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What Explains Personality Covariation? A Test of the Socioecological Complexity Hypothesis

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Abstract

Correlations among distinct behaviors are foundational to personality science, but the field remains far from a consensus regarding the causes of such covariation. We advance a novel explanation for personality covariation, which views trait covariance as being shaped within a particular socioecology. We hypothesize that the degree of personality covariation observed within a society will be inversely related to the society's socioecological complexity, that is, its diversity of social and occupational niches. Using personality survey data from participant samples in 55 nations ($N = 17{,}637$), we demonstrate that the Big Five dimensions are more strongly intercorrelated in less complex societies, where the complexity is indexed by nation-level measures of economic development, urbanization, and sectoral diversity. This inverse relationship is robust to control variables accounting for a number of methodological and response biases. Our findings support the socioecological complexity hypothesis and more generally bolster functionalist accounts of trait covariation.

Keywords

behavioral syndromes, Big Five Inventory (BFI), General Factor of Personality (GFP), socioecological complexity, trait covariation

One of the personality psychology's primary achievements has been the factor analytic derivation of models of personality trait structure, which distill intercorrelated behavioral descriptors down to broader dimensions (Digman, 1997; John, Naumann, & Soto, 2008; Lee & Ashton, 2004; McCrae & Costa, 2008). Despite the centrality of intercorrelated behaviors to personality science, there is no consensus regarding the causes of such covariation (Cramer et al., 2012; Wood, Gardner, & Harms, 2015). Amid this ambiguity, we highlight a central question: What determines the extent to which distinct aspects of personality covary within individuals and manifest as a certain number of independent personality dimensions at the population level?

A popular explanation for trait covariation is that distinct behaviors are correlated because they are caused by the same latent psychological variable (Boorsboom et al., 2003; Cattell, 1950). For example, if sociable and assertive behaviors are correlated, this would be explained by the fact that both classes of behavior are caused by a latent variable called "extroversion," which is one of the "Big Five" personality traits (McCrae & Costa, 2008). Likewise, correlations among the Big Five dimensions form the basis for either one (Musek, 2007) or two (Digman, 1997) highest-order personality dimensions, which ostensibly arise from corresponding latent variables that regulate nearly every aspect of human behavior. However, this latent variable approach has been criticized for its circularity; specifically, that latent variables are first inferred from, and then invoked to explain, patterns of behavioral covariation (Ashton, Lee, Goldberg, & De Vries, 2009; Borsboom, Mellenbergh, & van Heerden, 2003; Cramer et al., 2012; Wood et al., 2015).

Recently, functionalist theories have been proposed to explain the causes of personality covariation in humans (Cramer et al., 2012; Figueredo et al., 2011; Gurven, von Rueden, Massenkoff, Kaplan, & Lero Vie, 2013; Lukaszewski, 2013; Nettle, 2011; Wood et al., 2015) and nonhumans (Laskowski, Montiglio, & Pruitt, 2016; Sih et al., 2015; Wolf & Krause, 2014). These evolutionary perspectives share several key

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features. First, they posit that manifest behaviors will be intercorrelated if they are influenced by the same functional motivations; for example, status pursuit, resource accrual, self-protection, or parental investment. Second, they acknowledge that behaviors may be elicited in different ways as a function of socioecological contingencies in the attainment of functional objectives. For example, imagine that, in Society A, obtaining high status usually requires both social networking and organizational skill. Given this incentive structure, variation across individuals in status motivation would be expected to produce a positive correlation between extroverted and conscientious behaviors. Within Society B, on the other hand, high status can be obtained through investment in social networking *or* organizational skill *or* other specializations—in which case elevated status motivation would elicit extroverted or conscientious behaviors (or neither) selectively across individuals, leaving these dimensions more weakly correlated.

These considerations imply that patterns of personality covariation may vary across populations encountering different socioecological conditions. Consistent with this view, accumulating evidence suggests that the degree and structure of trait covariation differ across societies (Gurven et al., 2013; Saucier et al., 2014). Particularly, striking is recent evidence that "distinct" traits tend to covary more strongly in small-scale subsistence societies than in postindustrial societies (Bailey et al., 2013; Gurven et al., 2013).

This article advances a novel hypothesis regarding the origins of cross-cultural differences in personality covariation: that distinct aspects of personality will be more weakly intercorrelated within more complex societies containing a larger number of diverse specialized social and occupational niches.

The Socioecological Complexity Hypothesis

Humans are zoologically unusual in the extent to which we are adapted for large-scale collective action (Kaplan, Hooper, & Gurven, 2009; Powers, van Schaik, & Lehmann, 2016). Cooperation in stable groups not only unlocks potential benefits that could not otherwise be produced but also permits group members to benefit from the efficiencies of labor divisions with individuals enhancing productivity by specializing in particular social or occupational niches (Jaeggi, Hooper, Beheim, Kaplan, & Gurven, 2016; Mises, 1949; Tooby, Cosmides, & Price, 2006). In small-scale societies, such as those in which humans evolved, niche specialization occurs within kin-based "households" where men, women, and children focus on complementary tasks such as gathering, hunting, childcare, toolmaking, and cooking (Gurven, Winking, Kaplan, von Rueden, & McAllister, 2009; Stieglitz, Gurven, Kaplan, & Hooper, 2013). At the community level, there is less specialization though certain individuals may take a larger role in leadership, group defense, conflict arbitration, healing, or food production (Kelly, 1995; Sugiyama & Scalise-Sugiyama, 2003; von Rueden, Gurven, Kaplan, & Stieglitz, 2014). Through specialization, individuals can exchange services, resulting in net cooperative benefits (Jaeggi et al., 2016).

Although niche specialization is pronounced within small-scale human societies relative to other primates, it is limited relative to that observed in postindustrial societies. Indeed, the story of modern history is characterized by increasing *socioecological complexity*—that is, niche specialization within large-scale cooperative groups and institutions. This process was spurred by the neolithic agricultural revolution, which enabled larger, denser, more stratified, and sedentary populations (Powers & Lehmann, 2014). Technological and occupational diversity expanded with these demographic changes (Bonner, 2004; Carneiro, 1967; Kaplan et al., 2009). For example, among Indigenous North Americans, the number of leadership functions (e.g., military, religious, judicial, productive) increased with a society's maximal community size (Feinman & Neitzel, 1984). Socioecological complexity accelerated further with the industrial and technological revolutions and the expansion of markets in a monetized economy (Ridley, 2010). Whereas our foraging ancestors had to be "jacks of all trades" (Kelly, 1995; Sugiyama & Scalise-Sugiyama, 2003), residents of postindustrial societies specialize in highly particular roles and rely upon specialists from other households and communities to provide complementary goods and services. Urbanization further concentrates large numbers of individuals in competitive labor, mating, and social markets (Henrich et al., 2005), which increases the local density of distinct niches and thereby the incentive to specialize in novel ways (Jeanson, Fewell, Gorelick, & Bertram, 2007; Mises, 1949). Larger populations with specialization often benefit from greater economic efficiency through "economies of scale," whereby high volume reduces production costs, and through "economies of scope," whereby payoffs increase from the diversification of goods and services (Panzar & Willig, 1981).

We propose that the degree of personality covariation observed within a society will be inversely related to its socioecological complexity. Our logic relies on the premise that the number of niches available within a society correlates positively with the specificity of those niches, and therefore, the extent to which phenotypic specialization is an optimal strategy for pursuing one's interests. If so, it follows that the number of personality profiles that manifest within a society will correspond with the diversity and specificity of available niches.

Citizens of complex societies can pursue their interests through a broad array of specialized niches—such that an individual can produce resources, seek status, and care for offspring in various ways that are compatible with a diverse set of personality profiles. For example, there may be specialized roles whose fulfillment is optimally facilitated by a combination of low extroversion, low agreeableness, and high conscientiousness (e.g., an insurance claims adjuster), and others that are most effectively fulfilled by individuals with high extroversion, agreeableness and openness, and any level of conscientiousness (e.g., a nightclub promoter). As individuals become specialized for these (and many other) niches within complex societies, the ontogenetic feedback loops between trait-exemplifying behaviors and successful role fulfillment (Sih et al., 2015; Wolf & Krause, 2014; Wood et al., 2015) should lead to the development of a correspondingly diverse set of personality profiles.

Within less complex societies, individuals tend to face more similar socioecological contingencies presenting fewer alternatives for how to specialize. In small-scale societies, people tend to live in small groups of related and other familiar individuals with reduced choice in social partners. Individuals of the same age and sex tend to engage in similar forms of subsistence work and social exchange (Gurven et al., 2009). Achieving success within the fewer available niches may be facilitated by relatively few *combinations* of behavioral attributes (Figueredo et al., 2011; Gurven et al., 2013; von Rueden et al., 2014). For example, due to the egalitarian ethic and consensual decision-making of many small-scale societies, extroversion without agreeableness and conscientiousness can be costly when community members gather. Thus, within low-complexity societies, the feedback loops between behaviors and successful role fulfillment may tend to produce positive correlations between multiple aspects of personality (Gurven et al., 2013).

We evaluate this hypothesis by testing one of its main predictions: that distinct aspects of personality will be more strongly intercorrelated within less complex societies. To this end, we analyze the average interfactor correlations among the Big Five personality traits across 55 nations of varying socioecological complexity. Because correlations across survey items may also vary due to properties of subject samples that are not relevant to our hypothesis, we include multiple pertinent controls in our cross-national analysis. Although we were agnostic regarding which interfactor correlations would associate most strongly with cross-national variation in socioecological complexity, we also conducted exploratory analyses to reveal these specific patterns for future theoretical development.

Method

Participants

Participants were 17,637 men (N = 7,347) and women (N = 10,290) from 55 nations. They participated in a standardized data collection as part of the International Sexuality Description Project (ISDP; Schmitt et al., 2007). The ISDP contains participant samples from countries in all major world regions including North and South America; Northern, Southern, and Eastern Europe; the Middle East; Africa; South, Southeast, and East Asia; and Australia/Oceania. Online Supplemental Material (S2) report nation-level demographic and other summary information for these ISDP samples.

Measures

Personality covariation (the Big Five). Personality was assessed by the Big Five Inventory (BFI; Benet-Martinez & John, 1998), a 44-item, self-report instrument that measures each of the Big Five dimensions: agreeableness (A), conscientiousness (C), emotional stability (ES), extroversion (E), and openness to experience (O; John et al., 2008). Across nations, the BFI was administered in 29 different languages; 45 of the 55 participant samples completed the surveys in their primary native language, whereas 10 bilingual samples completed surveys in a secondary language. Scores for each of the BFI scales were computed by Schmitt et al. (2007), and these scores were employed in the current analyses. Each nation's degree of personality covariation was computed as the mean pair-wise correlation among the BFI scales, in the metric of r^2. We first squared each of the 10 individual pair-wise correlations before taking an average of the r^2 values for each nation.

Consistent with prior research on higher order factors of personality (McCrae et al., 2008; van der Linden, Nijenhuis, & Bakker, 2010), correlations among the BFI scales were overwhelmingly positive. Of 550 interfactor correlations (10 Interfactor Correlations $\times$ 55 Nations), none were statistically significant negative associations.

Socioecological complexity. There is no single metric that fully captures the notion of socioecological complexity at the nation level. However, we can estimate each focal nation's complexity by employing three indirect measures that should each be positively associated with socioecological complexity. Two measures supplied by the United Nations (UN; hdr.undp.org/en) include the Human Development Index (HDI) and the level of urbanization. For all focal nations, we took these indices from the year 2000, when the ISDP personality data were collected. In addition, we employed a nation-level measure of sectoral diversity provided by Harvard University's Atlas of Economic Complexity (atlas.cid.harvard.edu).

HDI is computed based on three indicators from each nation: average levels of education, gross domestic product, and life expectancy (UN, hdr.undp.org/en). These indicators have been found to serve as reliable proxies for the extent to which a nation's people (i) have access to social, political, and economic institutions that incentivize the acquisition of niche-specialized skills; (ii) possess specialized and economically productive capacities (Stewart, 2013); and (iii) benefit from economies of scale and scope.

Urbanization was also estimated for each nation based on UN statistics (UN, hdr.undp.org/en). This measure is computed as the percentage of a nation's population that lives in an urban (vs. rural) setting. Urban centers are hubs of socioeconomic complexity, with many specialists clustered in close proximity to efficiently exchange services (Mises, 1949). More rural areas, on the other hand, have lower population densities and fewer distinct social and occupational niches.

Sectoral diversity reflects how many different types of products a nation is able to produce. It is computed based on a nation's volume of exports by Harvard University's Atlas of Economic Complexity (atlas.cid.harvard.edu). This export-based index is widely used in macroeconomics as a proxy for sectoral diversity (Hausmann & Hidalgo, 2014). Sectoral diversity scores were only available for 49 of the 55 focal nations in the current study, so we used regression to impute the six missing values based on HDI and urbanization scores.

In order to combine these nation-level indicators, we created a composite *socioecological complexity index* for each nation by conducting a principal components analysis wherein HDI, urbanization, and sectoral diversity were forced to load onto a single factor (which explained 82% of the total variance). Loadings onto this factor were .93 (HDI), .89 (sectoral diversity), and .86 (urbanization). Standardized factor scores weighted by these loadings were computed according to the regression method.

Control variables. The following seven control variables were selected to test alternative explanations for the predicted patterns:

Sample size was included in order to control for possible variation across samples in the reliability of the mean interfactor correlations, which should be lower in smaller samples. Sample size was positively skewed, so we applied a logarithmic transformation to this variable that reduced its skewness from 5.22 to 1.28. This log-transformed sample size variable (log *N*) was employed for all analyses.

Literacy was controlled to test the hypothesis that trait covariation would be greater among less literate samples due to imprecise understanding of items. We operationalized literacy in two ways. First, we employed each nation's literacy rate as reported by the UN (hdr.undp.org/en). Second, we coded whether each subject sample completed the BFI in their native (vs. secondary) language.

Negative item bias is the tendency to agree with affirmatively worded items for a given construct more than negatively worded items, which could generate artifactual correlations across different scales. To control for this, we took values from Schmitt and Allik (2005), who computed negative item bias for the samples based on their scores on the Rosenberg Self-Esteem Scale (Rosenberg, 1965).

Acquiescence bias refers to the tendency to agree with items regardless of content (i.e., to agree with positively and negatively scored items for the same construct). Acquiescence bias scores were taken from Schmitt et al.'s (2007) analysis of the current BFI data.

Evaluative bias is the tendency of people to rate themselves as having socially desirable characteristics. The first evaluative bias indicator is each nation's mean score on the BFI Agreeableness scale, which is the most unambiguously socially desirable of the Big Five dimensions. The second indicator is each nation's mean score on the Rosenberg Self-Esteem Scale (Rosenberg, 1965), which was taken for the current sample from Schmitt and Allik (2005).

Statistical Analyses

Measurement invariance tests (BFI). Because the mean correlation among the Big Five factors was employed as the primary measure of personality covariation, it was relevant to test whether the BFI items exhibited MI, that is, whether the BFI items assessed the latent variables posited by the five-factor model similarly across nations. Testing for MI using multigroup confirmatory factor analysis (CFA) is an iterative process wherein one first attempts to establish the weakest form of MI, configural invariance, before proceeding to test progressively more stringent forms of MI (Milfont & Fischer, 2010; Steencamp & Baumgartner, 1998). Within this process, one only proceeds to the next (more stringent) MI test if the prior (less stringent) MI test was affirmative. For the initial tests of configural invariance, we employed EQS (v6.2) to run CFAs examining the absolute fit of multigroup models for each BFI factor scale (where good absolute fit would indicate configural invariance). In these tests, a given BFI scale's items loaded onto the corresponding latent factor (e.g., conscientiousness), and all parameters (item loadings, variances, etc.) were permitted to vary freely across the 55 national samples. As reported below (and explained in more detail in Online Supplemental Material [S1]), none of the BFI scales exhibited configural invariance, which precluded the possibility that they would exhibit other forms of MI.

Hypothesis testing. To test the focal predictions arising from the socioecological complexity hypothesis, we examined zero-order correlations among all measured variables using Pearson's *r*. We also employ Spearman's ρ to guard against the possibility that observed cross-national correlations might be driven by a few outlying nations.

We next employed generalized estimating equations (GEEs) to determine whether the association of socioecological complexity with trait covariation remained when including control variables. GEE extends the generalized linear model to situations where observations are correlated (Agresti, 2013). Our cross-national sample contained data from countries spread across six continents. Countries within the same continent may share historical, cultural, or geographical similarity that can produce autocorrelation in the data, so our GEE models treat continent as a random component (nations nested within continents); this increases the validity of standard error estimation. We specified an exchangeable correlation structure that assumes similar covariance among countries from the same continent (Agresti, 2013). An unstructured correlation structure was rejected because it produced substantially worse model fit based on quasi-likelihood information criterion (QIC), a modified form of the Akaike information criterion that is appropriate for GEE (Pan, 2001).

Our systematic modeling procedure is as follows: In Models 1–8, socioecological complexity, as well as each individual control variable, was entered as univariate predictors of personality covariation in sequence. In Models 9–15, socioecological complexity was entered as a simultaneous predictor along with each individual control variable in sequence. Model 16 includes socioecological complexity along with all control variables as simultaneous predictors. Model 17 includes socioecological complexity, and all covariates that were significant

Table 1. Descriptive Statistics for All Measured Variables.

Measure	# Nations	*M*	*SD*	Range
Sample size (log *N*)	55	2.39	0.27	1.79 to 3.45
National literacy (percentage literate)	55	92.35%	12.39	39 to 100%
Big Five Inventory language (secondary vs. native)	55	0.81	0.39	0 (n = 10) or 1 (n = 45)
Negative item bias	55	1.74	0.75	0 to 3.4
Acquiescence bias	55	46.5	3.58	37.8 to 52.9
Agreeableness	55	47.5	2.73	42.2 to 53.7
Rosenberg self-esteem	55	30.5	1.51	25.5 to 33.6
Human Development Index	55	0.72	0.14	0.28 to 0.90
Urbanization (percent urban)	55	69.40%	18.60	17.5 to 100%
Sectoral diversity	49	0.54	0.87	−1.15 to 2.12
Socioecological complexity index	55	0	1.00	−3.14 to 1.36
Mean interfactor correlation (r^2)	55	.05	.03	.01 to .21

Table 2. Cross-National Correlations Among All Measured Variables.

Measures	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1. Sample size (log *N*)	—	−.31**	.00	−.01	.18	.21	.11	.37**	.29*	.36**	.38**	−.40**
2. Negative item bias	−.30*	—	.14	.21	−.22	−.35**	−.07	−.54**	−.38**	−.56**	−.54**	.45**
3. Acquiescence bias	.02	.14	—	.10	.29*	−.06	.08	.19	.06	−.35**	−.22	−.11
4. Agreeableness	−.09	.19	.07	—	.32*	−.31*	−.23	−.30*	−.30*	.31*	−.33*	.34*
5. Rosenberg self-esteem	.19	−.35**	.20	.29*	—	.22	.27*	.15	.12	.00	.10	−.14
6. Literacy	.21	−.45**	−.31*	−.29*	.09	—	.55**	.85**	.63**	.66**	.79**	−.34*
7. BFI language	.08	−.16	.07	−.25	.31*	.50**	—	.47**	.26	.35**	.40**	−.14
8. HDI	.46**	−.61**	−.28*	−.23	.15	.75**	.34*	—	.76**	.84**	.96**	−.51**
9. Urbanization	.40**	−.42**	−.04	−.27*	.15	.27*	.14	.64**	—	.57**	.86**	−.52**
10. Sectoral diversity	.33*	−.55**	−.42**	−.26	.08	.71**	.32*	.85**	.49**	—	.89**	−.41**
11. Socioecological complexity	.44**	−.58**	−.27*	−.28*	.11	.61**	.26	.92**	.82**	.87**	—	−.53**
12. Interfactor correlation (r^2)	−.47**	.54**	−.02	.32*	−.19	−.27*	−.01	−.49**	−.53**	−.35**	−.49**	—

Note. Correlations are presented in the metric of Pearson's r above the diagonal and Spearman's ρ beneath the diagonal. BFI = Big Five Inventory; HDI = Human Development Index.
*$p < .05$. **$p < .01$.

predictors in Models 1–8. The final two models exclude socioecological complexity but include all control variables simultaneously (Model 18) or all control variables that were significant univariate predictors in Models 1–8 (Model 19). Complete results from all 19 GEE models are presented in Online Supplemental Material (S3). To assess comparative fit across all models, we ranked models according to Akaike weights, which were calculated based on corrected QIC (Pan, 2001). Larger weights indicate better comparative model fit.

Results

Descriptives

Nation-level descriptive statistics for all variables are presented in Table 1. ISDP samples were drawn from a diverse set of nations, whose socioecological complexity ranged from very low (e.g., Bangladesh, Ethiopia) to very high (e.g., Belgium, Japan). There was also substantial variation across nations in personality covariation, with mean interfactor r^2 values ranging from .01 to .21 (mean r values ranged from +0.10 to +0.46).

MI Tests (BFI)

To test for configural invariance (the weakest form of MI) of the BFI scales across nations, we evaluated the fit of multigroup CFAs (one for each BFI factor) across the 55 samples. These models fit very poorly for all five scales (all CFI $\leq$ .25, all RMSEA $\geq$ .21; see Online Supplemental Materials [S1]). The poor absolute fit of these multigroup CFAs is inconsistent with configural invariance of the BFI, which means that the items for each BFI scale exhibit a different latent covariance structure across nations (see Online Supplemental Materials [S1] for a more detailed presentation of these tests). The lack of configural invariance precluded further tests for more stringent forms of MI.

This result suggests the need for caution when comparing the BFI scales across nations. As explained further below (see Discussion section), however, the BFI's lack of MI would be much more problematic if our goal was to test predictions regarding cross-national variation in configurations or levels of specific personality dimensions. Here, the mean correlation among the BFI scales is being used primarily as a measure of overall levels of personality covariation within each

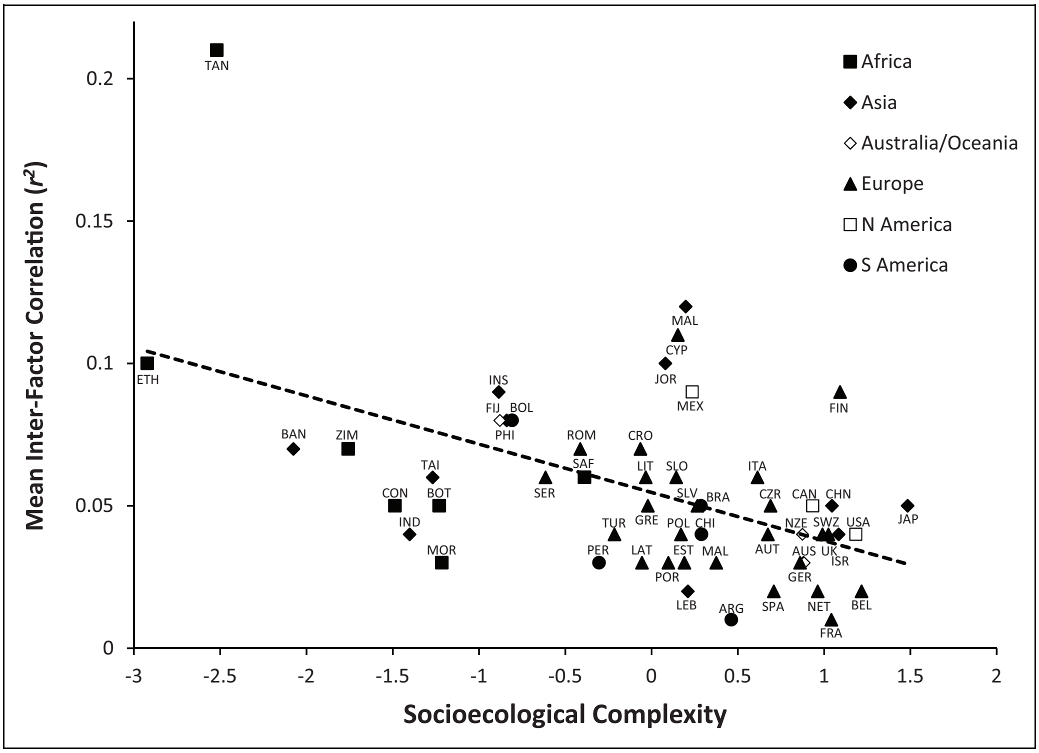

Figure 1. Scatterplot depicting the cross-national association between personality covariation (mean interfactor correlations among the Big Five dimensions) and the socioecological complexity index. The key for three-letter nation codes can be found in Online Supplemental Material (S2).

nation—which would be expected to manifest in greater correlations among a large set of possible personality items or groupings (parcels) thereof. We therefore moved forward with focused analyses, wherein the mean interfactor correlation was employed as a rough proxy for overall personality covariation.

Predictors of Personality Covariation

Zero-order correlations supported our predictions derived from the socioecological complexity hypothesis (Table 2). HDI, urbanization, and sectoral diversity all exhibited robust negative cross-national correlations with personality covariation. The cross-national correlation between the socioecological complexity index and personality covariation was −.53 in the metric of Pearson's r and −.49 in the metric of Spearman's ρ (Figure 1).

However, many of the control variables were also correlated with the focal variables (Table 2). The socioecological complexity index and personality covariation were both correlated with sample size, negative item bias, mean agreeableness, national literacy, and BFI language. Thus, a stronger test of the socioecological complexity hypothesis is to determine whether the association between these focal variables remains when controlling for these other factors.

The GEE models supported the conclusion that socioecological complexity is the strongest unique predictor of personality covariation. Across all 19 models evaluated, socioecological complexity always exhibited a much larger effect size than any of the predictors it competed with to explain variance (Online Supplemental Material [S3]), ranging from −0.376 (Model 17) to −0.692 (Model 10). Nonetheless, it was of interest to determine which combination(s) of predictor variables best accounted for differences in personality covariation across nations. Table 3 presents Models 1–8 (the single-predictor models) as well as the best fitting model. The best fitting model (Akaike weight = .18) included only socioecological complexity and acquiescence bias as predictors, with the former exhibiting a much larger effect size (Table 3; see also Online Supplemental Material [S3]). The second-ranked model (Akaike weight = .16) included only socioecological complexity and sample size as predictors, with the former again exhibiting a much larger effect size (see Online Supplemental Material [S3]). The third-ranked model (Akaike weight = .12) was Model 1, in which socioecological complexity was the only predictor (Table 3; Online Supplemental Material [S3]).

Because the predictors in these models tended to correlate, it was important to address collinearity concerns. To this end, in each GEE model, we evaluated the parameter correlation of each covariate with that for socioecological complexity. As can be seen in Online Supplemental Material (S3), there were several models wherein parameter correlations approached or surpassed .90. Fortunately, given that model fit can be high even with collinear predictors, none of the three top-ranking (i.e., best fitting) models had parameter correlation values that warranted collinearity concerns.

Table 3. Selected GEE Models Predicting Personality Covariation Across Nations.

Model #		Standardized Coefficient	Standard Error	Wald 95% CI	Wald χ^2	Akaike Weight (Model Fit)
Single-predictor models						
1	Socioecological complexity	−.54	.02	[−.59, −.50]	523.87***	.12
2	Native language	−.11	.02	[−.53, .32]	0.25	<.001
3	National literacy	−.40	.03	[−.46, −.34]	180.95***	<.001
4	Sample size (log *N*)	−.41	.10	[−.61, −.21]	16.15***	<.001
5	Negative item bias	.48	.08	[.33, .64]	36.56***	.01
6	Acquiescence bias	−.13	.14	[−.42, .16]	0.767	<.001
7	Self-esteem	−.11	.10	[−.32, .08]	1.38	<.001
8	Agreeableness	.34	.06	[.21, .46]	26.78***	<.001
Best fitting model						
15	Socioecological complexity	−.60	.01	[−.63, −.57]	1,829.59***	.18
	Acquiescence bias	−.23	.06	[−.33, −.12]	16.78***	

Note. This table presents only a subset of all 19 models evaluated (Models # 1–8 and 15). Akaike weights are based on a comparison of all 19 models, which are presented in Online Supplemental Material (S3) along with additional model statistics. As described in text, generalized estimating equation (GEE) models were computed using an exchangeable working correlation matrix.
***p < .001.

Table 4. Associations of Specific Interfactor Big Five Inventory Correlations With Socioecological Complexity.

Interfactor Correlation	Association With Socioecological Complexity: Zero Order (*r*)	Association With Socioecological Complexity: Acquiescence Bias Controlled (GEEs)
C/A	−.54***	−.55***
C/O	−.52***	−.60***
C/ES	−.41**	−.46***
ES/O	−.40**	−.36***
A/O	−.34*	−.35***
E/O	−.23	−.24**
A/ES	−.22	−.31**
E/C	−.20	−.16
E/A	−.14	−.20
E/ES	−.04	−.08

Note. As described in text, GEEs controlled for acquiescence bias and treated continent as a random factor (see Online Supplemental Material [S4] for complete model statistics). A = agreeableness; C = conscientiousness; E = extroversion; ES = emotional stability; O = openness; GEE = generalized estimating equation.
*p < .05. **p < .01. *** p < .001.

Exploratory Analyses Predicting Specific BFI Interfactor Correlations

Table 4 presents the results of analyses examining which specific patterns of interfactor correlations drove the association of socioecological complexity with trait covariation. At the zero-order level, complexity was significantly negatively associated with (positive) interfactor correlations between C/A, C/O, C/ES, ES/O, and A/O (Table 4).

As described above, the best fitting GEE model predicting mean trait covariation controlled for acquiescence bias. We therefore computed parallel GEE models predicting each specific interfactor correlation (Table 4; see Online Supplemental Material [S4] for complete model statistics). These models upheld, and strengthened, the associations evident in the zero-order correlations (Table 4).

Discussion

Our findings suggest that distinct aspects of human personality covary to a greater degree in nations with lower socioecological complexity as indexed by broad measures of human socioeconomic development, urbanization, and sectoral diversity. Specifically, the Big Five dimensions tended to be positively intercorrelated, and these correlations were larger on average in less complex societies. These associations were not due to geographic autocorrelation and survived multiple controls for literacy indicators, sample size, and psychometric biases—which helps argue against several plausible alternative explanations for the findings.

Although the present study confirmed the existence of cross-national correlations predicted by the socioecological complexity hypothesis, it contained several limitations. While the association of complexity with trait covariation withstood various controls, some caution is warranted in the interpretation of these effect size estimates. Quantitative simulations suggest that controlling for confounding variables is problematic when measures for covariates are unreliable or vary in reliability (Westfall & Yarkoni, 2016). It will be important for future research to bolster the internal validity of the observed correlations and to test any alternative explanations that are put forth.

Another issue pertains to the finding that none of the BFI scales were measurement invariant across nations—a result of basic importance for personality science. Prior research has found evidence to support the BFI's MI in other large, cross-national studies. For example, in data sets with responses from large subject samples in over 60 nations (Bleidorn et al., 2013; Gebauer et al., 2014), the BFI has shown evidence not only of configural invariance but also more stringent forms of MI. Possible explanations for this discrepancy include the ISDP sample's (i) greater variation in sample size across nations, (ii) inclusion of a larger number of low-complexity (especially African) nations, and (iii) much larger number of language translations (the ISDP administered the BFI in >25 different languages, whereas Bleidorn et al. and Gebauer et al. administered the BFI in four languages). Testing these (and other) possibilities will require detailed analyses that reveal which individual ISDP samples (or BFI translations) show good (vs. poor) fit. Regardless of why the BFI scales failed to exhibit MI, this finding raises the possibility that the cross-national associations we report could be influenced by method artifacts. Thus, the findings from this initial study should be interpreted cautiously.

That being stated, the BFI's lack of MI may be somewhat less problematic for the validity of the current findings than for the types of cross-cultural comparisons that are made more typically in personality research. In our primary analysis, the mean correlation among the BFI scales was not being used to evaluate specific claims about levels or configurations of particular personality constructs at the nation level; rather, we employed this measure as a rough proxy for overall levels of personality covariation within each national sample. If, as we propose, distinct behavioral attributes are generally more intercorrelated within some nations than others, this would be expected to show up in correlations of scales composed of a large set of possible personality items. In this sense, the BFI scales could be viewed minimally as "parcels" of items employed to assess overall trait covariation across nations. Of course, this does not eliminate the aforementioned concerns regarding the BFI's measurement variance. We controlled for several indicators of methodological response bias, but it remains possible that our focal measure of personality covariation reflects method artifacts rather than, or in addition to, valid patterns of phenotypic variation.

The measurement variance of the BFI scales suggests that we should be especially circumspect when interpreting the observed associations of specific interfactor correlations with socioecological complexity. Even so, these analyses might facilitate future theory development by shedding light on which behavioral descriptors tend to cluster together more strongly as complexity decreases. The factor combinations whose associations diminished most strongly with greater complexity were more likely to involve openness (four of the four: O/C, O/A, O/ES, O/E) and conscientiousness (three of the four: C/E, C/A and C/ES) than emotional stability (two of the four: ES/C, ES/O), agreeableness (two of the four: A/C, A/O), or extroversion (one of the four: E/O). These findings might help illuminate why specific factors like openness sometimes fail to extract in emic studies (De Raad, 1994). The fact that extroversion's association with other factors did not covary strongly with complexity was not predicted but is potentially consistent with the idea that this dimension reflects variation in status motivation (Ashton, Lee, & Paunonen, 2002). The pursuit of status is a universal human motive (Anderson, Hildreth, & Howland, 2015), but occupancy of prestigious niches may be facilitated by different combinations of behavioral attributes that correspond to variable local imperatives of collective benefit generation (von Rueden, Gurven, & Kaplan, 2008). If so, perhaps some aspects of extroversion universally track status motivation along with variable combinations of personality indicators (von Rueden, Lukaszewski, & Gurven, 2015).

Our findings suggest the need for additional research on personality structure and measurement within populations across the full spectrum of human socioecological variation. The samples from the current study included more variation than typically exists in human personality research, but those from low-complexity nations were largely undergraduates who are not representative. Although we believe this sample uniformity likely worked *against* finding support for predictions, future research should replicate the findings with more representative samples.

In particular, none of our samples were from small-scale subsistence societies who would otherwise have scored the lowest in socioecological complexity. The only study using the BFI to measure personality in a small-scale society (Tsimane' hunter-horticulturalists of Bolivia; Gurven et al., 2013) conforms to the trend evident in our cross-national data. Within this subsistence-level society, which has lower complexity than any population in the present sample, the BFI scales shared 29% of their variance on average (which is 38% higher than the largest r^2 value in the current study). This bodes well for the generalizability of the socioecological complexity hypothesis but highlights the need for research that (i) includes subjects whose socioecology differs fundamentally from that of postindustrial citizens and (ii) develops techniques for valid cross-cultural personality measurements.

In conclusion, we report striking cross-cultural patterns that any complete theory of personality covariation must be able to explain. Whereas recent debates have addressed whether positive correlations among the Big Five dimensions reflect phenotypic reality or evaluative bias, our perspective holds that a better question may be: Under what circumstances will distinct aspects of personality be intercorrelated (or not) to varying degrees? The present findings suggest that the socioecological complexity hypothesis provides part of the answer to this foundational question.

Authors' Note

A.W.L. and M.G. share the first authorship.

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