Is within-individual variation in personality traits associated with changes in health behaviors? Analysis of 7 longitudinal cohort studies

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Abstract

Personality traits are related to health behaviors but it is unknown whether changes in personality would lead to changes in health behaviors. We examined whether naturally occurring, within-individual variation in personality traits over time is associated with corresponding changes in smoking, physical activity, alcohol consumption, and body mass index. Data were from 7 longitudinal cohort studies with a total sample of 56,786 participants with 2 or 3 repeated measurements of the Five Factor Model personality traits assessed over 4 to 19 years. Repeated measurements were used to tease apart between-individual and within-individual associations. In the within-individual analysis, all the personality traits were associated with physical activity, and extraversion was associated with risky alcohol consumption. There were no other within-individual associations. In the between-individual analysis, lower conscientiousness, emotional stability, agreeableness, and openness to experience, and higher extraversion, were associated with many risky health behaviors. Our findings suggest that health behaviors are related mostly to stable, between-individual differences in personality traits, but changes in adult personality may have only limited association with changes in health behaviors.

Personality has been related to many important health outcomes, including all-cause mortality (Graham et al., 2017; Jokela et al., 2013), dementia (Low, Harrison, & Lackersteen, 2013), cardiovascular disease (Jokela, Pulkki-Råback, Elovainio, & Kivimäki, 2014), obesity (Jokela et al., 2013), and type-2 diabetes (Jokela, Elovainio, et al., 2014). Personality has also been associated with health behaviors, such as smoking (Hakulinen, Hintsanen, et al., 2015), physical inactivity (Sutin et al., 2016), and heavy alcohol consumption (Hakulinen, Elovainio, et al., 2015), and with subclinical biomarkers of health, such as systemic inflammation (Luchetti, Barkley, Stephan, Terracciano, & Sutin, 2014) and lung function (Terracciano, Stephan, Luchetti, Gonzalez-Rothi, & Sutin, 2016). Of the personality traits included in the Five Factor Model, low conscientiousness has emerged as the most robust personality correlate of poor health, being associated with a wide range of diseases, risky health behaviors and mortality from all causes and specific causes. High extraversion and lower emotional stability are also associated with poor health behaviors but less so with all-cause mortality or most chronic diseases (Jokela, 2018). Low agreeableness and low openness to experience have predicted some specific health outcomes, such as increased risk for Alzheimer's disease (Terracciano et al., 2014) and lower frequency of physical activity (Sutin et al., 2016).

Studies of personality could help to identify psychological characteristics that expose people to modifiable health risks and thus inform health preventions and interventions (Hampson, 2012; Turiano, Chapman, Gruenewald, & Mroczek, 2015). Under the assumption of causality, the associations between personality traits and health behaviors imply that changes in a person's personality traits will lead to corresponding changes in their health behaviors (English & Carstensen, 2014). For example, a person whose conscientiousness increases over time would be expected to become more physically activity and reduce smoking and alcohol consumption. If, on the other hand, the personality traits were mere risk

markers for poor health behaviors, there would be no causal associations and therefore no co-occurring changes of personality and health behaviors would be expected (Kim, 2016; Turiano et al., 2012).

To address the issue of causality, one would ideally carry out a randomized trial where personality traits were modified in the treatment group. Changes in health behaviors would then be compared with those in a control group over a sufficient follow-up time (Chapman, Hampson, & Clarkin, 2014; Conrod et al., 2013). Such an experiment might not be feasible because it would require an effective treatment protocol for a long-term personality change and a sufficiently long follow-up period to allow health behaviors to change. In the absence of such experiments, quasi-experimental study designs can be used to gather clues of causality. Any single quasi-experimental study design cannot provide a definitive answer to the question of causality but converging evidence from different quasi-experimental studies can triangulate reasonable evidence for or against causal interpretations (Lawlor, Tilling, & Smith, 2017).

A longitudinal study with only one baseline measurement of personality does not provide robust evidence for causality because this study design is not effective in controlling for potential confounders that influence both personality and health behaviors. A better study design would include repeated measurements of both personality traits and health behaviors from the same participants to test whether naturally occurring variation in personality is accompanied by corresponding changes in health behaviors (Gunasekara, Richardson, Carter, & Blakely, 2014; Jokela, 2014, 2015). The within-individual analysis of repeated measurements is not affected by any of the person's characteristics that remain the same over time for, as the analysis only considers within-individual variations across measurement times. Family background, genetic dispositions, and adult educational level are some of the potential confounding factors that might explain associations between personality and health

behaviors (e.g., Morton, Turiano, Mroczek, & Ferraro, 2018; Jokela et al., 2013; Kim, 2016) but they cannot confound the within-individual associations insofar as they do not change over time for the same individual. Within-individual analysis is particularly useful in addressing potential confounding because one does not need to measure the confounders to adjust for them in the analysis.

In this multi-cohort study, we used repeated-measurement data to examine whether within-individual variation in personality traits is related to within-individual variation in health behaviors. We hypothesized that personality traits are causally related to health behaviors and thereby the naturally occurring personality variation over time is associated with variation in health behaviors. The effect sizes of the within-individual associations are therefore expected to be similar to the between-individual effect sizes. To obtain robust evidence, we tested this hypothesis in 7 longitudinal studies from the United States, the United Kingdom, Germany, Australia, and Japan with a total sample size of more than 56,000 participants. We had not preregistered any hypotheses.

Materials and Methods

Participants were from 7 independent studies with a total of 8 cohorts, as one of the studies included two subsamples. The included studies were the Household, Income, and Labour Dynamics in Australia (HILDA); the Health and Retirement Study (HRS); the Midlife in the United States (MIDUS); the Midlife in Japan (MIDJA) study; the German Socioeconomic Panel Study (SOEP); the Wisconsin Longitudinal Study with the graduate and sibling samples (WLSG and WLSS); and the UK Household Longitudinal Study (UKHLS) which originally began as the British Household Panel Survey (BHPS) in 1991 and was extended to UKHLS in 2009 with the repeated measurements derived from participants who participated both in the UKHLS and BHPS. The descriptive statistics of the cohorts are reported in **Table**

1 and full description of the cohorts can be found in the Online Supplementary Material. We cannot make the data openly available because we do not own the rights to the datasets, but all the data are openly available from the Inter-university Consortium for Political and Social Research (icpsr.umich.edu), the UK Data Service (ukdataservice.ac.uk), or the study websites as described in the Online Supplementary Material, which also provides the variable names in the different datasets and templates for the statistical analyses used to produce the results.

Supplementary appendix reports the details of the measures in each cohort study. Briefly, *personality* was assessed with different instruments of the Five Factor Model, including a 36-item Big Five Markers Scale (HILDA); a 25-item Big Five scale developed in the MIDUS study (MIDUS, HRS, MIDJA); a 29-item version of the Big Five Inventory (WLSG, WLSS); and a 15-item short Big Five Inventory (SOEP, UKHLS). *Smoking* was coded dichotomously (non-smoker vs. current smoker) based on self-reports. For participants who were smokers we also examined the number of cigarettes smoked per day (coded as a continuous variable). *Physical inactivity* was assessed with self-reported frequencies of moderate or vigorous leisure-time physical activity. Physical inactivity was coded as a dichotomous variable because different studies had different ways of measuring it, making it impossible to harmonize a continuous measure across cohorts. Alcohol consumption was assessed with three different indicators: *number of alcoholic drinks per week* (treated as a continuous variable), *heavy alcohol consumption* (21 or more drinks per week for men and 14 or more drinks for women per week), and *binge drinking* (having had 5 or more drinks in one occasion during the last month). *Body mass index* was calculated as weight in kilograms divided by height in meters squared, based on self-reported height and weight. We also created a *sum of health risks* by summing together dichotomous indicators of physical inactivity, heavy alcohol consumption, smoking, and obesity (BMI>30kg/m^2). MIDJA and

UKHLS were not included in the analysis of the sum score because these cohorts did not have data on all the health indicators.

Statistical analysis

The data were transformed into a multilevel data structure of person-observations in which each participant could contribute multiple person-observations to the dataset. Random-intercept regression models with person as the level-2 clustering factor were fitted to take into account the non-independence of the repeated person-observations and individual differences in the averages of the outcome variables. The analysis is based on separating within-individual variation over time from the stable between-individual differences in average personality trait levels by examining only the within-individual variation around the person's own average level of the trait. The regression equation then becomes: $y_{ij} = \alpha + \beta_{0i} + \beta_B(\bar{x}_{i.}) + \beta_W(x_{ij} - \bar{x}_{i.}) + \varepsilon_{ij}$ in which y_{ij} is the observed outcome variable for person i at measurement time j, α is the overall intercept, β_{0i} is the person-specific intercept, x_{ij} is the personality trait of person i assessed at measurement time j, $\bar{x}_{i.}$ is the within-person average of x_i across all measurement times, and ε_{ij} is the level-1 residual term. The coefficient β_B gives the between-individual association and β_W the within-individual association. The within-individual analysis requires variation in the outcome variable, so participants for whom the outcome does not vary over time do not contribute information of the estimation of within-individual coefficients. For example, participants who were non-smokers in all their measurement times would not contribute data to within-individual estimation, as their smoking status did not vary over time. They did contribute information for the estimation of between-individual associations. We report separately the numbers of participants who contributed to the within-individual associations in different outcome variables.

Personality traits were all standardized within each cohort using the baseline measurement time as the reference value (baseline personality trait mean = 0, sd = 1). The overall associations between personality and health behaviors were first assessed by including all participants in the analyses (up to 80,216 participants). In the comparison of between-individual vs within-individual associations we only included participants who had data from at least two measurement times (excluding a total of 25,746 participants with only one measurement time) to estimate between-individual associations only among participants who could contribute to the within-individual analysis. Within-individual stability of personality and health behaviors across measurement times were estimated using intraclass correlations that quantify the proportion of the total variance in the variable explained by the average between-individual differences—the higher the intraclass correlation, the less within-individual variation.

Physical inactivity, smoking, heavy alcohol consumption, and binge drinking were analyzed with logistic regression, with coefficients expressed as logit odds ratios per 1SD difference in personality trait; BMI, number of alcoholic drinks per week, and number of cigarettes per day with linear regression, with coefficients expressed as outcome difference in standardized units (standard deviation, SD=1) of the outcome per 2SD difference in personality trait (we used 2SD in order to avoid overly small coefficients); and the sum of health risks with negative binomial regression, with coefficients expressed as logit incidence rate ratios per 1SD difference in personality trait. All regression models were adjusted for age, gender, race/ethnicity, and all the personality traits were included in the same model, that is, they were mutually adjusted for each other. Results for models including one personality trait at a time (i.e., without mutually adjusting all the personality traits in the same model) are reported in supplementary material.

The regression models were first fitted within each cohort separately. These estimates were then pooled to yield a single estimate across the cohorts by using fixed-effect meta-analysis. With a sample size of more than 56,000 participants, we had sufficient statistical power to detect even small effect sizes.

Results

Descriptive statistics are shown in **Table 1** and study years are shown in **Table 2**. Except for MIDJA and UKHLS, all the cohorts had up to three repeat measurements. Except for physical activity, the intra-class correlations of the variables across measurement times were moderately high (**Table 3**). For example, an intra-class correlation of 0.80 for BMI indicated that 80% of the total variance in BMI was due to the between-individual differences in average BMI across measurement times and only 20% was explained by within-individual variation over the participants' average BMI.

In multilevel negative binomial regression, the sum of health risks was related to lower conscientiousness (one standard deviation difference in personality trait being associated with logit rate-ratio difference of B=–0.07, CI=–0.08, –0.06), lower emotional stability (B=–0.04, CI=–0.05, –0.03), lower openness to experience (B=–0.07, CI=–0.08, –0.06), and weakly with higher agreeableness (B=0.01, CI=0.001, 0.019) but not with extraversion (B=0.003, CI=–0.006, 0.013). These associations represented how the sum of health risks was related to the weighted combination of (1) average differences in personality traits between different individuals and (2) differences in personality traits within the same individuals across measurement times.

Figure 1 shows the associations of personality with the sum of health risks when the between-individual and within-individual associations are modeled as separate components in the regression model. The between-individual associations were all statistically significant

whereas the within-individual associations were much weaker and not statistically significant, with one exception: association of extraversion was statistically significant but in the opposite direction to the corresponding between-individual association.

Figure 2 shows the overall meta-analytic associations of personality with each of the health-risk variables when the between-individual and within-individual associations are not modeled as separate components. As expected, lower conscientiousness and emotional stability were associated with most health behaviors. Higher extraversion and lower agreeableness were associated with higher alcohol consumption. **Figure 3** shows the separately modeled contributions of between-individual and within-individual associations that underlie the overall associations shown in **Figure 2**. Many of the between-individual associations were statistically significant and consistent with previously reported associations. By contrast, most of the within-individual associations were weaker and not statistically significant, thus not replicating the associations observed in the between-individual analysis. There were two exceptions: the within-individual associations between all five personality traits and physical inactivity were all statistically significant, and the within-individual association between extraversion and higher alcohol consumption was also significant.

Supplementary Figures 1 to **24** show the study-specific associations for the pooled results reported above. Correlations between personality traits across studies are shown in **Supplementary Table 1**. When the associations shown in **Figures 2** and **3** were fitted separately for each personality trait the conclusions remained mostly unchanged (**Supplementary Figure 25** to **32**), except that the within-individual associations between extraversion and smoking (B=0.07) and between conscientiousness and lower heavy alcohol consumption (B=–0.09) became statistically significant. Also, the unexpected association of higher agreeableness and higher risk of physical inactivity (**Figure 2**) appeared to be caused

by mutual adjustment of the traits because when examined separately physical inactivity was related to lower agreeableness (**Supplementary Figure 30**). **Supplementary Figures 33** to **35** show the results of **Figures 1** to **3** when adjusted for education (coded as 1=primary, 2=secondary, 3=tertiary education in each cohort). This did not have major effect on most of the associations of personality, expect for openness to experience for which the attenuations were larger. **Supplementary Figure 36** to **40** show the between-individual and within-individual associations adjusted for education but not for the other personality traits.

Discussion

To evaluate personality traits as potentially modifiable risk factors for health behaviors, we examined whether people's health behaviors change when their personality traits change naturally over time. We found only limited evidence for within-individual associations, suggesting that adult health behaviors are associated mostly with people's stable personality traits but less so with the variation in personality traits over time. This implies that these associations may not be causal in the sense that a change in personality trait would lead to changes in health behaviors. There were two exceptions to this pattern: Participants were more likely to be physically inactive in measurement times in which they were less extraverted, less emotionally stable, more agreeable, less conscientious, and less open to experience in comparison to their average personality levels. In addition, participants were more likely engage in risky alcohol consumption in times when their extraversion was higher than their average level of extraversion. Many health behaviors were associated with stable, between-individual personality differences, especially with low conscientiousness, emotional stability, agreeableness, and openness to experience, and with high extraversion.

Our findings cast some doubt on the assumption that personality traits are modifiable, causal determinants of health behaviors. However, before drawing such a conclusion, it is

important to consider study limitations and open questions that need to be addressed in future research. First, personality traits and health behaviors were measured only two or three times. Because of the more constrained variance, within-individual associations were estimated with more measurement error than between-individual associations. This might help to explain why within-individual associations were observed for physical inactivity, which showed the lowest levels of within-individual stability. However, the confidence intervals of all the within-individual estimates were not overly wide compared to the overall associations. We note that variation in personality traits across two or three measurement times is commonly used to study personality development, indicating that such changes are often considered substantial rather than as mere measurement error. Furthermore, sibling studies such as discordant twin-pair comparisons are based on a similar analysis as our current within-individual analysis (e.g., Kim, 2016). Despite the moderately high intraclass correlations in these studies, especially within monozygotic twin pairs (Bratko, Butkovic, Hlupic, 2017), they are rarely criticized for not having more than two siblings from the same family.

Second, the majority of the participants were middle-aged individuals. Many health behaviors, smoking initiation in particular (Freedman, Nelson, & Feldman, 2012), are strongly determined already in young adulthood and they remain somewhat stable over time (Jones, Hinkley, Okely, & Salmon, 2013). It is possible that early personality in adolescence and young adulthood does have a causal impact on how people adopt healthy or unhealthy behaviors (Hampson, Edmonds, Goldberg, Dubanoski, & Hillier, 2013, 2015), and people then tend to follow these early-set healthy trajectories. If this were the case, one would not expect changes in adult personality to lead to changes in health behaviors—the adult associations would only reflect the residue of the causal associations operating in adolescence and young adulthood. It is also possible that there is a time lag between personality change and changes in health behaviors, which our study design might not have detected. Third, we

only examined naturally occurring variation and not experimentally induced change, and the results might be different with the latter.

Fourth, the associations between personality and health behaviors were cross-sectional, so the associations could be due to personality influencing health behavior or health behavior influencing personality (Allen, Vella, & Laborde, 2015; Jokela, Hakulinen, Singh-Manoux, & Kivimäki, 2014; Stephan, Sutin, & Terracciano, 2014). However, any reverse causality would probably have amplified rather than attenuated the associations because these bidirectional associations are likely to work in the same directions. For example, physical inactivity, smoking, and alcohol consumption have been associated with decreasing conscientiousness (Allen et al., 2015), but this would strengthen any associations of low conscientiousness on risky health behaviors in cross-sectional analyses. Fifth, the within-individual analysis does not eliminate unobserved confounding variables that vary within individuals over time, so some of the within-individual associations may still reflect confounding due to time-varying third variables (Gunasekara et al., 2014). Finally, the associations between personality and health behaviors might be related to specific personality facets or even lower-level nuances instead of broad personality traits (e.g., Vainik, Mõttus, Allik, Esko, & Realo 2015; Seeboth & Mõttus, 2018), in which case the analysis of broad traits could be too coarse to observe the true causal associations that could be operating at a lower level. Most of the current studies used only brief measures of personality which were different across most of the studies, so we could not examine more nuanced analyses below the trait level.

Most of our results suggested that changes in adult personality might not produce changes in health behaviors. There were two notable exceptions. First, we observed systematic within-individual associations between physical inactivity and all of the Five Factor Model personality traits. Longitudinal studies have associated personality traits with

physical activity measured several years later (Allen, Magee, Vella, & Laborde, 2017) and physical activity has also been associated with personality development over time (Stephan et al., 2014). It thus seems that physical activity is the most susceptible health behavior related to personality differences. Given the previously reported bidirectional associations between personality and physical activity, our current findings cannot say whether the within-individual associations are due to changes in personality causing changes in physical activity, or vice versa, or whether they co-occur simultaneously.

Second, within-individual variation in extraversion was related to higher alcohol consumption. This could be because higher extraversion leads to increased social engagement, which then may lead to more frequent alcohol use in social occasions (Hakulinen, Elovainio, et al., 2015). Heavy alcohol consumption (but not alcohol problems) has also been associated with increasing extraversion over time (Hakulinen & Jokela, in press) so this within-individual association may also be due to bidirectional association similar to those observed for physical inactivity.

Some within-individual associations showed the opposite directions compared to their corresponding between-individual associations. On average, people who were smokers had lower emotional stability, lower agreeableness, and lower conscientiousness than non-smokers. But among smokers who changed their smoking status across measurement times, smoking was related to higher emotional stability, higher agreeableness, and higher conscientiousness. This might be due to the effects of smoking on decreasing anxiety and improving concentration on the one hand (Heishman, Kleykamp, & Singleton, 2010), and the withdrawal symptoms of increasing anxiety and irritability on the other hand (Taylor et al., 2014). More detailed measures of smoking cessation and withdrawal symptoms would be needed to test such time-varying associations of smoking.

Previous studies have examined interrelated changes of personality and health status across time, often examining correlations of change scores or parallel growth curves and finding that "adverse" personality change is associated with increasing health problems (Human, Biesanz, Miller, Chen, Lachman, & Seeman, 2012; Konradt, Hagemeyer, Neyer, & Kandler, 2018; Mroczek & Spiro, 2007), or vice versa (Jokela, Hakulinen, et al., 2014). In the MIDUS study (Turiano, Whiteman, Hampson, Roberts, & Mrczek 2012), increase in substance abuse was associated with concurrent increases in neuroticism and openness to experience and decreases in conscientiousness and agreeableness, which is mostly in line with a recent meta-analysis of alcohol use and personality change (Hakulinen & Jokela, 2018). Our results may differ from most of these studies because we focused on health behaviors rather than physical illnesses that may be driven by different dynamics (e.g., a person may develop type-2 diabetes but then start exercising, stop smoking, and reduce alcohol consumption to control the disease). Moreover, we examined how people's time-specific personality scores varied around their overall mean scores whereas the previous studies have examined how people's personality changes from their baseline level. Further studies are needed to compare different methods of modeling personality change to test whether such methodological approaches produce different results and whether they relate to different causal mechanisms.

The focus of our study was on within-individual associations but this is not to say that stable, between-individual associations would not be important. Individuals who had stable levels of higher extraversion, lower emotional stability, lower agreeableness, lower conscientiousness, and lower openness to experience were more likely to have risky health behaviors. Stable personality scores can still be informative in many ways, for example, in developing health risk profiles, selecting most promising intervention strategies, and predicting relapse risk in health interventions. The lack of within-individual associations does

not reduce the predictive validity of personality traits; it is well known that aggregated scores of multiple measurements are more accurate indicators of underlying personality dispositions than single measurements (Epstein, 1983). The present quasi-experimental study design cannot be leveraged to gain insight on causality of between-individual measures but only on time-varying personality differences. Other quasi-experimental study designs are needed to test the causality of stable personality traits (Briley, Livengood, & Derringer, 2018; Constantini & Perugini, 2018; Lawlor et al., 2017; Mõttus, 2016; Zapko-Willmes, Riemann, & Kanlder, 2018).

In conclusion, our analysis suggests that stable personality traits are consistently associated with multiple health behaviors. By contrast, naturally occurring changes in personality traits are weakly, if at all, associated with changes in health behaviors—physical activity being a notable exception. This implies that adult personality traits may not be modifiable, causal risk factors for most health behaviors. Additional experimental and quasi-experimental evidence from different study designs is needed to support or refute the current conclusions from the within-individual analysis.

Acknowledgements

All the datasets used in the present study are publicly available via the Inter-university Consortium for Political and Social Research (icpsr.umich.edu/), the UK Data Service (ukdataservice.ac.uk), or directly from the study websites. *HILDA:* This paper uses unit record data from the Household, Income and Labour Dynamics in Australia (HILDA) Survey. The HILDA Project was initiated and is funded by the Australian Government Department of Social Services (DSS) and is managed by the Melbourne Institute of Applied Economic and Social Research (Melbourne Institute). The findings and views reported in this paper, however, are those of the author and should not be attributed to either DSS or the

Melbourne Institute. *HRS:* The HRS (Health and Retirement Study) is sponsored by the National Institute on Aging (grant number NIA U01AG009740) and is conducted by the University of Michigan. The Health and Retirement Study public use dataset (Ann Arbor, MI, 2016) is produced and distributed by the University of Michigan. *MIDJA:* This research was supported by a grant from the National Institute on Aging (5R37AG027343) to conduct a study of Midlife in Japan (MIDJA) for comparative analysis with MIDUS (Midlife in the United States, P01-AG020166). *MIDUS:* Since 1995 the MIDUS study has been funded by John D. and Catherine T. MacArthur Foundation Research Network, National Institute on Aging (P01-AG020166), and National institute on Aging (U19-AG051426). SOEP: The data used in this publication were made available to us by the German Socio-Economic Panel Study (SOEP) at the German Institute for Economic Research (DIW), Berlin. UKHLS: Understanding Society is an initiative funded by the Economic and Social Research Council and various Government Departments, with scientific leadership by the Institute for Social and Economic Research, University of Essex, and survey delivery by NatCen Social Research and Kantar Public. The research data are distributed by the UK Data Service. Neither the original collectors of the data nor the distributors of the data bear any responsibility for the analyses or interpretations presented here. *WLS:* The research uses data from the Wisconsin Longitudinal Study (WLS) of the University of Wisconsin-Madison. Since 1991, the WLS has been supported principally by the National Institute on Aging (AG-9775 and AG-21079), with additional support from the Vilas Estate Trust, the National Science Foundation, the Spencer Foundation, and the Graduate School of the University of Wisconsin-Madison. A public use file of data from the Wisconsin Longitudinal Study is available from the Wisconsin Longitudinal Study, University of Wisconsin-Madison, 1180 Observatory Drive, Madison, Wisconsin 53706 and at

http://www.ssc.wisc.edu/wlsresearch/data/. The interpretations, opinions, and inferences based on the data are solely the responsibility of the authors.

Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

Supplemental Material

Additional supporting information can be found at the Journal website

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Table 1. Descriptive statistics of the cohort studies included in the analysis of between-individual and within-individual associations

	HILDA	HRS	MIDJA	MIDUS	SOEP	UKHLS	WLSG	WLSS
Smoking status								
Non-smoker	20571 (81.9)	19176 (88.0)	980 (77.8)	8962 (85.2)	27134 (73.6)	11600 (78.1)	14503 (87.7)	7904 (87.2)
Current smoker	4561 (18.1)	2604 (12.0)	280 (22.2)	1553 (14.8)	9719 (26.4)	3260 (21.9)	2030 (12.3)	1163 (12.8)
Physical inactivity								
Physically active	18983 (73.6)	15446 (64.5)	–	5516 (52.8)	23211 (59.2)	–	12545 (82.1)	6886 (82.2)
Physically inactive	6807 (26.4)	8502 (35.5)	–	4926 (47.2)	15975 (40.8)	–	2739 (17.9)	1491 (17.8)
Alcohol consumption								
Abstainer	6703 (38.0)	11082 (56.2)	453 (35.1)	3035 (30.3)	3508 (13.0)	–	1826 (14.7)	2111 (27.3)
Moderate consumption	9109 (51.6)	8164 (41.4)	737 (57.2)	6536 (65.2)	19210 (71.0)	–	10021 (80.5)	5337 (69.0)
Heavy consumption	1827 (10.4)	464 (2.4)	99 (7.7)	455 (4.5)	4353 (16.1)	–	596 (4.8)	289 (3.7)
Binge drinking								
No binge drinking	–	17196 (87.3)	931 (72.5)	5579 (88.7)	–	–	6892 (83.8)	4749 (87.7)
Binge drinking	–	2498 (12.7)	354 (27.5)	713 (11.3)	–	–	1337 (16.2)	669 (12.3)
Sex								
Men	11928 (46.0)	9591 (40.0)	614 (47.3)	4712 (44.8)	18759 (47.6)	6674 (44.0)	7659 (45.6)	4286 (46.3)
Women	13998 (54.0)	14364 (60.0)	684 (52.7)	5805 (55.2)	20631 (52.4)	8492 (56.0)	9155 (54.4)	4981 (53.7)
Body mass index*	26.9 (5.5)	28.4 (5.9)	–	27.5 (5.7)	26.2 (4.7)	27.9 (5.3)	27.7 (5.0)	27.7 (5.1)
Number of cigarettes*	11.9 (9.5)	14.5 (11.3)	27.1 (14.3)	25.7 (13.3)	–	3.1 (7.2)	21.9 (15.8)	21.0 (16.1)
Alcoholic drinks per week*	6.6 (10.7)	3.0 (6.7)	6.2 (9.6)	3.0 (6.2)	4.1 (7.4)	–	4.4 (6.4)	3.6 (6.0)
Age*	43.8 (16.8)	66.3 (9.5)	54.8 (13.5)	47.1 (12.1)	46.8 (16.7)	45.3 (16.4)	54.1 (0.5)	52.5 (6.9)
Sum of health risks*	0.76 (0.83)	0.80 (0.80)	–	0.91 (0.83)	0.99 (0.86)	–	0.57 (0.72)	0.57 (0.73)
Number of measurements								
Two	2427 (25.7)	6093 (60.8)	649 (100.0)	1564 (38.8)	5889 (39.0)	7583 (100.0)	2302 (36.1)	1518 (42.2)
Three	7024 (74.3)	3923 (39.2)	–	2463 (61.2)	9204 (61.0)	–	4070 (63.9)	2077 (57.8)
n(participants)†	9451	10016	649	4027	15093	7583	6372	3595
n(person-observations)‡	25920	23955	1292	10517	39381	14991	16789	9252

Note: Values are numbers of participants (and percentages) unless otherwise noted. * Values are means (and standard deviations). † Values are numbers of participants. ‡ Values are numbers of person-observations over all the follow-up times.

Table 2. Study years of the cohort studies

Cohort study	First wave	Second wave	Third wave
HILDA	2005	2009	2013
HRS*	2006/2008	2010/2012	2014
MIDJA	2008	2012	–
MIDUS	1995-6	2003-4	2013-4
SOEP	2005	2009	2013
UKHLS	2005	2010-2	–
WLSG	1992-4	2003-5	2011
WLSS	1992-4	2003-5	2011

* In HRS, half of the sample were administered personality inventories in 2006, 2010 ja 2014 (three measurements), and the other half in 2008 and 2012 (2 measurements).

Table 3. Intraclass correlations (multiplied by 100) of the study variables

	HILDA	HRS	MIDJA	MIDUS	SOEP	UKHLS	WLSG	WLSS
Extraversion	74	69	74	68	60	58	74	75
Emotional stability	66	58	66	61	56	60	67	67
Agreeableness	66	62	63	64	51	46	62	61
Conscientiousness	69	61	63	60	52	45	62	63
Openness to Experience	70	68	70	66	58	55	71	69
Current smoker	83	78	75	64	77	77	58	61
Cigarettes per day	58	52	57	59	–	78	–	–
Physical inactivity	33	39	–	22	52	–	22	18
Drinks per week	69	71	68	64	45	–	60	63
Heavy consumption	53	46	46	53	45	–	34	37
Binge drinking	–	39	39	48	–	–	52	41
Body mass index	80	89	–	80	86	75	77	79
Number of participants with two or three measurement times								
Two	2427	6093	649	1564	5889	7583	2302	1518
Three	7024	3923	–	2463	9204	–	4070	2077
n(person-observations)*	25920	23955	1292	10517	39381	14991	16789	9252

Note: The intraclass correlations were calculated using the analysis of variance estimator and then multiplied by 100 to omit decimal dots.

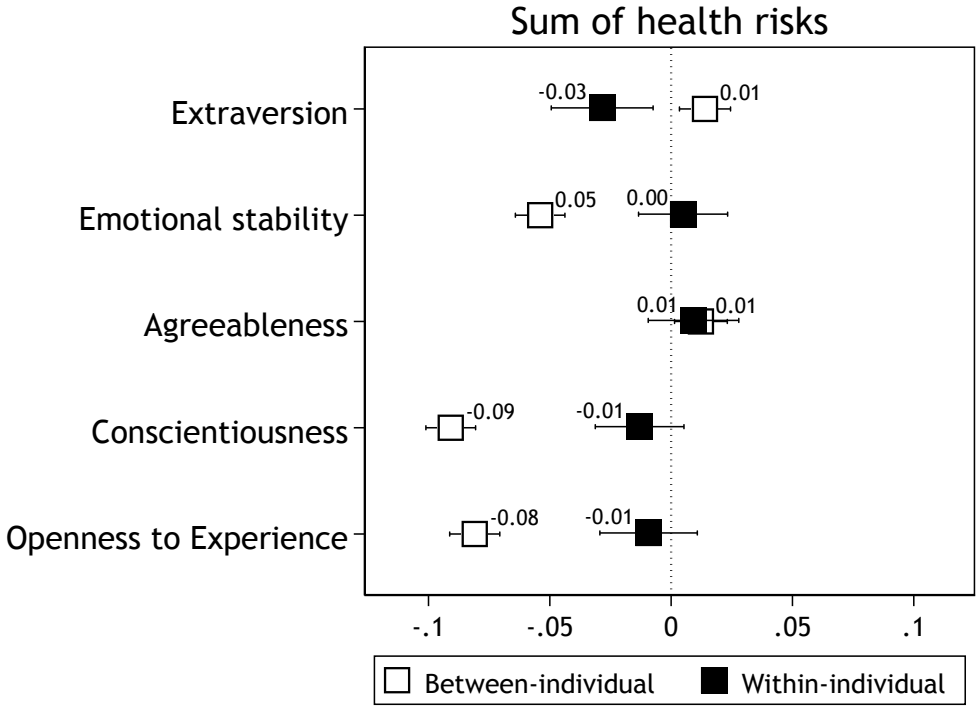

Figure 1. Between-individual and within-individual associations of personality traits with the sum score of physical inactivity, heavy alcohol consumption, smoking, and obesity (n= 46,059 participants with 32,203 participants contributing to the estimation of within-individual associations); MIDJA and UKHLS cohort were not included due to lack of data on some health indicators). Values are logit coefficients of incidence rate ratios (and 95% confidence intervals) of a negative binomial regression model. All associations were adjusted for age, sex, and race/ethnicity and the between-individual and within-individual associations of the other four personality traits.

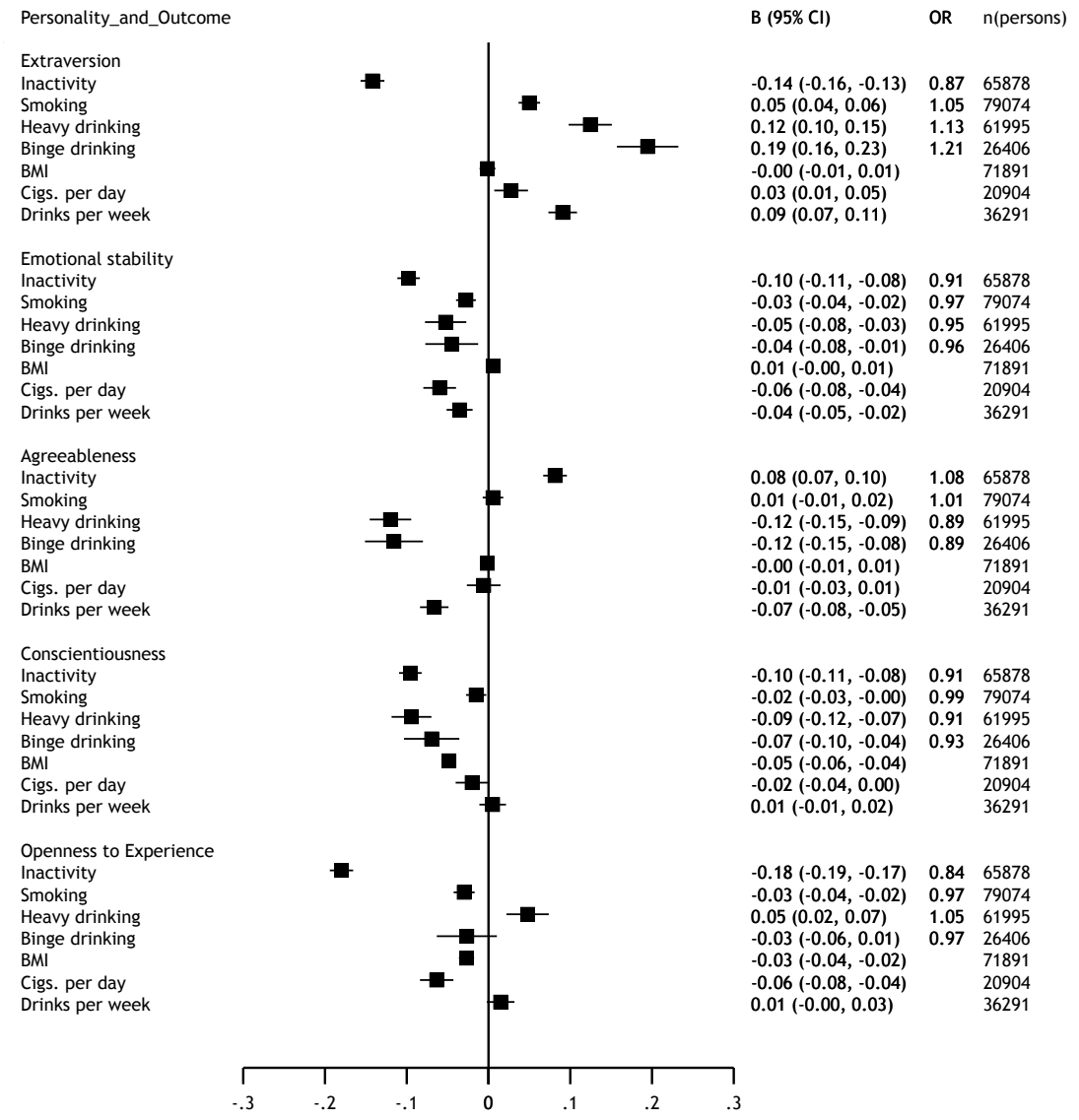

Figure 2. Overall associations between personality traits and health behaviors pooled across individual studies using fixed-effect meta-analysis. Values are logit coefficients of logistic regressions (for inactivity, smoking, and heavy and binge drinking) and standardized coefficients of linear regressions (standard deviations of BMI, cigarettes per day, and drinks per week associated with 2 standard deviations of personality trait) and their 95% confidence intervals, with separate models fitted for each outcome. OR=odds ratio. All associations were adjusted for the other four personality traits, age, sex, and race/ethnicity.

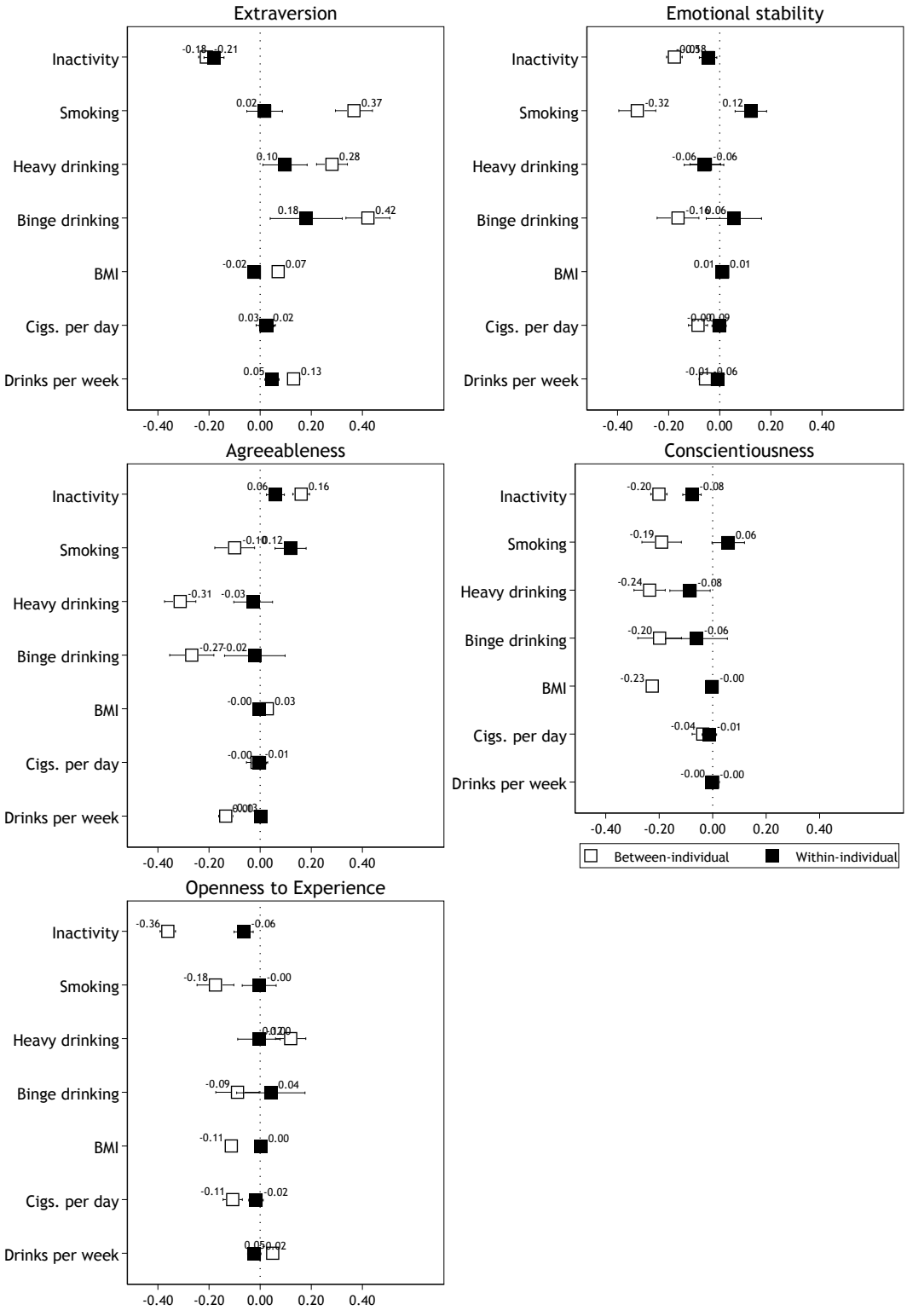

Figure 3. Between-individual and within-individual associations of personality traits with health behaviors (n = 12,356 to 56,671 participants). Values are logit coefficients of logistic regressions (for inactivity, smoking, and heavy and binge drinking) and standardized coefficients of linear regressions (standard deviations of BMI, cigarettes per day, and drinks per week associated with 2 standard deviations of personality trait) and their 95% confidence intervals, with separate models fitted for each outcome. All associations were adjusted for the other four personality traits, age, sex, and race/ethnicity.

SUPPLEMENTARY MATERIAL

Is within-individual variation in personality traits associated with changes in health behaviors? Analysis of 7 longitudinal cohort studies

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Supplementary text describes the details of the cohorts. **Supplementary Table 1** shows the correlations between personality traits averaged over all studies using meta-analysis. **Supplementary Figures 1** to **3** provide the study-level data that underlie the pooled associations presented in **Figure 1** of the main manuscript. **Supplementary Figures 4** to **24** provide the study-level data that underlie the pooled associations presented in **Figures 2** and **3** of the main manuscript. **Supplementary Figures 25** to **27** present the same analysis as in **Figure 1** of the main manuscript but by examining one trait at a time, that is, not mutually adjusting all the traits in the same model but fitting 5 separate regression models. **Supplementary Figures 28** to **32** present the same analyses as in **Figure 3** of the main manuscript but by examining one trait at a time, that is, not mutually adjusting all the traits in the same model but fitting 5 separate regression models. **Supplementary Figures 33** to **35** show the results of **Figures 1** to **3** of the main manuscript when education level was adjusted for (education coded as 1=primary, 2=secondary, 3=tertiary educational level). **Supplementary Figures 36** to **40** show the results when education level was adjusted for and when the associations were not adjusted for the other personality traits.

The authors do not have authority to redistribute the datasets used in the study, but all the data are available via the Inter-university Consortium for Political and Social Research (icpsr.umich.edu), the UK Data Service (ukdataservice.ac.uk), or the studies own websites cited below in the cohort descriptions. **Supplementary Table 2** lists the names of the variables used in the study. Stata code templates for the analyses are attached at the end of this supplement.

Household, Income and Labour Dynamics in Australia (HILDA) Survey

The Household, Income and Labour Dynamics in Australia (HILDA) Survey is a household-based panel study which began in 2001, developed particularly to collects information about economic and subjective well-being, labour market dynamics and family dynamics. The survey began with a large national probability sample of Australian households occupying private dwellings (n=7,682 households with 19,914 individuals at baseline). All members of the households providing at least one interview in wave 1 form the basis of the panel to be pursued in each subsequent wave. Interviews are conducted annually with all adult members of each household. The sample has been gradually extended to include any new household members resulting from changes in the composition of the original households. From wave 9, new household members that arrived in Australia for the first time after 2001 were also added to the sample.

Personality was assessed in study wave 5 in 2005, wave 9 in 2009, and wave 13 in 2013 using a 36-item Five Factor Personality self-reported inventory based on the Saucier's and Goldberg's Big Five Markers Scale,(8) with 8 items for extraversion (α=0.77), 7 items for emotional stability (α=0.79), 7 items for agreeableness (α=0.77), 7 items for conscientiousness (α=0.79), and 6 items for openness to experience (α=0.73; the original item "traditional" was omitted from the scale because of a very low factor loading of 0.03 and a very low correlation of 0.02 between the item and a scale constructed from the rest of the items). The participants rated the items on a 7-point scale (1=Does not describe me at all, 7=Describes me very well). Personality sum scales were calculated for individuals with no more than 1 missing item in the scale.

Data on **race/ethnicity** was based on participants' self-reports and was coded as a dichotomous variable (0=white, non-Hispanic; 1=other). **Physical inactivity** was assessed as how often the person participates in physical activity (Physically inactive = Not at all / Less than once a week; Physically active = Every day / More than 3 times a week / 3 times a week / 1-2 times a week). **Number of alcoholic drinks per week** was determined on the basis of how often and how much the person reported drinking alcohol, with **heavy alcohol consumption** defined as 21 or more units for men and 14 or more units for women per week. **Smoking** status and **number of cigarettes** smoked were self-reported.

Study website: http://www.melbourneinstitute.com/hilda/

Acknowledgements: This paper uses unit record data from the Household, Income and Labour Dynamics in Australia (HILDA) Survey. The HILDA Project was initiated and is funded by the Australian Government Department of Social Services (DSS) and is managed by the Melbourne Institute of Applied Economic and Social Research (Melbourne Institute). The findings and views reported in this paper, however, are those of the author and should not be attributed to either DSS or the Melbourne Institute.'

Health and Retirement Study (HRS)

The HRS is a nationally representative longitudinal study of more than 30,000 individuals representing the U.S. population older than 50 years. Telephone or in-person interviews are conducted every 2 years, administered under the NIA and the University of Michigan's Institute for Social Research. As of 1998, the HRS consists of 4 sources of data collection: (1) The original HRS began as two distinct surveys that were merged in 1998. The original HRS was initially administered in 1992 to a nationally representative sample of Americans born in the years 1931 through 1941. In the case of married couples, both spouses (including spouses who were younger than 51 or older than 61) were also interviewed; (2) The second survey, originally referred to as the Study of Assets and Health Dynamics Among the Oldest Old (AHEAD), was first administered in 1993 to a nationally representative sample of Americans born in 1923 or earlier (n=8,000) and merged with the HRS in 1998. In the case of married couples, interviews were conducted with both spouses; (3) In 1998, a subsample of individuals born between 1924 and 1930, referred to as Children of the Depression Age (CODA) was added to HRS; (4) Another subsample consisting of people born between 1942 and 1947 (War Baby cohort) was added to replenish the sample of people in their early 50s as the original HRS cohort aged. The Health Sciences Institutional Review Board at the University of Michigan approved the HRS.

Personality was measured using a self-reported instrument adapted from the MIDUS study(7) with 5 items for extraversion (α=0.74), 4 items for emotional stability (α=0.63), 5 items for agreeableness (α=0.78), 5 items for conscientiousness (α=0.63), and 7 items for openness to experience (α=0.79), rated on a 4-point rating scale. The personality instrument was administered to half of the sample in 2006 and to the other half in 2008. Thus, the study baseline was 2006 for half of the sample and 2008 for the other half of the sample. The second personality measurement was carried out for both subsamples 4 years (2 study waves) after the first measurement. Data for the third measurement was carried out 8 years after baseline and was available only for those who were administered the first personality test in 2006. Mean scores for personality scales were calculated for individuals with a maximum of 1 missing item in the scale.

Data on **race/ethnicity** was based on participants' self-reports and was coded as a dichotomous variable (0=white, non-Hispanic; 1=other). Frequencies of moderate and vigorous physical activity were both reported on a 5-point scale (0=Hardly ever or never, 1=1-3 times a month, 2=once a week, 3=more than once a week, 4=every day). **Physical inactivity** was defined as participating as moderate activity less than once a week (values 0 and 1) *and* vigorous activity less than 1-3 times a month (value 0). Otherwise the participant was considered physically active. **Number of alcoholic drinks per week** was determined on the basis of how often and how much the person reported drinking alcohol, with **heavy alcohol consumption** defined as 21 or more units for men and 14 or more units for women per week. **Binge drinking** was determined with the question "In the last three months, on how many days have you had four or more drinks on one occasion?" with binge drinking defined as 1 or more times. **Smoking** status and **number of cigarettes** smoked were self-reported.

Study website: http://hrsonline.isr.umich.edu

Acknowledgements: The HRS (Health and Retirement Study) is sponsored by the National Institute on Aging (grant number NIA U01AG009740) and is conducted by the University of Michigan. The Health and Retirement Study public use dataset (Ann Arbor, MI, 2016) is produced and distributed by the University of Michigan.

Survey of Midlife Development in Japan (MIDJA)

The MIDJA study is a probability sample of Japanese adults (N = 1,027) aged 30 to 79 from the Tokyo metropolitan area. Survey data were collected on sociodemographic characteristics (age, gender, marital status, educational status), psychosocial characteristics (e.g., personality traits, goal orientations, social support, social responsibility), mental health (depression, anxiety, well-being, life satisfaction), and physical health (chronic conditions, health symptoms, functional limitations, health behaviors). All the measures parallel those in the Midlife Development in the United States (MIDUS, see details below).

Personality was assessed at baseline in 2008 and in the follow-up wave in 2012 with a model based on the Five Factor Model, including 5 items of extraversion (α=0.83), 4 items for emotional stability (α=0.50), 5 items for agreeableness (α=0.87), 5 items for conscientiousness (α=0.66), and 7 items for openness to experience (α=0.83). Items were rated using a 4-point rating scale on how well different adjectives described them (1=not at all, 4=a lot).

Frequencies of moderate and vigorous activity were reported on 6-point scales (0=never, 1=less than once a month, 2=about once a month, 3=several times a month, 4=about once a week, 5=several times a week or more). **Alcohol consumption** was determined on the basis of how often and how much the person reported drinking alcohol, with **heavy alcohol consumption** defined as 21 or more units for men and 14 or more units for women per week. **Binge drinking** was determined with the question "Considering all types of alcoholic beverages, how many times during the past month did you have 5 or more drinks on the same occasion?" with binge drinking defined as 1 or more times. **Smoking** status and **number of cigarettes** smoked were self-reported.

Study website: http://midus.wisc.edu/midja/index.php

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Data Reference: Ryff, Carol D., Shinobu Kitayam, Mayumi Karasawa, Hazel Markus, Norito Kawakami, and Christopher Coe. Survey of Midlife Development in Japan (MIDJA), April-September 2008 [Computer file]. ICPSR30822-v2. Ann Arbor, MI: Inter-university Consortium for Political and Social Research [distributor], 2011-10-27. doi:10.3886/ICPSR30822.v2

Midlife Development in the United States (MIDUS)

The MacArthur Foundation Survey of Midlife Development in the United States (MIDUS) is based on a nationally representative random-digit-dial sample of non-institutionalized, English-speaking adults, aged 25 to 74 years, selected from working telephone banks in the coterminous United States in 1995-1996. The total original sample (n=7108) includes main respondents (n=3487), their siblings (n=950), a city oversample (n=757), and a twin subsample (n=1914). Data were collected in a telephone interview and with a mail questionnaire. A follow-up study of the original cohort was conducted in 2004-2005.

Personality was assessed at baseline with a model based on the Five Factor Model, including 5 items of extraversion (α=0.78), 4 items for emotional stability (α=0.75), 5 items for agreeableness (α=0.81), 4 items for conscientiousness (α=0.56), and 7 items for openness to experience (α=0.78). Items were rated using a 4-point rating scale on how well different adjectives described them (1=not at all, 4=a lot). Full data on personality traits at baseline were available for 6,261 participants.

Data on **race/ethnicity** was based on participants' self-reports and was coded as a dichotomous variable (0=white, non-Hispanic; 1=other). Frequencies of moderate and vigorous activity were reported on 6-point scales (0=never, 1=less than once a month, 2=about once a month, 3=several times a month, 4=about once a week, 5=several times a week or more). **Physical inactivity** was determined as moderate activity less than at least several times a week (values 0, 1, 2, 3 and 4) *and* vigorous activity less than once a week (values 0 and 1). Otherwise the participant was considered physically active. **Alcohol consumption** was determined on the basis of how often and how much the person reported drinking alcohol, with **heavy alcohol consumption** defined as 21 or more units for men and 14 or more units for women per week. **Binge drinking** was determined with the question "Considering all types of alcoholic beverages, how many times during the past month did you have 5 or more drinks on the same occasion?" with binge drinking defined as 1 or more times. These specific questions on alcohol consumption and binge drinking were not asked in the first study wave, so only data from the second and third study waves were used for the analysis of alcohol consumption in MIDUS. **Smoking** status and **number of cigarettes** smoked were self-reported.

Study website: http://www.midus.wisc.edu/

Acknowledgement: Since 1995 the MIDUS study has been funded by John D. and Catherine T. MacArthur Foundation Research Network, National Institute on Aging (P01-AG020166), and National institute on Aging (U19-AG051426)

Data references: Brim, Orville G., et al. NATIONAL SURVEY OF MIDLIFE DEVELOPMENT IN THE UNITED STATES (MIDUS), 1995-1996 [Computer file]. ICPSR02760-v4. Ann Arbor, MI: DataStat, Inc./Boston, MA: Harvard Medical School, Dept. of Health Care Policy [producers], 2007. Ann Arbor, MI: Inter-university Consortium for Political and Social Research [distributor], 2007-04-16.

Ryff, Carol, et al. MIDLIFE DEVELOPMENT IN THE UNITED STATES (MIDUS2), 2004-2006 [Computer file]. ICPSR04652-v1. Madison, WI: University of Wisconsin, Survey Center [producer], 2006. Ann Arbor, MI: Inter-university Consortium for Political and Social Research [distributor], 2007-03-22.

Ryff, Carol, et al. National Survey of Midlife Development in the United States (MIDUS 3), 2013-2014. ICPSR36346-v4. Ann Arbor, MI: Inter-university Consortium for Political and Social Research [distributor], 2016-03-10. http://doi.org/10.3886/ICPSR36346.v4

Socio-Economic Panel Study (SOEP)

The German Socio-Economic Panel Study (SOEP) is a longitudinal study of private households. The study started in 1984 in West Germany with two subsamples: Sample A, the main sample, covering the population of private households, and Subsample B, which oversampled the "guest worker households" with Turkish, Spanish, Italian, Greek and Yugoslavian household heads. The original sample included 5921 households and 12,245 individual respondents. Several additional samples have subsequently been integrated in the study, including a sample of Germans from the late East Germany in 1990 (2,179 households; 4,453 individuals), an immigrant sample in 1994/1995 (522 households; 1,078 individuals), a refreshment sample of existing subsamples in 1998 (1,056 households; 1,910 individuals), an "innovation" subsample again covering all existing subsamples in 2000 (6,043 households; 10,880 individuals), a high-income subsample of households with net earnings more than 4500 euros/month in 2002 (1,224 households; 2,671 individuals), a second refreshment sample covering all existing subsamples in 2006 (1,506 households; 2,616 individuals), and an "incentive" sample covering all existing subsamples in 2009 (1,531 households; 2,509 individuals). All household members aged 17 years or older are invited for interview, which are carried out annually. Altogether, a total of 34,881 individuals have participated in the study at least in one study wave.

Personality was assessed in 2005, 2009, and 2013 using the 15-item version of the Big Five Inventory (BFI). The Cronbach alphas were 0.66 for extraversion, 0.60 for emotional stability, 0.51 for agreeableness, 0.62 for conscientiousness, and 0.63 for openness to experience.

Data on **race/ethnicity** was based on participants' self-reports and was coded as a dichotomous variable (0=white, non-Hispanic; 1=other). **Height** and **weight** were self-reported by the participants in the 23rd data collection wave in 2006. **Physical inactivity** was defined as never or almost never participating in sports or exercise reported on a 4-point scale (0=Almost never or never, 1=Several times a year, 2=At least once a month, 3=At least once a week). Alcohol consumption was reported as the frequency of drinking (1) beer, (2) wine, (3) spirits, and (4) cocktail drinks, each reported separately using a 4-point scale (0=Never, 1=Seldom, 2=Once in a while, 3=Regularly). **Heavy alcohol consumption** was defined by the sum of the four items being 6 or higher. **Smoking** status and **number of cigarettes** smoked were self-reported.

Study website: http://www.diw.de/en/soep

Acknowledgement: The data used in this publication were made available to us by the German Socio-Economic Panel Study (SOEP) at the German Institute for Economic Research (DIW), Berlin.

UK Household Longitudinal Survey (UKHLS), previously the British Household Panel Survey (BHPS)

The UK Household Longitudinal Survey (UKHLS) originally began as the British Household Panel Survey (BHPS), which is a longitudinal survey of a nationally representative sample of over 5000 British households with annual follow-ups. The original cohort included 10,264 individuals aged 16-97 at baseline in 1991, and was based on a clustered, stratified sample of addresses throughout Great Britain south of the Caledonian Canal (excluding North of Scotland and Northern Ireland). New participants have been included in the sample over the years if they are born to original sample member, if they have moved into a household in the original sample, or if a member of the original sample moves into a new household with one or more new people. In addition, the sample was enriched with additional recruitment of participants at waves 9 and 11, from Scotland and Wales, and from Northern Ireland, respectively, so extending the sample to cover the whole UK. The most recent (18th) follow-up of the BHPS was carried out in 2008-2009. The cohort then became merged with the larger UKHLS, also known as the Understanding Society Study.

Personality was assessed in the 15th data collection wave of the BHPS in 2005 and the second time in the third study wave of UKHLS in 2010-2012 using the 15-item version of the Big Five Inventory (BFI(2, 3)) with three items assessing each personality trait, rated on a 7-point scale. Personality scales were calculated for individuals with no missing items in the scale. Cronbach alpha reliabilities were 0.54 for extraversion, 0.68 for emotional stability, 0.53 for agreeableness, 0.51 for conscientiousness, and 0.67 for openness to experience.

Data on **race/ethnicity** was based on participants' self-reports and was coded as a dichotomous variable (0=white, non-Hispanic; 1=other). **Height** and **weight** were self-reported by the participants in the 16th data collection wave in 2006. **Smoking** status and **number of cigarettes** smoked were self-reported.

Study websites:
http://www.understandingsociety.org.uk/
http://www.esds.ac.uk/longitudinal/access/bhps/L33196.asp

Acknowledgements: Understanding Society is an initiative funded by the Economic and Social Research Council and various Government Departments, with scientific leadership by the Institute for Social and Economic Research, University of Essex, and survey delivery by NatCen Social Research and Kantar Public. The research data are distributed by the UK Data Service. Neither the original collectors of the data nor the distributors of the data bear any responsibility for the analyses or interpretations presented here.

Data references: University of Essex. Institute for Social and Economic Research, NatCen Social Research and Kantar Public, [producers]: Understanding Society: Waves 1-6, 2009-2015 [computer file]. 8th Edition. Colchester, Essex: UK Data Service [distributor], November 2016. SN: 6614

University of Essex. Institute for Social and Economic Research. (2010). British Household Panel Survey: Waves 1-18, 1991-2009. [data collection]. 7th Edition. UK Data Service. SN: 5151, http://doi.org/10.5255/UKDA-SN-5151-1

Wisconsin Longitudinal Study (WLS), Graduate and Sibling Samples

Graduate sample. The Wisconsin Longitudinal Study has followed a random sample of 10317 participants (5326 women, 4991 men) who were born between 1937 and 1940 and who graduated from Wisconsin high schools in 1957. After baseline data collection in 1957, survey data have been collected from the participants or their parents in 1964, 1975, 1992/3, 2003/5, and 2011. The present study used data from the 1993 follow-up. The WLS sample is broadly representative of white, non-Hispanic American men and women who have completed at least a high school education (among Americans aged 50 to 54 in 1990 and 1991, approximately 66 percent were non-Hispanic white persons who completed at least 12 years of schooling). It is estimated that about 75 percent of Wisconsin youth graduated from high school in the late 1950s – everyone in the primary WLS sample graduated from high school.

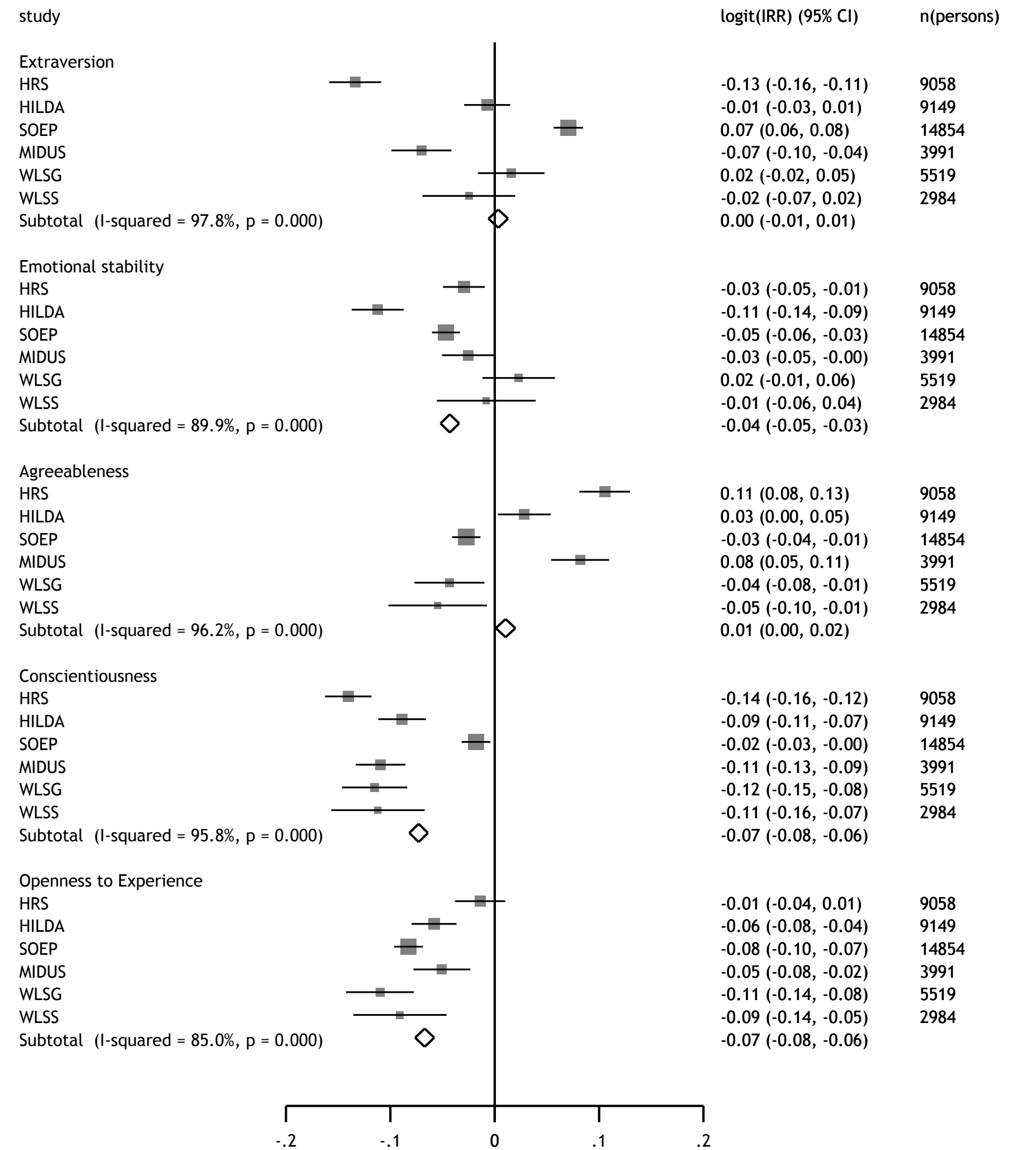
Sibling sample. In addition to the main sample of the 1957 high school graduates, the WLS has also collected data on a selected sibling of a sample of the graduates. The data collection in adulthood has been very similar although not entirely identical for the siblings as for the graduates. For the present purposes, the sibling sample was analyzed separately from the graduate sample, because the sampling frame of the individuals for the graduate cohort and sibling cohort was considered to sufficiently to justify the decision of not combining the samples.

Personality data were collected in 1992-1994, 2003-2005, and 2011 via mail questionnaire including a 29-version of the Big Five Inventory (BFI). Participants were asked whether they agreed or disagreed that certain personality descriptions fitted themselves using a 6-point rating scale. The Cronbach alpha reliabilities were 0.76 for extraversion in graduates (0.65 in siblings) for extraversion, 0.78 (0.63) for emotional stability, 0.69 (0.70) for agreeableness, 0.64 (0.70) for conscientiousness, and 0.61 (0.70) for openness to experience. A mean score for a trait was calculated if no more than 2 items of the scale were missing.

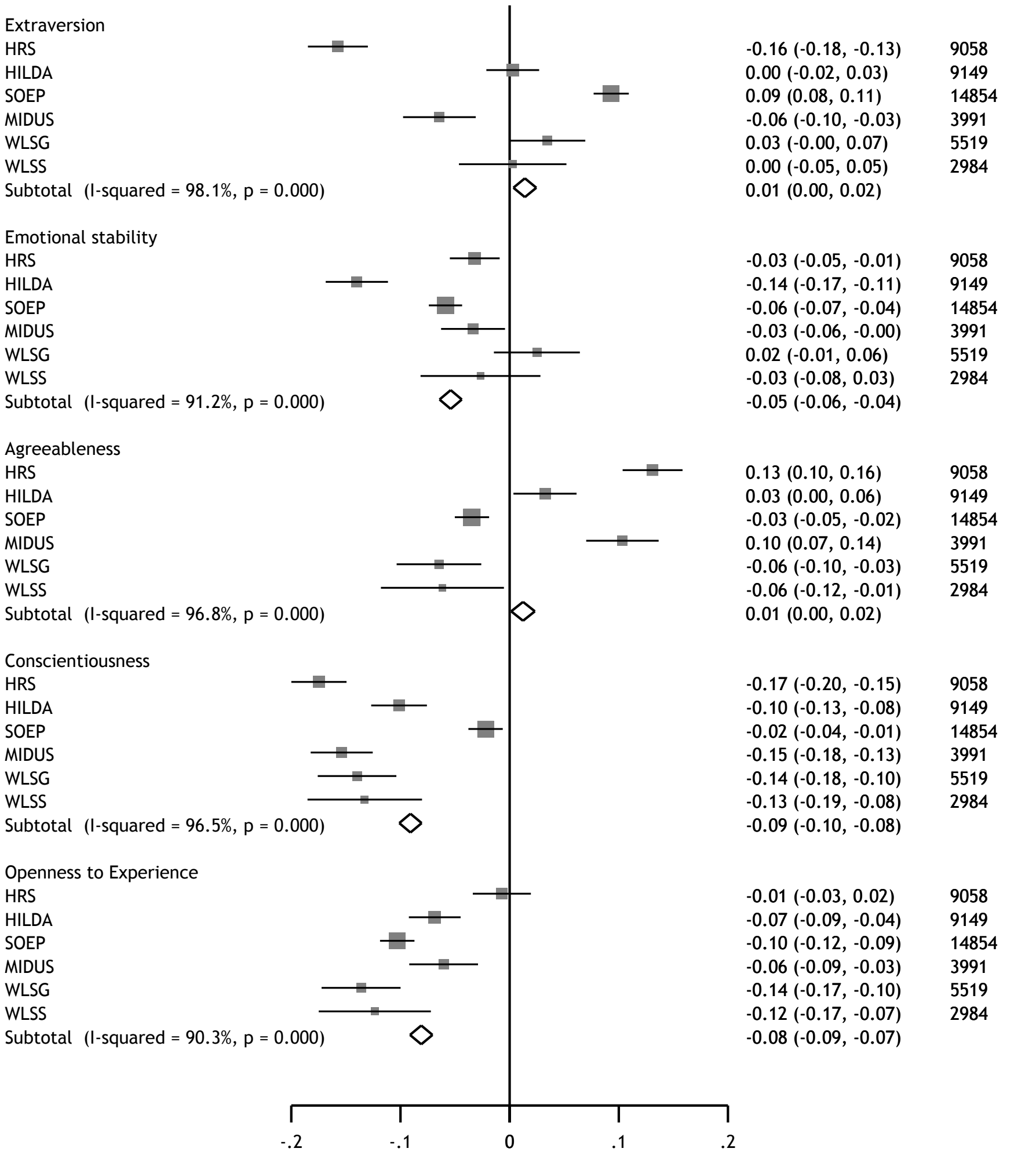
Height and **weight** were self-reported by the participants. **Smoking** status and **number of cigarettes** smoked were self-reported. Frequencies of moderate and vigorous activity were each reported on a 4-point scale (0=less than once a month, 1=about one to three times per month, 2=once or twice a week, 3=three or more time per week), and **physical inactivity** was defined as moderate activity less than once or twice a week (values 0 and 1) *and* vigorous activity less than once or twice a week (values 0 and 1). Otherwise the participant was considered physically active. **Number of alcoholic drinks per week** was calculated based on how often and how much the participant reported drinking alcohol during the last month, with **heavy alcohol consumption** defined as 21 or more units for men and 14 or more units for women per week. Binge drinking was based on the number of times the participant reported having 5 or more drinks on the same occasion during the last month, with binge drinking defined as 1 or more times.

Study website: http://www.ssc.wisc.edu/wlsresearch/

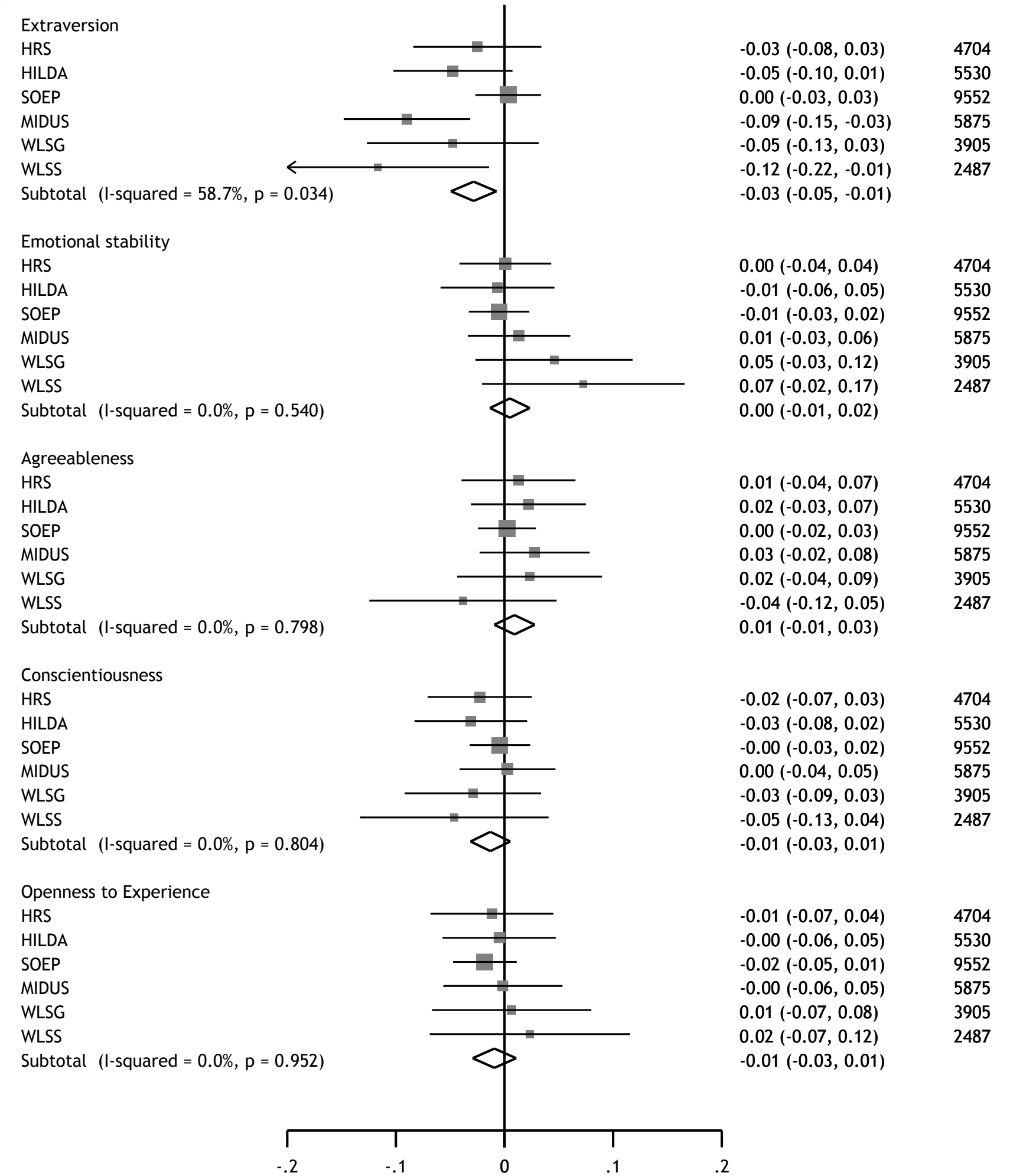
Acknowledgements: The research uses data from the Wisconsin Longitudinal Study (WLS) of the University of Wisconsin-Madison. Since 1991, the WLS has been supported principally by the National Institute on Aging (AG-9775 and AG-21079), with additional support from the Vilas Estate Trust, the National Science Foundation, the Spencer Foundation, and the Graduate School of the University of Wisconsin-Madison. A public use file of data from the Wisconsin Longitudinal Study is available from the Wisconsin Longitudinal Study, University of Wisconsin-Madison, 1180 Observatory Drive, Madison, Wisconsin 53706 and at http://www.ssc.wisc.edu/wlsresearch/data/. The interpretations, opinions, and inferences based on the data are solely the responsibility of the authors.



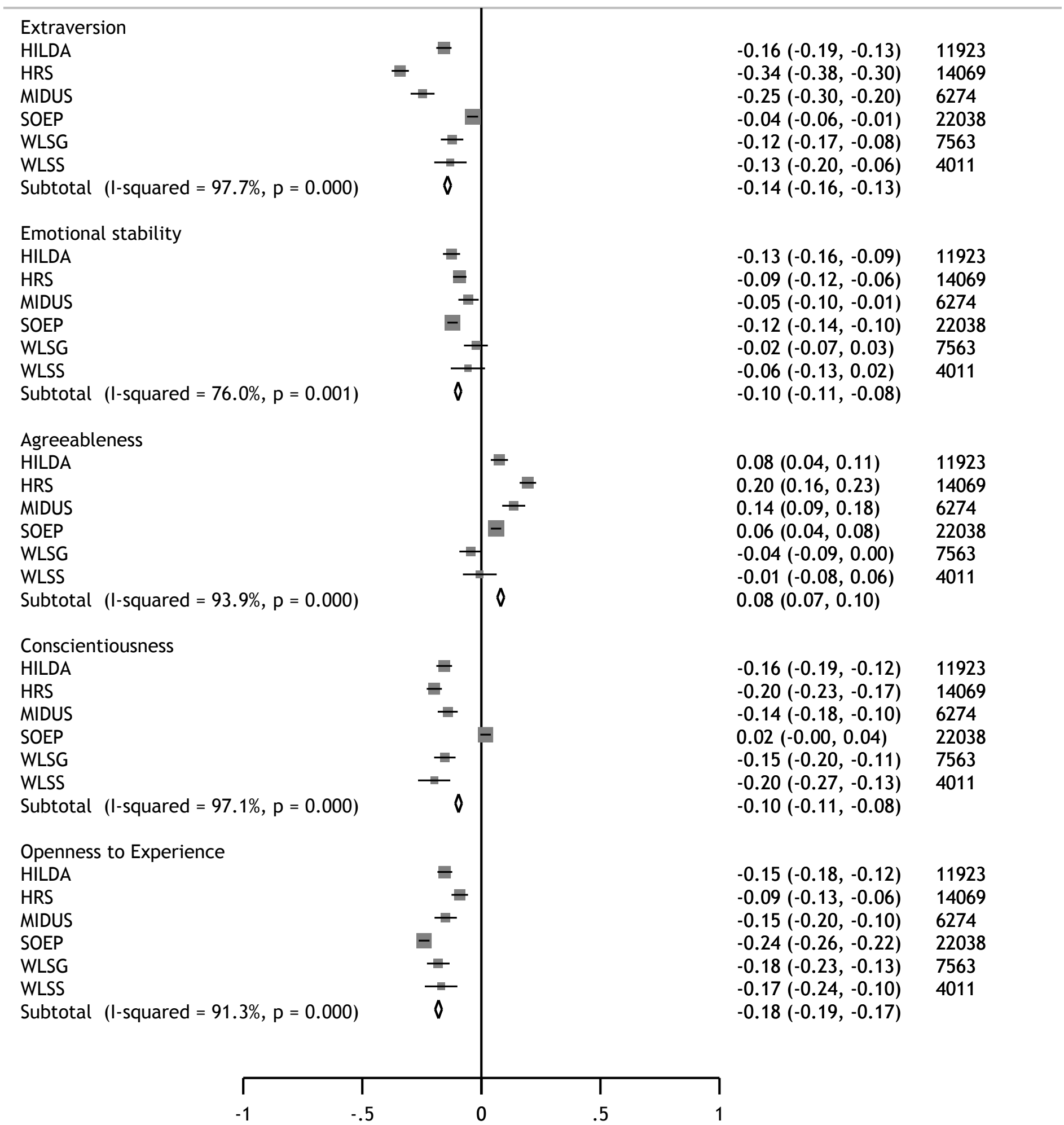
Supplementary Figure 1. Overall associations of personality traits with sum of health risks.



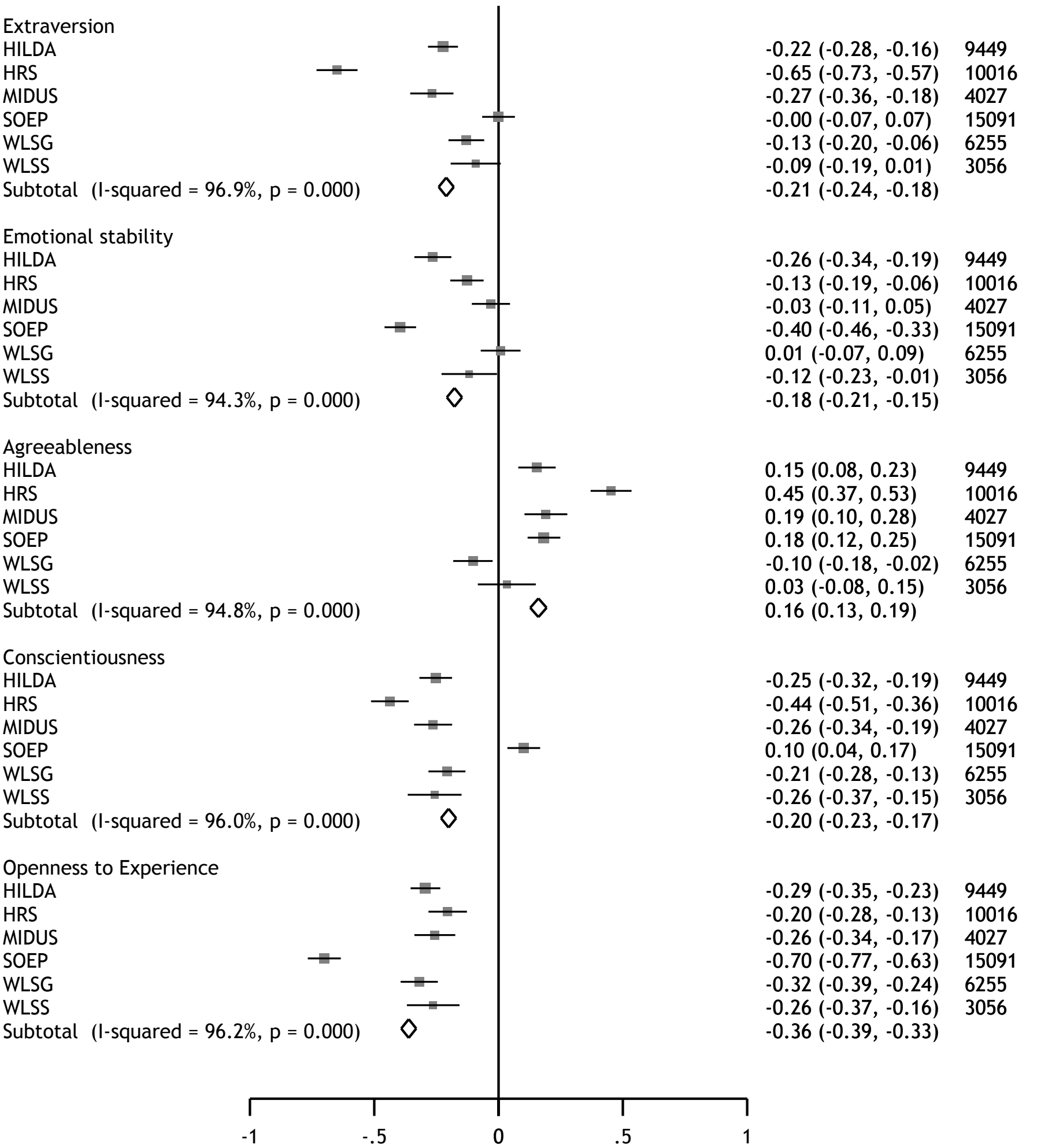
Supplementary Figure 2. Between-individual associations of personality traits with sum of health risks



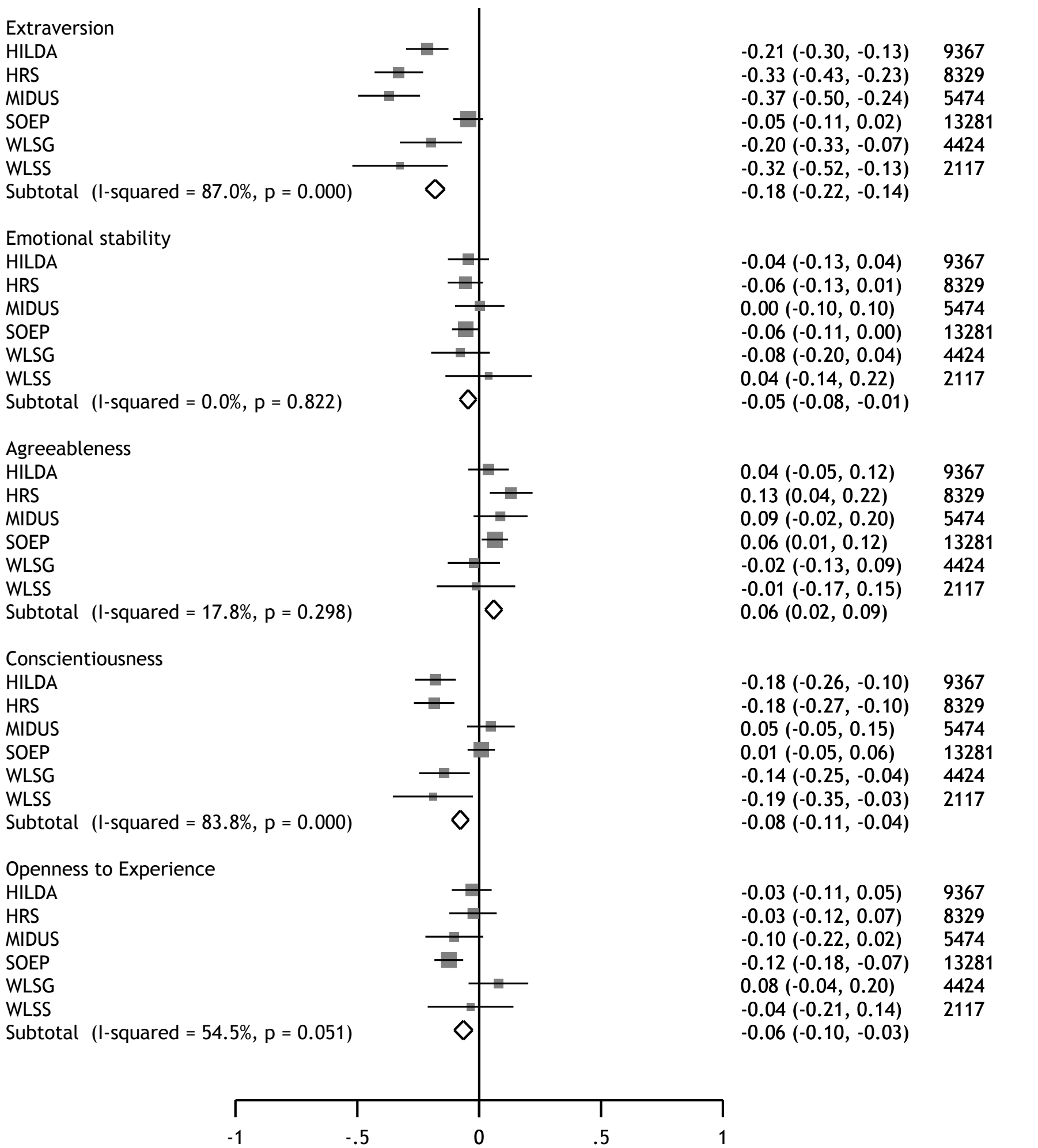
Supplementary Figure 3. Within-individual associations of personality traits with sum of health risks.



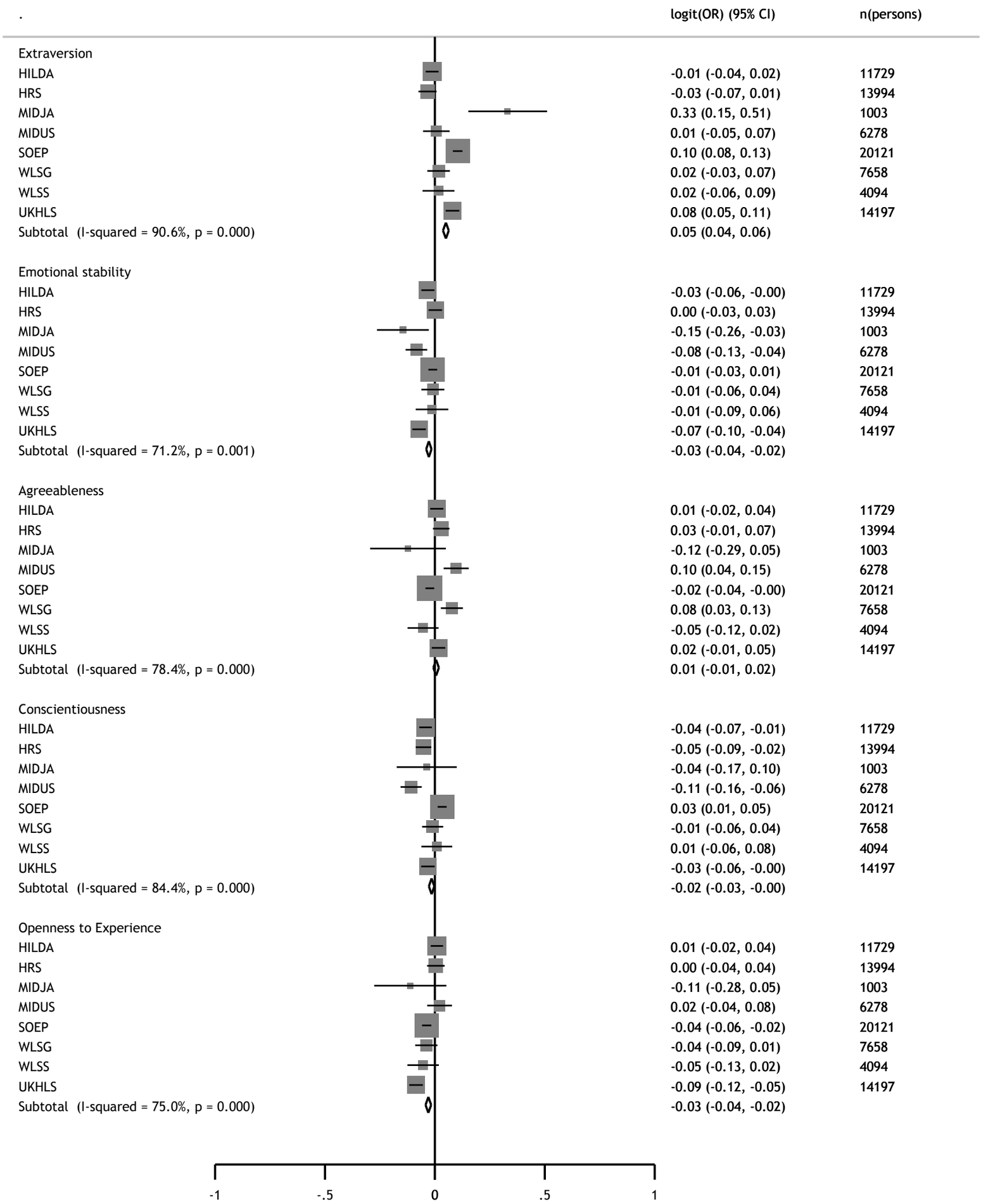
Supplementary Figure 4. Overall associations of personality traits with physical inactivity.



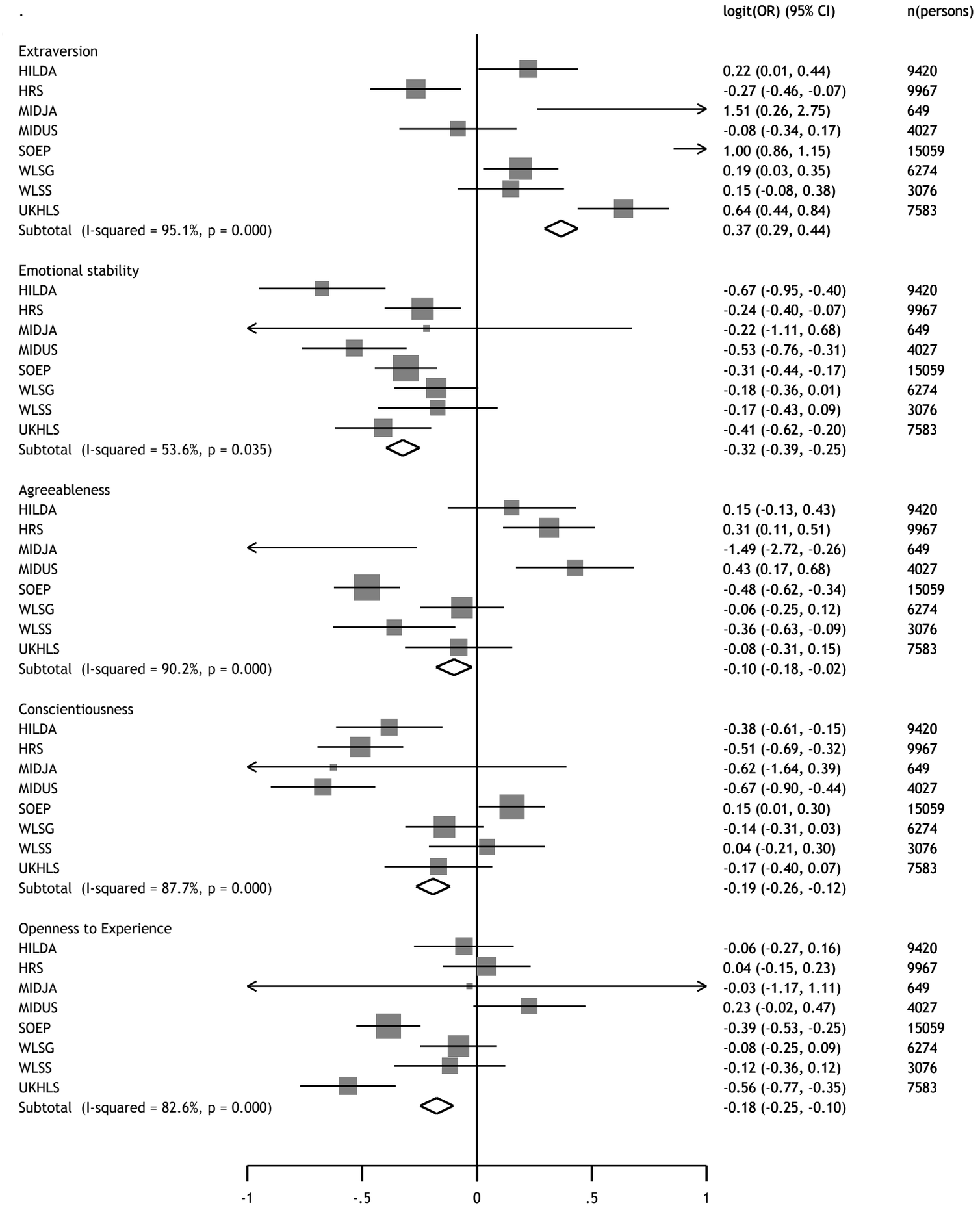
Supplementary Figure 5. Between-individual associations of personality traits with physical inactivity.



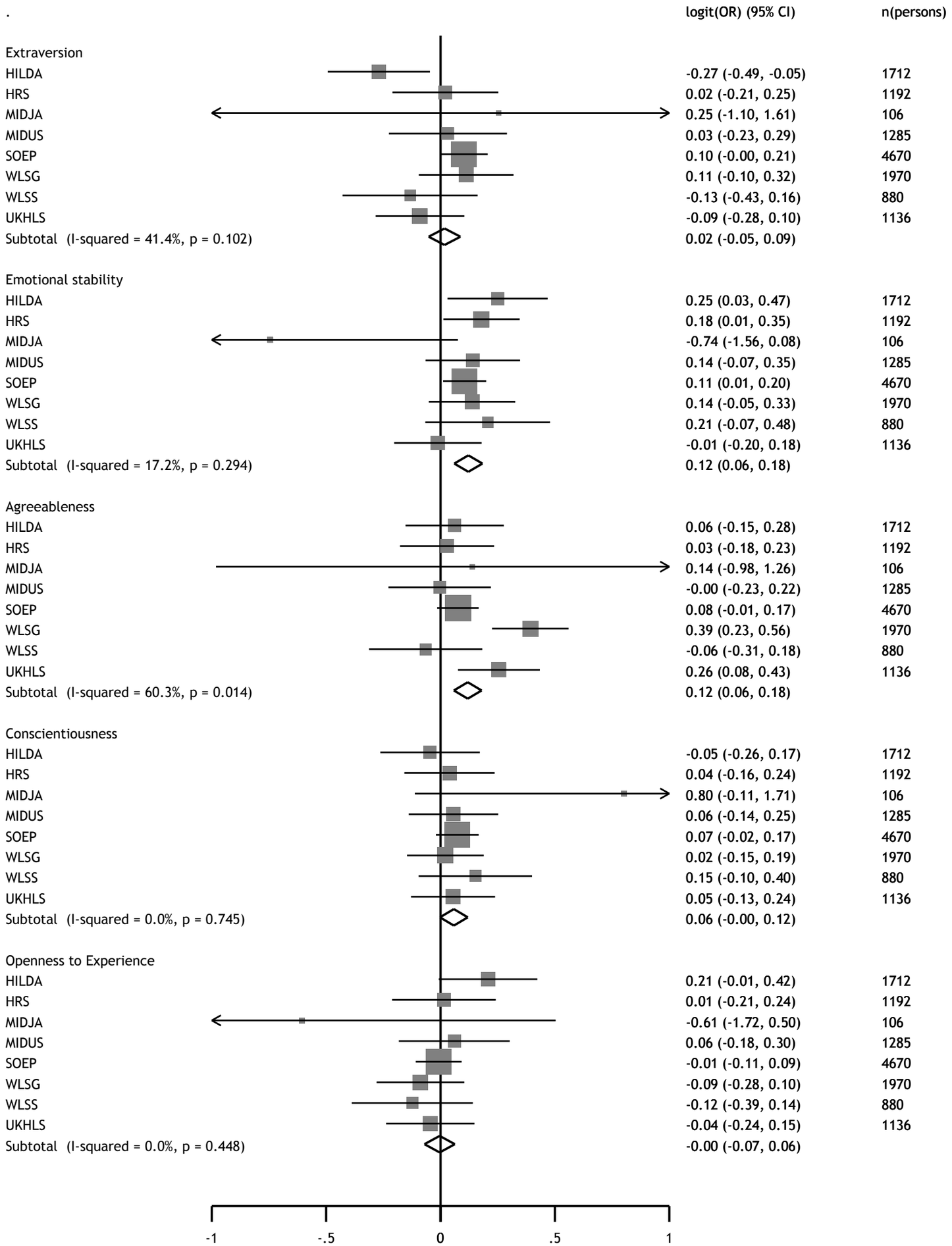
Supplementary Figure 6. Within-individual associations of personality traits with physical inactivity.



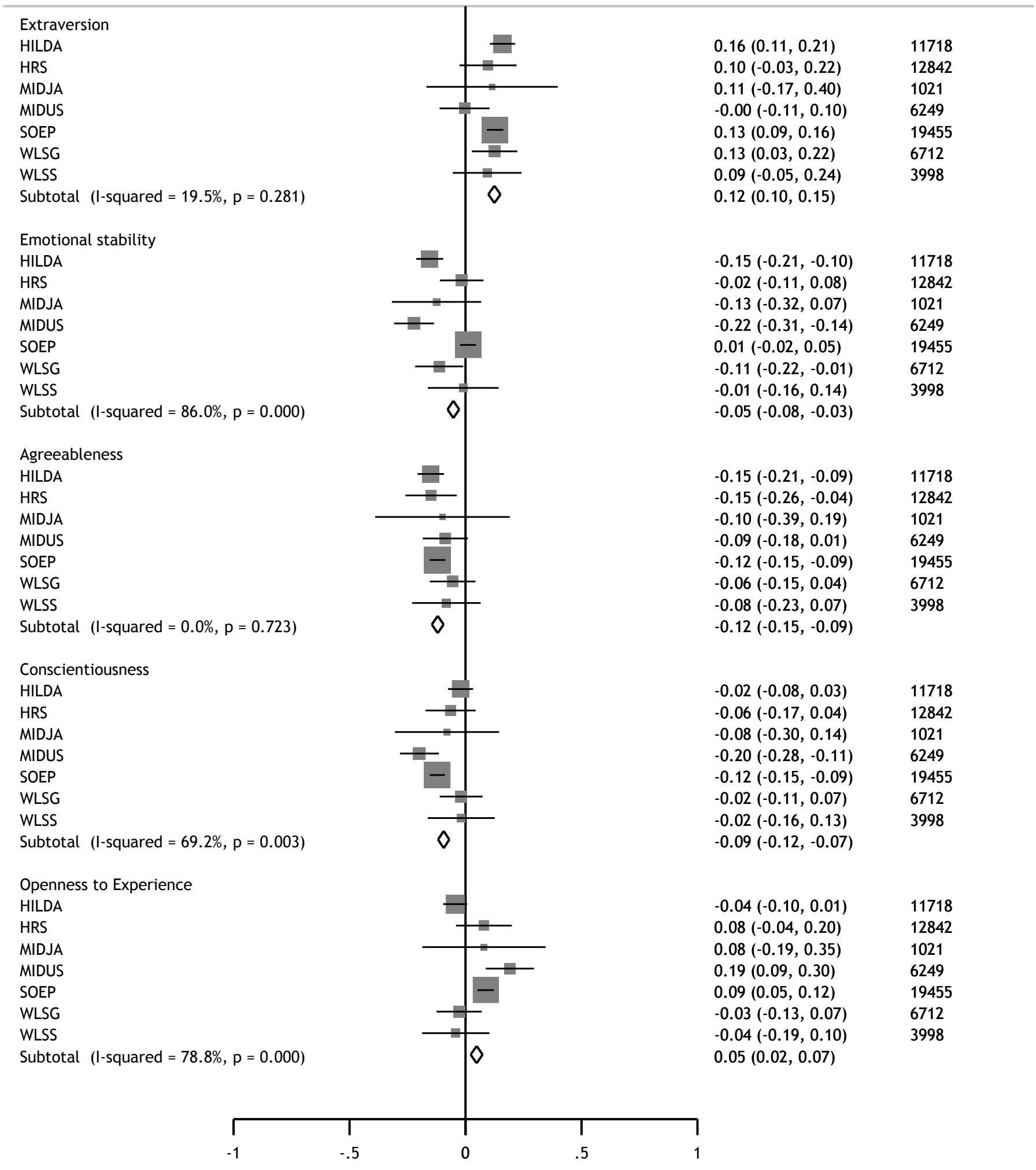
Supplementary Figure 7. Overall associations of personality traits with smoking.



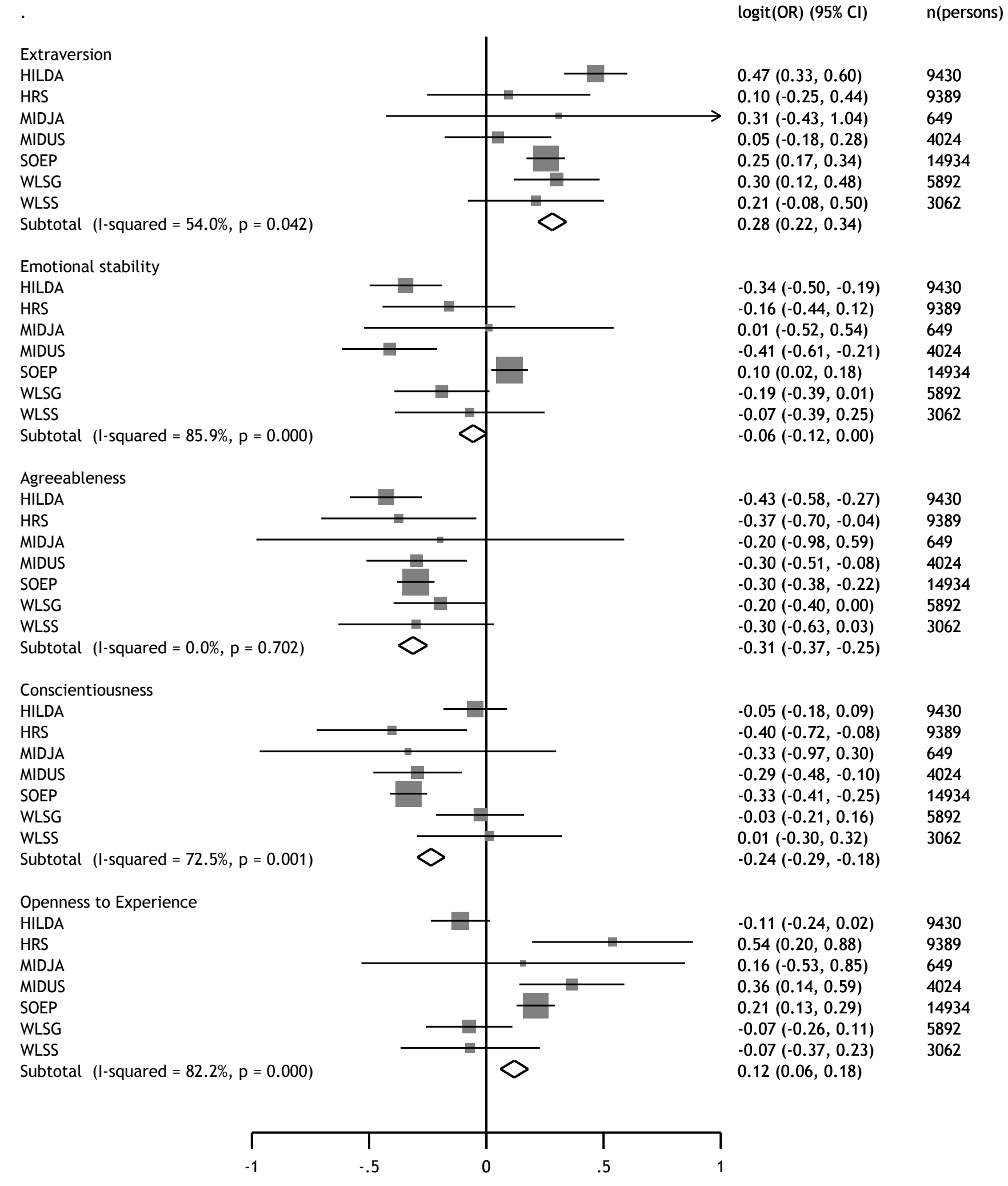
Supplementary Figure 8. Between-individual associations of personality traits with smoking.



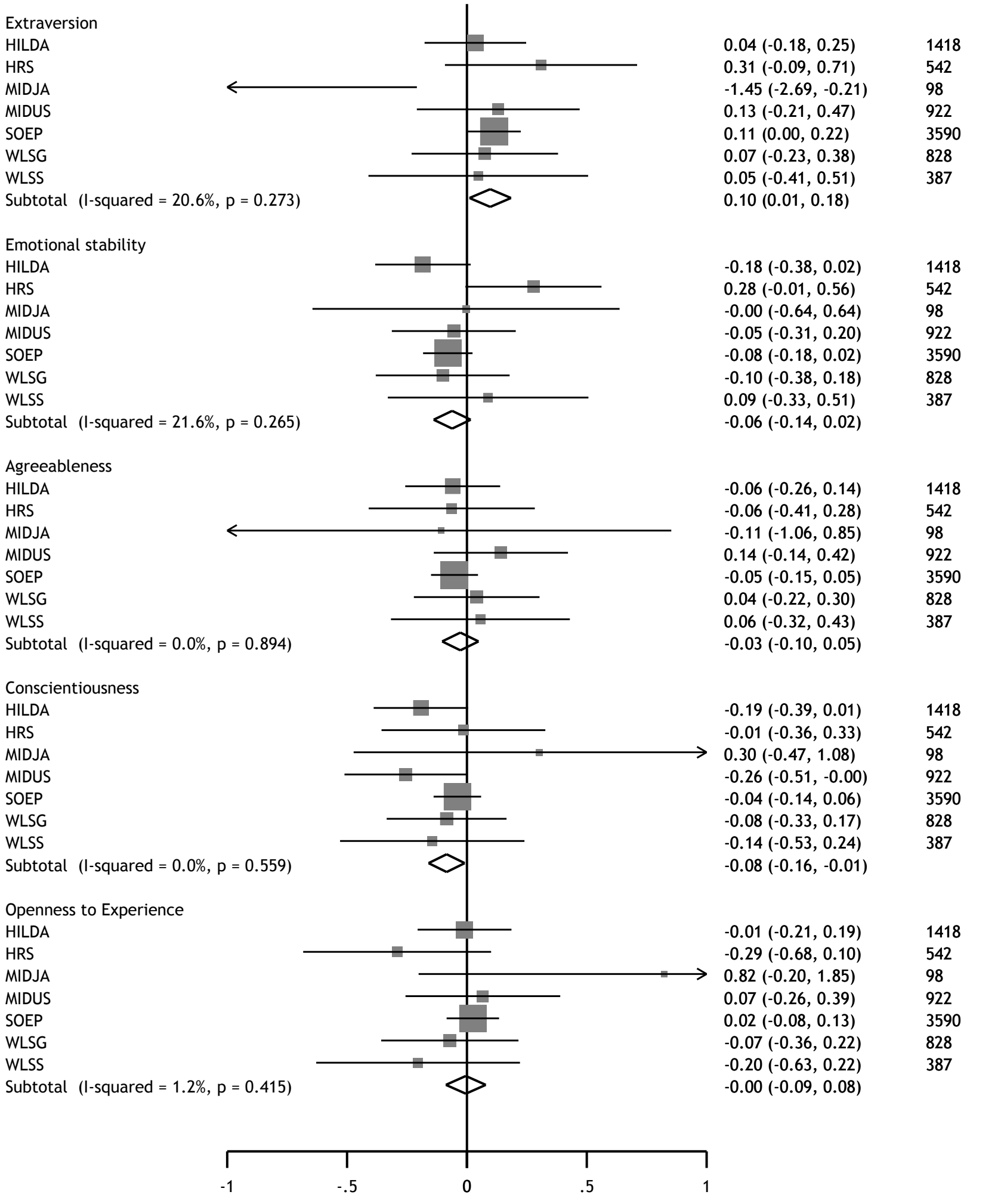
Supplementary Figure 9. Within-individual associations of personality traits with smoking.



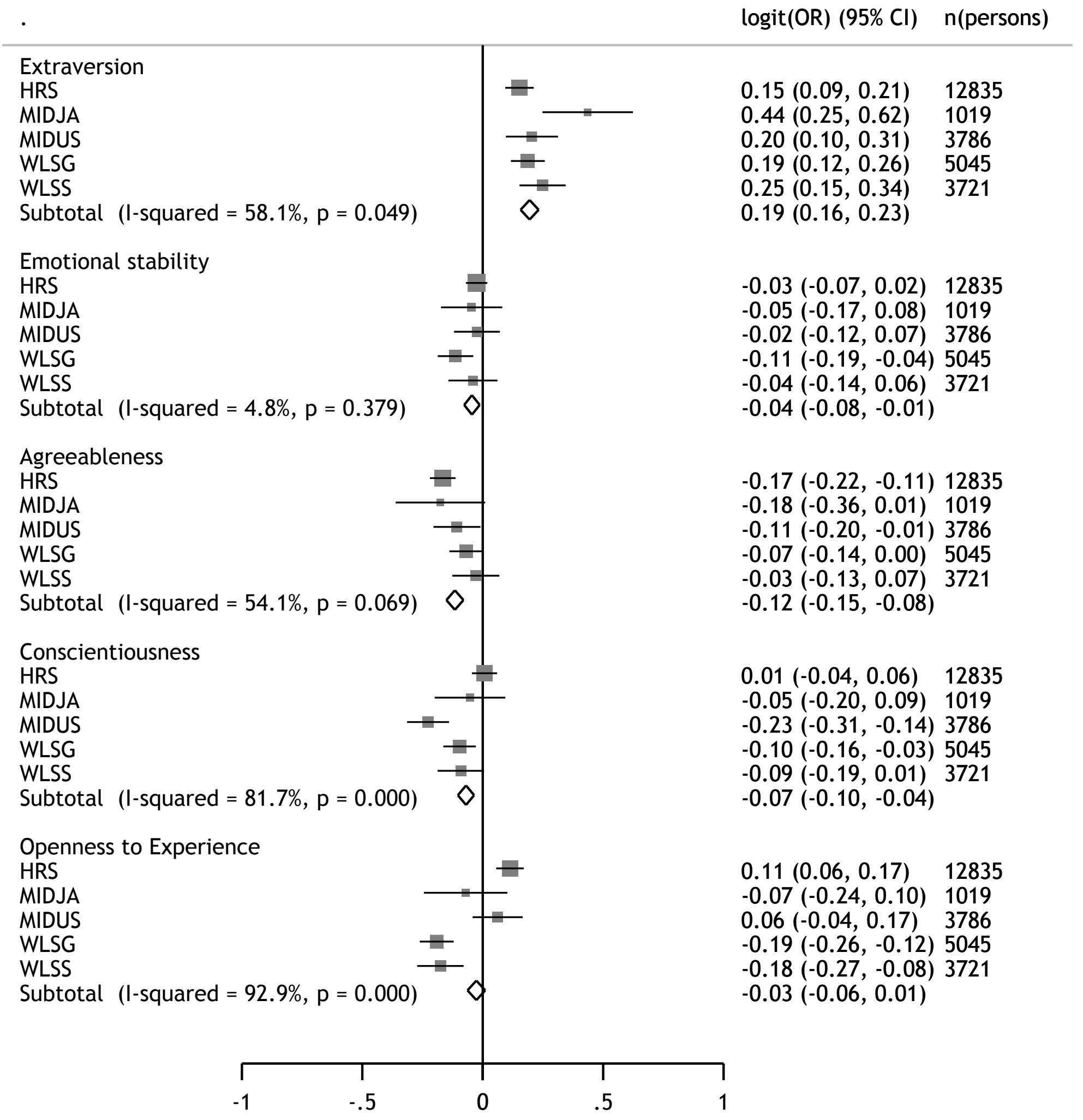
Supplementary Figure 10. Overall associations of personality traits with heavy drinking.



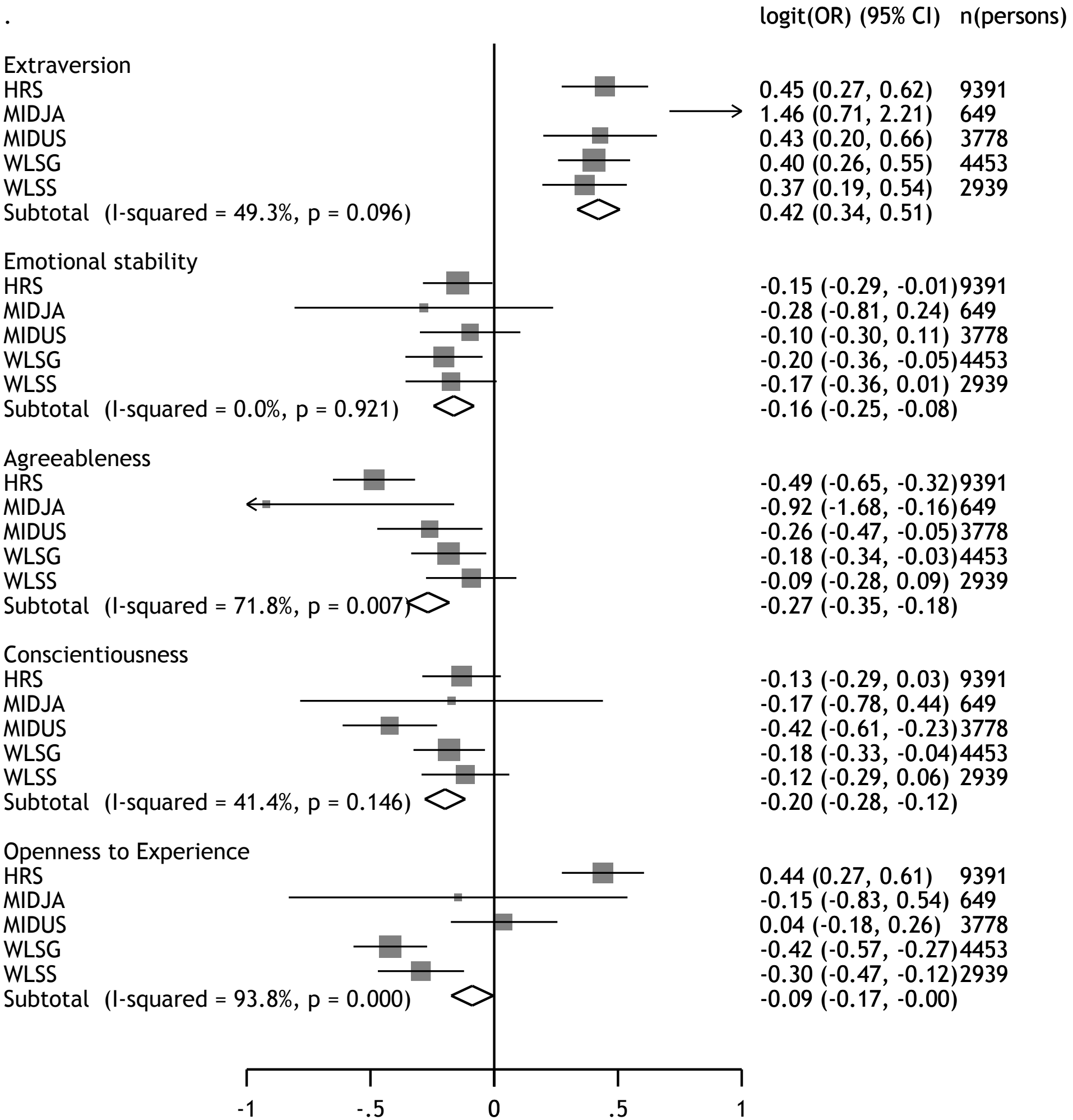
Supplementary Figure 11. Between-individual associations of personality traits with heavy drinking.



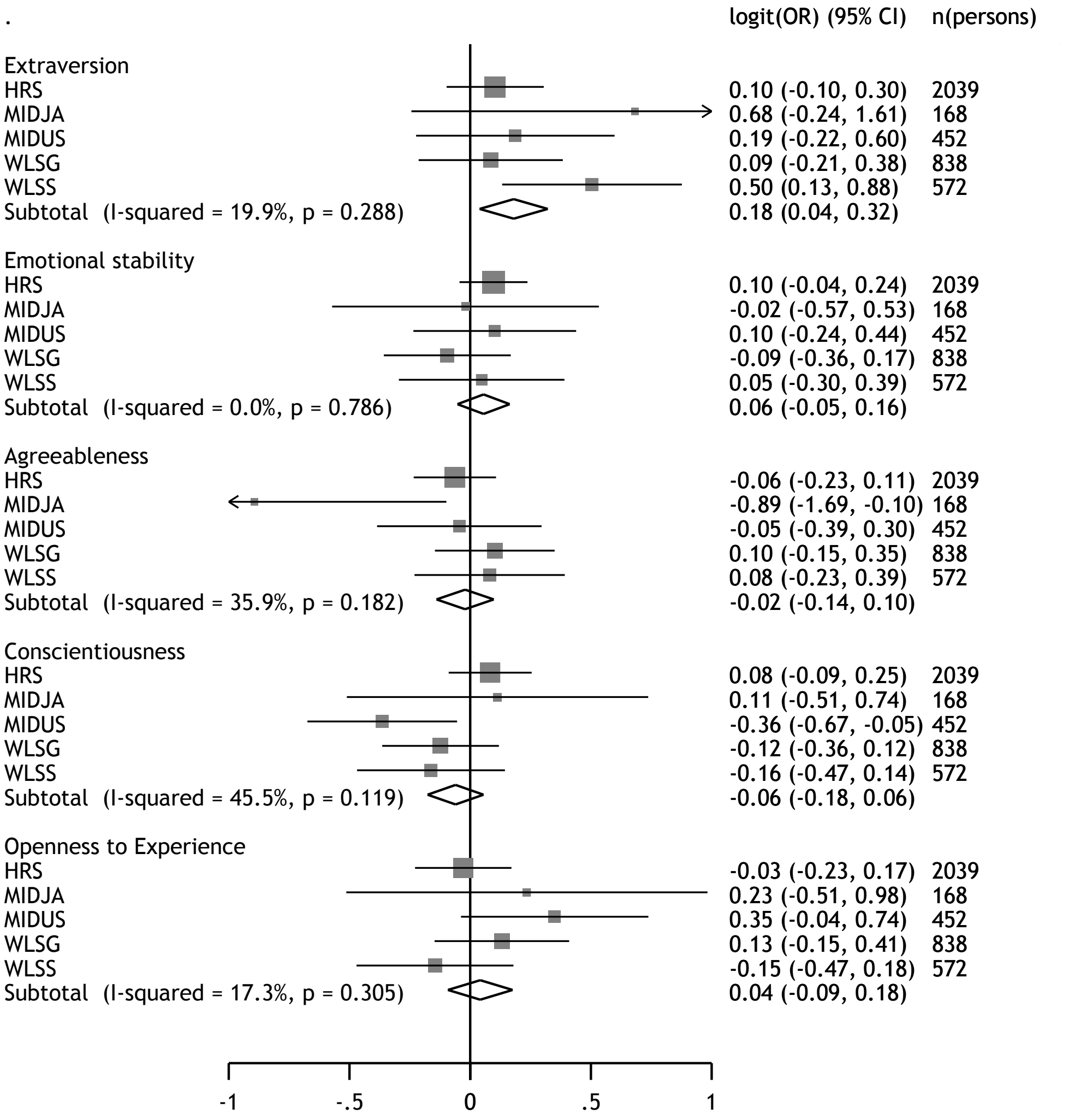
Supplementary Figure 12. Within-individual associations of personality traits with heavy drinking.



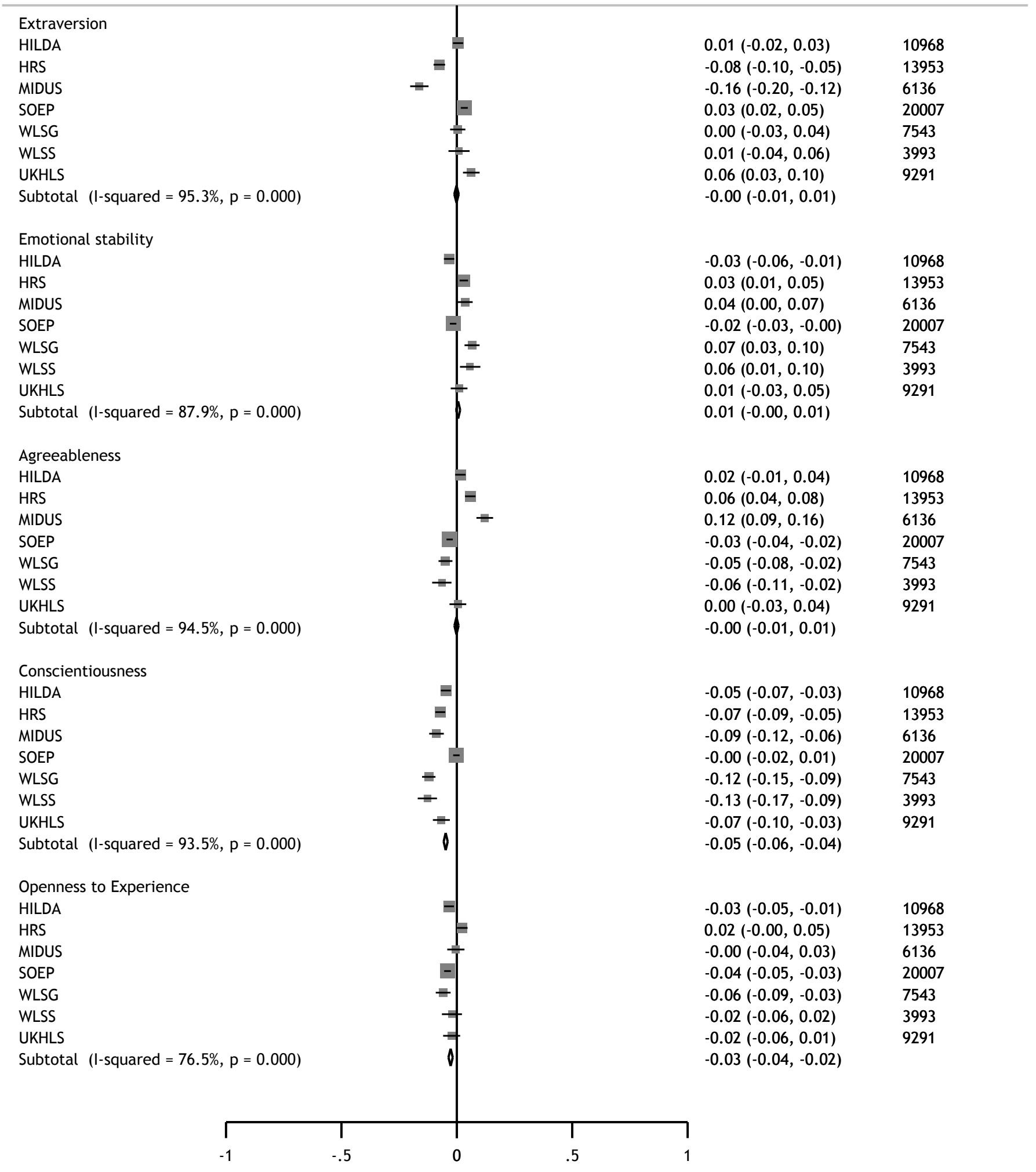
Supplementary Figure 13. Overall associations of personality traits with binge drinking.



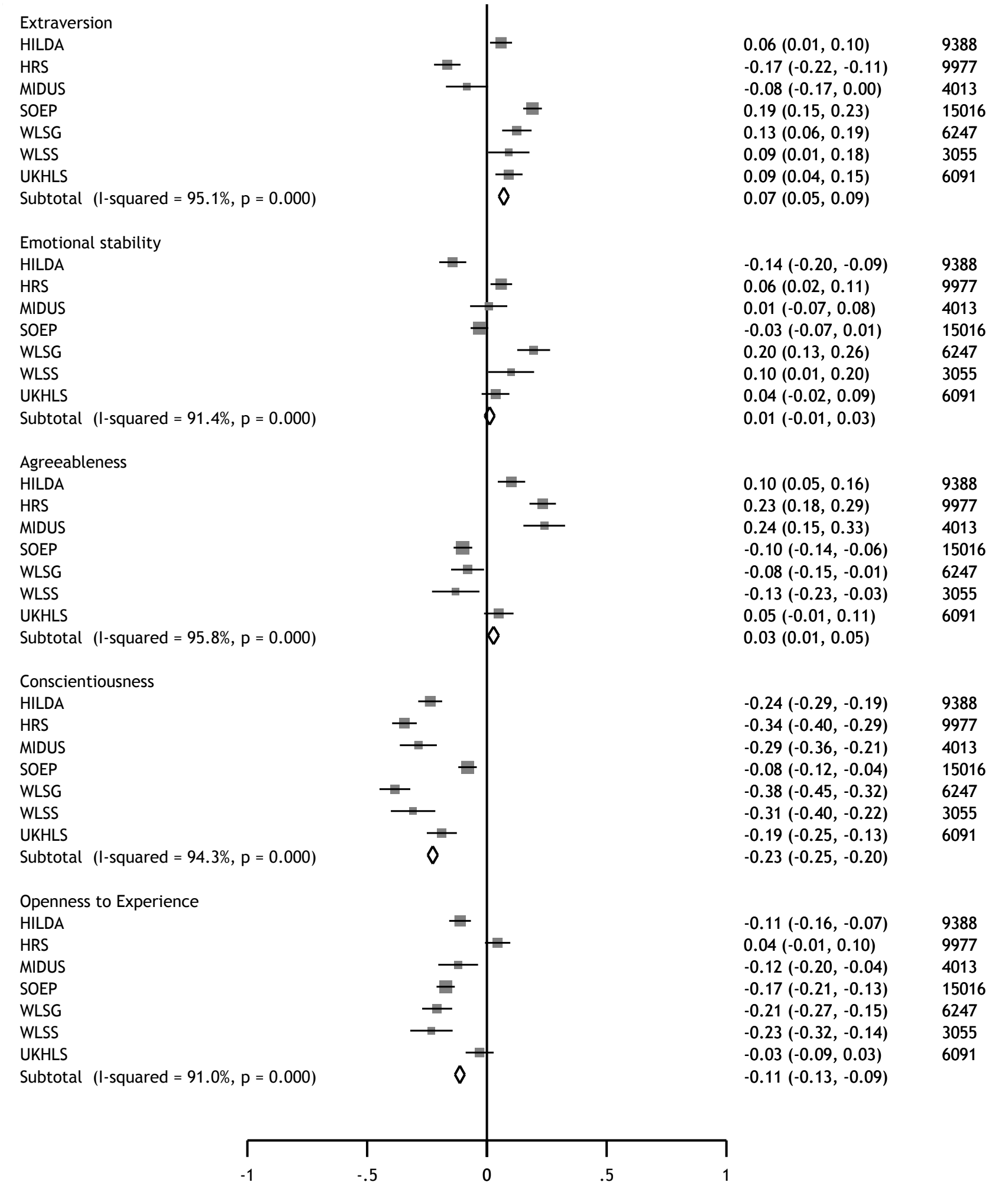
Supplementary Figure 14. Between-individual associations of personality traits with binge drinking.



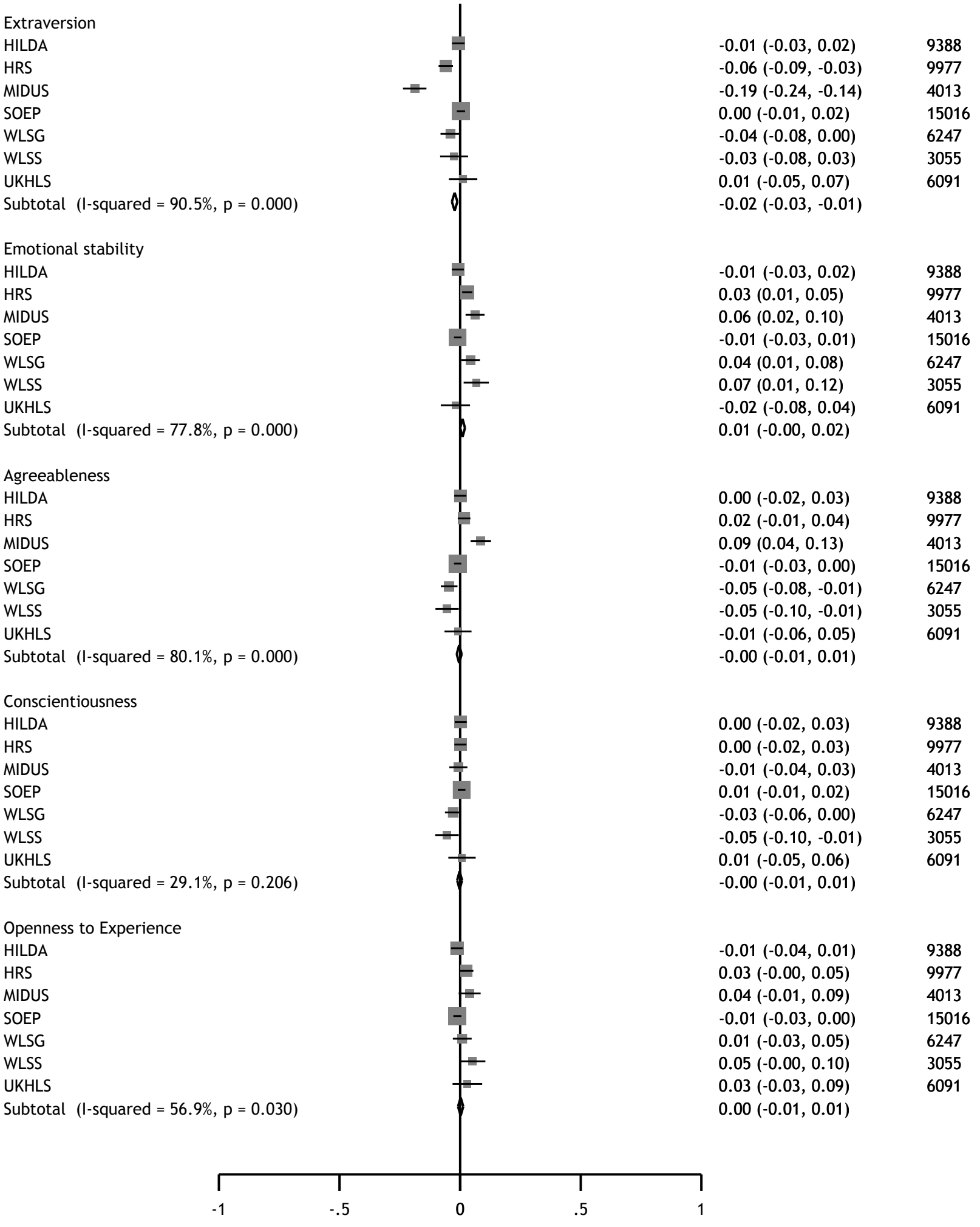
Supplementary Figure 15. Within-individual associations of personality traits with binge drinking.



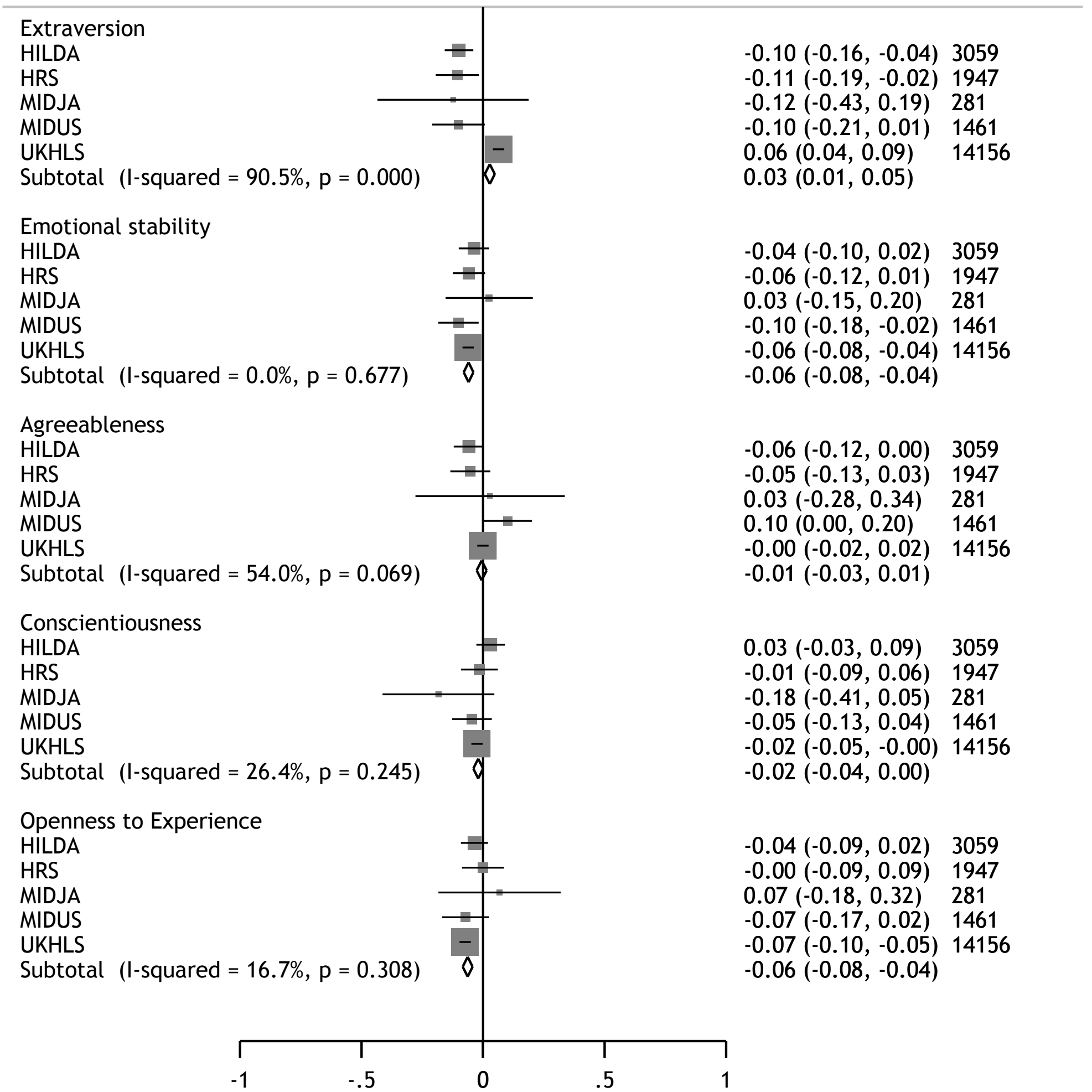
Supplementary Figure 16. Overall associations of personality traits with BMI.



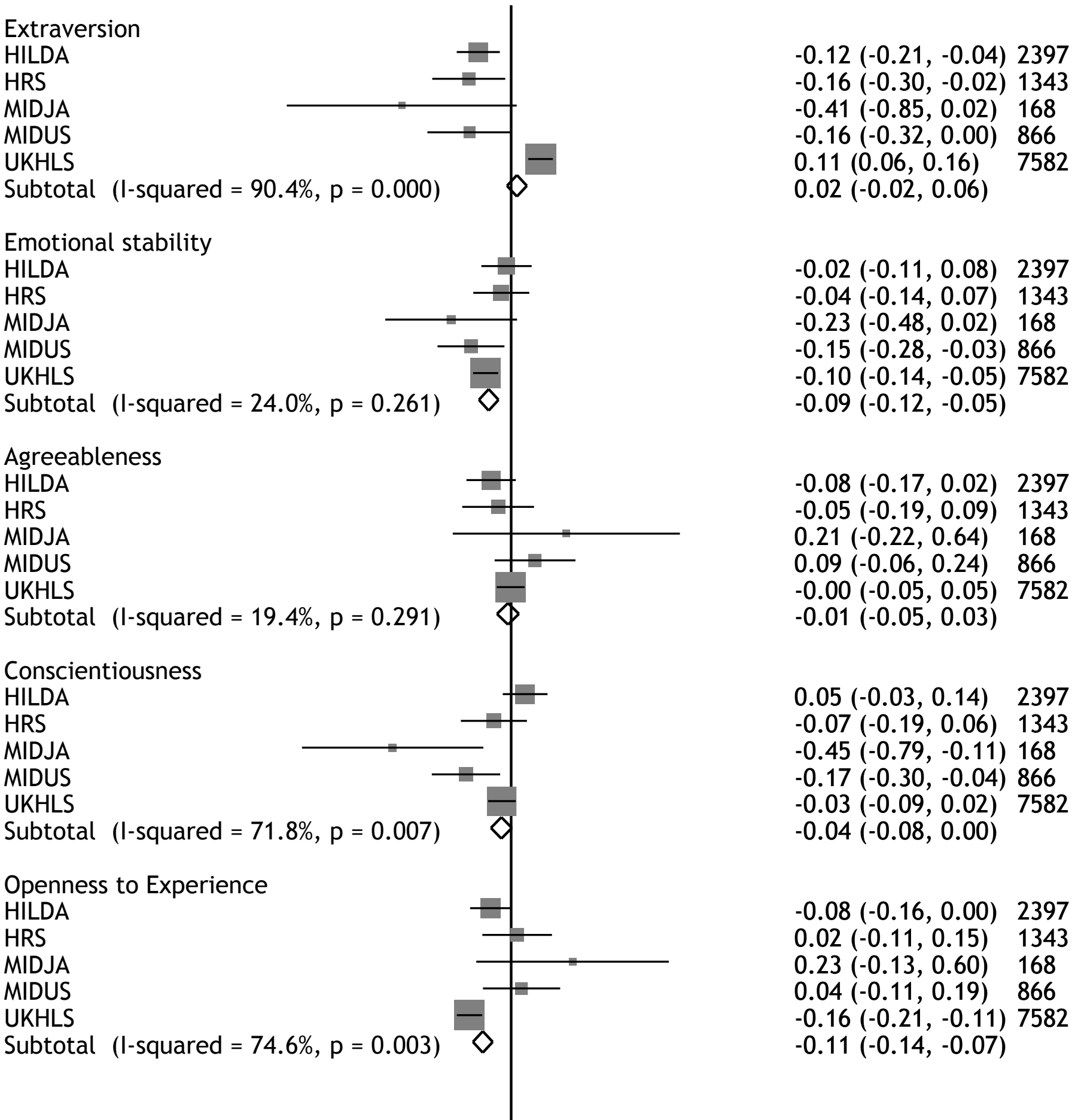
Supplementary Figure 17. Between-individual associations of personality traits with BMI.



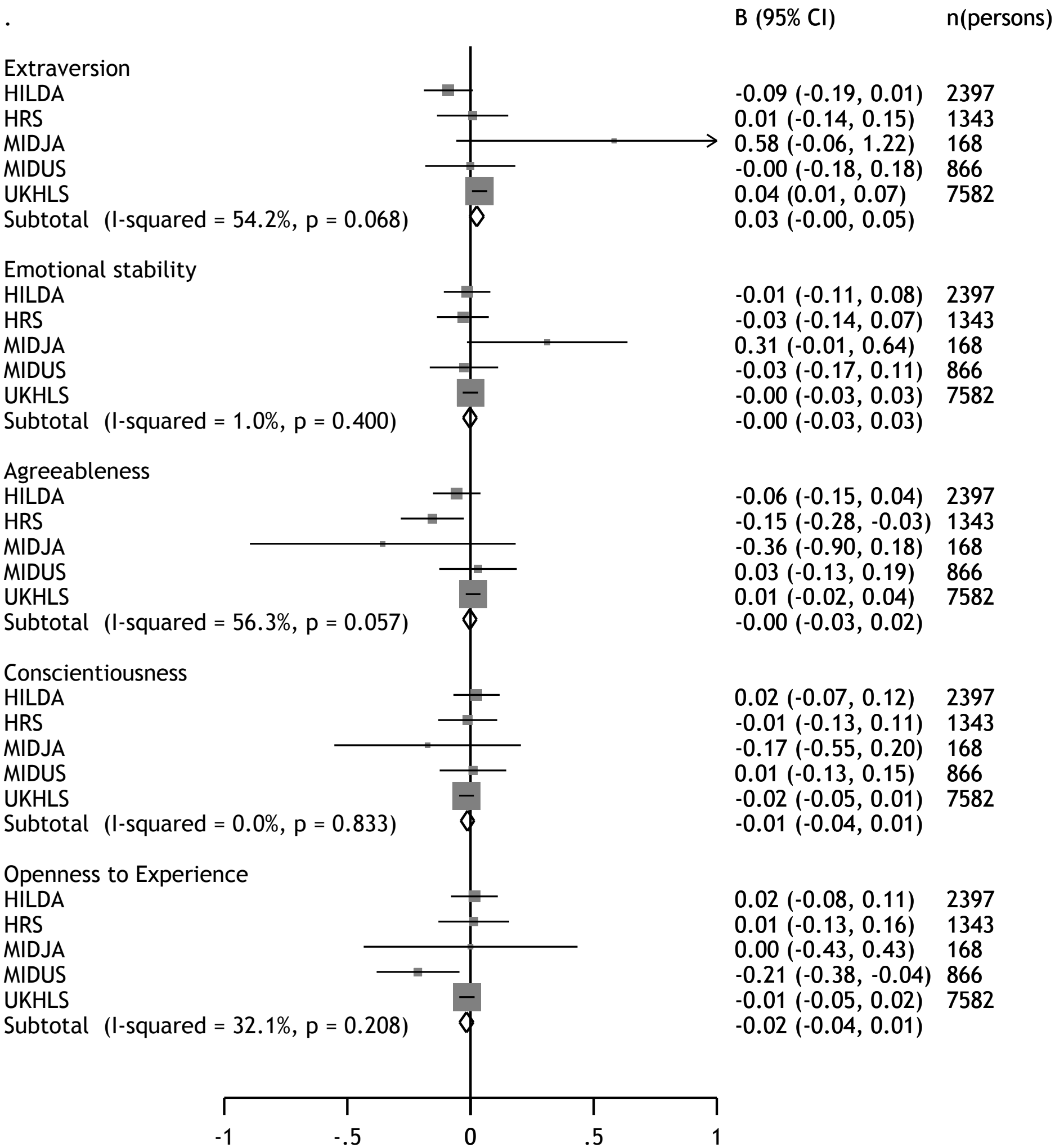
Supplementary Figure 18. Within-individual associations of personality traits with BMI.



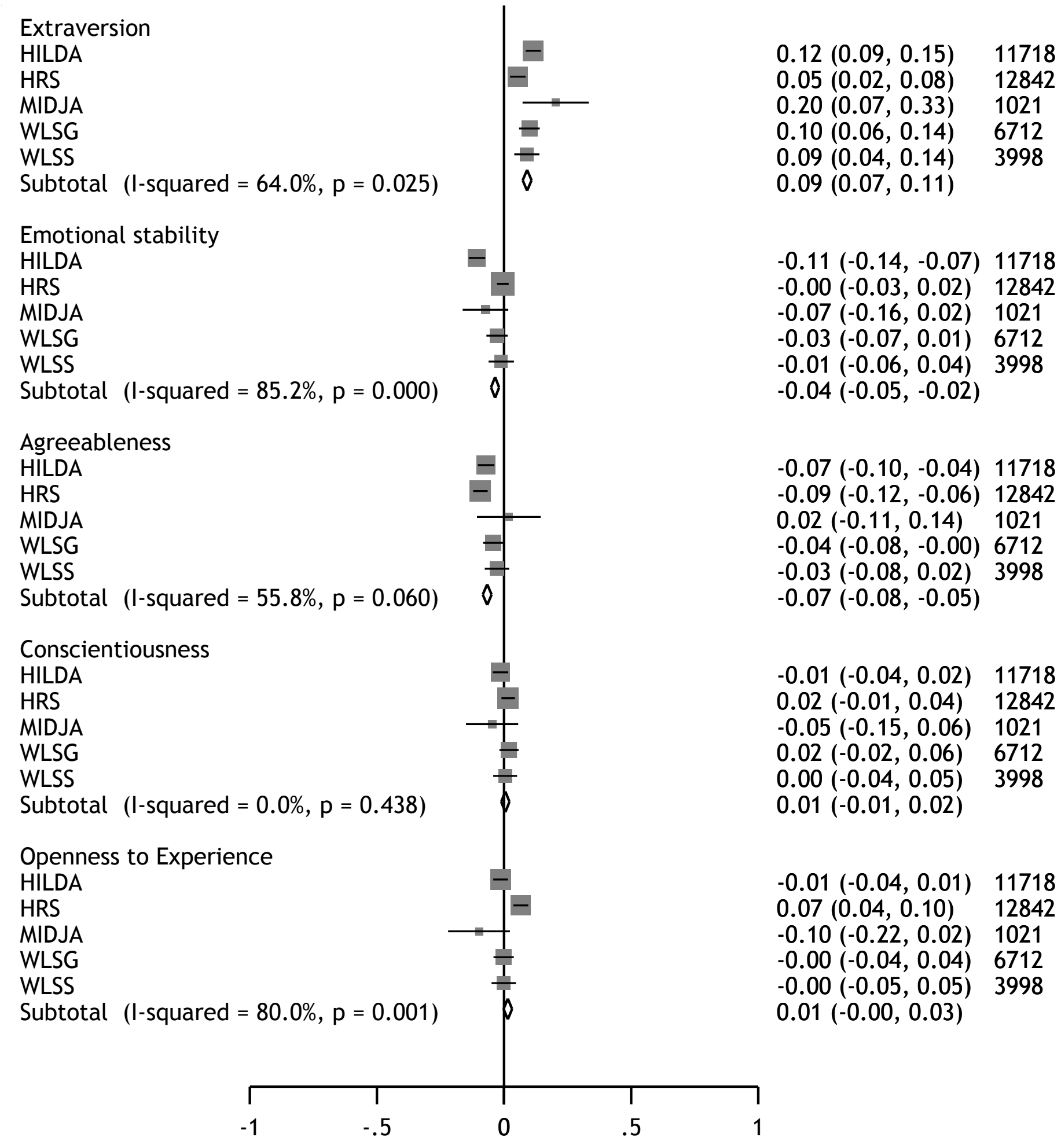
Supplementary Figure 19. Overall associations of personality traits with cigarettes per day.



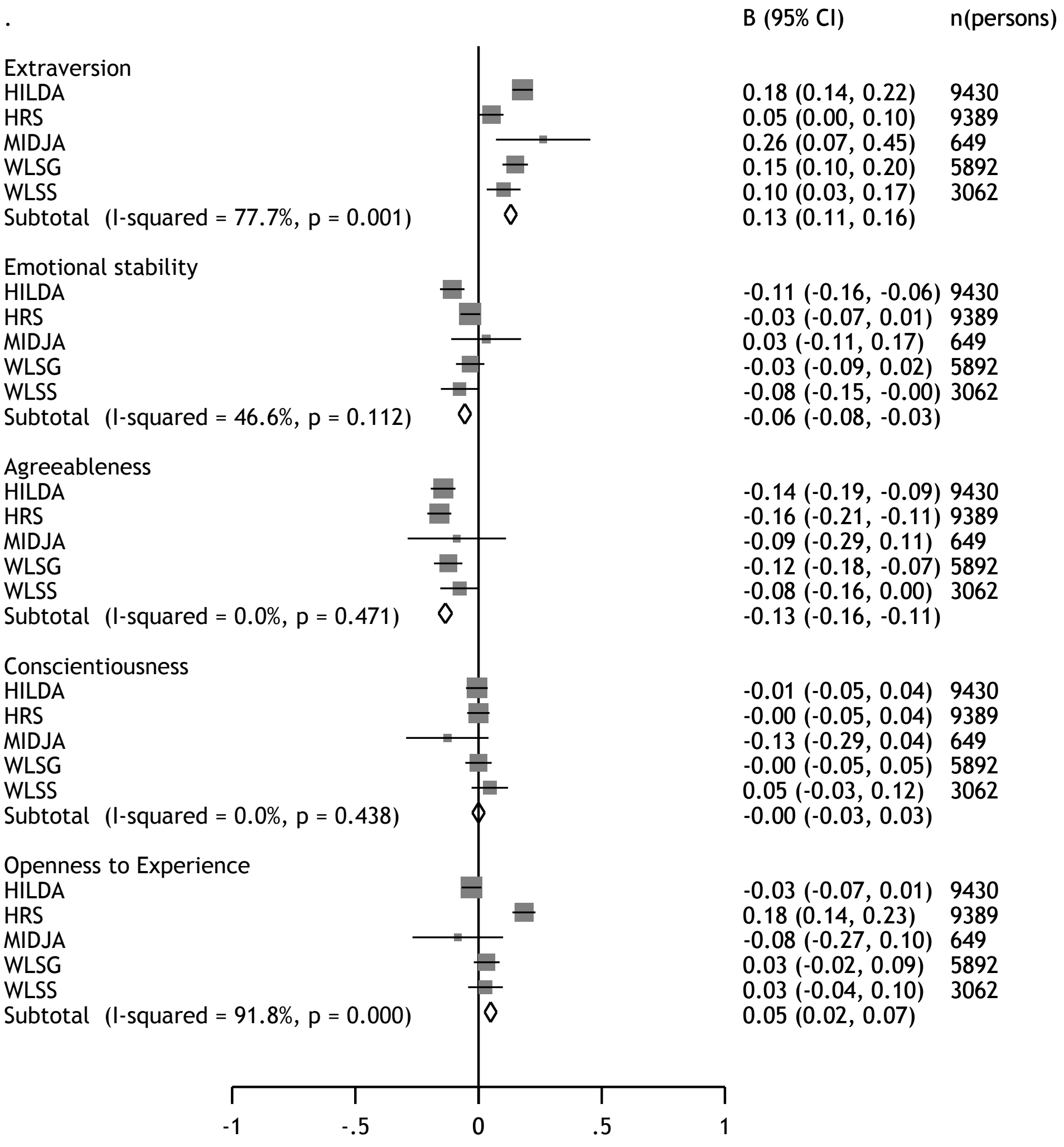
Supplementary Figure 20. Between-individual associations of personality traits with cigarettes per day



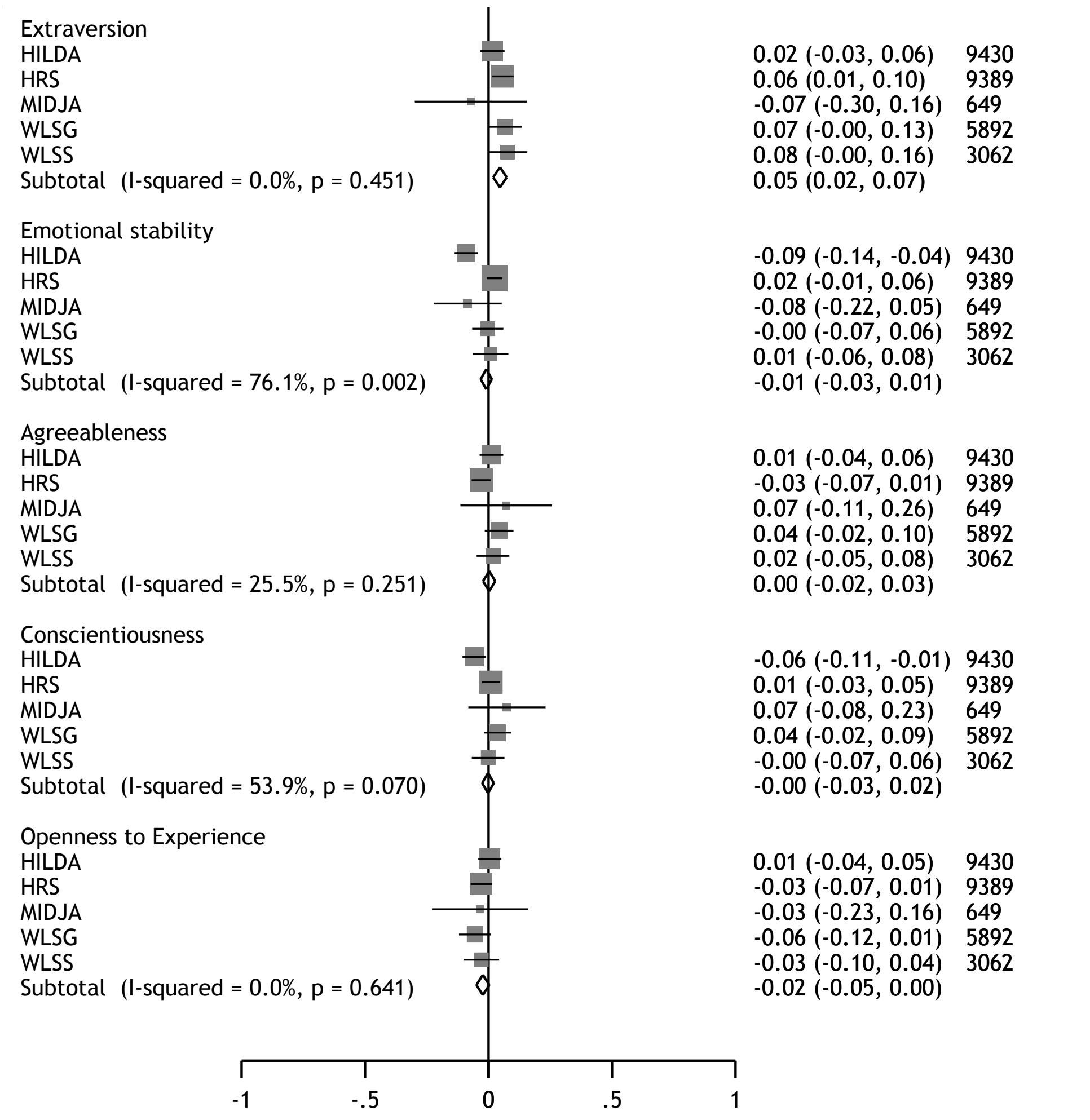
Supplementary Figure 21. Within-individual associations of personality traits with cigarettes per day.



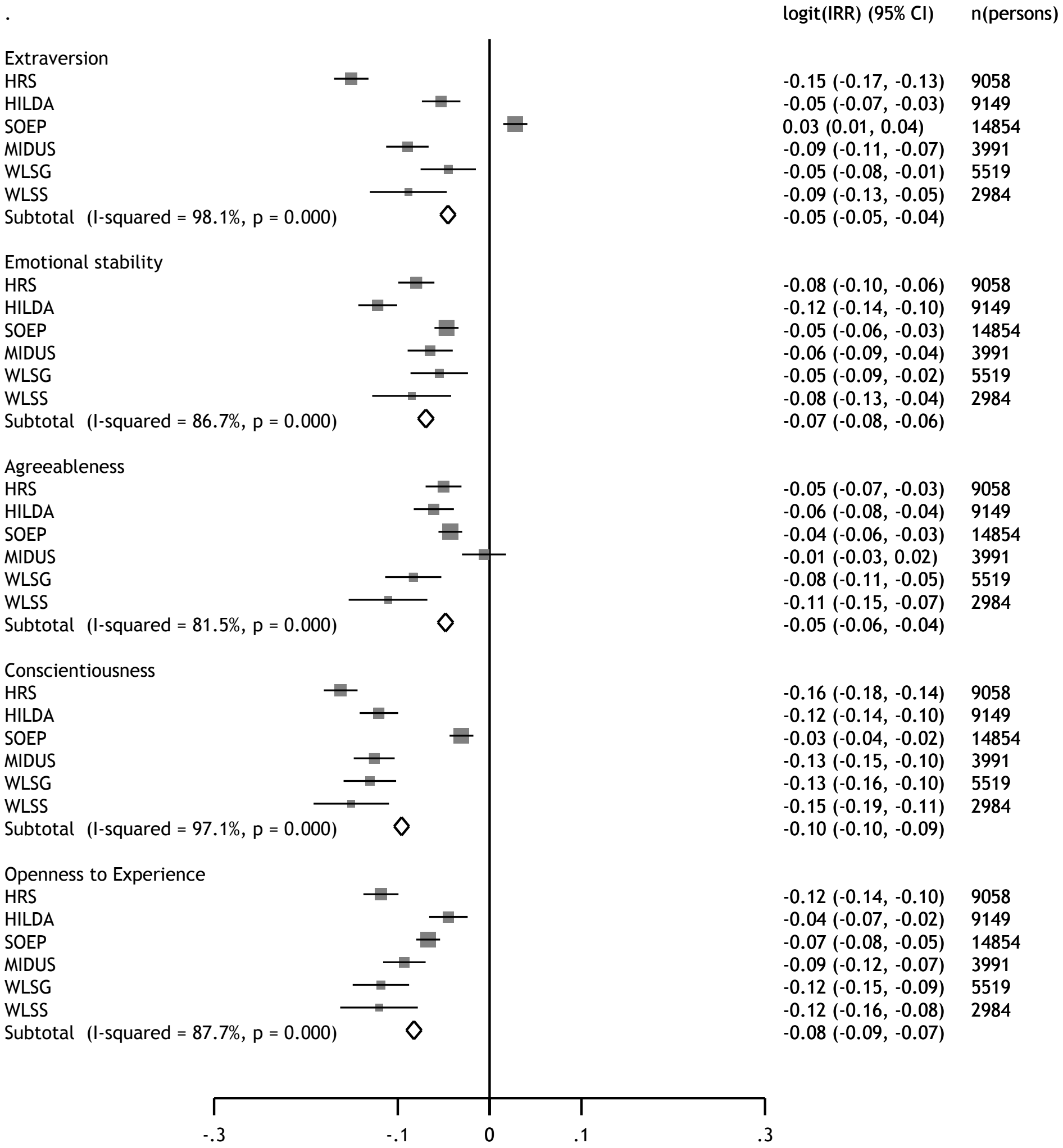
Supplementary Figure 22. Overall associations of personality traits with drinks per week.



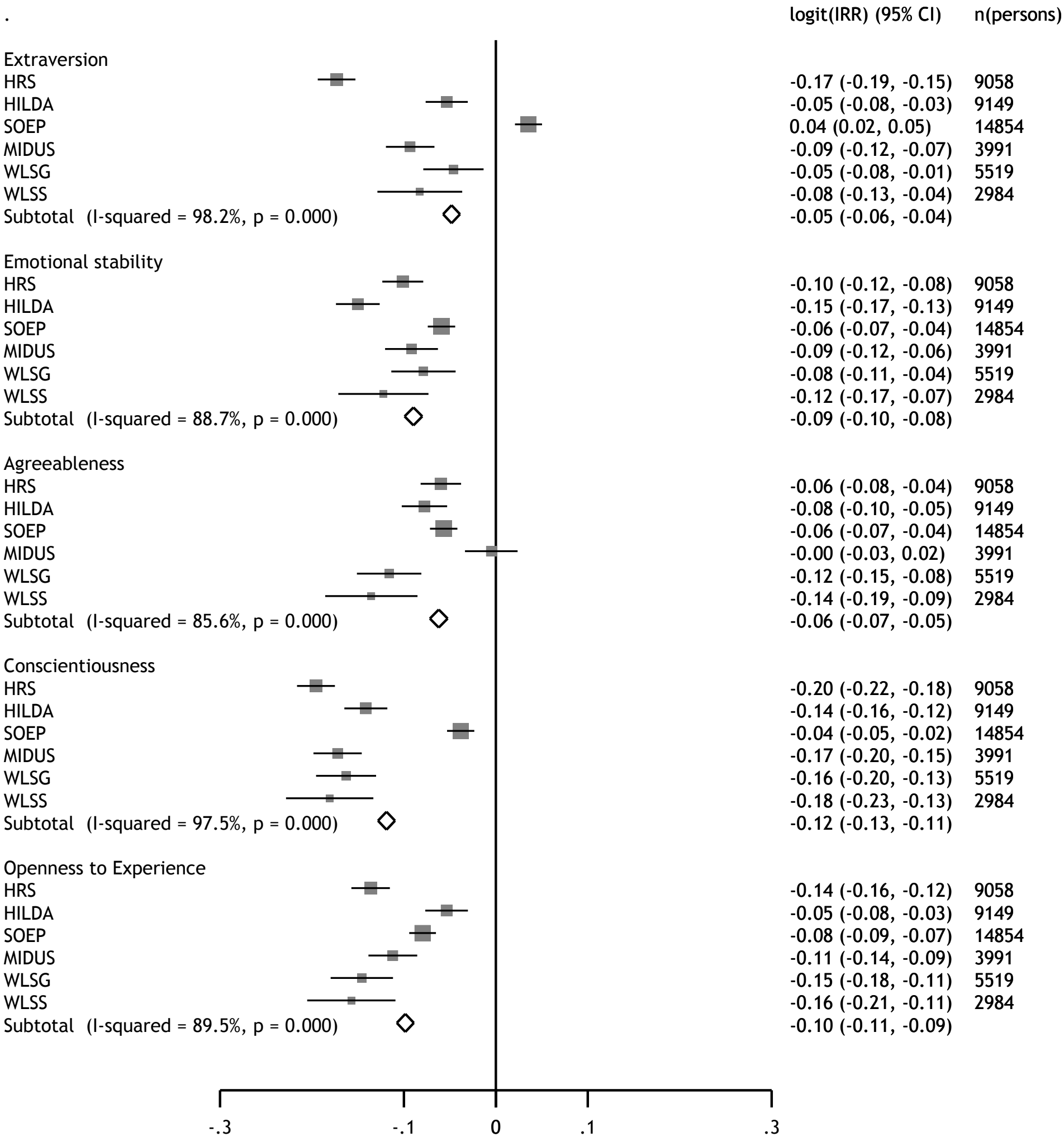
Supplementary Figure 23. Between-individual associations of personality traits with drinks per week.



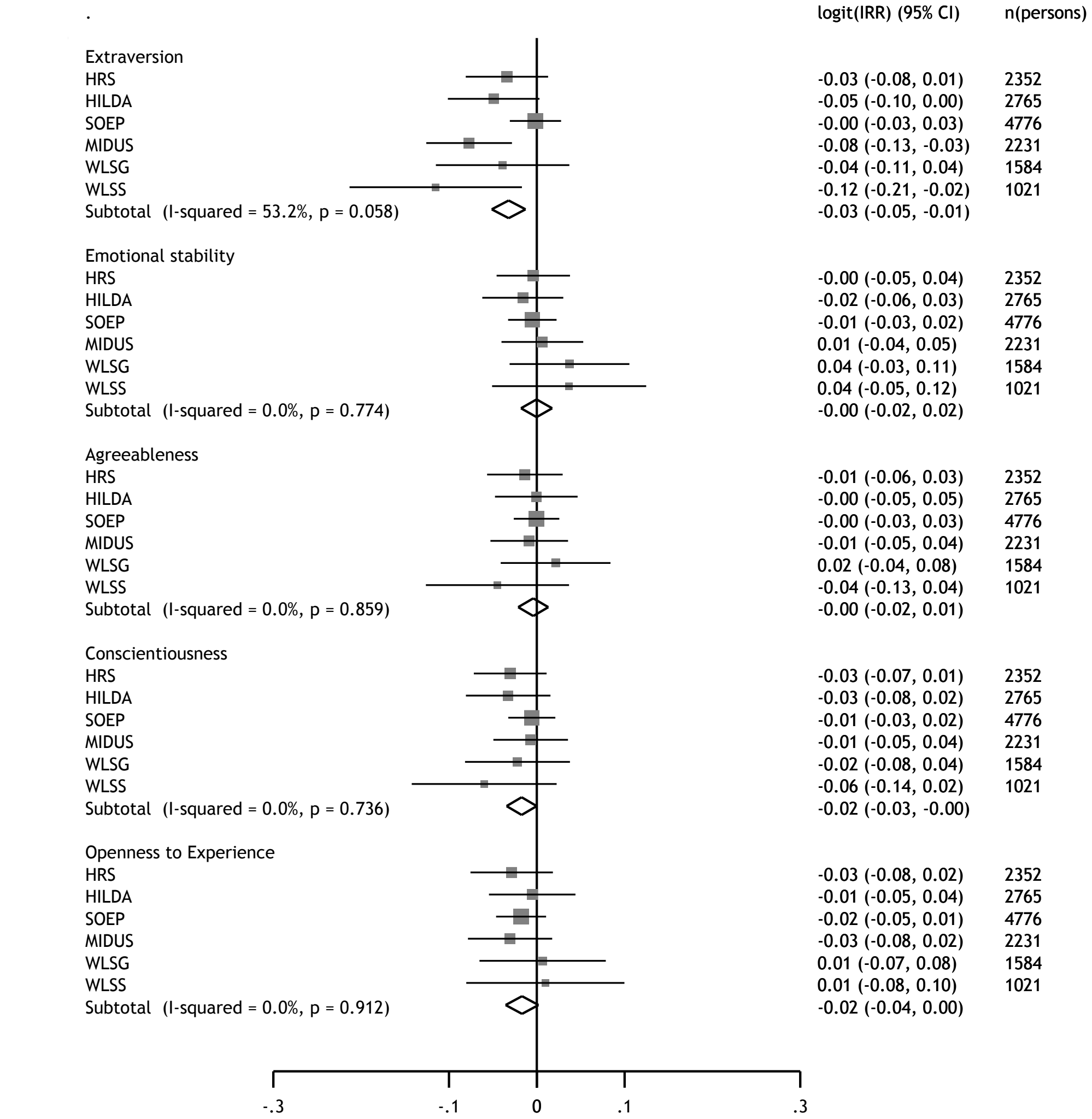
Supplementary Figure 24. Within-individual associations of personality traits with drinks per week.



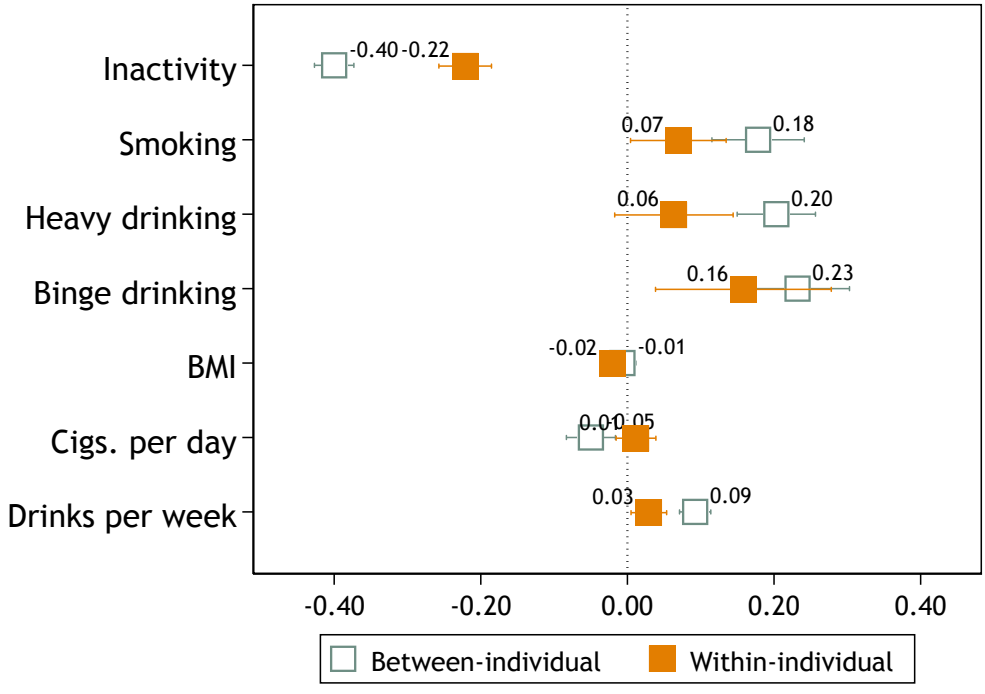
Supplementary Figure 25. Overall associations with sum of health risks unadjusted for other traits



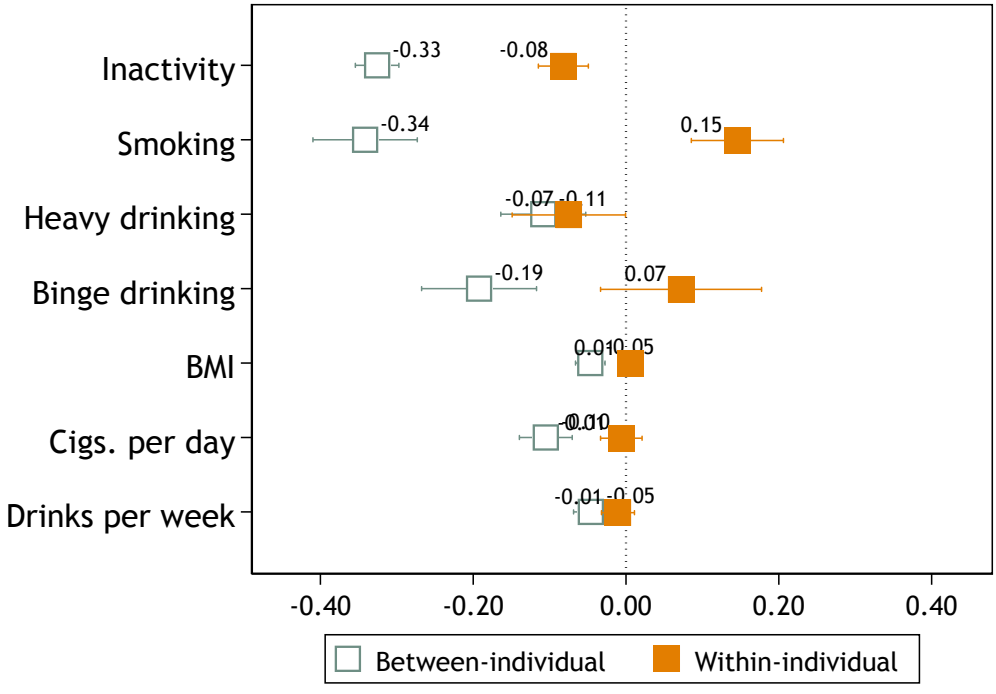
Supplementary Figure 26. Between-individual associations with sum of health risks unadjusted for oth



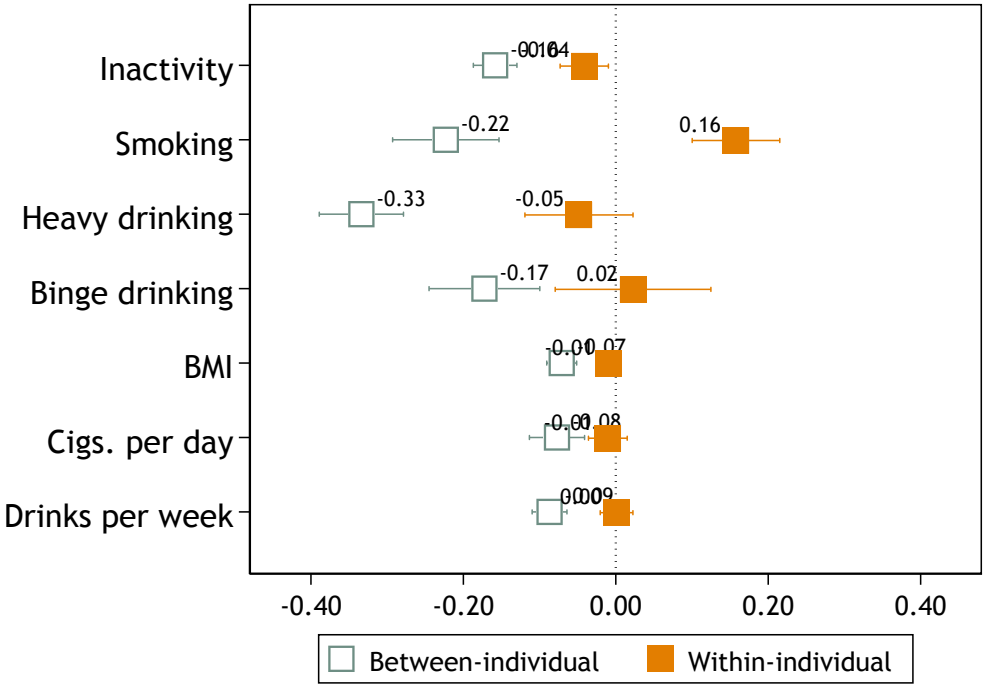
Supplementary Figure 27. Within-individual associations with sum of health risks unadjusted for other



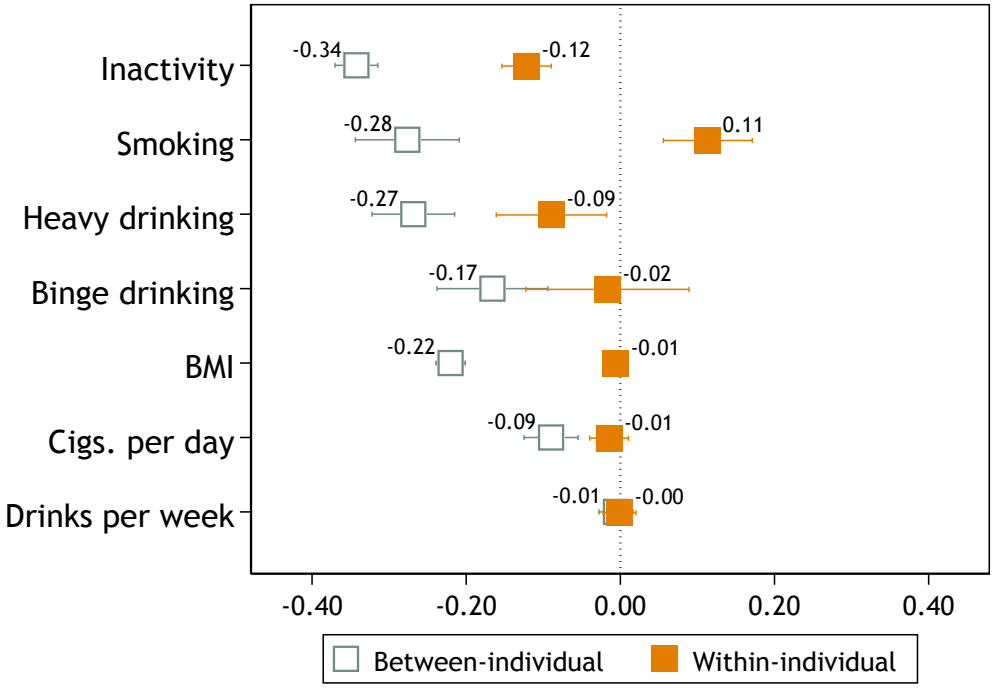
Supplementary Figure 28. Pooled associations of extraversion when not adjusted for other traits



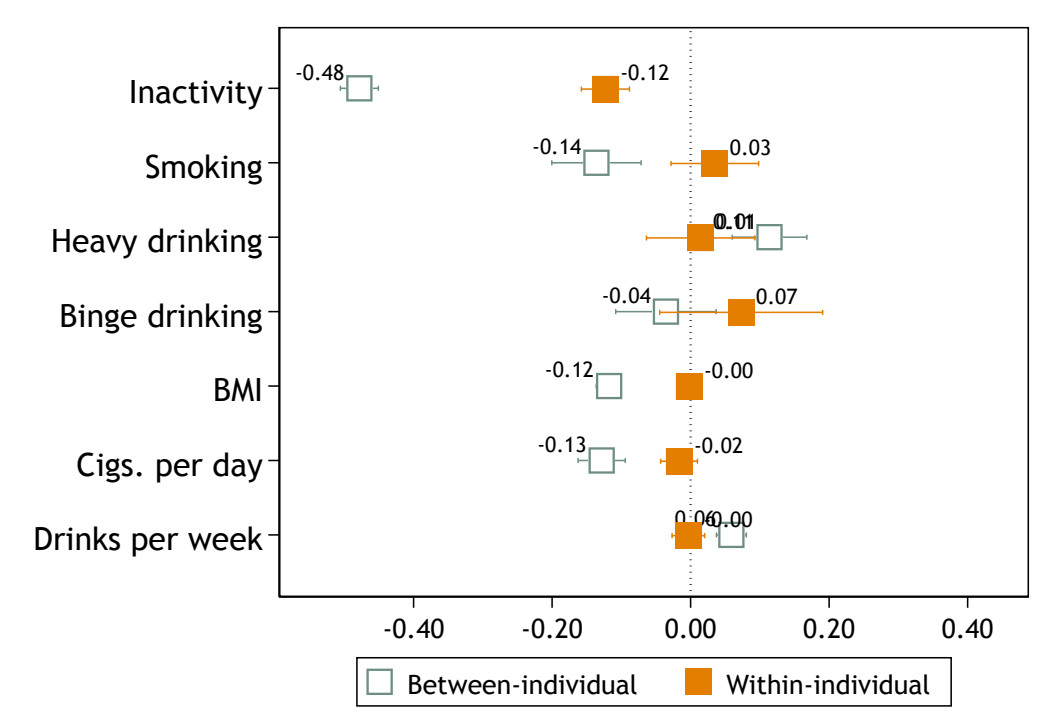
Supplementary Figure 29. Pooled associations of emotional stability when not adjusted for other traits



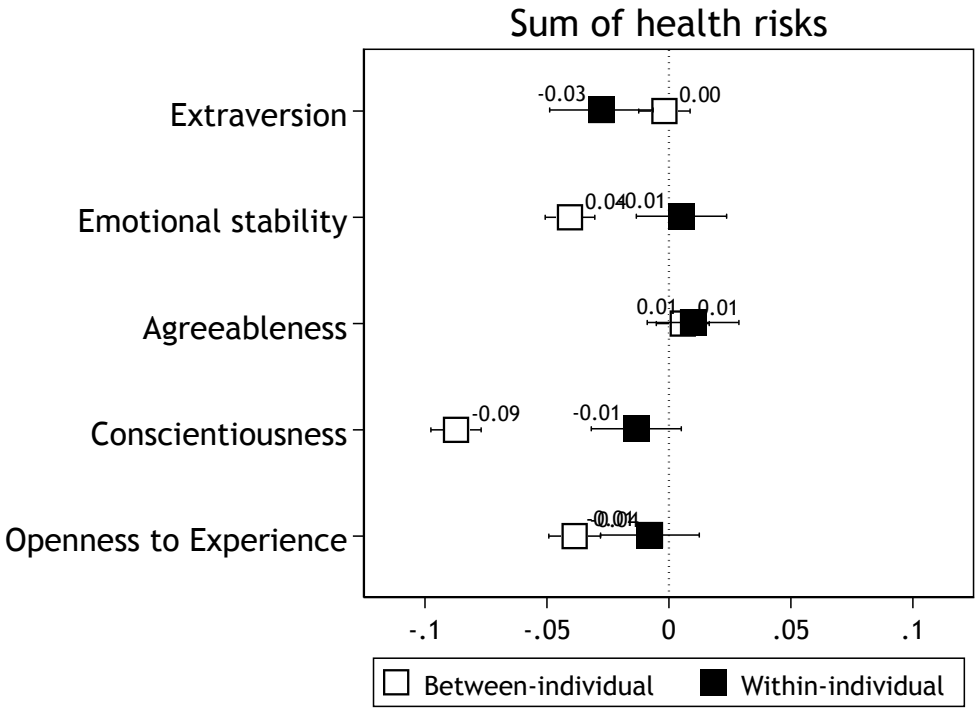
Supplementary Figure 30. Pooled associations of agreeableness when not adjusted for other traits



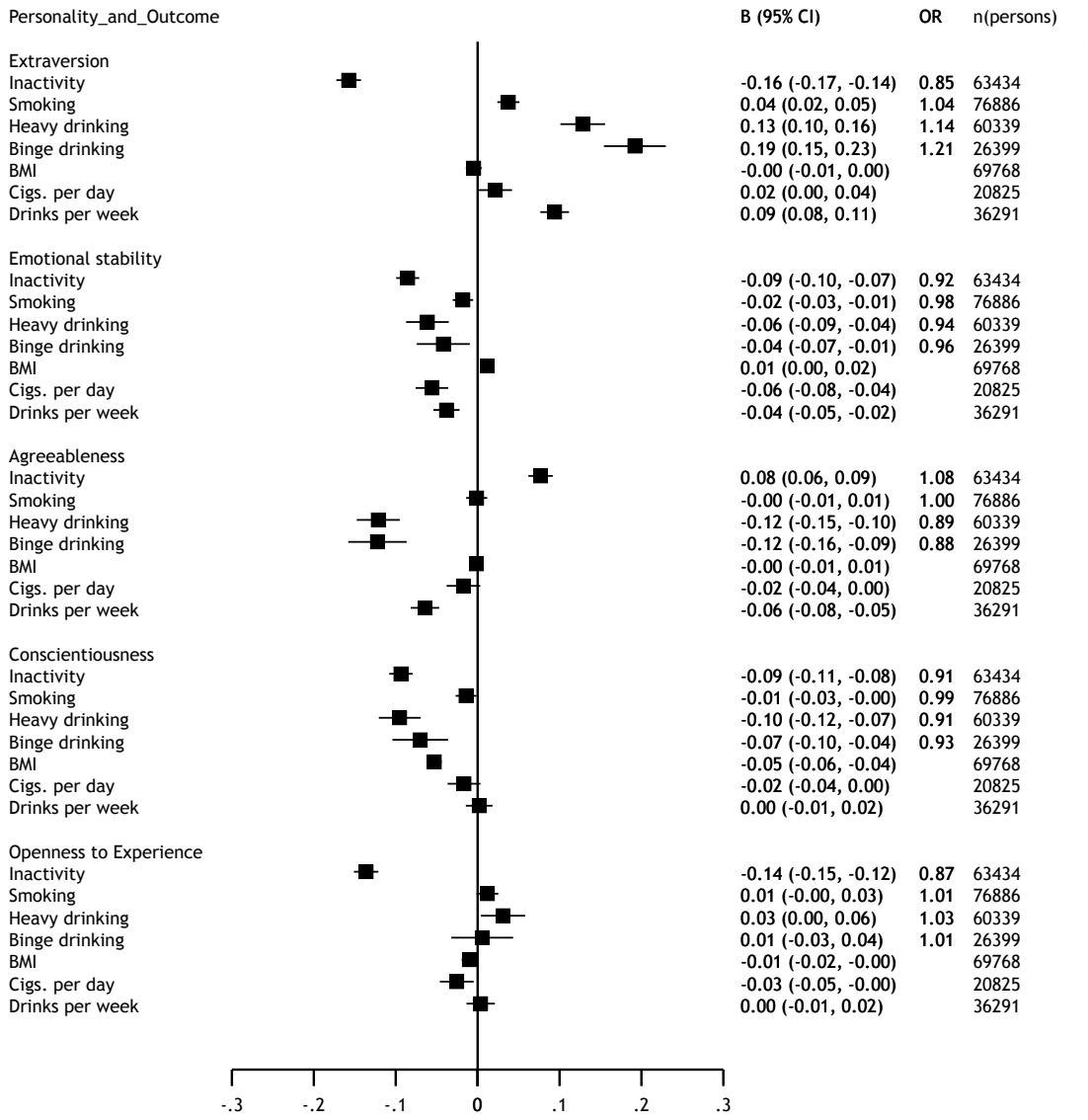
Supplementary Figure 31. Pooled associations of conscientiousness when not adjusted for other traits



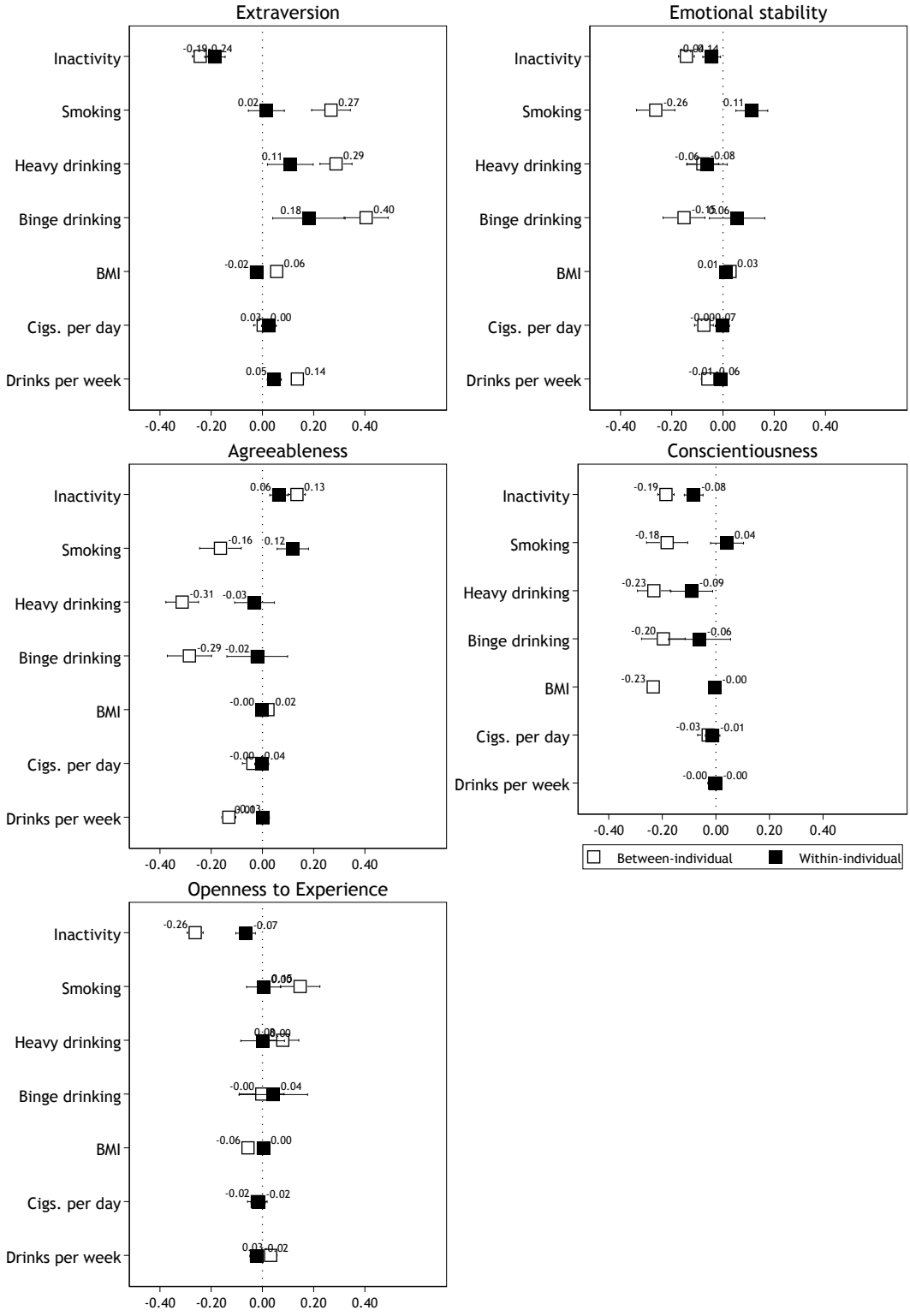
Supplementary Figure 32. Pooled associations of openness to Experience when not adjusted for other traits



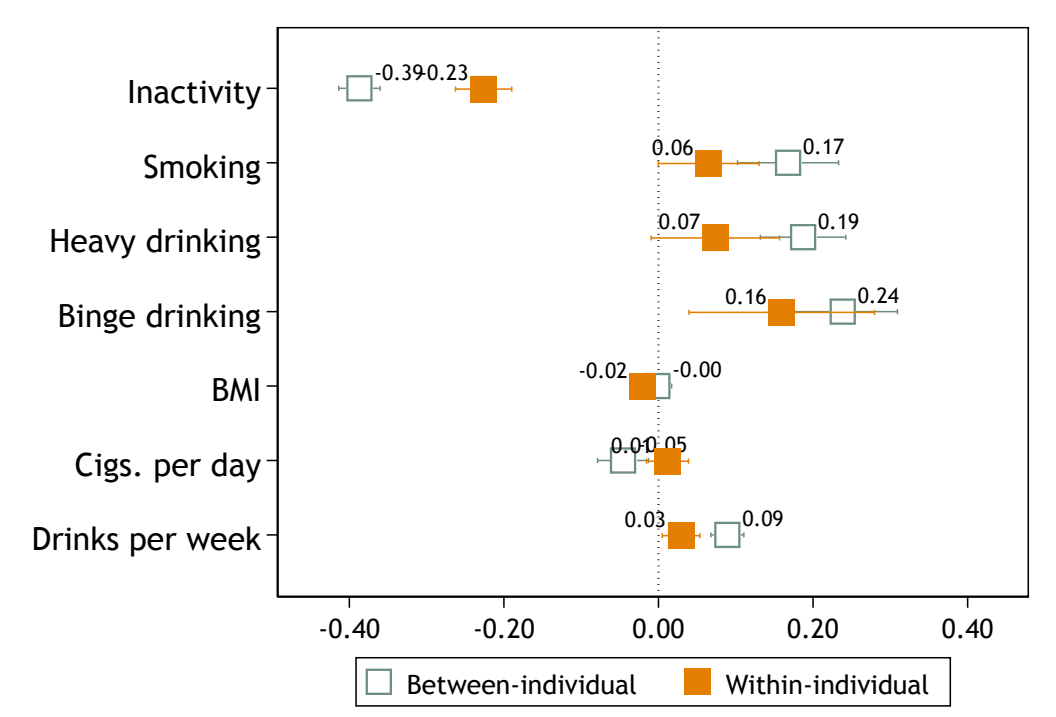
Supplementary Figure 33. Between-individual and within-individual associations of personality traits with the sum score of physical inactivity, heavy alcohol consumption, smoking, and obesity (n= 46,059 participants with 32,203 participants contributing to the estimation of within-individual associations); MIDJA and UKHLS cohort were not included due to lack of data on some health indicators). Values are logit coefficients of incidence rate ratios (and 95% confidence intervals) of a negative binomial regression model. All associations were adjusted for education, age, sex, and race/ethnicity and the between-individual and within-individual associations of the other four personality traits.



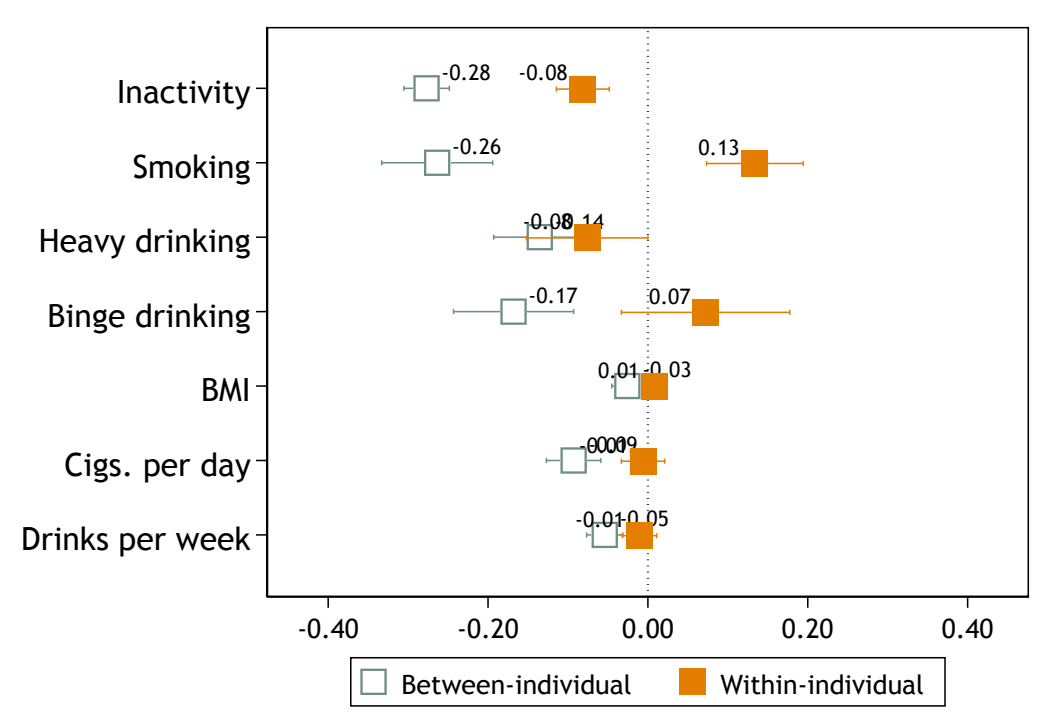
Supplementary Figure 34. Overall associations between personality traits and health behaviors pooled across individual studies using fixed-effect meta-analysis. Values are logit coefficients of logistic regressions (for inactivity, smoking, and heavy and binge drinking) and standardized coefficients of linear regressions (standard deviations of BMI, cigarettes per day, and drinks per week associated with 2 standard deviations of personality trait) and their 95% confidence intervals, with separate models fitted for each outcome. OR=odds ratio. All associations were adjusted for education, the other four personality traits, age, sex, and race/ethnicity.



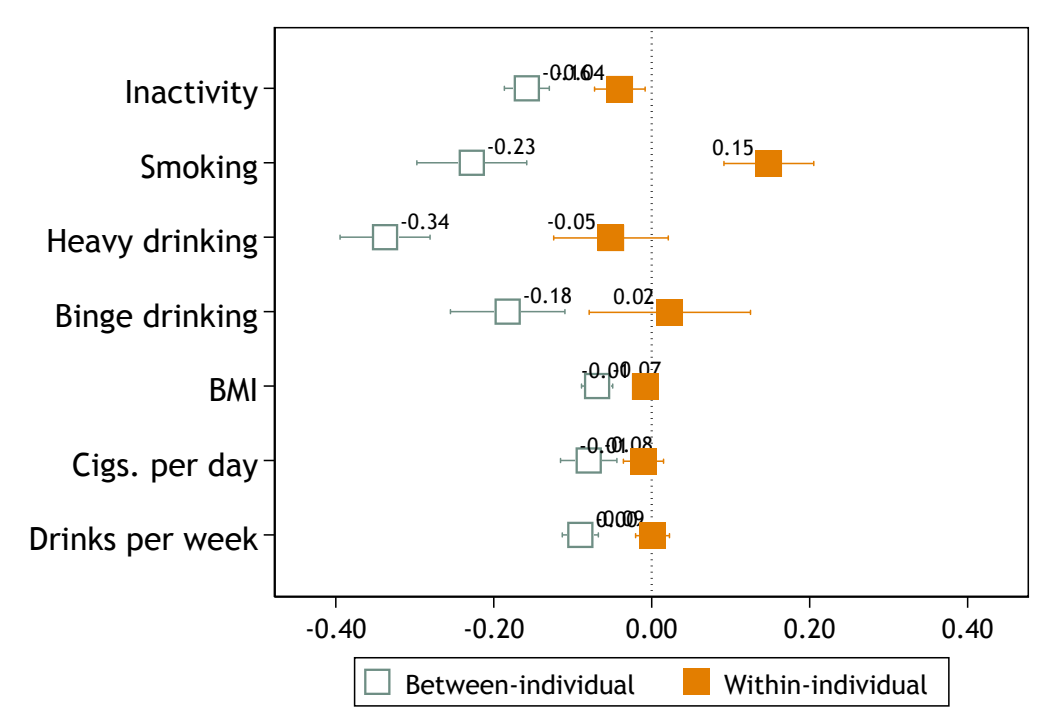
Supplementary Figure 35. Between-individual and within-individual associations of personality traits with health behaviors (n = 12,356 to 56,671 participants). Values are logit coefficients of logistic regressions (for inactivity, smoking, and heavy and binge drinking) and standardized coefficients of linear regressions (standard deviations of BMI, cigarettes per day, and drinks per week associated with 2 standard deviations of personality trait) and their 95% confidence intervals, with separate models fitted for each outcome. All associations were adjusted for education, the other four personality traits, age, sex, and race/ethnicity.



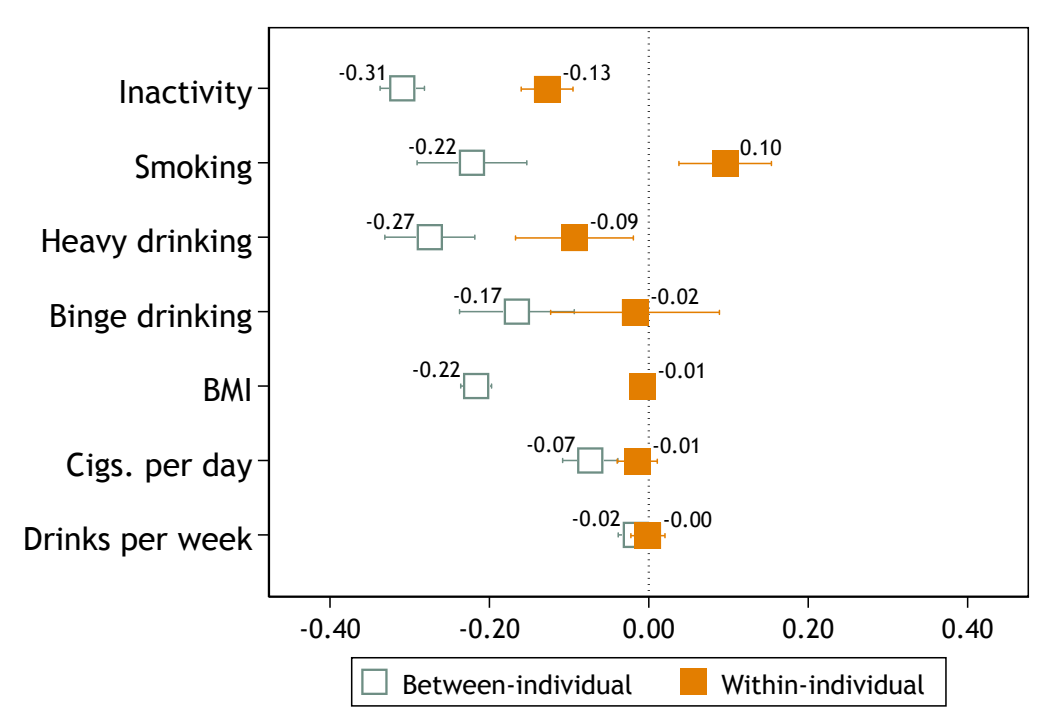
Supplementary Figure 36. Pooled associations of extraversion adjusted for education but not for other traits



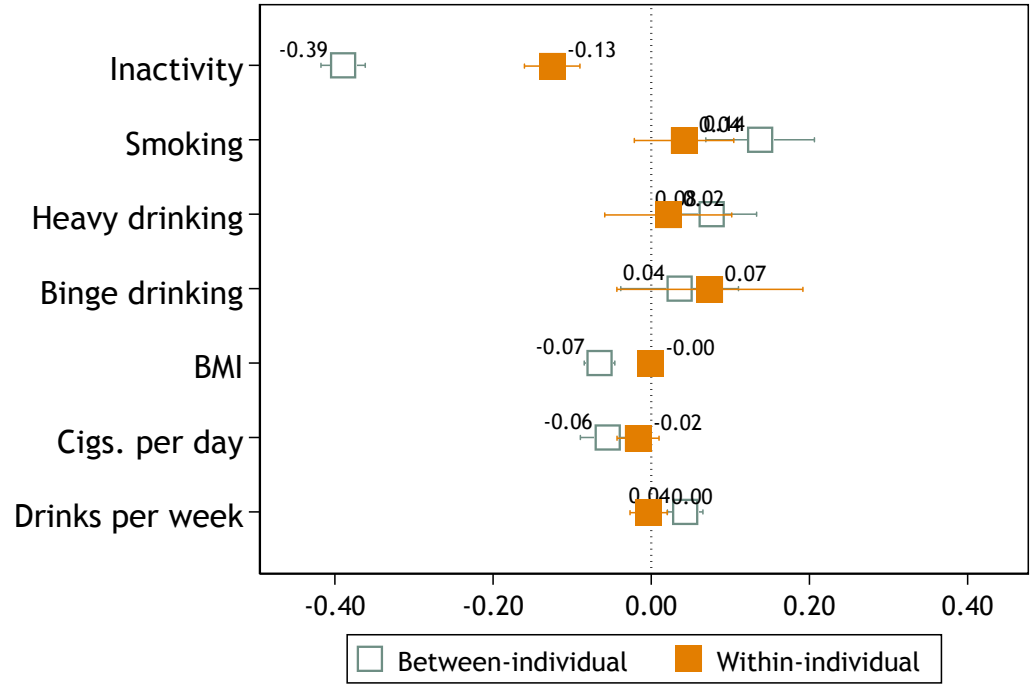
Supplementary Figure 37. Pooled associations of emotional stability adjusted for education but not for other



Supplementary Figure 38. Pooled associations of agreeableness adjusted for education but not for other trai



Supplementary Figure 39. Pooled associations of conscientiousness adjusted for education but not for other t



Supplementary Figure 40. Pooled associations of openness to Experience adjusted for education but not for oth

Supplementary Table 1. Correlations between personality traits, averaged across all study samples (n = up to 77,171 participants)

	E	S	A	C
S	0.22			
A	0.28	0.21		
C	0.25	0.20	0.36	
O	0.36	0.12	0.23	0.25

E=Extraversion, S=Emotional stability, A=Agreeableness, C=Conscientiousness, O=Openness to Experience

Values are partial correlation coefficients between personality traits measured at baseline, adjusted for age and gender, pooled with meta-analysis across the studies.

Supplementary Table 2. Variable names of the study variables in the datasets

	HILDA	HRS†	MIDJA	MIDUS
Smoking status				
Wave 1	elssmkf	r8smokev	j1sb1a	a1pa40
Wave 2	ilssmkf	r10smokev	k1sb1	b1pa38a
Wave 3	mlssmkf	oc117	–	c1pa38a
Physical inactivity				
Wave 1	elspact	kc223 kc224	–	a1sa18 a1sa19 a1sa20 a1sa21
Wave 2	ilspact	mc223 mc224	–	b1sa30e b1sa30f b1sa31e b1sa31f
Wave 3	mlspact	oc223 oc224	–	c1sa27e c1sa27f c1sa26e c1sa26f
Alcoholic drinks per week				
Wave 1	elsdrkf elsdrka	kc129 kc130	j1sc1 j1sc2	a1sa45
Wave 2	ilsdrkf ilsdrka	mc129 mc130	k1sc1 k1sc2	b1pa51 b1pa52
Wave 3	mlsdrkf mlsdrka	oc129 oc130	–	c1pa51 c1pa52
Binge drinking				
Wave 1	–	kc131	j1sc3	–
Wave 2	–	mc131	k1sc3	b1pa53
Wave 3	–	oc131	–	c1pa53
Body mass index				
Wave 1	fbmi	r8bmi	–	a1sbmi
Wave 2	ibmi	r10bmi	–	b1sbmi
Wave 3	mbmi	oc139	–	c1sbmi
Number of cigarettes				
Wave 1	elstbcn	kc118	j1sb5	a1pa44
Wave 2	ilstbcn	mc118	k1sb2	b1pa40
Wave 3	mlstbcn	oc118	–	c1pa40
Extraversion				
Wave 1	epnextrv	klb033a klb033e klb033i klb033s klb033w	j1sextra	a1sextra
Wave 2	ipnextrv	mlb033a mlb033e mlb033i mlb033s mlb033w	k1sextra	b1sextra
Wave 3	mpnextrv	olb033a olb033e olb033i olb033s olb033w	–	c1sextra
Neuroticism				
Wave 1	epnemote	klb033c klb033g klb033k klb033p	j1sneuro	a1sneuro
Wave 2	ipnemote	mlb033c mlb033g mlb033k mlb033p	k1sneuro	b1sneuro
Wave 3	mpnemote	olb033c olb033g olb033k olb033p	–	c1sneuro
Agreeableness				

Wave 1	epnagree	klb033b klb033f klb033j klb033o klb033v		a1sagree
Wave 2	ipnagree	mlb033b mlb033f mlb033j mlb033o mlb033v		b1sagree
Wave 3	mpnagree	olb033b olb033f olb033j olb033o olb033v	–	c1sagree
Conscientiousness				
Wave 1	epnconsc	klb033d klb033h klb033m klb033t klb033z		a1scons
Wave 2	ipnconsc	mlb033d mlb033h mlb033m mlb033t mlb033z		b1scons
Wave 3	mpnconsc	olb033d olb033h olb033m olb033t olb033z	–	c1scons
Openness to Experience				
Wave 1	epnopene	klb033l klb033n klb033q klb033r klb033u klb033x klb033y		a1sopen
Wave 2	ipnopene	mlb033l mlb033n mlb033q mlb033r mlb033u mlb033x mlb033y		b1sopen
Wave 3	mpnopene	olb033l olb033n olb033q olb033r olb033u olb033x olb033y	–	c1sopen

† Data for HRS between 2006 and 2012 were derived from the RAND dataset while the data of 2014 were derived from the original datasets. ‡ The first wave of UKHLS were derived from the 15th wave of the BHPS dataset.

Supplementary Table 2. Variable names of the study variables in the datasets

	SOEP	UKHLS‡	WLSG	WLSS
Smoking status				
Wave 1	p4287	osmoker	mx012rer	nx038re
Wave 2	p4287	b_smnow	ix012rer	dx012rer
Wave 3	p4287	–	jx012rer	px012rer
Physical inactivity				
Wave 1	m11104	–	mx005rer mx006rer	nx017rer nx018rer
Wave 2	m11104	–	ixe01rer ixe02rer	dxe01rer dxe02rer
Wave 3	m11104	–	jz165rer jz168rer jz171rer jz174rer	pz165rer pz168rer pz171rer pz174rer
Alcoholic drinks per week				
Wave 1	p4914 p4915 p4916 p4917	–	ru025re ru028re	su025re su028re
Wave 2	p4914 p4915 p4916 p4917	–	gu025re gu028re	cu025re cu028re
Wave 3	p4914 p4915 p4916 p4917	–	hu025re hu028re	ku025re ku028re
Binge drinking				
Wave 1	–	–	ru029re	su029re

Wave 2	–	–	gu029re	cu029re
Wave 3	–	–	–	–
Body mass index				
Wave 1	m11122 m11123	phlhtm phlhtf phlhti phlhtc phlwtk phlwte phlwts phlwtp	mx011rec	nx025rec
Wave 2	m11122 m11123	c_bmival	ix011rec	dx011rec
Wave 3	m11122 m11123	–	jx011rec	px011rec
Number of cigarettes				
Wave 1	–	oncigs	mx015rer	nx041red
Wave 2	–	b_ncigs	ixt08rer	dxt08rer
Wave 3	–	–	jxt08rer	pxt08rer
Extraversion				
Wave 1	p4761 p4767 p4771	optrt5e1 optrt5e2 optrt5e3	mh003rer mh004rer mh005rer mh006rer mh007rer mh008rer	nh003rer nh004rer nh005rer nh006rer nh007rer nh008rer
Wave 2	p4761 p4767 p4771	c_big5e_dv	ih003rer ih004rer ih005rer ih006rer ih007rer ih008rer	dh003rer dh004rer dh005rer dh006rer dh007rer dh008rer
Wave 3	p4761 p4767 p4771	–	jh003rer jh004rer jh005rer jh006rer jh007rer jh008rer	ph003rer ph004rer ph005rer ph006rer ph007rer ph008rer
Emotional stability				
Wave 1	p4764 p4769 p4774	optrt5n1 optrt5n2 optrt5n3	mh027rer mh028rer mh029rer mh030rer mh031rer	nh027rer nh028rer nh029rer nh030rer nh031rer
Wave 2	p4764 p4769 p4774	c_big5n_dv	ih027rer ih028rer ih029rer ih030rer ih031rer	dh027rer dh028rer dh029rer dh030rer dh031rer
Wave 3	p4764 p4769 p4774	–	jh027rer jh028rer jh029rer jh030rer jh031rer	ph027rer ph028rer ph029rer ph030rer ph031rer
Agreeableness				
Wave 1	p4762 p4765 p4772	optrt5a1 optrt5a2 optrt5a3	mh011rer mh012rer mh013rer mh014rer mh015rer mh016rer	nh011rer nh012rer nh013rer nh014rer nh015rer nh016rer
Wave 2	p4762 p4765 p4772	c_big5a_dv	ih011rer ih012rer ih013rer ih014rer ih015rer ih016rer	dh011rer dh012rer dh013rer dh014rer dh015rer dh016rer
Wave 3	p4762 p4765 p4772	–	jh011rer jh012rer jh013rer jh014rer jh015rer jh016rer	ph011rer ph012rer ph013rer ph014rer ph015rer ph016rer
Conscientiousness				
Wave 1	p4760 p4766 p4770	optrt5c1 optrt5c2 optrt5c3	mh019rer mh020rer mh021rer mh022rer mh023rer mh024rer	nh019rer nh020rer nh021rer nh022rer nh023rer nh024rer
Wave 2	p4760 p4766 p4770	c_big5c_dv	ih019rer ih020rer ih021rer ih022rer ih023rer ih024rer	dh019rer dh020rer dh021rer dh022rer dh023rer dh024rer
Wave 3	p4760 p4766 p4770	–	jh019rer jh020rer jh021rer jh022rer jh023rer jh024rer	ph019rer ph020rer ph021rer ph022rer ph023rer ph024rer

Openness to Experience				
	p4763	optrt5o1	mh034rer mh035rer	nh034rer nh035rer
Wave 1	p4768	optrt5o2	mh036rer mh037rer	nh036rer nh037rer
	p4773	optrt5o3	mh038rer mh039rer	nh038rer nh039rer
	p4763		ih034rer ih035rer	dh034rer dh035rer
Wave 2	p4768	c_big5o_dv	ih036rer ih037rer	dh036rer dh037rer
	p4773		ih038rer ih039rer	dh038rer dh039rer
	p4763		jh034rer jh035rer	ph034rer ph035rer
Wave 3	p4768	–	jh036rer jh037rer	ph036rer ph037rer
	p4773		jh038rer jh039rer	ph038rer ph039rer

† Data for HRS between 2006 and 2012 were derived from the RAND dataset while the data of 2014 were derived from the original datasets. ‡ The first wave of UKHLS were derived from the 15th wave of the BHPS dataset.

Stata code templates for the analyses

```
// Figure 1

** Fit cohort-specific models
* standardize personality traits
foreach pp in e s a c o {
        summ `pp'1
        gen z`pp'1=(`pp'1-r(mean))/r(sd)
        gen z`pp'2=(`pp'2-r(mean))/r(sd)
        cap gen z`pp'3=(`pp'3-r(mean))/r(sd)
        }
* create between and within estimators
foreach pz in ze zs za zc zo {
        bysort numid: egen b_`pz'=mean(`pz') if `v'<.
        gen d_`pz'=`pz'-b_`pz' if `v'<.
        }
* fit negative binomial regression
foreach pp in e s a c o {
        * overall associations
        xtnbreg `v' i.race sex i.year age1 ze zn za zc zo
        * within-individual and between-individual
        xtnbreg `v' i.race sex i.year age1 d_* b_*, iterate(30)
        }
** Fit meta-analysis for overall, between, and within estimators (rf=1 to 3) and personality traits (p=1
to 5)
forvalues rf=1/3 {
forvalues p=1/5 {
metan or lci hci if trait==`p' & ran_fix==`rf', fixedi
}
}
```

```
// Figures 2 and 3

** Fit cohort-specific models
* standardize personality traits
foreach pp in e s a c o {
        summ `pp'1
        gen z`pp'1=(`pp'1-r(mean))/r(sd)
        gen z`pp'2=(`pp'2-r(mean))/r(sd)
        cap gen z`pp'3=(`pp'3-r(mean))/r(sd)
        }
* create between and within estimators
foreach pz in ze zs za zc zo {
        bysort numid: egen b_`pz'=mean(`pz') if `v'<.
        gen d_`pz'=`pz'-b_`pz' if `v'<.
        }
* fit overall, within, and between estimator regressions
foreach v in nopa smoked alc_heavy binge {
        * overall associations
        xtlogit `v' i.race sex i.year age1 ze zs za zc zo, pa
        * within-individual and between-individual associations
        xtlogit `v' i.race sex i.year age1 d_* b_* if nobs>=2
}
foreach v in zbmi zsmoke_ncig zalc {
        xtreg `v' sex i.year age1 ze zs za zc zo
        xtreg `v' sex i.year age1 d_* b_* if nobs>=2
}
** Fit meta-analysis for overall, between, and within estimators (rf=1 to 3), health behaviors (hv=1 to
7), and personality traits (p=1 to 5)
forvalues rf=1/3 {
forvalues hv=1/7 {
forvalues p=1/5 {
metan or lci hci if trait==`p' & hvar==`hv' & ran_fix==`rf', fixedi
}
}
}
```