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High Intelligence is Not Associated with a Greater Propensity for Mental Health Disorders

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1 ***High Intelligence is Not Associated with a Greater Propensity for Mental Health***
2 ***Disorders***

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23 **Conflict of interest** - On behalf of all authors, the corresponding author states that there is no
24 conflict of interest.

25 **Data/Code Availability** - This research has been conducted using data from UK Biobank, a
26 major biomedical database (<http://www.ukbiobank.ac.uk/>). Restrictions apply to the
27 availability of these data, which were used under license for this study: application 46007.
28 Preregistration, code, and supplemental tables and data are available on OSF:

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31 **Ethics Approval Statement-** All participants provided informed consent (“Resources tab” at
32 <https://biobank.ctsuo.ox.ac.uk/crystal/field.cgi?id=200>). All procedures involving human
33 subjects/patients were approved by the Research Ethics Committee (reference 11/NW/0382)
34 and the present study was conducted based on application 46 007.

35

36 **Abstract**

37

38 **Background:** Studies reporting that highly intelligent individuals have more mental health
39 disorders often have sampling bias, no or inadequate control group, or insufficient sample size.
40 We addressed these caveats by examining the difference in the prevalence of mental health
41 disorders between individuals with high and average general intelligence (g-factor) in the UK
42 Biobank.

43

44 **Methods:** Participants with general intelligence (g-factor) scores standardized relative to the
45 same-age UK population, were divided into 2 groups: a high g-factor group (g-factor 2 SD
46 above the UK mean; N=16,137) and an average g-factor group (g-factor within 2 SD of the UK
47 mean; N=236,273). Using self-report questionnaires and medical diagnoses, we examined
48 group differences in prevalence across 32 phenotypes, including mental health disorders,
49 trauma, allergies, and other traits.

50

51 **Results:** High and average g-factor groups differed across 15/32 phenotypes and did not
52 depend on sex and/or age. Individuals with high g-factors had less general anxiety (OR=0.69,
53 95%CI[0.64;0.74]) and PTSD (OR=0.67, 95%CI[0.61;0.74]), were less neurotic (β =-0.12,
54 95%CI[-0.15;-0.10]), less socially isolated (OR=0.85, 95%CI[0.80;0.90]), and were less likely
55 to have experienced childhood stressors and abuse, adulthood stressors, or catastrophic trauma
56 (OR=0.69-0.90). They did not differ in any other mental health disorder or trait. However, they
57 generally had more allergies (e.g., eczema; OR=1.13-1.33).

58

59 **Conclusions:** The present study provides robust evidence that highly intelligent individuals
60 have no more mental health disorders than the average population. High intelligence even
61 appears as a protective factor for general anxiety and PTSD.

62

63 **Word count:** 240

64

65 **Key words:** Intelligence; Psychopathology; Post-Traumatic Stress Disorder; Anxiety;

66 Allergies

67

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88 1. Introduction

89 Intelligence – the ability to learn, reason, and solve problems (Arvey et al., 1994) – is
90 associated with greater physical health and longevity . And yet, some researchers report that
91 highly intelligent individuals are at a higher risk of developing mental health and somatic
92 disorders (Karpinski et al., 2018; Kermarrec et al., 2020; Lancon et al., 2015; Smith et al.,
93 2015). The majority of studies that report a negative effect of intelligence on mental and
94 somatic health, however, often suffer from sampling bias, the lack of a control group, or
95 insufficient sample size (Gauvrit, 2014; Martin et al., 2010). The present paper addresses these
96 caveats by examining the difference in the prevalence of health and somatic disorders and other
97 traits between the highly intelligent (2 sd above mean) and averagely intelligent (within 2 sd
98 of the mean) individuals of the UK Biobank ($N \approx 261,500$).

99 The notion of general intelligence (g) stems from the positive correlation in
100 performance across most cognitive tests (Spearman, 1904). It is formally defined as the
101 common source of variance underlying performance across a wide range of tests and is usually
102 computed using factor analysis. Intelligence Quotient (IQ) reflects a person's average
103 performance across cognitive tests relative to a representative sample of the same-age national
104 population. Henceforth, IQ and g will be used interchangeably and as shortcuts for general
105 intelligence scores.

106 Over the last decades, intelligence has proved to be a strong predictor of education
107 (Deary et al., 2007), socio-economic success (Schmidt & Hunter, 2004; Strenze, 2007), and
108 health outcomes (Calvin et al., 2017; Twig et al., 2018; Wraw et al., 2018; Wrulich et al., 2014).
109 For instance, having a childhood IQ one standard deviation (sd) above the mean decreases one's
110 risk of accidents and developing heart, respiratory, and digestive disease by 20-25% (Wraw et
111 al., 2018; Wrulich et al., 2014). And yet, whether intelligence also serves as a protective factor
112 for mental health disorders is still subject to debate. While some postulate that high intelligence
113 serves as a protective factor for several mental and somatic disorders (Burdick et al., 2009;
114 Ghaffari et al., 2014, 2014; Koenen et al., 2009, 2009; Sjölund et al., 2015), others suggest that
115 high intelligence is a risk factor for these phenotypes (Kanazawa, 2010; Karpinski et al., 2018;
116 Lancon et al., 2015; Smith et al., 2015, 2015; White & Batty, 2012; K. M. Williams et al.,
117 2017) or that the effects of intelligence vary across mental health phenotypes (Wraw et al.,
118 2016).

119 The most recent study examining the prevalence of mental health and somatic (i.e.,
120 allergies, asthma, immunodeficiencies) disorders in highly intelligent individuals reported that
121 high IQ was a risk factor for affective disorders, neurodevelopmental disorders, and diseases

122 related to the immune system (Karpinski et al., 2018). However, the study suffers from
123 sampling bias because participants were recruited from the American Mensa Ltd. – a society
124 open to individuals that at some point scored in the top 2% on a verified intelligence test
125 (N=3,715). Since IQ tests are typically administered to children when parents or teachers notice
126 behavioral problems or by individuals experiencing stereotypical characteristics associated
127 with IQ, selecting individuals from a sample of individuals who actively decided to take an IQ
128 test or become members of a highly intelligent society may exacerbate the correlation between
129 having a high IQ and mental health disorders and/or behavioral problems (Gauvrit, 2014;
130 Martin et al., 2010). The present paper thus aims to address these limitations.

131 We investigated the difference in prevalence between individuals with high (2 sd above
132 the population mean) and average (within 2 sd from the population mean) general intelligence
133 scores (g-factor scores; Williams et al., 2022) in the UK Biobank across mental health
134 disorders, somatic disorders, and certain traits. We examined group differences in the
135 prevalence of available mental health and somatic disorders in the UK Biobank, as well as
136 phenotypes that are thought to differ in prevalence in highly intelligent individuals, such as
137 subjective well-being phenotypes (e.g., well-being, social isolation; Li & Kanazawa, 2016;
138 Zettergren & Bergman, 2014), myopia (Czepita et al., 2008), chronotype (Ujma et al., 2020),
139 and trauma (McGuire & Jackson, 2020). Finally, we included sexual behaviors because studies
140 have shown heterogeneous results concerning the relationship between sexual behaviors and
141 IQ (Rahman et al., 2012; Rowe, 2002). As a point of comparison, we report differences in
142 prevalence across phenotypes between the average and low (2 sd under the population mean)
143 g-factor groups as exploratory analyses.

144

145

146 2. Methods

147 Analyses were conducted using R (R Core Team, 2022). R Packages are listed in S3 and the
148 preregistration, code, and supplements are available here:

149 https://osf.io/cywd6/?view_only=fa9f5091de124d96be3eb1a55a4e7f01).

150 2.1. Participants

151 Participants were taken from the UKBiobank, an open-access large prospective study with
152 phenotypic, genotypic, and neuroimaging data from more than 500,000 participants recruited
153 between 2006 and 2011 at 40 to 69 years old (Sudlow et al., 2015). All participants provided
154 informed consent (“Resources tab” at <https://biobank.ctsu.ox.ac.uk/crystal/field.cgi?id=200>).
155 All procedures involving human subjects/patients were approved by the Research Ethics
156 Committee (reference 11/NW/0382). The present study was conducted based on the UK
157 Biobank application 46 007.

158 2.2. G-factor

159 We defined our g-factor groups using g-factor scores from a previous paper that are relative
160 to the UK population (C. M. Williams et al., 2022). In brief, we calculated g-factor scores for
161 individuals that completed at least one of the UK Biobank cognitive tests.

162 UK Biobank participants completed a variety of cognitive tests upon each of their visits to
163 the UKBiobank assessment center (Category 100026) and online (Category 116), including:
164 Fluid Intelligence, Matrix Pattern Completion, Tower Rearranging, Numeric Memory, Pairs
165 Matching, Symbol Digit Substitution, Reaction Time, and Trail Making tests (Section S1.1).
166 Most tests were completed at the first visit and we used the score of the first instance of
167 completion if the test was completed several times.

168 Although the UK Biobank cognitive battery contains adapted versions of commonly-used
169 tests and tests designed for the UK Biobank, the g-factor from well-validated tests correlates
170 highly with the g-factor from the UK Biobank cognitive tests ($r=0.83$; Fawns-Ritchie & Deary,
171 2020).

172 Because UK Biobank participants tend to live in less socioeconomically deprived areas and
173 are healthier than the UK population (Fry et al., 2017), we expected more than 2% of UK
174 participants in the highly intelligent group (aka individuals with g-factor > 2 sd from the UK
175 mean). To accurately identify highly intelligent individuals in the UK Biobank, we created a
176 g-factor that would be relative to the UK mean.

177 To adjust for sampling bias, we calculated weights for each UK Biobank participant based
178 on their country of residence, sex, age range, occupation status, and occupation SOC group

179 using public the 2001 UK census data. We then adjusted for age with a semiparametric
180 continuous norming method that considers weights (Lenhard et al., 2016).

181 From the age-standardized cognitive tests that are relative to the UK population, we
182 extracted a g-factor from a single-factor model. We then computed the g-factor scores'
183 weighted mean and sd, using the census weighting factors. Finally, we standardized each
184 person's g-factor score with the weighted sample mean and weighted sample sd for a general
185 population mean of 0 and sd of 1.

186 We estimated the quality of the g-factor based on the combination of completed tests,
187 and we selected participants who had a reliable estimate of the g-factor (correlation with full g
188 factor > 0.7; N= 261,701 participants; Section S1.2). Participants were excluded when there
189 was a mismatch between the self-reported (field 31) and genetic sex (field 22001). Self-
190 reported sex was coded -0.5 for males and 0.5 for females.

191 2.3. G-factor Groups

192 We created 3 g-factor groups: a high g-factor group (g-factor 2 sd above the population
193 mean), a low g-factor group (g-factor 2 sd below the population mean), and an average g-factor
194 group (g-factor within 2 sd from the population mean). About 90% of individuals were in the
195 average g-factor group (236,273/261,701), 6.2% in the high g-factor group (16,137/261,701),
196 and 3.6 % in the low g-factor group (9,291/261,701; sex differences in Section S1.2).

197 2.4. Phenotypes

198 To maximize the number of participants with a diagnosis, each phenotype was created
199 by combining questions and diagnoses from mental health professionals and self-reported
200 questionnaires (Davis et al., 2020; Guggenheim et al., 2015; Smith et al., 2013; Tables SA,
201 Section 1.3). We examined 32 phenotypes using one or several binary, ordinal, or continuous
202 variables (Table SA; Table SB1-B2).

203 **Table 1.** Phenotypic Prevalence in the UK Biobank across and by Sexes

Phenotypes	Both Sexes			Men			Women		
	Without	With		Without	With		Without	With	
	N	N	%	N	N	%	N	N	%
Eating Disorder	124,092	1,489	1.19	54,488	116	0.21	69,604	1,373	1.93
Anorexia	124,886	750	0.6	54,583	35	0.06	70,303	715	1.01
Anxiety	69,555	12,337	15.06	34,437	4,219	10.91	35,118	8,118	18.78
Social Anxiety	117,099	1,412	1.19	50,835	654	1.27	66,264	758	1.13
Depression Ever	22,872	11,556	33.57	11,678	3,765	24.38	11,194	7,791	41.04
Probable Depression	86,282	30,995	26.43	43,254	10,970	20.23	43,028	20,025	31.76
Bipolar Disorder	30,035	226	0.75	14,494	108	0.74	15,541	118	0.75
Schizophrenia	125,387	194	0.15	54,497	107	0.2	70,890	87	0.12
Self-Harm Thought or Action	220,343	41,079	15.71	103,443	15,215	12.82	116,900	25,864	18.12
Post-Traumatic Stress Disorder	117,290	7,820	6.25	51,826	2,626	4.82	65,464	5,194	7.35
Obsessive-Compulsive Disorder	156,192	1,268	0.81	67,781	400	0.59	88,411	606	0.68
Alcohol Hazardous Substance Use or Dependence	117,083	6,591	5.33	49,594	4,072	7.59	67,489	2,519	3.6
Other Hazardous Substance Use or Dependence	258,625	2,760	1.06	117,119	1,520	1.28	141,506	1,240	0.87
Cannabis Use Ever	97,040	28,375	22.62	40,330	14,195	26.03	56,710	14,180	20
General Allergy	73,287	29,550	28.73	32,990	12,538	27.54	40,297	17,012	29.68
Asthma	86,918	15,919	15.48	38,860	6,668	14.65	48,058	9,251	16.14
Hay Fever Rhinitis	450,094	51,200	10.21	205,755	22,680	9.93	244,339	28,520	10.45
Other Allergies	489,588	11,682	2.33	224,543	3,880	1.7	265,045	7,802	2.86
Myopia	76,190	33,881	30.78	34,734	15,489	30.8	41,456	18,392	30.7
Eczema	252,947	8,448	3.23	114,743	3,902	3.29	138,204	4,546	3.18
Insomnia	57,376	204,142	78.06	32,753	85,948	72.41	24,623	118,194	82.76
Loneliness	452,782	23,105	4.86	204,356	11,782	5.45	248,426	11,323	4.36
Social Isolation	444,466	45,053	9.2	201,014	21,856	9.81	243,452	23,197	8.7

Chronotype (More Evening)	145,500	87,667	37.6	63,275	39,521	38.45	82,225	48,146	36.93
Same-sex sexual behavior	15,757	432,740	96.49	8,873	197,539	95.7	6,884	235,201	97.16
Adulthood Abuse	20,479	20,479	16.32	4,701	4,701	8.62	15,778	15,778	22.25
Adulthood Stressors	51,167	51,167	40.91	21,289	21,289	39.12	29,878	29,878	42.28
Catastrophic Trauma	63,893	63,893	50.88	30,748	30,748	56.31	33,145	33,145	46.7
Childhood Abuse	14,060	14,060	11.2	5,387	5,387	9.87	8,673	8,673	12.22
Childhood Stressors	42,779	42,779	34.07	17,770	17,770	32.54	25,009	25,009	35.24

204 N.B. Probable Depression and Cannabis Use are ordinal but here reflect the prevalence of ever meeting the criteria regardless of severity.

205

206 Since the age of onset of disorders was not available for all participants and/or
 207 measures, we used the maximum age at which an individual provided the most recent measure
 208 of a disorder to approximate lifetime prevalence (Section S1.4).

209 2.6. Statistical Analyses

210 To reduce the number of statistical tests when examining group differences across
 211 phenotypes, we first examined age and sex effects and interactions on each phenotype (Section
 212 S1.5.1). If age and sex's main effects or interactions did not predict a phenotype ($p > 0.05$),
 213 they were excluded from the g-factor group analyses. Equation 1 corresponds to the model with
 214 all possible predictors (f corresponds to the logit function for binary and ordinal phenotypes
 215 and to the linear function for continuous phenotypes).

216 Participants were included in the g-factor group analyses if they had a g-factor measure
 217 and answered all of the questions used to create that phenotype, except when the same question
 218 was asked several times. If participants responded as having the phenotype across any of the
 219 questions, they were marked as having the phenotype, otherwise, they were marked as not
 220 having the phenotype.

221 Age was mean-centered in ordinal and binary regressions, while age and continuous
 222 phenotypes were mean-centered and divided by 1sd in linear regressions to report standardized
 223 betas.

224 **Equation 1:**

$$\begin{aligned}
 225 \quad & f(\text{Phenotype}) \\
 226 \quad & = \beta_0 + \beta_1 * \text{age} + \beta_2 * \text{age}^2 + \beta_3 * \text{sex} + \beta_4 * CA_{\text{Group}} + \beta_5 \\
 227 \quad & * \text{age} * \text{sex} + \beta_6 * \text{age}^2 * \text{sex} + \beta_7 * \text{sex} * CA_{\text{Group}} + \beta_8 * \text{age} \\
 228 \quad & * CA_{\text{Group}} + \beta_9 * \text{age}^2 * CA_{\text{Group}} + \beta_{10} * \text{age} * \text{sex} * CA_{\text{Group}} + \beta_{11} \\
 229 \quad & * \text{age}^2 * \text{sex} * CA_{\text{Group}}
 \end{aligned}$$

230 We report results with the g-factor group predictor that survived a Bonferroni correction
 231 for multiple comparisons of 0.05 divided by the number of coefficients in the equation with the
 232 g-factor group term times the number of coefficients of interest times the number of
 233 investigated phenotypes (e.g., 0.05/ (6*32) for equation 1). Since the analyses on the low g-
 234 factor group were exploratory, we applied the same multiple comparison correction as for the
 235 high g-factor group (e.g., 0.05/ (6*32) for equation 1). Odd Ratios (ORs) reflect the odds that
 236 a person will have a phenotype or disorder given that they are highly compared to averagely
 237 intelligent and were calculated as the exponent of the regression estimate.

238

239 **3. Results**

240 The model assumptions of low-powered phenotypes with few cases in the UK Biobank
241 (including, Anorexia, Eating Disorder, Schizophrenia, Bipolar Disorder, OCD, Social Anxiety,
242 and Other Hazardous Substance Use) were not met and should be interpreted with caution
243 (Supplemental Files S9-40). We additionally ran the analyses with the g-factor scores instead
244 of the g-factor group and found consistent results with our group analyses (S2.4, Figures S5-8
245 and Supplemental Files S9-S40).

246 **3.1. Differences in the Prevalence of Phenotypes between Participants with High and**
247 **Average CA**

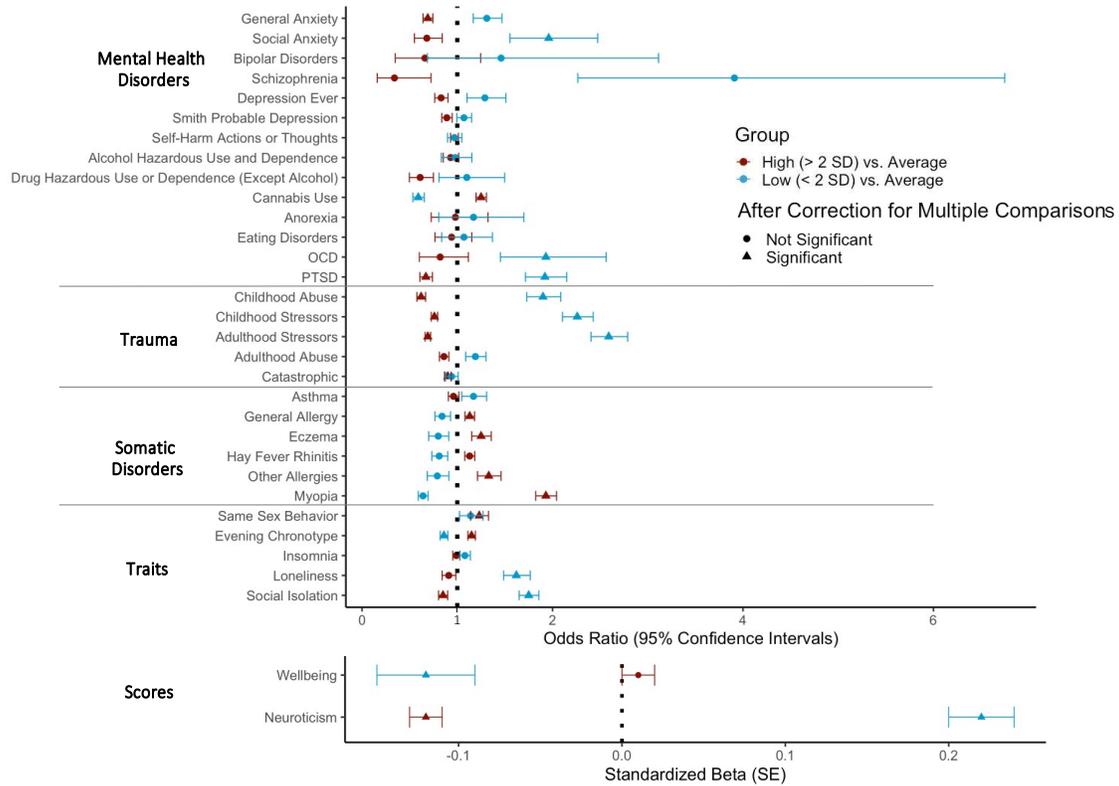
248 Sex and age effects across phenotypes are described in S2.1. and in Supplemental Tables
249 SC. In Supplemental Tables SD, we provide the phenotypic prevalence by g-factor group and
250 the mean and sd of the g-factor, Townsend Index, birth year, number of children, and number
251 of individuals in the household of each g-factor group by diagnosis to describe the investigated
252 populations. Regression results are reported in Supplemental Tables SE.

253 Across the 32 phenotypes, the prevalence differed between the high g-factor and average
254 g-factor groups in 15 phenotypes (47%) and between the low g-factor and average g-factor
255 groups in 12 phenotypes (38%; Figure 1). Phenotypic differences between the Low and
256 Average g-factor are discussed in S2.3. There were no significant interactions in the analyses
257 comparing the average to the high g-factor groups.

258 **3.1.1. Mental Health Disorders**

259 Compared to individuals in the average g-factor group, there was a 33% decrease in the
260 odds of suffering from Post-Traumatic Stress Disorder (OR=0.67, 95%CI[0.61;0.74]) and a
261 31% decrease in the odds of having general anxiety (OR=0.69, 95%CI[0.64;0.74]) in the high
262 g-factor group (Table 2). There was no significant difference across other mental health
263 disorders (Figure 1).

264



265

266 **Figure 1.** Group Differences in Prevalence between High and Average and Low and Average
 267 g-factor Groups across Phenotypes and Scores. OCD: Obsessive-Compulsive Disorder;
 268 PTSD: Post-Traumatic Stress Disorder. Correction for multiple comparisons varies by
 269 phenotype. See supplemental tables standard error (SE) for p-value thresholds for multiple
 270 comparison corrections. High g-factor: participants with a g-factor score 2SD above the mean.
 271 Low g-factor: participants with a g-factor score 2SD under the mean. Average g-factor:
 272 participants with a g-factor score between + or – 2SD from the mean.

273 **Table 2.** Phenotypes that differ in Prevalence between Average and High General Intelligence Groups.

							<i>Average g-Factor</i>			<i>High g-Factor</i>		
		<i>Estimate</i>	<i>SE</i>	<i>OR</i>	<i>t/z</i>	<i>p</i>	<i>Control</i>	<i>Cases</i>	<i>%</i>	<i>Control</i>	<i>Cases</i>	<i>%</i>
<i>High > Average</i>	<i>Other Allergies</i>	0.28	0.06	1.33	4.50	6.71E-06	229,995	6,012	2.55	15627	500	3.10
	<i>Eczema</i>	0.22	0.06	1.25	3.96	7.61E-05	228,451	7,556	3.20	15472	655	4.06
	<i>Cannabis Use Ever</i>	0.22	0.03	1.25	7.06	1.64E-12	86,279	24,836	22.35	8092	3,088	27.62
	<i>Same-Sex Behavior</i>	0.21	0.05	1.23	3.89	1.02E-04	209,239	8,741	4.01	14659	752	4.88
	<i>Chronotype (E vs M)</i>	0.14	0.02	1.15	5.99	2.04E-09	132,775	82,172	38.23	8483	6,092	41.80
	<i>General Allergy</i>	0.12	0.03	1.13	4.00	6.29E-05	64,788	25,833	28.51	6851	3,149	31.49
	<i>Myopia</i>	0.66	0.10	1.93	6.49	8.79E-11	70,191	30,851	30.53	2903	2,281	44.00
<i>High < Average</i>	<i>Trauma Catastrophic</i>	-0.10	0.03	0.90	-3.70	2.20E-04	54,472	56,797	51.04	5640	5,554	49.62
	<i>Social Isolation</i>	-0.16	0.04	0.85	-4.28	1.83E-05	210,478	23,110	9.89	14634	1,414	8.81
	<i>Trauma Childhood Stressors</i>	-0.27	0.03	0.76	-8.92	4.62E-19	73,178	38,076	34.22	8141	3,053	27.27
	<i>Trauma Adulthood Stressors</i>	-0.37	0.03	0.69	-12.43	1.83E-35	65,178	45,654	41.19	7608	3,565	31.91
	<i>General Anxiety</i>	-0.37	0.05	0.69	-7.18	7.00E-13	61,127	11,118	15.39	6925	847	10.90
	<i>Post-Traumatic Stress Disorder</i>	-0.40	0.07	0.67	-5.77	7.70E-09	103,826	7,022	6.33	10730	441	3.95
	<i>Trauma Childhood Abuse</i>	-0.48	0.05	0.62	-9.18	4.14E-20	98,544	12,688	11.41	10374	819	7.32
	<i>Neuroticism Score</i>	-0.12	0.01		-10.17	2.87E-24						

274 N.B. G-Factor: General Intelligence. High g-Factor: participants with a g-factor score 2SD above the mean. Average g-Factor: participants with a
 275 g-factor score between + or - 2SD from the mean. Neuroticism estimate is a standardized beta. Cannabis Use: Never used vs. used at least once.
 276 E: Evening, M: Morning. Cannabis Use: never used versus used at least once.

277 3.1.2. Somatic Phenotypes

278 Compared to individuals in the average g-factor group, the odds of having some type of
279 allergy increased by 13% for individuals in the high g-factor group (OR=1.13,
280 95%CI[1.08;1.18]). This was explained by their greater propensity to having eczema and other
281 allergies (e.g., food; respectively 1.25 and 1.33 times more likely), which were included in the
282 general allergy diagnosis (Table 2). The odds of being myopic increased by 93% in the high g-
283 factor group (OR=1.93, 95%CI[1.82;2.04]) and this remained significant when controlling for
284 educational attainment (OR=1.75; S2.2).

285 3.1.3. Trauma

286 Compared to individuals in the average g-factor group, the odds of experiencing
287 catastrophic trauma, adulthood stressors, childhood abuse, and childhood stressors decreased
288 by 10% (OR=0.90, 95%CI[0.87;0.94]), 31% (OR=0.69, 95%CI[0.66;0.72]), 38% (OR=0.62,
289 95%CI[0.58;0.67]), and 24% (OR=0.76, 95%CI[0.73;0.79]; Table 2) in the high g-factor
290 group, respectively.

291 3.1.4. Traits

292 Compared to individuals in the average g-factor group, the odds of feeling more socially
293 isolated decreased by 15% in the high g-factor group (OR=0.85, 95%CI[0.80;0.90]), whereas
294 the odds of having an evening-like chronotype, ever engaging in same-sex behavior, and ever
295 using cannabis increased by 15% (OR=1.15, 95%CI[1.11;1.19]), 23% (OR=1.23,
296 95%CI[1.14;1.33]), and 25% (OR=1.25, 95%CI[1.20;1.31]) respectively in the high g-factor
297 group. Fig S4 shows that there are more individuals with a higher-than-average g-factor that
298 have used cannabis 1 to 100 times and that over 100 times there are no group differences. The
299 high g-factor group had a lower neuroticism score than individuals in the average g-factor
300 group ($\beta=-0.12$, SE=0.01; Table 2).

301 3.2. Phenotypes with group differences between both the high and average and the low and 302 average g-factor groups

303 Childhood stressors, childhood abuse, adulthood stressors, PTSD, and social isolation
304 were more prevalent in the low compared to the average g-factor group (Table S2) and were
305 more prevalent in the average compared to the high g-factor group (Table 2), suggesting that
306 the prevalence of these phenotypes decreases with an increasing g-factor. The low g-factor
307 group had a higher neuroticism score than the average g-factor group ($\beta=0.22$, SE=0.02), which
308 had a higher neuroticism score than the high g-factor group. The odds of ever trying cannabis
309 and having an evening-like chronotype respectively decreased by 41% (OR=0.59,

310 95%CI[0.53;0.65]) and 14% (OR=0.86, 95%CI[0.82;0.90]) in the low compared to the average
311 g-factor group.
312

313 4. Discussion

314 We examined differences in the prevalence of mental health disorders, somatic and
315 certain traits between individuals with high (2 sd above mean) and average g-factor scores
316 (within 2 sd of the mean) in the UK Biobank ($N \approx 7,266 - 252,249$). We contrasted these results
317 with differences observed between individuals with low and average g-factor scores.

318 We found that the high g-factor group did not have more mental health disorders than
319 the average g-factor group in general and that they were less likely to have general anxiety and
320 PTSD. Individuals with higher intelligence were also less likely to have experienced trauma and
321 stressors, except for adulthood abuse, which may be part of the explanation for the previous
322 finding. The high g-factor group was also less neurotic and felt less socially isolated. In
323 contrast, the low g-factor group was more neurotic, felt more socially isolated, and had a greater
324 prevalence of trauma, stressors, and PTSD than the average g-factor group, suggesting that the
325 prevalence of these phenotypes decreases with increasing intelligence. Among the few somatic
326 disorders that were examined, we found that individuals with high intelligence were more
327 myopic and had more allergies, although they had a lower prevalence of hay fever rhinitis, and
328 asthma. Individuals with high intelligence were also more likely to present certain traits, such
329 as having an afternoon-evening chronotype, ever tried cannabis, and ever engaged in same-sex
330 behavior, whereas the low g-factor group was less likely to have ever tried cannabis and
331 engaged in same-sex behavior than the average g-factor group. There were no differences
332 between groups in the prevalence of insomnia.

333 The result of the present study contradicts several studies that reported an increased risk
334 for various psychiatric disorders in individuals with high intelligence (e.g., Karpinski et al.,
335 2018; Smith et al., 2015). These studies were generally based on small samples and suffered
336 from major sampling bias or a lack of a control group (Gauvrit, 2014; Martin et al., 2010). We
337 find that high intelligence is not a risk factor for psychiatric disorders and even a protective
338 factor for general anxiety. Higher intelligence was associated with a decrease in trauma
339 exposure, and consequently PTSD. This is consistent with previous findings (McGuire &
340 Jackson, 2020) and with the association of childhood trauma with lower intelligence (Enlow et
341 al., 2012).

342 With regard to somatic disorders, we replicate the increased risk of allergies in
343 individuals with high intelligence (Benbow, 1985; Karpinski et al., 2018). One possible
344 explanation for this association is that allergies and intelligence share neural correlates
345 (Takeuchi et al., 2018). Another possibility is that more intelligent individuals with a higher g-
346 factor live in more urban areas (Jokela, 2014), where allergies are more prevalent (Schröder et

347 al., 2015), or that individuals with high intelligence are more aware of allergic symptoms and
348 have better access to health care. However, the prevalence between groups did not differ across
349 all allergies (e.g., Asthma, Hay Fever Rhinitis).

350 In line with a previous literature review (Czepita et al., 2008), the risk of myopia was
351 greater for individuals with high intelligence. While near-work activities (e.g., reading and
352 computer use) seem to be a risk factor for myopia (Huang et al., 2015; Mutti et al., 2002), this
353 association appears to be distinct from that of higher intelligence and education level (K. M.
354 Williams et al., 2017). Although additional years of education contribute to an increase in the
355 risk of developing myopia (Mountjoy et al., 2018), most of the evidence points toward shared
356 genetic factors between intelligence and myopia (K. M. Williams et al., 2017), which is
357 consistent with our observation that the risk of myopia associated with a high g-factor only
358 slightly decreased when adjusting for educational attainment.

359 Our results indicate more afternoon-evening chronotypes in individuals with high
360 intelligence than in individuals with average intelligence, which could be explained by
361 differences in the work schedules of the different g-factor groups (Ujma et al., 2020). In line
362 with a previous study (Rahman et al., 2012), we find that individuals with high intelligence are
363 more likely to ever have engaged in same-sex behavior. Although consistent with previous
364 studies (Rahman et al., 2012; Willmott & Brierley, 1984), our measure reflects sexual
365 exploration rather than sexual orientation. We also found an association between ever trying
366 cannabis and intelligence, but this was only true for individuals who consumed cannabis less
367 than 101 times in their lifetime, suggesting that this measure also reflects a tendency to explore.
368 One possibility is that individuals with higher intelligence, which is positively correlated with
369 the "Openness to Experience" personality trait ($r=0.30$; Stankov, 2018), may be more likely to
370 seek out new experiences and explore alternative behaviors than the average.

371 This paper was first limited in its ability to study neurodevelopmental disorders and
372 some psychotic disorders, which were absent or had few cases in the UK Biobank. We
373 nonetheless investigated phenotypic differences in prevalence between g-factor groups across
374 a greater number of psychiatric disorders than previously done (Brown et al., 2021; Karpinski
375 et al., 2018) and examined additional phenotypes, including traumatic experiences.

376 Second, the prevalence of some psychiatric disorders and traits differs from the general
377 population (Davis et al., 2020) because the UK Biobank has a "healthy volunteer" bias (Fry et
378 al., 2017). However, this should not affect the validity of the group comparisons because the
379 phenotypes were designed with the same criterion between high and average IQ groups.

380 Third, while some data may not be missing at random, our participants are more
381 representative of highly intelligent individuals in the general population than those from
382 previous Mensa studies, which did not have a control group and examined individuals that had
383 to take or decided to take an IQ test and join a society for the highly intelligent.

384 Fourth, although we used self-report diagnoses, which are less precise than professional
385 diagnoses, UK Biobank participants self-reporting any psychiatric diagnosis appear to have an
386 elevated risk of any symptom-based outcome (Davis et al., 2019). By using professional and
387 probable diagnoses with validated short mental health tests, we included individuals with
388 mental health disorders that have not sought or received mental health assistance (Kessler et
389 al., 2007; Newson et al., 2011).

390 Fifth, the prevalence of psychiatric disorders and traits between g-factor groups may
391 differ across the lifespan. However, we were interested in lifetime prevalence, making the UK
392 Biobank, a prospective aging study, a good candidate for the question at hand.

393 Therefore, while this paper is not without limitations, we provide a large scaled analysis
394 of the difference in the prevalence of numerous phenotypes, including mental health and
395 somatic disorders, across individuals of varying intelligence. We find that high intelligence is
396 not a risk factor for psychiatric disorders and is a protective factor for general anxiety and PTSD.
397 Whereas our results support the advantageous nature of higher intelligence (Brown et al.,
398 2021), general intelligence may still be relevant for psychiatric evaluation: higher intelligence
399 may affect the presentation of symptoms and the available resources for recovery.

400

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