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Is Country-Level Extraversion Associated with the Number of COVID-19 Cases and Deaths?

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An evolutionary explanation of between-country variation in extraversion assumes that it is more adaptive in the absence of pathogens but less adaptive in pathogen-prevalent environments. We attempted to test this assumption by correlating country-level extraversion scores and the number of COVID-19 cases and deaths. There are at least five country-level extraversion scores available, three of which were significantly correlated with the number of COVID-19 cases and two of which were significantly correlated with the number of COVID-19 deaths. This apparent partial support for the assumption is puzzling because the validity of country-level extraversion scores was low. Brief numerical simulations suggest that a statistical artefact due to combining two mutually non-independent subgroups (European/American countries and African/Asian countries) may account for the observed country-level correlations.

Keywords
personality, extraversion, COVID-19

Introduction

People vary in their behavioral tendencies. Some people are more open to new experiences, while others are more conservative. One of the dominant views on such individual differences is the five-factor model of personality (Digman, 1990), which posits that human individual differences can be represented by five mutually independent factors: agreeableness, conscientiousness, extraversion, neuroticism, and openness to experience. Behavioral genetic studies have revealed that approximately half of the variance in these five personality traits is attributable to genetic differences—their heritability scores are between .40 and .60 (Bouchard, 2004).

It is also known that the average scores of the five traits vary across countries (Allik et al., 2017; McCrae et al., 2005; Schmitt et al., 2007). An evolutionary explanation of such geographical variation in personality traits draws on historical pathogen prevalence. Schaller and Murray (2008) showed that the region-level historical pathogen prevalence is negatively correlated with country-level extraversion (r = −.26 to −.67) and openness to experience (r = −.24 to −.59). Both extraversion and openness to experience motivate people to interact with others (in the case of openness, possibly with foreigners), thus conferring fitness benefits by expanding social networks (including mating partners). However, a meta-analytic review showed that extraversion and openness to experience were negatively associated with disease avoidance traits, such as disgust sensitivity and germ aversion (Oosterhoff et al., 2018). Therefore, in pathogen-prevalent environments, the beneficial effects of gregariousness may be outweighed by the heightened risk of contracting infectious diseases (see Nettle, 2005).

Given the fitness cost of gregariousness in pathogen-prevalent environments, there are three possible explanations for the observed negative correlation between pathogen prevalence and extraversion/openness to experience (Schaller & Murray, 2008; Thornhill et al., 2010). First, natural selection might have eliminated a significant portion of genes causing gregariousness in historically pathogen-prevalent regions. Second, personality traits may exhibit context-dependent phenotypic plasticity, meaning people develop personality traits that are less gregarious in response to the environmental cues of pathogen prevalence. Third, adaptive cultural traditions that restrict exposure to pathogens might have emerged in historically pathogen-prevalent regions. Despite the differences in the mechanisms causing the region-level negative correlation between pathogen prevalence and gregariousness, all three explanations share the assumption that gregarious traits are vulnerable to infectious diseases. The COVID-19 pandemic caused by the spread of a novel strain of coronavirus (i.e., severe acute respiratory syndrome coronavirus 2 [SARS-CoV-2]) provides an opportunity to test this assumption: whether the number of COVID-19 cases/deaths is positively correlated with country-level gregarious trait scores.

However, the research employing country-level analyses in the context of pathogen prevalence has been criticized for at least three reasons (Pollet et al., 2014; see also Hruschka & Hackman, 2014): the possible presence of ecological fallacy (i.e., correlations among aggregate data may not be parallel with correlations at the individual level), non-independence of observations (i.e., geographically close countries tend to be similar in many aspects), and cross-cultural non-equivalence of the measurement (i.e., scores of different countries may not be comparable). The first problem (i.e., ecological fallacy) may be relevant to openness to experience in the context of COVID-19. At the individual level, openness to experience is not associated with more vulnerable behavioral patterns—although individuals high in extraversion were

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less likely to comply with stay-at-home policies and new hygiene norms, individuals high in openness to experience were rather more obedient (Blagov, 2021; Götz et al., 2021). Therefore, in the present study, we primarily focused on extraversion.

The purpose of this study is to critically examine the assumption of previous studies that extraversion is associated with vulnerability to infectious diseases at the country level. We specifically test whether this assumption is tenable even if the above three criticisms are taken into consideration. In other words, if we find that the country-level correlation apparently supports the assumption, we need to proceed to verify whether the observed support is genuine or instead has to be interpreted as a statistical artefact.

Methods

Big Five Personality Traits

There were at least five non-overlapping studies that reported country-level Big Five personality scores for at least 50 countries or regions. Schmitt et al. (2007) administered the Big Five Inventory (BFI; John et al., 1991) in 56 countries. BFI was also used in the Gosling-Potter Internet Personality Project, whereby the Big Five personality scores were collected from 106 regions (Gebauer et al., 2015). Allik et al. (2017), an expansion of McCrae's (2001) original project, reported personality data from 62 cultures using the Revised NEO Personality Inventory (NEO-PI-R) to measure five personality traits. NEO-PI-R was also used to assess country-level other-rated personality traits for 51 regions (respondents rated someone from their own cultures; McCrae et al., 2005). Most recently, using the Ten Item Personality Inventory (TIPI; Gosling et al., 2003), Götz et al. (2021) measured personality traits of people from 55 regions as part of the Measuring Worldwide COVID-19 Attitudes and Beliefs Project.

Variables Related to COVID-19

The number of COVID-19 cases/deaths for each country is reported on the website of the World Health Organization (WHO). We used the cumulative number of cases/deaths (per one million population) on December 13, which was reported in the 15-December-2020 version of the WHO's (2020) Weekly Epidemiological Update. We chose this date to eliminate the effect of vaccinations, which could have an even greater impact on COVID-19 cases/deaths. The world's earliest COVID-19 vaccination campaign was launched in Israel on December 20, 2020 (Rosen et al., 2021).

The number of cases/deaths (per one million population) was positively skewed (1.29 and 1.07 for cases and deaths, respectively). The log-transformation made them negatively skewed (−1.09 and −0.78). The square root transformation made skewness closer to 0 (0.21 and 0.32), thus we report the analyses using the square root-transformed number of cases/deaths. However, the analyses using the untransformed data yielded mostly comparable results.

Control Variables

We also collected control variables, such as the Gross National Income per capita. However, due to space limitations, we report the analyses including the control variables in Section 1 of Supplementary Material. The analyzed dataset and R code are available in the Open Science Framework (OSF: https://osf.io/8b7ha/).

Results

Mutual Correlation between Big Five Personality Traits

We first examined the between-study correlations of personality scores. Since we had five datasets (i.e., Allik et al., 2017; Gebauer et al., 2015; Götz et al., 2021; McCrae et al., 2005; Schmitt et al., 2007), there were ten pairs of studies. The correlation coefficients with 95% confidence interval (CI) are summarized in Figure 1. These mutual correlations were low and not necessarily significant. For extraversion (average r = .32), only five out of 10 pairwise correlations were significant. Furthermore, for the other four traits (average rs = .20, .17, .10, and .26 for openness to experience, agreeableness, conscientiousness, and neuroticism, respectively), only three out of 10 pairwise correlations were significant. The datasets based on the same scale were not necessarily correlated with each other (see the shaded rows in Figure 1). These results indicate the low validity of the country-level personality scores.

Hypothesis Testing

The low validity of the country-level extraversion scores discourages hypothesis testing. Notice, however, that the same low validity problem is shared by previous studies;

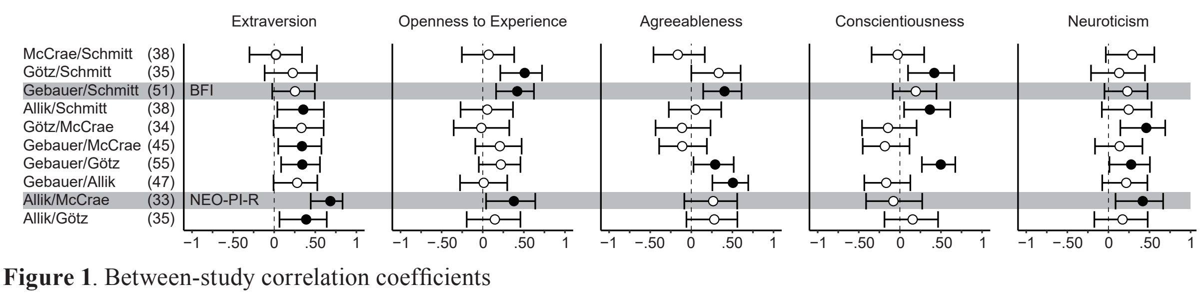


Figure 1. Between-study correlation coefficients

Note. Error bars indicate the 95% confidence intervals. Black circles indicate significant correlations, and white circles indicate non-significant correlations. Each dataset is referred to by the first author's name. For example, "McCrae/Schmitt" indicates the correlation coefficients between personality scores reported in McCrae et al.'s (2005) study and Schmitt et al.'s (2007) study. The shaded pairs indicate the studies that used the same scale. Numbers in parentheses indicate the sample size of the corresponding pair of studies.

nonetheless, they observed significant correlations between historical pathogen prevalence and country-level extraversion. One possibility is that "true" country-level extraversion is correlated with country-level impacts of infectious diseases so strongly that even extraversion measures with low validity could yield significant correlations with disease impact. With this possibility in mind, we computed the correlations between the personality traits taken from the five studies and the cumulative number of COVID-19 cases/deaths (square root-transformed). Figure 2 shows these country-level correlations and 95% CIs. Despite the low validity of the country-level extraversion scores, three out of five extraversion scores were significantly positively correlated with the cumulative number of cases (average r = .26) and two were significantly positively correlated with the cumulative number of deaths (average r = .24).

Discussion

The results partially support the hypothesis that country-level extraversion is associated with the number of COVID-19 cases/deaths, since three of the five correlations between extraversion scores and COVID-19 cases, and two of the correlations for deaths, were positive and significant. The remaining five correlations were also all positive, although one of them (between Schmitt et al.'s extraversion scores and COVID-19 deaths) was almost nil (r = .02). In the following sections, implementing two brief numerical simulations, we consider whether the observed positive correlations are genuine or should be interpreted as a statistical artefact.

Numerical Simulation 1: "True" Extraversion × COVID-19 Correlation

If the "true" country-level extraversion is highly correlated with the COVID-19 variables, the "measured" country-level extraversion (no matter how low its validity is) may still be correlated with the COVID-19 variables. To examine the plausibility of this explanation, we estimated the level of correlation between "true" country-level extraversion × the COVID-19 variable that could yield the observed level of correlation (average = .26 and .24 for cases and deaths, respectively).

The general procedure of Simulation 1 is depicted in Figure 3a (see also Section 3 of Supplementary Materials and the R Markdown HTML file in OSF). At Step 1, we made a relatively lenient assumption that the validity of the "measured" country-level extraversion scores is ρ = .60. The validity can be conceptualized as the correlation between the "true" scores (X) and the "measured" scores (Y). When we set ρ = .60, the correlation between two simulated "measured" variables (Y_1 and Y_2) was approximately .36, which slightly exceeded the average of correlations between two observed extraversion scores (.32). At Step 2, we generated random sequences (Y and W), varying $r(W, X)$ from .10 to .90 in increments of .10 (n for each sequence was 55, which approximated the sample sizes of the actual studies; see ns in Figure 2). Notice that $r(W, X)$ conceptually corresponds to the correlation between "true" country-level extraversion (X) and the COVID-19 variables (W). We then computed $r(Y, W)$s 10,000 times for each level of $r(W, X)$.

The distributions of the simulated $r(Y, W)$s are shown in Figure 3b. The means of the distributions are close to the dashed line in Figure 3b when $r(W, X)$ was approximately .40 to .50. In other words, given that the validity of country-level extraversion scores was low (ρ = .60), $r(W, X)$ needs to be as high as about .40 to .50 in order to observe an average correlation between country-level extraversion and COVID-19 cases/deaths of .26/.24. This result (i.e., $r(W, X)^2$ = .16 to .25) implies that approximately 20% of variance in the COVID-19 variables (W) is accounted for by the "true" country-level extraversion (X). Although it is not impossible, this seems implausible because social distancing and hygiene behaviors are significantly correlated with other five-factor scores at the individual level (Blagov, 2021), and other variables, such as government effectiveness, also influence COVID-19 outcomes (see Section 1 of Supplementary Materials).

Numerical Simulation 2: Clustered Observations

An alternative explanation for the observed correlations is based on the non-independence of country-level variables (Hruschka and Hackman, 2014; see also Pollet et al., 2014). Hruschka and Hackman specifically argued that country-

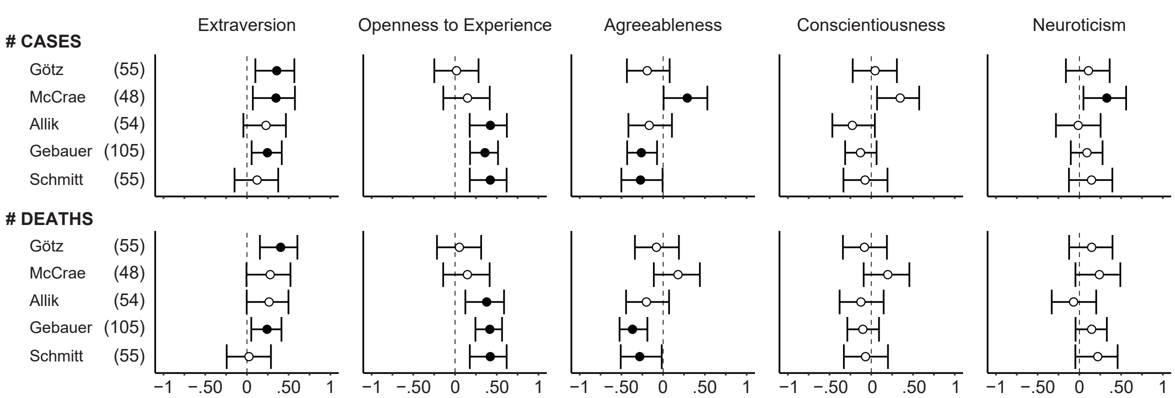


Figure 2. Country-level correlations between personality traits and the number of COVID-19 cases and deaths

Note. Upper row indicate the number of COVID-19 cases and lower row indicate the number of COVID-19 deaths. The COVID-19 variables were square root-transformed. Error bars indicate the 95% confidence intervals. Black circles indicate significant correlations, and white circles indicate non-significant correlations.

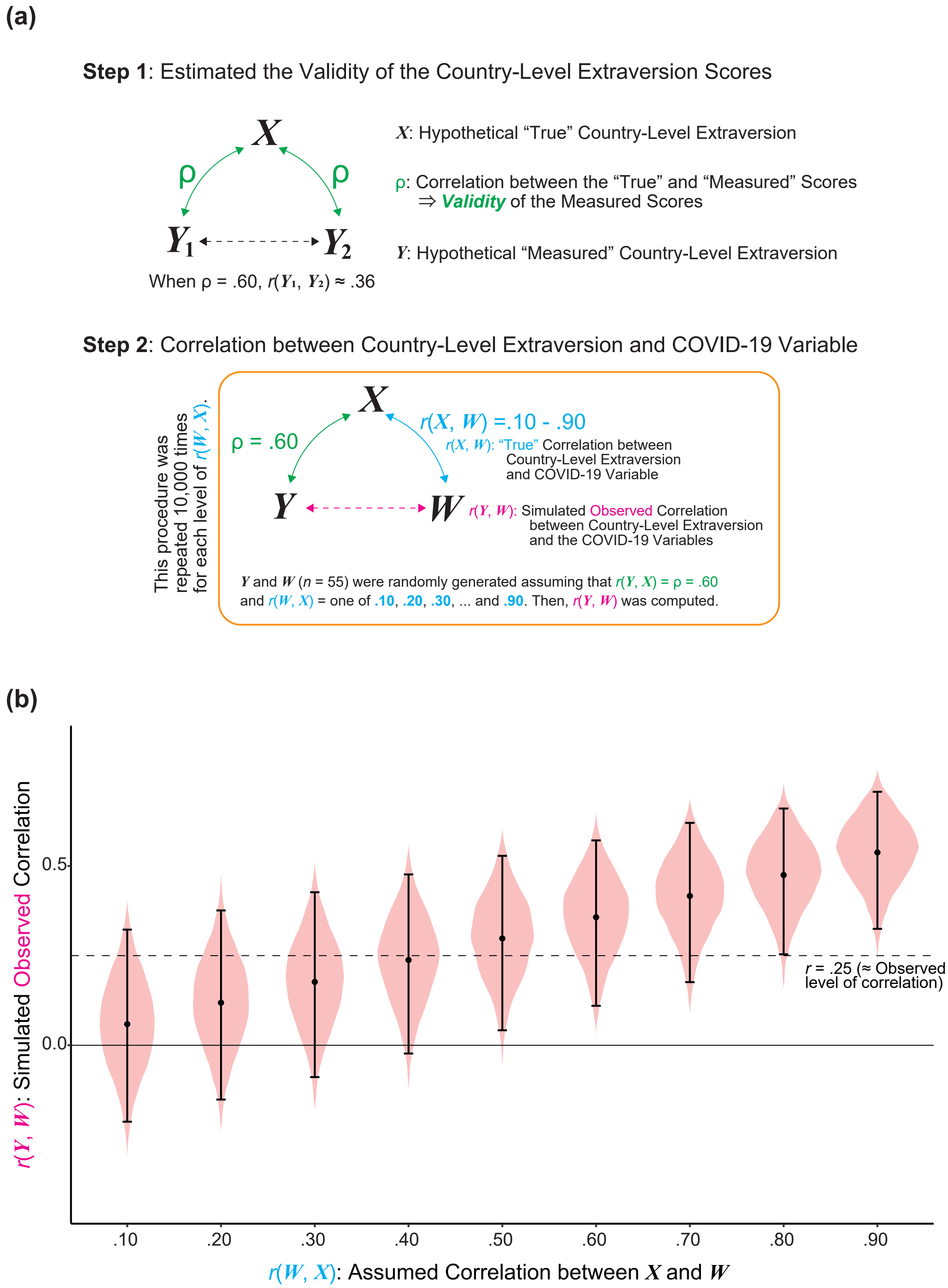
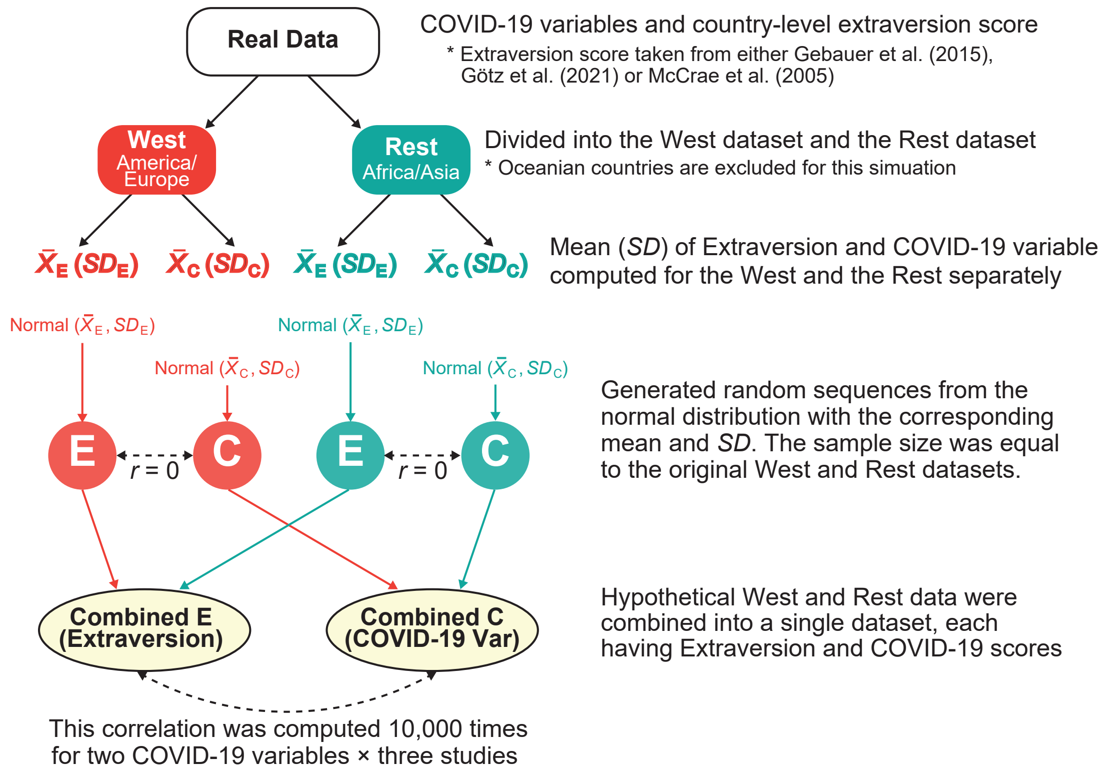


Figure 3. Numerical Simulation 1

Note. (a) Graphical outline of the procedure of Numerical Simulation 1. (b) Distributions (violin plots and means plus error bars covering the 95% of each distribution) of the simulated correlation coefficients between COVID-19 impact and "measured" country-level extraversion. The dashed line indicates $r(Y, W) = .25$, which is approximately equivalent to the observed average correlation between the country-level extraversion and COVID-19 variables.

(a)



(b)

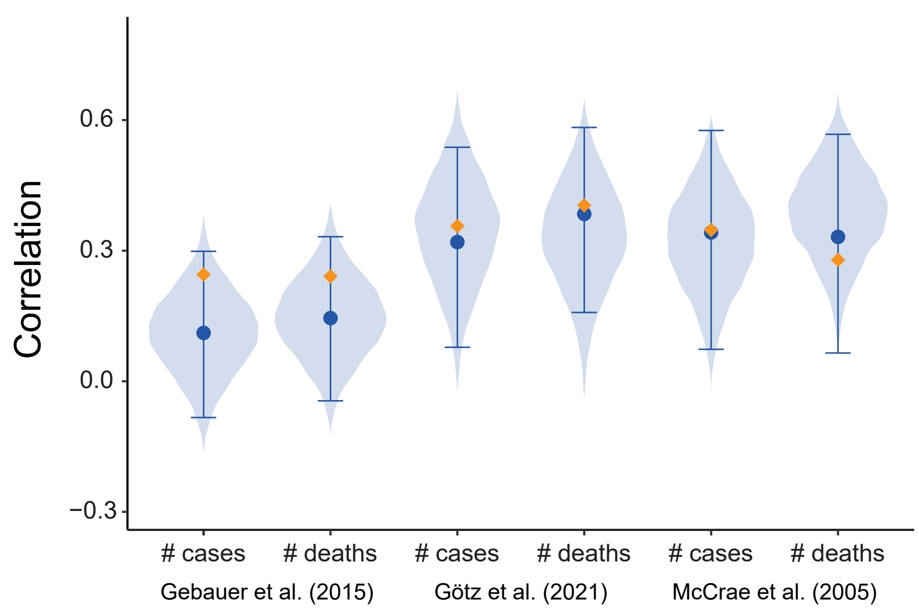


Figure 4. Numerical Simulation 2

Note. (a) Graphical outline of the procedure of Numerical Simulation 2. (b) Distributions (violin plots and means plus error bars covering the 95% of each distribution) of the 10,000 simulated correlation coefficients between COVID-19 cases/deaths and "measured" country-level extraversion. All scores were randomly generated from the normal distribution with the observed means and *SD*s of the American/European cluster and the African/Asian cluster separately, and then combined. The error bars cover the 95% of the simulated correlations. The orange diamonds indicate the observed correlation coefficients.

level data may be divided into two dominant clusters: the West and the Rest. Suppose that extraversion is not inherently related to the COVID-19 variables, but the Western extraversion and COVID-19 variables happen to have higher means than those variables in the rest of the world for unrelated reasons. This pattern would yield a positive correlation between the country-level extraversion and COVID-19 variables despite the absence of an inherent relationship between the two.

In order to examine the plausibility of this explanation, we ran another brief numerical simulation (see Figure 4a for an outline of the simulation, and the R Markdown HTML file in OSF). We divided the entire data into two groups: European/American countries (West) and African/Asian countries (Rest) using the United Nation's (1999) M49 standard. We calculated the means and *SD*s of three country-level extraversion scores (Gebauer et al., 2015; Götz et al., 2021; McCrae et al., 2005) and the COVID-19 variables for the West and the Rest separately (for these means and *SD*s, see Section 4 of Supplementary Materials). We then generated 10,000 sets of four random sequences (i.e., COVID-19 in the West, Extraversion in the West, COVID-19 in the Rest, and Extraversion in the Rest) from the normal distributions with the corresponding observed means and *SD*s. Although the two random sequences (i.e., COVID-19, Extraversion) within each cluster were not correlated with each other, the two random sequences tended to be positively correlated when the West and Rest random sequences were combined. The distributions of 10,000 correlations for the six sets (i.e., three studies × two COVID-19 variables) are depicted in Figure 4b. The 95% ranges of the hypothetical correlations are indicated by error bars and the observed correlations are indicated by the orange diamonds. In all six cases, the observed correlations were located within the error bars. In other words, the observed country-level correlations are not significantly different from the level of correlation expected from Hruschka and Hackman's (2014) explanation.

Conclusion

This study intended to test the hypothesis that country-level extraversion is correlated with the number of COVID-19 cases and deaths. Although we found apparent support for this hypothesis, it was rather problematic because of the low validity of the country-level extraversion scores. One possible explanation for this partial support was that the "true" country-level extraversion is so highly correlated with the COVID-19 variables that even less valid measures of extraversion would be correlated with the COVID-19 variables. The results of Numerical Simulation 1 suggest that the required correlation between the "true" extraversion and COVID-19 variables (i.e., approximately .40 to .50) is too high for this to be a realistic explanation. The second explanation is that the observed correlations are artefacts due to the statistical interdependence of the data points. The Western countries (i.e., European and American countries) as a group may differ from the rest of the world in various aspects for various reasons. Numerical Simulation 2 indicated that this explanation is sufficient to generate the observed level of correlation between country-level extraversion and COVID-19 cases/deaths.

One may be puzzled by the low validity of the extraversion scores. The Big Five scales, such as NEO-PI-R and BFI, are widely used in many studies and have yielded meaningful results. It is important to note that our finding does not negate the validity of such scales used at the individual level. Our finding instead casts serious doubt on the validity of the country-level extraversion scores (see Section 2 of Supplementary Materials and Heine et al., 2008, for relevant discussions).

In summary, we observed some positive correlations between country-level extraversion and the number of COVID-19 cases/deaths despite the low validity of the country-level extraversion scores. Two brief simulations suggest that the observed correlations may not be genuine but instead are more likely to be a statistical artefact due to combining non-independent sets of data. Thus, the empirical part of this study accompanied by two simulations demonstrated that the non-independence of country-level psychological variables is serious enough to yield significant correlations between inherently unrelated two country-level measures. This conclusion calls for critical re-examinations of previously reported correlations between country-level psychological/behavioral traits and pathogen prevalence.

Supplementary Material

Electronic supplementary materials are available online.

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