COVID-19 and mental health of individuals with different personalities

Eugenio Proto[a,b,c,d,1,2] and Anwen Zhang[a,1]

[a]Economics Subject, Adam Smith Business School, University of Glasgow, Glasgow G12 8QQ, United Kingdom; [b]Center for Economic Policy Research, London EC1V 0DX, United Kingdom; [c]IZA–Institute of Labor Economics, 53113 Bonn, Germany; and [d]CESIfo (Center of Economic Studies and ifo Institute), 81679 Munich, Germany

Edited by Susan T. Fiske, Princeton University, Princeton, NJ, and approved August 1, 2021 (received for review May 19, 2021)

Several studies have been devoted to establishing the effects of the COVID-19 pandemic on mental health across gender, age, and ethnicity. However, much less attention has been paid to the differential effect of COVID-19 according to different personalities. We do this using the UK Household Longitudinal Study (UKHLS), a large-scale panel survey representative of the UK population. The UKHLS allows us to assess the mental health of the same respondent before and during the COVID-19 period based on their "Big Five" personality traits and cognitive skills. We find that during the COVID-19 period, individuals who have more extravert and open personality traits report a higher mental health deterioration, while those scoring higher in agreeableness are less affected. The effect of openness is particularly strong: One more SD predicts up to 0.23 more symptoms of mental health deterioration in the 12-item General Health Questionnaire (GHQ-12) test during the COVID-19 period. In particular, for females, cognitive skills and openness are strong predictors of mental health deterioration, while for non-British White respondents, these predictors are extraversion and openness. Neuroticism strongly predicts worse mental health cross-sectionally, but it does not lead to significantly stronger deterioration during the pandemic. The study's results are robust to the inclusion of potential confounding variables such as changes in physical health, household income, and job status (like unemployed or furloughed).

COVID-19 | mental health | Big Five | cognitive skills

The question of whether COVID-19 affects the mental health of different individuals in different ways is very open and compelling. Several studies have been devoted to establishing the effects on different ages, genders, and ethnicities (e.g., refs. 1–6). However, little attention has been paid to the differential effect of COVID-19 according to the differences in individual personalities (exceptions include refs. 7–10, which we will discuss in detail later in the text).

Analyzing the differential effect of the pandemic according to personality is important for at least three reasons. First, it can lead to identification of at-risk groups, as well as more personalized psychological or psychiatric treatments, even for the post-COVID period. Second, understanding how individuals with different personalities react to an extreme condition like a lockdown can shed more light on the link between personality and mental health. Third, it can make clearer unintended consequences of COVID-19 restrictions and inform policy making.

The COVID-19 period can be thought of as a natural experiment, where a sort of stress test is naturally induced. The UK Household Longitudinal Study (UKHLS) provides longitudinal data for the same sample of individuals representative of the UK population, where mental health is monitored before and during the COVID-19 period. Furthermore, the UKHLS dataset provides necessary information about personality traits and cognitive skills that are the main explanatory variables in the current study. Hence, the UKHLS is an ideal tool to analyze the effects of this pandemic on mental health deterioration among individuals with different personalities.

Some confounding factors are potentially relevant in our study. We show that our results are robust to the inclusion of controls, such as changes in physical health, household income, job status (like unemployed or furloughed), marital status, household size, and geographic location, during the COVID-19 period.

There is a widespread consensus on the personality classification based on the openness, conscientiousness, extraversion, agreeableness, and neuroticism five-factor model, or Big Five (11–14). And, following this classification, there is a large literature analyzing the link between personality and mental health (e.g., refs. 15–17).* Further, there are several contributions studying how personality affects self-reported subjective well-being (e.g., refs. 20–23). We show that the data used in the current study produce results that are consistent with these contributions. Building on this literature, we show using longitudinal data representative of a country-large population how an external shock interacts with personality to affect mental health. The panel structure of the UKHLS dataset (i.e., the same individuals observed in different periods) allows us to analyze the deterioration of mental health with respect to a pre–COVID-19 baseline period and, therefore, to estimate the effect of the different traits excluding the confounding effects due to any time-invariant factor.

Significance

Analyzing how personality affects mental health deterioration during the COVID-19 pandemic is important because it can lead to more personalized psychological or psychiatric treatments. Drawing on a longitudinal dataset representative of the UK population before and during the pandemic, we document that personality can be an important factor. In particular, agreeableness is a negative predictor, while openness and, to a lower extent, extraversion are positive predictors; the effect of neuroticism is surprisingly weak. In female respondents, cognitive skills and openness, and in non-British White respondents, extraversion and openness are particularly strong predictors of mental health deterioration. The fact that neuroticism has an effect that is weaker than expected represents an interesting puzzle.

Author contributions: E.P. and A.Z. designed research, performed research, analyzed data, and wrote the paper.

The authors declare no competing interest.

This article is a PNAS Direct Submission.

[1]E.P. and A.Z. contributed equally to this work.

[2]To whom correspondence may be addressed. Email: eugenio.proto@glasgow.ac.uk.

This article contains supporting information online at https://www.pnas.org/lookup/suppl/doi:10.1073/pnas.2109282118/-/DCSupplemental.

Published September 10, 2021.

*A comprehensive review of this large literature is beyond the scope of this paper. We refer the reader to ref. 18 for exhaustive meta-analysis and review of this literature and to ref. 19 for an illustration of the models linking personality to depression.

Some recent contributions (7–10) have emphasized how personality traits can affect individual mental health during the pandemic period. While they are generally consistent with our results, these studies are based on nonprobability sampling methods and smaller samples than the one used in this study, and they do not use a clear pre–COVID-19 baseline of data to precisely identify the deterioration of mental health. In *Discussion*, we will describe these contributions in more detail.

We find that during the COVID-19 period, individuals who have a more extravert and open personality report a higher mental health deterioration, while the ones scoring high in agreeableness are less affected. The effect of openness is particularly strong and seems increasing in magnitude thorough the entire period.

Neuroticism seems to predict more mental health deterioration, but this effect is not significant in the main specifications of the estimated model. This last result unveils an important puzzle since neuroticism is considered an index of sensibility to threats; hence, highly neurotic individuals should be particularly affected in an environment like the COVID-19 pandemic. We further discuss this issue—together with the other main results—in detail in *Discussion*.

Materials and Methods

Data. Our main data source is the COVID-19 Survey from the UKHLS, or Understanding Society. We combine seven waves of the COVID-19 Survey (April, May, June, July, September, and November 2020 and January 2021) with the Wave 9 main survey (2017–2019), which serves as the baseline for the pre–COVID-19 period (24, 25). This leads to seven panels, each with a during– and pre–COVID-19 period. Each panel is balanced (i.e., contain two observations per respondent) with 11,166 data points each.

We apply the longitudinal sampling weights provided in the UKHLS to make inferences on the UK population. A key feature of the COVID-19 Survey is that it is longitudinal, enabling individuals to be tracked over the course of the pandemic. In this balanced panel, there are 8,772 individuals with basic demographic information on gender, age, and ethnicity (*SI Appendix*, Table S1). We further merge these data with Wave 9 main survey to construct the pre-COVID baseline data and the Wave 3 main survey to include information on personality traits and cognitive skills. At the end of this process, we have a total of 5,583 individuals and an attrition of about 36%, of which about 21% (i.e., determined by the difference between 8,772 and 6,928) is due to exogenous survey sampling factors related to the difference in the respondents across different waves, while the remaining 16% (i.e., determined by the difference between 6,928 and 5,583) is due to missing data.

While this attrition rate can be considered substantial, it positively compares with previous research using the same data (3, 6). This attrition does not significantly bias the panel in terms of personality, traits, gender, or education, as we note from *SI Appendix*, Table S1, column 5. Our main concern with attrition is that respondents with certain personality traits systematically drop out of the sample, thus causing a sampling bias in terms of personality traits. Comparisons in columns 5 and 6 show that this is not the case, lending support to our research design. The final sample is, however, 3.7 y older than the initial one. A main reason is that since the Wave 3 main survey, younger individuals have been added to and older individuals have dropped out from the survey. In the final panel, the age range is 24 to 93, while in the initial balanced COVID-19 Study panel, this was 16 to 96; hence, to the extent that we consider this sample as representative of the UK population within the age range of 24 to 93, the exogenous attrition should not represent a threat to representativeness of our sample.

With this in mind, we note from column 6 (measuring the effect of the attrition due to missing data) that there is no significant difference in the mental health indicators (12-item General Health Questionnaire [GHQ-12]) and in almost all the socioeconomic factors. The age difference is significantly reduced to less than 1 y, and, accordingly, the only significant difference at the 5% level is now in the share of retired (about 0.02 smaller). All that provides support that sample-selection bias plays little or no role in our analysis and little or no threat to the representativeness of the sample (to the extent that we consider the sample as representative of adults aged between 24 and 93). All variables included in the regressions and with their statistical descriptions are listed in *SI Appendix*, Table S2.

Mental health. The index of mental health we use is the GHQ-12 (26). The GHQ-12 is a well-known self-report instrument for evaluating minor psychiatric disorders, which may signal the beginning of serious disorders, where the respondent must report the extent to which 12 symptoms of mental health deterioration were present in the past few weeks on a Likert scale; we consider the "caseness" formulation ranging from 0 to 12, which represents the number of symptoms felt "more than usual" or "much more than usual" (we present the questionnaire in *SI Appendix*, section 1). We prefer this to the "score" formulation—which is the sum of each single answer from 1 to 4—because the latter is a cumulative measure of the symptoms' intensity, which is arguably less objective and, hence, less comparable across individuals. We will see below that the results are qualitatively similar—stronger if anything—when we use the score formulation.

Big Five personality traits. We use the personality classification based on the Five-Factor Model, which is the most common classification (11–13). These "Big Five" personality traits are: neuroticism (or emotional stability), extraversion, conscientiousness, agreeableness, and openness, usually measured through self-report based on the so-called NEO Five-Factor Inventory (see e.g., ref. 14), with 60 items (12 items per domain). However, scale-development studies have indicated that the Big Five traits can be reliably assessed with a smaller number of items (e.g., refs. 27 and 28) that can be used in large-scale surveys. The current data are measured with a short 15-item questionnaire (3 per each of the Big Five traits). A detailed description of the questions is available in *SI Appendix*, section 1. This information is measured in Wave 3 of the UKHLS main survey (in 2011–2013). Ref. 29 argues that personality traits vary little for individuals aged between 18 and 65. Given that traits and cognitive skills have been measured in 2011–2013, we will check whether excluding participants over age 60 and under age 27 from the analysis substantially changes our results.† In *SI Appendix*, Table S3, we present the correlation matrix between personality traits, cognitive skills, and gender. As it is normally observed, neuroticism is negatively correlated with all other traits that are otherwise positively correlated with each other. As is normally the case, the correlation between openness and cognitive skills is positive and rather substantial (see *Discussion* for more details on this).

Control variables. We use a measure of cognitive skills as a control variable. They have also been measured in the Wave 3 main survey of the UKHLS (in 2011–2013). We use the 1st principal component of all measures provided in the main UKHLS dataset, apart from the self-rated memory (the questions are presented in *SI Appendix*, section 1; see ref. 31 for details). Furthermore, we introduce as control variables job status, household income (in logarithm), missing income (dummy), any long-term health condition, month of the interview (dummies), age, region, marital status, household size, and presence of children in the household. Summary statistics for all variables are listed in *SI Appendix*, Table S2.

Econometric Models. We have a series of balanced panels with two periods each, so every respondent is recorded twice: once in the pre–COVID-19 wave (i.e., Wave 9 main survey, related to the period 2017–2019) and once in each of the waves within the COVID-19 period (April, May, June, July, September, and November 2020 and January 2021). Using this dataset, we estimate the following model for each two-period panel:

$$GHQ_{i,t} = t\theta_i\Gamma + y_{i,t}\Delta + r_i + \epsilon_{i,t}; \quad [1]$$

where i represents the individual, $t = 0$ indicates the period of the Wave 9 main survey, and $t = 1$ denotes each period of the seven waves during the COVID-19 pandemic. $GHQ_{i,t}$ is the mental health indicator; θ_i is the vector of the time-invariant individual characteristics, including personality traits—our variables of interest—cognitive skills, and gender; $y_{i,t}$ are the time-variant control variables for each respondent (e.g., income); and r_i are the individual-specific fixed effects. The vector of time-invariant characteristics is:

$$\theta_i = (N_i, E_i, C_i, A_i, O_i, CS_i, Sex_i, 1);$$

where N = neuroticism, E = extraversion, C = conscientiousness, A = agreeableness, O = openness, CS = cognitive skills, Sex = female, and one is the constant term. The term $t\theta_i\Gamma$ represents the interaction of a personality trait and other time-invariant individual characteristics with t, which is equal to one for the COVID-19 period and zero otherwise. Therefore, some components of vector Γ represent our main coefficients of interest. $\epsilon_{i,t}$ is an idiosyncratic error assumed, as usual, to be uncorrelated with the regressors.

†Furthermore ref. 30 shows that they change very little, even after very serious shocks like bereavement or unemployment.

In the regression estimating Eq. 1, we cluster the SEs at the individual levels (i.e., we make the standard assumption, given the above specification of the model with individual fixed effects, that errors are uncorrelated across individuals, but correlated within).

Results

In *SI Appendix*, section 2, we report a sanity check of our data. We show that the results (*SI Appendix*, Tables S4–S7) are, to a large extent, consistent with the findings in the literature analyzing how personality affects mental health (e.g., refs. 18 and 19) and also in line with the literature on subjective well-being (e.g., refs. 20–23), with a strong negative effect of neuroticism and positive effects of conscientiousness and extraversion that are smaller in magnitude.

Fig. 1, *Upper Left* presents the evolution of average mental health deterioration, as measured by the increase in GHQ-12 caseness (or symptoms) between each wave during COVID-19 and the baseline (2017–2019), for all selected respondents from April 2020 to January 2021.

We note a timeline of significant COVID-19 restriction policies adopted by the UK government. On March 23, 2020, the Prime Minister (PM) announced a UK-wide lockdown; on May 10, "Stay at home" became "stay alert," and the PM set out a lockdown-lifting plan; on July 4, most restrictions were lifted in England. On October 31, the PM announced that England was being placed under another national lockdown. On December 2, England's national lockdown came to an end and was replaced by a strengthened three-tier system. On January 4, 2021, the PM announced a third national lockdown for England.

In Fig. 1, we observe a V-shaped path of mental health deterioration from April 2020 to January 2021. Fig. 1 shows a dramatic rise in GHQ-12 in April of about one unit (i.e., one more symptom per individual), then a decline during late spring and early summer and an increase again in autumn 2020 and January 2021. This path roughly mirrors the evolution of the infections and restrictions. The average mental health deterioration (i.e., average GHQ-12 changes) over the entire period from April 2020 to January 2021 is around 0.66 symptoms (i.e., two out of three respondents experienced one more symptom on average).

Fig. 1, *Upper Center*, *Upper Right*, and *Lower* present the GHQ-12 evolution for individuals scoring high and low in each personality trait (more precisely, belonging to the top and bottom 25% of each personality score). A visual inspection of the five panels reveals clear differences in mental health deterioration for respondents at the top and bottom ends of all five traits. In particular, individuals high in openness and low in agreeableness seem to have experienced stronger mental health deterioration than their counterparts to the other extremes. Neuroticism seems to affect individuals in the natural direction; i.e., respondents scoring high in neuroticism experienced worse mental health deterioration than those scoring low. Extraversion seems to have more heavily affected respondents at the beginning of the period, while conscientiousness did in the second half.

The evidence presented in Fig. 1 provides a first indication of a differential impact of the COVID-19 period on mental health. There are, however, some potential confounding factors in the relationship between personality and mental health deterioration during the period of analysis. For example, personality can affect the probability of becoming unemployed or lead to a lower wage during the COVID-19 period (e.g., refs. 23 and 29), and, in turn, both of these factors can affect mental health. Therefore, we move on to estimate model 1, which controls for such confounding factors, to assess the relationships suggested in Fig. 1.

Estimation results of model 1 are presented in Fig. 2 and *SI Appendix*, Table S9. Fig. 2 plots the main coefficients of interest to visualize the differential effects of COVID-19 on mental health across different personality traits for each month during the pandemic (April, May, June, July, September, and November 2020 and January 2021), compared against the pre–COVID-19 baseline period (i.e., Wave 9 main survey, 2017–2019). For comparison, results for a specification excluding control variables are presented in *SI Appendix*, Table S8 and Fig. S1.

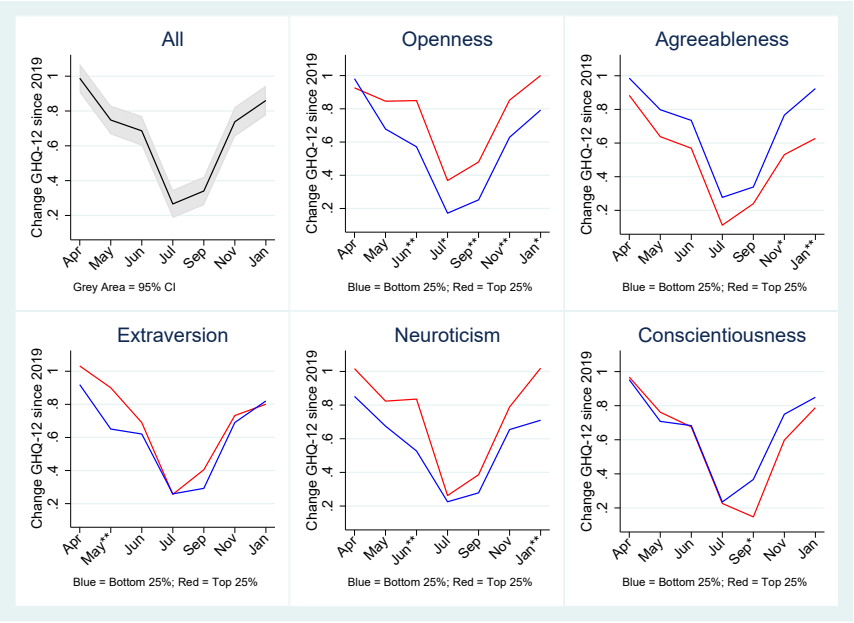

Fig. 1. Mental health deterioration in the COVID-19 period, in total and among individuals with different personality traits. The changes in GHQ-12 represent mental health deterioration between the pre-COVID wave and each wave during the COVID-19 period. The black line in *Upper Left* panel represents the overall average, while the other panels report the averages among subjects with the top (red lines) and bottom (blue lines) 25% score in each personality trait. GHQ-12 index is the number of symptoms—up to 12—indicating some form of mental disorders. $*P < 0.1$; $**P < 0.05$ (statistical significance of the difference between the two lines).

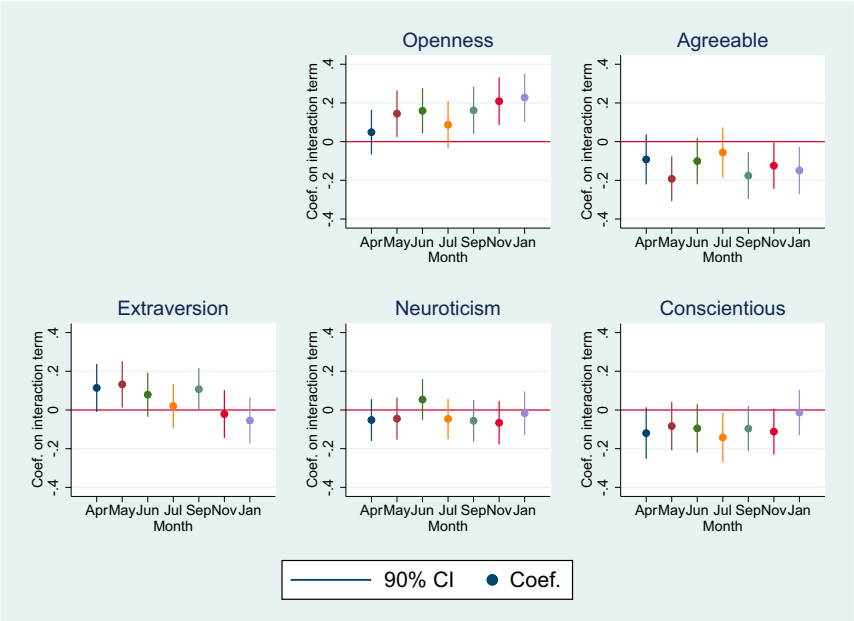

Fig. 2. Coefficient (coef.) plots of the effects of COVID-19 on mental health by personality traits. This figure plots the main coefficients of interest, estimated using model 1 for each pair of a period during COVID-19 and the pre–COVID-19 baseline period. The dependent variable is GHQ-12. Each dot represents the coefficient of an interaction term between a specific trait and the COVID-19 period, for each COVID-19 wave. The spike plots refer to the 90% CIs.

We note that some personality traits significantly predict more mental health deterioration, with a nonnegligible magnitude. To have an idea, a coefficient of about 0.15 implies that one SD in personality increases leads to 0.15 symptoms on the GHQ-12 measure—i.e., one out of seven respondents reporting one more symptom in the COVID-19 period—and we recall that the average mental health deterioration in the COVID-19 period is about 0.66 more symptoms.

In particular, personalities with a low score in agreeableness and a high score in openness are predictive of more mental health deterioration during the COVID-19 period. The effect of openness seems to be increasing throughout the period, and it is remarkably high in January 2021, where a one-SD increase in openness predicts an increase of 0.23 symptoms on average. The interaction with extraversion is weakly significant in the second period, but if we consider the GHQ-12 scale (range 0 to 36) instead (*SI Appendix*, Table S10), this becomes strongly significant at a 5% level for the second period and marginally significant at 10% for the first and third periods. The interaction with conscientiousness is weakly significant in the fourth wave. Neuroticism is surprisingly insignificant in this specification.‡ We also test whether neuroticism significantly interacts with other personality traits in predicting mental health deterioration, but we find no evidence supporting this (*SI Appendix*, Table S12).

To make sure we are not picking up diverging trends or time effects due to different personality traits, we further run a placebo test, with Wave 9 in the main survey as the intervention period and Wave 8 as the baseline period. The coefficients of interest are plotted in Fig. 3. In this test, we are not able to detect any significant differential effects due to personality traits across these two waves, lending support to the notion that the diverging trends in mental health across different levels of personality traits are specific to the COVID-19 period. Further details of this test are provided in *SI Appendix*, Table S13. We also check for robustness to other psychological factors that might be correlated with personality traits, including optimism, risk attitude, and locus of control (*SI Appendix*, Table S14). The results are also very similar if we omit sampling weights (*SI Appendix*, Table S15) or apply inverse probability weighting to address attrition issue (*SI Appendix*, Table S16 and Fig. S2), exclude those over 60 and under 27 (*SI Appendix*, Table S17), or consider different specifications of model 1 (*SI Appendix*, Tables S18 and S19).

We further explore heterogeneity across demographic dimensions. In Table 1, we report the results of the estimation of model 1 for males and females separately.§ First of all, we observe in Table 1 (and in *SI Appendix*, Table S9) that, consistent with existing evidence, female respondents report more symptoms of mental health deterioration than males during the COVID-19 period (1, 3–6). Even if some coefficients lose significance in comparison with the estimations presented in Fig. 2 (and in *SI Appendix*, Table S9), given the lower power of this test, we note that both openness and cognitive skills (which is insignificant when we consider all together) are particularly strong predictors of mental health deterioration in female respondents.

We also explore differential patterns by ethnicity and age groups, by further including interaction terms for ethnicity/age, personality traits, and the indicator for the COVID-19 period (*SI Appendix*, Tables S22 and S23). The results in *SI Appendix*, Table S22 suggest that B.A.M.E. (Black, Asian, and minority ethnic) respondents with high extraversion or high openness suffer even more mental health deterioration compared to their non-B.A.M.E. counterparts.

In terms of heterogeneity by age groups, *SI Appendix*, Table S23 shows that for old respondents (aged above 65), openness is a significantly negative predictor of mental health deterioration

‡To understand better this apparent discrepancy with Fig. 1, where there seem to be a significant difference between the top and bottom 25% neuroticism scorers, in *SI Appendix*, Table S11, we show that this difference vanishes once a general dummy variable indicating the COVID-19 period is introduced, suggesting that this effect is rather weak.

§For expositional simplicity, we only included Waves 2, 4, and 6 of the COVID-19 period; see *SI Appendix*, Tables S20 and S21 for full results, including all waves.

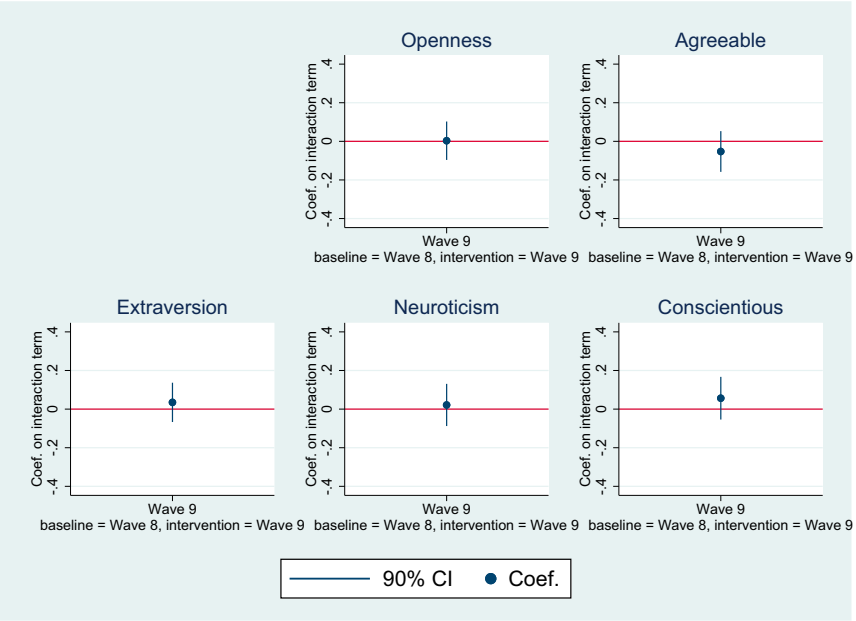

Fig. 3. Coefficient (coef.) plots for the effects of a placebo intervention on mental health by personality traits. This figure plots the main coefficients of interest, estimated using model 1 for each pair of a period during a placebo intervention period (Wave 9 main survey) and the baseline (Wave 8 main survey). The dependent variable is GHQ-12. Each dot represents a coefficient, and the spike plots the 90% CI. Each plot represents the coefficient and CI for the interaction term between "During intervention period" and a personality trait.

compared with their younger counterparts (for whom openness is a positive predictor), and conscientiousness is a significantly negative predictor (for younger counterparts, this becomes insignificant) during most months of the pandemic. While this is interesting, these results should be taken with caution, since personality traits and cognitive skills may not be fully reliable measures for old respondents, as discussed before.

To summarize our empirical findings, we can say that during the COVID-19 period agreeableness is a negative predictor of mental health deterioration, while openness and, to a lower extent, extraversion are positive predictors; neuroticism is surprisingly insignificant in all specifications of the model. In female respondents, cognitive skills and openness—and in B.A.M.E. respondents openness and extraversion—are particularly strong predictors of mental health deterioration.

Discussion

There is widespread evidence that mental health has been severely affected by the COVID-19 pandemic (e.g., refs. 1, 3, 32 and 33), and it will likely be a main issue in the post-COVID period as well (34). Therefore, it is crucial to identify the individuals that have been more affected in terms of mental health and, more generally, to shed more light on the link between personality and mental health. We believe this study provides a relevant contribution in these directions.

Our results show that openness is a strong predictor of mental health deterioration during the pandemic period. Openness is the trait that reflects preferences for exploration and new experiences (35, 36); in fact, this trait is often called "openness to experience." The pandemic period is characterized by several constraints that limit the capacity of making new experiences or seeking new sensations, and the fact that openness is positively associated with mental health deterioration reflect this view. Furthermore, openness is the Big Five trait that is more consistently positively associated with intelligence (as we can observe in *SI Appendix*, Table S2 for our data as well); in fact, openness is sometime referred as "intellect." Cognitive skills like fluid intelligence and working memory seem to be related primarily to the aspect of openness/intellect that can be described as intellect, which can be separated by the artistic and contemplative traits

Table 1. Personality and mental health deterioration during the COVID-19 period for males and females

	2019 and May 2020		2019 and Jul 2020		2019 and Jan 2021	
	Female	Male	Female	Male	Female	Male
During COVID-19 period	1.656*** (0.391)	0.863 (0.530)	−0.121 (0.444)	0.672 (0.480)	1.198** (0.505)	0.259 (0.471)
Agreeableness × during	−0.182* (0.103)	−0.199** (0.090)	−0.101 (0.126)	−0.028 (0.092)	−0.134 (0.101)	−0.149 (0.107)
Conscientious × during	−0.056 (0.099)	−0.135 (0.116)	−0.152 (0.119)	−0.118 (0.096)	−0.008 (0.096)	−0.051 (0.105)
Extraversion × during	0.187* (0.100)	0.082 (0.100)	0.102 (0.099)	−0.056 (0.086)	−0.152 (0.103)	0.063 (0.097)
Neuroticism × during	−0.019 (0.089)	−0.080 (0.101)	−0.030 (0.087)	−0.040 (0.093)	0.013 (0.093)	−0.022 (0.102)
Openness × during	0.132 (0.094)	0.158 (0.115)	0.050 (0.096)	0.129 (0.111)	0.284*** (0.091)	0.162 (0.126)
Cognitive skills × during	0.198** (0.084)	−0.130 (0.158)	0.233*** (0.084)	−0.171 (0.152)	0.136 (0.085)	−0.074 (0.135)
N	8,806	7,943	8,806	7,943	8,806	7,943

Dependent variable is GHQ-12 (range 0–12). Personality and cognitive skills variables are standardized. All models control for individual fixed effects, job status, household income, any long-term condition, month of the interview, age, region, marital status, household size, and presence of children. Clustered SEs at the individual level are in parentheses. *$P < 0.1$; **$P < 0.05$; ***$P < 0.01$.

that characterize the openness aspect (35, 37). In our main analysis, we introduce cognitive skills as a regressor together with openness; hence, we can separately analyze the two aspects of openness and intellect. Openness is a particularly strong negative predictor of mental health deterioration for women and members of the B.A.M.E. community. Interestingly, cognitive skills are particularly strong negative predictors of mental health deterioration for women, while there is no significant effect for men.

Agreeableness reflects a tendency toward the maintenance of social stability; for this reason, an individual with a more agreeable personality can cope better in the constrained environment following the lockdown (36). However, at the same time, individuals scoring high in agreeableness should have a general altruistic tendency and tend to be interested in and considerate of others' needs and feelings. In the pandemic, the knowledge that other people, either within the family or outside, are suffering for various reasons can negatively affect individuals with a more agreeable personality. Our evidence suggests that the first effect is stronger than the second.

Extraversion is, generally speaking, a trait related to sensitivity to social rewards (e.g., ref. 38). Therefore, in an environment where social contacts are restricted, it is natural to expect that extraverted individuals are particularly negatively affected. The fact that this seems to be true only in the first part of the COVID-19 period might be due to the fact that extravert respondents managed to adapt to this situation, perhaps by using social media platforms. In the B.A.M.E community, extraversion is a stronger predictor of mental health deterioration than among White British.

Neuroticism is linked to higher sensitivity to negative emotions like anger, hostility, or depression. For this reason, neuroticism is associated with sensibility to negative outcomes and threats (36) that should be pervasive during the current pandemic. Surprisingly, in our data, we find only weak evidence of this. A possible answer is that, given what we can observe from *SI Appendix*, Tables S4–S7, neuroticism is a strong negative predictor of mental health deterioration in general, and individuals with highly neurotic personalities have normally experienced several negative shocks in the course of their lives; hence, there might be a sort of habituation effect at play. Another possibility is that each individual does not normally experience too many symptoms of mental health deterioration as the ones measured in the GHQ-12 questionnaire; hence, respondents with a highly neurotic personality cannot experience more symptoms than what they experienced before the pandemic period.

The effects of extraversion and openness and the lack of a strong effect of neuroticism on mental health are consistent with ref. 39 field-experiment results. They show that subjects experiencing larger disruptions to their lifestyle behaviors, arguably subjects with a more open and extravert personality, faced the larger increase in depression symptoms and that the standard predictors of depression, like a highly neurotic personality, were less important.

Conscientiousness reflects a tendency to maintain motivational stability. For this reason, a conscientious individual can overcome better the practical constraints and manage better the negative feelings due to the pandemic. On the other hand, conscientious individuals have preferences to make long-term ambitious plans, something impossible to achieve in an highly uncertain environment; hence, there is no reason to expect a positive or negative effect.

Using a convenience sample of 484 University of Vermont first-year undergraduate students and considering as a baseline January 2020, ref. 8 analyzes how personality traits interact with the COVID period to affect some well-being indicators. They find negative effects of extraversion and openness as well, and, in line with our findings, they do not find a negative effect of neuroticism (they actually report a positive effect). Differently from us, the effect of agreeableness seems negative. While we are not aware of any particular coronavirus restrictions in Vermont in January 2020, the expectations that a world pandemic would be eventually declared was widespread, so it is not possible to rule out that the baseline used by ref. 8 was completely unaffected.

Ref. 10 uses a small convenience sample of 51 German individuals in a panel over three consecutive weeks within the COVID-19 period. They show that extraverts suffer from limitations and benefit from relaxation, and individuals with high neuroticism have not shown any change in dealing with the restrictions over time. The fact that both refs. 8 and 10 do not find any negative effect on neuroticism, as we do, is remarkable.

Furthermore, refs. 9 and 7 analyze the link between personality traits and psychological well-being with cross-sectional data. Hence, as we argued above, their designs do not allow them to control for individual fixed effects, and it is comparable with what we do in our sanity check (*SI Appendix*, Tables S4–S7). Ref. 9 surveyed a convenience sample of the Canadian population using the online platform Qualtrics in June/July 2020. Similarly as we do in our sanity checks, they find a negative effect of neuroticism and a positive effect of extraversion. Ref. 7 uses a convenience sample of the Japan population recruited through Yahoo! Crowdsourcing service and conducted in April 2020, and they find that neuroticism negatively affects well-being indicators, as we do in our sanity check. As we argued, controlling for individual fixed effects avoids potential confounding factors and allows us to more precisely identify the effect of COVID-19 on mental health.

Data Availability. Previously published data were used for this work [University of Essex, Institute for Social and Economic Research (24, 25); http://doi.org/10.5255/UKDA-SN-8644-9 and https://doi.org/10.5255/UKDA-SN-6614-14].

ACKNOWLEDGMENTS. 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. We thank several colleagues for discussions on this and related research, in particular, Dimitris Christellis, Dietmar Fehr, Climent Quintana-Domeque, Rajesh Ramachandran, and Andis Sofianos, and seminar participants at the Institute of Health and Wellbeing at the University of Glasgow, the Economics Department at the University of Heidelberg, and the Wellbeing Research Center at the University of Oxford. Responsibility for errors and confusion is ours.

1. J. Banks, X. Xu, "The mental health effects of the first two months of lockdown and social distancing during the Covid-19 pandemic in the UK" (IFS Working Paper w20/16, Institute for Fiscal Studies, London, 2020). https://ifs.org.uk/uploads/WP202016-Covid-and-mental-health.pdf. Accessed 25 August 2021.
2. C. Graham *et al*., "Coping with COVID-19: Implications of differences in resilience across racial groups for mental health and well-being" (HCEO Working Paper 2020-067, Human Capital and Economic Opportunity Global Working Group, University of Chicago, Chicago, 2020). https://hceconomics.uchicago.edu/research/working-paper/coping-covid-19-implications-differences-resilience-across-racial-groups. Accessed 25 August 2021.
3. M. Daly, A. R. Sutin, E. Robinson, Longitudinal changes in mental health and the COVID-19 pandemic: Evidence from the UK Household Longitudinal Study. *Psychol. Med.*, 10.1017/S0033291720004432 (2020).
4. A. Davillas, A. M. Jones, "The COVID-19 pandemic and its impact on inequality of opportunity in psychological distress in the UK" (ISER Working Paper 2020-07, Institute for Social and Economic Research, University of Essex, Colchester, United Kingdom, 2020). https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3614940. Accessed 25 August 2021.
5. B. Etheridge, L. Spantig, "The gender gap in mental well-being during the Covid-19 outbreak: Evidence from the UK" (ISER Working Paper 2020-08, Institute for Social and Economic Research, University of Essex, Colchester, United Kingdom, 2020). https://www.econstor.eu/handle/10419/227789. Accessed 25 August 2021.
6. E. Proto, C. Quintana-Domeque, COVID-19 and mental health deterioration by ethnicity and gender in the UK. *PLoS One* **16**, e0244419 (2021).
7. K. Qian, T. Yahara, Mentality and behavior in COVID-19 emergency status in Japan: Influence of personality, morality and ideology. *PLoS One* **15**, e0235883 (2020).

8. D. C. Rettew, E. W. McGinnis, W. Copeland, H. Y. Nardone, Y. Bai, J. Rettew, V. Devadenam, J. J. Hudziak, Personality trait predictors of adjustment during the covid pandemic among college students. *PLoS One* **16**, e0248895 (2021).
9. A. Shokrkon, E. Nicoladis, How personality traits of neuroticism and extroversion predict the effects of the COVID-19 on the mental health of Canadians. *PLoS One* **16**, e0251097 (2021).
10. M. Weiß, J. Rodrigues, J. Hewig, BIG 5 personality factors in relation to coping with contact restrictions during the COVID-19 pandemic: An explorative analysis. PsychArchives [Preprint] (2020).https://www.psycharchives.org/handle/20.500.12034/3099 (Accessed 25 August 2021).
11. L. R. Goldberg, The structure of phenotypic personality traits. *Am. Psychol.* **48**, 26–34 (1993).
12. J. M. Digman, "Child personality and temperament: Does the five-factor model embrace both domains" in *The Developing Structure of Temperament and Personality from Infancy to Adulthood*, C. F. Halverson, G. A. Kohnstamm, R. P. Martin, Eds. (Psychology Press, Hove, United Kingdom, 2014), pp. 323–338.
13. K. E. Markon, R. F. Krueger, D. Watson, Delineating the structure of normal and abnormal personality: An integrative hierarchical approach. *J. Pers. Soc. Psychol.* **88**, 139–157 (2005).
14. P. T. Costa Jr, R. R. McCrae, *The Revised NEO Personality Inventory (NEO-PI-R)* (Sage Publications, Inc., Thousand Oaks, CA, 2008).
15. D. Watson, L. A. Clark, Introduction to the special issue on personality and psychopathology. *J. Abnorm. Psychol.* **103**, 3 (1994).
16. R. F. Krueger, J. L. Tackett. Personality and psychopathology: Working toward the bigger picture. *J. Pers. Disord.* **17**, 109–128 (2003).
17. L. A. Clark, Temperament as a unifying basis for personality and psychopathology. *J. Abnorm. Psychol.* **114**, 505–521 (2005).
18. R. Kotov, W. Gamez, F. Schmidt, D. Watson, Linking "big" personality traits to anxiety, depressive, and substance use disorders: A meta-analysis. *Psychol. Bull.* **136**, 768–821 (2010).
19. D. N. Klein, R. Kotov, S. J. Bufferd, Personality and depression: Explanatory models and review of the evidence. *Annu. Rev. Clin. Psychol.* **7**, 269–295 (2011).
20. D. Watson, L. A. Clark, On traits and temperament: General and specific factors of emotional experience and their relation to the five-factor model. *J. Pers.* **60**, 441–476 (1992).
21. R. E. Lucas, E. Diener, "Personality and subjective well-being" in *Well-Being: The Foundations of Hedonic Psychology*, D. Kahneman, E. Diener, N. Schwarz, eds. (Russell Sage Foundation, New York, NY, 1999), pp. 213–229.
22. C. J. Boyce, A. M. Wood, Personality and the marginal utility of income: Personality interacts with increases in household income to determine life satisfaction. *J. Econ. Behav. Organ.* **78**, 183–191 (2011).
23. E. Proto, A. Rustichini, Life satisfaction, income and personality. *J. Econ. Psychol.* **48**, 17–32 (2015).
24. University of Essex, Institute for Social and Economic Research, Data from "Understanding Society: COVID-19 Study, 2020-2021." UK Data Service; SN: 8644. https://doi.org/10.5255/UKDA-SN-8644-9. Accessed 25 August 2021.
25. University of Essex, Institute for Social and Economic Research, NatCen Social Research, Kantar Public, Data from "Understanding Society: Waves 1-10, 2009-2019 and Harmonised BHPS: Waves 1-18, 1991-2009." UK Data Service. SN: 6614. https://doi.org/10.5255/UKDA-SN-6614-14. Accessed 25 August 2021.
26. D. P. Goldberg, P. Williams, *A User's Guide to the General Health Questionnaire: GHQ* (GL Assessment, London, United Kingdom, 1988).
27. S. D. Gosling, P. J. Rentfrow, W. B. Swann Jr, A very brief measure of the Big-Five personality domains. *J. Res. Pers.* **37**, 504–528 (2003).
28. V. Benet-Martínez, O. P. John, Los Cinco Grandes across cultures and ethnic groups: Multitrait multimethod analyses of the Big Five in Spanish and English. *J. Pers. Soc. Psychol.* **75**, 729–750 (1998).
29. L. Borghans, A. L. Duckworth, J. J. Heckman, B. T. Weel, The economics and psychology of personality traits. *J. Hum. Resour.* **43**, 972–1059 (2008).
30. D. A. Cobb-Clark, S. Schurer, The stability of big-five personality traits. *Econ. Lett.* **115**, 11–15 (2012).
31. S. McFall, "Understanding Society: UK Household Longitudinal Study: Cognitive ability measures" (Tech. Rep., Institute for Social and Economic Research, University of Essex, Colchester, United Kingdom, 2013).
32. A. Brodeur, A. E. Clark, S. Fleche, N. Powdthavee, COVID-19, lockdowns and well-being: Evidence from Google Trends. *J. Public Econ.* **193**, 104346 (2021).
33. C. K. Ettman, S. M. Abdalla, G. H. Cohen, L. Sampson, P. M. Vivier, S. Galea, Prevalence of depression symptoms in US adults before and during the COVID-19 pandemic. *JAMA Netw. Open* **3**, e2019686 (2020).
34. L. Aknin *et al*., Mental health during the first year of the COVID-19 pandemic: A review and recommendations for moving forward. https://doi.org/10.31234/osf.io/zw93g. Accessed 25 August 2021.
35. C. G. DeYoung, J. B. Peterson, D. M. Higgins, Sources of openness/intellect: Cognitive and neuropsychological correlates of the fifth factor of personality. *J. Pers.* **73**, 825–858 (2005).
36. C. G. DeYoung, J. R. Gray, "Personality neuroscience: Explaining individual differences in affect, behaviour and cognition" in *Cambridge Handbooks in Psychology*, P. J. Corr, G. Matthews, eds. (Cambridge University Press, Cambridge, United Kingdom, 2009), pp. 323–346.
37. C. G. DeYoung, L. C. Quilty, J. B. Peterson, Between facets and domains: 10 aspects of the Big Five. *J. Pers. Soc. Psychol.* **93**, 880 (2007).
38. R. A. Depue, J. V. Morrone-Strupinsky, A neurobehavioral model of affiliative bonding: Implications for conceptualizing a human trait of affiliation. *Behav. Brain Sci.* **28**, 313–350, discussion 350–395 (2005).
39. O. Giuntella, K. Hyde, S. Saccardo, S. Sadoff, Lifestyle and mental health disruptions during COVID-19. *Proc. Natl. Acad. Sci. U.S.A.* **118**, e2016632118 (2021).