)	0.89 (0.79–1.01)	0.91 (0.85–0.97) **	.01
O4: Actions	4.90 (.02)	4.99 (.02)	4.99 (.05)	0.99 (0.88–1.11)	0.89 (0.84–0.95) **	.03 *
O5: Ideas	4.45 (.02)	4.50 (.02)	4.36 (.04)	0.82 (0.72–0.92) **	0.94 (0.87–1.00)	−.00
O6: Values	4.10 (.02)	4.15 (.02)	4.12 (.04)	0.92 (0.81–1.06)	0.94 (0.88–1.01)	.00
Agreeableness	**4.74 (.02)**	**4.66 (.02)**	**4.60 (.04)**	**0.89 (0.78–1.01)**	**1.12 (1.04–1.20)** **	**−.05** **
A1: Trust	4.31 (.02)	4.29 (.02)	4.23 (.05)	0.94 (0.84–1.05)	1.01 (0.95–1.08)	−.02

	Self-reported Alcohol Consumption			Multinomial Logistic Regressions ORs (95% CI)		Linear Regressions (*β*s)
	No consumption	**Moderate consumption**	**Heavy consumption**	**Heavy vs. moderate consumption**	**No consumption vs. moderate consumption**	**Number of drinks/week**
A2: Straightforwardness	4.85 (.02)	4.75 (.02)	4.76 (.05)	0.95 (0.84–1.07)	1.12 (1.05–1.20) **	−.03 **
A3: Altruism	4.77 (.02)	4.71 (.02)	4.70 (.05)	0.97 (0.86–1.08)	1.07 (1.00–1.14) * *a*	−.03 *
A4: Compliance	4.45 (.02)	4.33 (.02)	4.22 (.05)	0.92 (0.83–1.02)	1.11 (1.04–1.17) **	−.06 **
A5: Modesty	5.27 (.02)	5.20 (.02)	5.19 (.04)	0.97 (0.86–1.10)	1.10 (1.02–1.18) *	−.03 **
A6: Tender-mindedness	5.34 (.02)	5.39 (.02)	5.35 (.05)	0.92 (0.83–1.03)	0.95 (0.89–1.01)	.01
Conscientiousness	**5.01 (.02)**	**4.93 (.02)**	**4.76 (.04)**	**0.79 (0.70–0.89)** **	**1.10 (1.03–1.18)** **	**−.05** **
C1: Competence	4.29 (.02)	4.28 (.02)	4.18 (.04)	0.87 (0.77–0.98) *	1.01 (0.95–1.08)	−.02
C2: Order	4.93 (.02)	4.84 (.02)	4.62 (.05)	0.75 (0.67–0.85) **	1.10 (1.03–1.17) **	−.05 **
C3: Dutifulness	5.14 (.02)	5.09 (.02)	5.01 (.04)	0.88 (0.78–1.00) *a*	1.06 (0.99–1.14)	−.03 **
C4: Achievement Striving	5.03 (.02)	5.01 (.02)	4.91 (.04)	0.87 (0.78–0.98) *a*	1.02 (0.96–1.10)	−.02
C5: Self-discipline	4.90 (.02)	4.82 (.02)	4.70 (.04)	0.84 (0.74–0.95) **	1.10 (1.03–1.18) **	−.05 **
C6: Deliberation	5.62 (.02)	5.54 (.02)	5.44 (.05)	0.92 (0.83–1.02)	1.08 (1.01–1.14) *	−.03 *

Note. Means (and standard errors) of personality traits and facets are adjusted for sociodemographic factors and administration mode. ORs = Odds Ratios; 95 % CI = 95 % Confidence Interval. The reference category in multinomial regression was moderate alcohol consumption; ORs are expressed as 1SD increase in each personality trait or facet of interest.

[a]Effects were reduced to non-significance when controlling for smoking and BMI, and when excluding individuals with liver diseases.

*$p < .05$,

**$p < .01$.

Table 3

Associations between personality and alcohol biomarkers among drinkers

	Multiple Linear Regressions (βs)			
	GGT	**AST**	**ALT**	**MCV**
Neuroticism	**.05****	**.02**	**.01**	**.01**
N1: Anxiety	.00	.01	−.00	.01
N2: Angry Hostility	.03	.01	.00	−.03
N3: Depression	.03	.01	−.00	.02
N4: Self-consciousness	.03*	.02	.01	−.00
N5: Impulsiveness	.05*a	.03	.04*a	.02
N6: Vulnerability	.04*	.01	−.00	.02
Extraversion	**−.01**	**−.02**	**.01**	**.02**
E1: Warmth	−.00	.01	.02	.03*a
E2: Gregariousness	−.00	−.02	.01	.04*
E3: Assertiveness	−.02	−.02	−.03	−.03
E4: Activity	−.04*	.00	.01	.01
E5: Excitement-seeking	.02	−.01	.02	.03
E6: Positive emotions	.01	−.02	.00	.00
Openness	**−.05****	**−.02**	**−.03**	**.03**
O1: Fantasy	−.04*a	.02	−.00	.02
O2: Aesthetics	−.01	−.01	−.02	.02
O3: Feelings	−.04*	−.01	−.03	.01
O4: Actions	−.02	−.03	−.03	.04*a
O5: Ideas	−.02	−.01	.00	−.01
O6: Values	−.05**	−.02	−.03	.04*a
Agreeableness	**−.04*a**	**−.02**	**−.03**	**.01**
A1: Trust	−.01	−.02	−.01	.02
A2: Straightforwardness	−.05**	−.05*a	−.07**	.00
A3: Altruism	−.00	−.00	−.00	.03*
A4: Compliance	−.02	.00	.01	−.01
A5: Modesty	−.04*	−.02	−.03	.01
A6: Tender-mindedness	−.00	.01	.00	−.00
Conscientiousness	**−.03**	**.02**	**.00**	**−.02**
C1: Competence	−.01	.02	.01	−.03
C2: Order	−.04*	.00	−.00	−.02
C3: Dutifulness	−.03*a	−.01	−.00	−.01
C4: Achievement Striving	−.00	.03	.00	−.00
C5: Self-discipline	−.03	.00	−.01	−.01

	Multiple Linear Regressions (*β*s)			
	GGT	**AST**	**ALT**	**MCV**
C6: Deliberation	−.01	.02	.01	−.01

Note. Dependent variables were naturally log transformed. All analyses controlled for sociodemographic factors and administration mode; for MCV, we further account for presence of thalassemia.

[a] Effects were reduced to non-significance when additionally controlling for smoking and BMI, and when excluding individuals with liver diseases.

* $p < .05$,

** $p < .01$.