The Big Five Across Socioeconomic Status:
Measurement Invariance, Relationships, and Age Trends

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Abstract

Associations between socioeconomic status (SES) and personality, traits and developmental trajectories, have important implications for theory and application. Progress in understanding these associations depends on evaluating how well personality measures function in socioeconomically diverse samples. In the present study, we will use the confirmatory dataset from AIID, a large online study, to address three basic questions about personality and SES. First, we will evaluate the measurement invariance of a common measure of personality, the Big Five Inventory, across indicators of education, income, and occupational prestige. Second, we will estimate previously reported associations between SES indicators and personality in new data to see if they align with past evidence. Third, we will test whether mean-level age trends in personality generalize across levels of SES. The results will have important implications for the validity of past and future research on associations between personality and SES. Additionally, the results will provide insight into differences in personality development trajectories that can inform future work investigating the causal mechanisms between personality and SES.

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A growing body of evidence has observed a relationship between personality traits and socioeconomic status (SES). For example, conscientiousness positively predicts SES over and above intelligence (Heckman & Kautz, 2012) and neuroticism is negatively associated with income (Kajonius & Carlander, 2017). Moreover, these relationships are linked to important outcomes; for example, personality can explain ~20% of the increased all-mortality risk associated with being lower in SES (Chapman, Fiscella, Kawachi, & Duberstein, 2009). Documenting these kinds of associations is an important precursor to developing theories about transactional pathways between personality and social contexts, including how social roles and experiences might shape personality development and vice versa.

Before proceeding with such theoretical work, however, it is important to address basic methodological and descriptive empirical questions about personality and SES. Personality measures are often developed in samples of college students, but in order to study the associations between personality and SES, the measures have to function equivalently in more socioeconomically diverse samples. Few studies report analyses of measurement invariance before presenting substantive associations. Thus, efforts to explain associations between SES and personality may be misguided if those associations are not replicable and generalizable.

In this research we address three important questions in the study of personality and SES. First, how valid are comparisons of personality across different socioeconomic strata? We address this question by analyzing the measurement invariance of a widely used personality measure, the Big Five Inventory (John & Srivastava, 1999), across multiple SES indicators. Second, how do Big Five personality traits correlate with education, income, and occupational

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prestige? We investigate the associations between the Big Five and socioeconomic indicators.

And third, how well do age trends in personality generalize across levels of socioeconomic status? We consider mean-level age trends in the Big Five that are often described as representing typical developmental pathways in adulthood.

Background: Socioeconomic Status and Its Relevance to Personality

SES is a widely studied contextual phenomenon in psychology. Broadly speaking, SES refers to an individual's standing within the social hierarchies of a society. More specific definitions and approaches vary, with some researchers emphasizing economic hierarchies and others emphasizing social variables like prestige (Bradley & Corwyn, 2002). In practice, SES is frequently measured through one or more of three variables: educational attainment, income, and occupational prestige (Adler et al., 1994 ; Diemer, Mistry, Wadsworth, Lopez, & Reimers, 2013; Saegert et al., 2007). In the present research we will consider all three of these variables, each of which has been shown to be associated with personality traits (Jonassaint, Siegler, Barefoot, Edwards, & Williams, 2011).

Why is it important to study the relationship between SES and personality? SES is defined by differential access to economic and social resources that can both affect (Bradley & Corwyn, 2002; Conger et al., 2002; Jonassaint et al., 2011) and be affected by personality (Damian, Su, Shanahan, Trautwein, & Roberts, 2015; Heckman & Kautz, 2012). For example, childhood SES predicts patterns in personality, such that growing up in a high SES home is associated with higher levels of Extraversion and Openness, whereas growing up in a low SES home is associated with high neuroticism and low conscientiousness (Jonassaint et al., 2011). Similarly, an individual's personality measured in high school can better predict future socioeconomic success than their parent's SES (Damian et al., 2015). Researchers and

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policymakers are increasingly recognizing the potential for interventions on personality development to affect social and economic indicators and vice versa, making this a key area for societally relevant basic and translational research (Bleidorn et al., in press).

Measurement Invariance

Prior to investigating the associations between SES and personality, it is important to assess if personality, as measured, reflects the same construct (i.e., has the same structure) across levels of SES. Measurement invariance concerns the extent to which a measure works similarly across levels of some factor or group (e.g., across different cultures, age groups, gender, income and education, etc.). It is important to examine measurement invariance for two reasons. First, measurement invariance is an important aspect of structural validity, or the extent to which the hypothesized structure of a measure is reflected empirically in the data (Flake, Pek, & Hehman, 2017; John & Soto, 2007). Thus, establishing measurement invariance is a psychometric goal in its own right, providing evidence that a proposed measurement model is structurally valid. Second, establishing measurement invariance is a precondition for unambiguously interpreting differences in that measured construct across groups. For example, an observed relation between conscientiousness and educational attainment (e.g., a correlation between conscientiousness and years of educational attainment, or a mean difference in conscientiousness between high school graduates and college graduates), could either reflect a true relation between these constructs or differences in how people of varying educational backgrounds respond to the items of the scale used to measure conscientiousness. Only by establishing measurement invariance across levels of educational attainment could an analysis like this unambiguously reflect a relation between the constructs.

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Measurement invariance can be tested with multiple-group confirmatory factor analysis (CFA) in which parameters are constrained to be equal across levels of a grouping variable (Gregorich, 2006). Each level of measurement invariance enables the unambiguous interpretation of certain comparisons. *Metric invariance* is established when factor loadings are equal across groups, and it enables comparisons of variances and covariances among latent factors (e.g., a correlation between latent conscientiousness and education). *Scalar invariance* is established when item intercepts are equal, and it enables comparisons of both latent and observed means (e.g., a mean difference between high school and college graduates). *Strict factorial invariance* is established when residual variances are equal across groups, and it enables comparisons of observed variances and covariances (e.g., a correlation between conscientiousness scale scores and education; Gregorich, 2006). Our planned analyses include differences in Big Five observed means and covariances (e.g., with age). Strict factorial invariance most fully supports these analyses, though this is often considered too strict a test of measurement quality (Nye & Drasgow, 2011), and so our approach will include a pragmatic assessment of its impact.

To our knowledge, measurement invariance of the Big Five across different categories of SES has not been tested before, with one exception, where conscientiousness was shown to be partially invariant across SES (Ludwig, Flournoy, & Berkman, 2019). However, there is a rich literature on testing the measurement invariance across other variables, including nations (Thalmayer & Saucier, 2017), US states (Gebauer et al., 2014), age groups (del Barrio, Carrasco, & Holgado, 2006), cohorts (Borghuis et al., 2017), genders (Marsh et al., 2010), and ethnicity (Schmitt, Golubovich, & Leong, 2011). These studies provide mixed results in terms of the measurement invariance of the Big Five, with several studies demonstrating configural and metric, but not scalar (nor full) invariance across different groups (e.g., Vecchione, Alessandri,

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& Barbaranelli, 2012). Furthermore, a number of studies found measurement invariance for only a subset of the traits (e.g., Borghuis et al., 2017), and others were suggestive of partial invariance (e.g., Marsh et al., 2010). Most directly relevant to the current study, prior work has demonstrated differences in acquiescent responding across levels of education attainment (one pillar of SES), which could lead to differences in item loadings, intercepts, and residuals (Rammstedt, Goldberg, & Borg, 2010). These results point out the necessity of conducting a measurement invariance analysis of the Big Five across SES categories prior to conducting further analyses for which the interpretations are conditional on the quality and equivalence of our measurement (Borsboom, 2006).

Associations Between Personality and Socioeconomic Status

Relationships between socioeconomic status and Big Five traits have been previously reported across multiple studies. Positive associations have been observed between SES and agreeableness and emotional stability (Chapman et al., 2009), as well as openness and extraversion (Jonassaint et al., 2011). The bulk of the evidence to date, however, has centered on the association of SES with conscientiousness and neuroticism.

Multiple longitudinal studies have linked conscientiousness and its facets to two components of SES, educational achievement (Chamorro-Premuzic & Furnham, 2003; Nofle & Robins, 2007) and occupational attainment (Judge, Higgins, Thoresen, & Barrick, 1999; Shiner, Masten, & Roberts, 2003). Further, conscientiousness has been shown to moderate individual SES over the life course, such that those high in conscientiousness from low-SES backgrounds are more likely to experience socioeconomic mobility later in life than low-SES, low-conscientiousness peers (Damian et al., 2015). Proposed mechanisms for the observed positive trend between conscientiousness and SES include proclivity for long-term planning (Ludwig,

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Flournoy, & Berkman, 2019) and the selective encouragement of behaviors early in development that are thought to promote future professional success (Roberts, Kuncel, Shiner, Caspi, & Goldberg, 2007).

Whereas conscientiousness has been associated with positive socioeconomic outcomes, studies of SES and neuroticism have reported the opposite trend. Lower SES individuals tend to score higher in neuroticism (Lahey, 2009), and lower childhood SES predicts higher neuroticism in adulthood (Jonassaint et al., 2011). It is hypothesized that the lack of resources intrinsic to being low SES causes this observed trend of increased anxiety and depression (Santiago, Wadsworth, & Stump, 2011), and that being relatively high in neuroticism among this socioeconomic group can further increase the risk of mood disorders (Jokela, & Keltikangas-Järvinen, 2011). Finally, some evidence suggests that SES and neuroticism interact to increase rates of all-cause mortality among the relatively disadvantaged (Chapman et al., 2009).

The reviewed evidence presents two clear hypotheses relative to individual SES: that SES is positively associated with conscientiousness, and that it is negatively associated with neuroticism. The observed effect sizes were in the small-to-moderate ($r = .10 - .30$) range for all correlations (though we note that these estimates are not based on a full meta-analysis). There is some evidence to suggest that agreeableness and extraversion will be positively associated with SES as well, though the relatively smaller body of evidence provides less confidence for these traits.

Generalizability of Age Trends Across SES

In the past two decades, a consensus has emerged about how mean levels of Big Five traits change across the adult lifespan. Accordingly, mean levels of conscientiousness and agreeableness increase with age; neuroticism decreases, especially among women; and openness

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and extraversion change relatively little. This pattern has been documented in longitudinal studies (Specht, Egloff, & Schmukle, 2011); cross-sectional studies (Soto et al., 2011; Srivastava, John, Gosling, & Potter, 2003), and a meta-analysis (Roberts, Walton, & Viechtbauer, 2006). The pattern has been described as a generalizable principle of development (Roberts, Wood, & Caspi, 2008). We propose to test how well this pattern generalizes across levels of SES.

Mean-level change findings have been interpreted through a variety of lenses by multiple researchers, with different implications for generalizability. In their five-factor theory, McCrae and Costa (2008) proposed the intrinsic maturation hypothesis, which held that these patterns reflect endogenous development that is invariant across social environments (McCrae et al., 1999; McCrae et al., 2000). Five-factor theory therefore implies that age trends in the Big Five should be invariant across socioeconomic strata.

By contrast, Roberts et al. (2008) have described mean-level change as reflecting the maturity principle: during adulthood, the average person's personality changes to support them becoming a more productive, steady, and prosocial member of society. A second principle, the social investment principle, proposes a mechanism that drives these changes. According to the social investment principle, changes in personality result from psychological commitments to social institutions, such as work, family, and community. Through these role commitments, people are exposed to new expectations and contingencies that shape their behavior. If socioeconomic status is related to these role commitments and their normative timing, then according to the social investment principle, the magnitude and possibly even direction of mean-level change will vary as a function of socioeconomic class.

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How do these broad principles translate into specific predictions about SES and age trends in personality? In one test of the social investment principle, Bleidorn et al. (2013) studied how nation-level differences in the timing of social roles that are linked to SES (e.g, marriage, employment) were associated with age trends. Early normative timing of the completion of education (used as a proxy for entering the workforce) was associated with more of a decrease in neuroticism (a more negative slope) and more of an increase in conscientiousness (a more positive slope). Early normative timing of family roles, as indicated by teen marriage rates, teen birth rates, and mean age at first marriage, was associated with a more positive age slope for openness. These national differences were interpreted as reflecting the social investment processes that have been theorized to operate at an individual level.

The social role variables studied by Bleidorn et al. (2013) can be translated into predictions for SES indicators. Timing of the completion of education is closely related to educational attainment, a common status indicator, with higher SES reflecting later normative completion of education. Marriage and family roles are also associated with socioeconomic status. Education is associated with later normative age of marriage (Parker & Stepler, 2017; Wang, 2018) and family socioeconomic status is associated with greater teen pregnancy (Penman-Aguilar et al., 2013). Thus, applying the theoretical framework and findings of Bleidorn et al. (2013), we can generate a prediction that higher socioeconomic status will be positively associated with the age slope for neuroticism, negatively associated with the age slope for conscientiousness, and negatively associated with the age slope for openness.

The Present Research

The goal of the present study is to better understand the relationship between SES and personality by: (H1) testing if the BFI (John & Srivastava, 1999), a widely used personality

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measure, is measuring the same constructs across economic groups using income, education, occupational prestige, and occupational income as indicators of SES, (H2) estimating the associations between Big Five traits and SES, in an economically diverse sample, to test if they are consistent with previous findings, and (H3) test if the effect of the same four indicators of SES on mean-level age trends in personality development are consistent with differences in normative role timing.

We will test the following specific hypotheses for H2: (a) that the indicators of SES are positively associated with conscientiousness, agreeableness, and extraversion, and (b) that the indicators of SES are negatively associated with neuroticism. Based on the previously reviewed literature we expect to observe correlations in the small-to-moderate ($r = .10 - .30$) range. In addition to examining these bivariate relationships, using multiple regression, we will estimate the unique relationship between three of the SES indicators, income, education, and occupational prestige and each of the Big Five traits.

Based on normative role timing, we will test three specific hypotheses for H3: (a) that SES will be positively associated with the age slope for neuroticism, (b) SES will be negatively associated with the age slope for conscientiousness, and (c) SES will be negatively associated with the age slope for openness. In cross-sectional data such as in the present study, mean-level differences can also reflect cohort effects (Schaie, 1965). Convergence between cross-sectional and longitudinal approaches, the latter of which are unaffected by cohort, has largely led personality psychologists to interpret differences as reflecting age effects (Roberts et al., 2006). However, we will also consider the possibility of cohort main effects or cohort-by-SES interactions in interpreting the results.

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Method

Participants and Procedure

Data for this study comes from the Attitudes, Identities, and Individual Differences study (AIID; Hussey, Hughes, & Nosek, 2018). AIID was a large-scale ($N \approx 200,000$) study that was run on the Project Implicit website between 2004 and 2007. AIID participants were asked to complete demographic measures, including indicating their occupation, income, and educational attainment. In a planned missingness design, each AIID participant also completed a randomly selected set of individual-difference items. Two of the subsets included items from the Big Five Inventory (BFI; John & Srivastava, 1999). As a result of this design, the effective N for the present analyses will be smaller than the full AIID dataset.

Exclusion Criteria. We will initially screen participants from the AIID data and only include those who reside in the United States, completed one of the two BFI subsets (Agreeableness and Openness or, Extraversion, Conscientiousness, and Neuroticism), and did not select “unemployed” as their occupation. We will exclude “unemployed” individuals from the analyses for several reasons. First, being unemployed is a transient state, and without further information it is impossible to differentiate between short-term versus long-term unemployment, voluntary versus involuntary unemployment versus retirement, etc. Second, it is difficult to interpret self-reported income for individuals who select “unemployed” (e.g., given ambiguity in the instructions, some participants may have significant part-time or investment income, whereas others may have no current income but report a salary from their last job). Third, for these reasons we did not believe it would be valid to derive occupational indices for the “unemployed” category, which would leave unemployed participants missing on those variables. For analyses including the income measure, we will also exclude participants who indicated “don’t know”

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because for our analysis this response is equivalent to missing data. We will use all available data for each analysis (pairwise deletion), which will result in a different number of participants for each analysis.

For the measurement invariance analysis, we will include participants who indicated “student” as their occupation as a reference category, since a substantial amount of the evidence for the Big Five Inventory’s validity comes from student samples (John & Srivastava, 1999). For the Big Five and SES relationship (H2) and the age trend analysis (H3), we will exclude students and those under 25 in order to focus on the effects for individuals that are more likely to have completed their educations (making the “education” variable less transient and more indicative of social position), entered the workforce, and established an occupation.

Measures

Following recent recommendations for SES measurement (Diemer et al., 2013), we will use three indicators of SES: educational attainment, income, and occupational prestige. In addition, because of concerns about lack of fidelity in the AIID income measure, we will calculate an additional indicator of SES, *occupational income*.

Educational attainment. AIID participants reported their educational attainment. Different versions of the AIID questionnaire used slightly different sets of categories, so some of the categories in the analyses reflect combinations of categories from different versions. In addition, the “Not a high school graduate” had too few participants after exclusions, so we combined it with “High school graduate” to create a “No college” category. The final education categories for the analyses are: “No college,” “Some college or associate’s degree,” “Bachelor’s degree,” and “Graduate degree or graduate education.” For correlation and regression analyses,

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these categories will be assigned the numbers 1-4 respectively and entered into the models as a continuous variable.

Income. Participants self-reported their household income by selecting one of the following five categories: less than \$25,000; \$25,000 to \$49,999; \$50,000 to \$74,999; \$75,000 to \$149,999; greater than \$150,000; and “don’t know.” For correlation and regression analyses, “don’t know” responses will be excluded and the remaining categories will be assigned to the numbers 1-5, respectively, and entered into the models as a continuous variable.

Occupational prestige. Respondents were asked to indicate their occupation by selecting one of 98 job categories, including “student,” that most closely matched their current occupation, or could indicate that they were unemployed. These 98 categories were derived by combining similar job titles from the roughly 1,000 job titles in the U.S. Department of Labor/Employment and Training Administration (USDOL/ETA) O*NET occupational data, which is a government database that includes a list of job titles and associated characteristics.

To calculate the prestige scores for these 98 job categories, we begin with the prestige scores for all of the O*NET job titles collected in a study of people’s ratings of the prestige of various occupations (Hughes, Srivastava, Leszko, Condon, & Condon, n.p.). The prestige score for each job title represents the average ratings of the prestige of that job title from a minimum of 150 unique judges. The occupational prestige scores for each of the 98 AIID job categories will be the average of the prestige for the job titles within the category. For example, if a participant selected “Operations Management,” their occupational prestige ratings would be the average of the prestige ratings of the 20 job titles within this category (e.g., financial managers, purchasing managers, human resource managers).

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Occupational income. The income categories in the AIID study appear too broad to capture the effects of interest. For example, the range from \$25,000 - \$50,000 may capture both individuals who are living in poverty and those from lower-middle class homes. In addition, self-reported income is commonly misreported by participants (Epstein, 2006). To address these concerns, we will calculate a continuous occupational income score using national average income data from O*NET. Occupational income scores for the 98 job categories will be calculated in the same manner as prestige, by averaging the yearly income for each of the job titles within the category. Because this data was collected from 2004 to 2007, we will use the O*NET data for 2007 estimated average annual income for each of the job titles.

Personality traits. Big Five personality traits were assessed with items from the Big Five Inventory (BFI; John & Srivastava, 1999). As part of the planned missingness design of the AIID study, participants did not complete the entire BFI. Instead, a subset of AIID participants were randomly assigned either one of two subsets of BFI items: one subset contained the Agreeableness and Openness items; the other subset contained Extraversion, Conscientiousness, and Neuroticism items. Responses were on a 6-point Likert scale, with 1 anchored with “strongly disagree” and 6 anchored with “strongly agree.” The reversed keyed items in the BFI have already been reverse scored in the AIID data. Therefore, to calculate traits scores, we will average the items for that trait.

Analysis Plan

Inference Criteria

For H1 analyses, our interpretations and decisions will be based on fit indices; we discuss these considerations in greater detail below. For H2 and H3 analyses, we will calculate effect sizes (correlation and regression coefficients) and 95% confidence intervals, and we will base

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our interpretations on those statistics. In addition, we will calculate p -values. Following the recommendations of Benjamin et al (2018), we will interpret $p < .005$ as “significant” and $p < .05$ as “suggestive.” Given the large number of hypotheses to be tested, we have adopted this conservative approach to interpreting p -values reduce the change of over-interpreting unreplicable effects.

Measurement Invariance (H1)

We will examine measurement invariance across educational attainment, income, occupational income, and occupational prestige separately for each of the Big Five domains, resulting in a total of 20 sets of measurement invariance analyses. The correlation between occupational prestige and occupational income is substantially larger ($r = .74$) than between any of the other indicators of SES (next largest $r = .50$). This relationship may be artificially inflated because both are based on the same aggregated occupation codes, but income and prestige are conceptually distinct. For example, there are prestigious occupations (e.g., teachers) that have low income and there are low prestige jobs (e.g., sanitation workers) that have high incomes. We acknowledge that the measurement invariance analyses conducted with each of these occupational indicators of SES are unlikely to produce different results. However, because it is common practice for researchers to select a single indicator of SES for analysis it is important to assess invariance across both occupational measures.

Testing for measurement invariance across the continuous SES indicators requires splitting the respondents into discrete groups (Gregorich, 2006). The educational attainment and income measures collected in the AIID study each had five response choices. The educational attainment responses included a small number of participants in both the “not a high school graduate” and “high school graduate” categories. We combined these categories into a “no

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college” category and will test for invariance across this category and the three remaining responses. The income measure had an adequate number of participants in each response choice so we will consider each response choice a group and test for invariance across them. Unlike these “naturally” occurring response choice groups, the occupational measures are continuous and normally distributed (see Figure 1). We examined the distributions of occupational prestige and occupational income in both the exploratory and masked data and considered dividing them in a number of different ways, including tertile splits and by standard deviation. Figure 1 shows that dividing the data (both the exploratory and masked) into even tertiles results in individuals who clearly belong in the middle group being assigned to both the high and low groups. Dividing participants one standard deviation above and below the mean, instead of splitting the data into even groups, addresses this issue without relying on the idiosyncrasies of this data to determine groups. Based on these distributions, we will split the occupational variables, prestige and income, into three groups with low, medium, and high scores. Using standard deviations in this way means that the medium group will have more participants, and the “low” and “high” groups will be more extreme than they would be with an evenly spaced tertile split. In our judgment, informed in part by observing where these cutpoints fell in the data, this approach fits better with the everyday meaning of low and high standing in socioeconomic hierarchies.

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Figure 1. Distribution of occupational prestige and income scores with tertile and standard deviation splits.

Each of the Big Five will be fit as a single latent variable with all of the corresponding items treated as indicators; for example, extraversion will be modeled as a latent variable with the eight BFI extraversion items as its indicators. For each comparison, we will first fit an unrestricted model that allows each group to have its own measurement mode, assuming only configural invariance (i.e., that the items on an a priori scale have a one-factor structure). We will then examine metric, scalar, and strict factorial invariance by assessing the decrement in fit in increasingly constrained, nested models produced by setting the loadings, intercepts, and residual variances equal across groups respectively. We will assess the magnitude of invariance by calculating effect sizes created by Nye and Drasgow (2011), which provide item- and scale-level estimates of the impact of differences in item loadings and intercepts across groups. Models

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will be fit using the lavaan package (version $\geq 0.6.4$; Rosseel, 2012) in R (version $\geq 3.6.1$; R Core Team, 2019) and we will use the dmacs package (version $\geq 0.1.0$; Dueber, 2019) to calculate the effect sizes.

We will evaluate measurement invariance by comparing model fit indices and the effect sizes developed by Nye and Drasgow (2011). For fit indices, we will use change in McDonald's Noncentrality Index (ΔMFI ; as recommended by Kang, McNeish, and Hancock (2016), change in Root Mean Squared Error of Approximation (ΔRMSEA), and change in Akaike Information Criterion (ΔAIC); however, we will base our interpretations most heavily on ΔMFI if the different fit measures are in conflict. We will also use the three effect sizes proposed by Nye and Drasgow (2011). The first is an item-level effect size called d_{MACS} that represents the extent of invariance in the loadings and intercepts (together) of each item in a scale on a metric designed to be similar to Cohen's d ; the empirically-derived benchmarks for small, medium, and large effects for d_{MACS} are .20, .40, and .70 respectively (Nye, Bradburn, Olenick, Bialko, Drasgow, 2019). In addition to item-level d_{MACS} , there are two scale-level estimates that capture the practical consequences of measurement invariance on observed scale scores. They are Δ_{Mean} and Δ_{Var} which correspond to expected differences in observed means and variances (respectively) due to measurement invariance (Nye & Drasgow, 2011; see also Clark et al., 2016) .

Interpretation can be based on fit indices in a continuous and calibrated way, and several authors caution against using hard thresholds when not necessary (Kang et al., 2016; Nye & Drasgow, 2011). However, thresholds are often needed for behavioral decisions; one such decision is whether to proceed with analyses using an *a priori* scale, or to drop differentially functioning items in order to produce an invariant scale. Regardless of the results of the measurement invariance analyses, we will conduct the remaining analyses (for H2 and H3) with

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a priori Big Five scale scores. In addition, if any Big Five scale(s) show a ΔMFI value greater than .01 from configural to metric invariance or metric to scalar invariance and a ΔMean greater than .20, we will attempt to construct invariant scales based on a subset of items, guided principally by items' dMACS (i.e., by dropping items with high dMACS). We will then report results for the invariant scale(s) alongside the *a priori* scales and calibrate our interpretations accordingly. The choice of a ΔMFI value of .01 as a cutoff is based on the recommendation of Kang et al. (2016) and the choice of a ΔMean of .20 is based on practical considerations (i.e., that a difference of at least 0.20 on a likert scale mean is non-negligible).

Selecting the reference indicator. When pursuing a partial invariance model, the choice of the reference indicator becomes consequential, as using a non-invariant reference indicator might change the outcome of the measurement invariance analyses (Yoon & Millsap, 2007). Based on simulation studies investigating measurement invariance across two groups, with balanced sample sizes, Jung and Yoon (2017) recommend choosing the item with the smallest modification index as the reference indicator. Although the present research will test for invariance across more than two groups, with uneven group sizes, which makes Jung and Yoon's (2017) recommendations not directly applicable, the logic behind choosing the item with the smallest modification index as the reference indicator is reasonable. Accordingly, if we find evidence of non-invariance or partial invariance for any of the models, we will use the following steps to select the reference indicator: 1) run a full invariance model, 2) calculate the mean of modification indices for each indicator, and 3) select the indicator with the smallest mean of modification indices as the reference indicator.

In addition to testing measurement invariance, we will look at the structural invariance of the Big Five by determining the extent to which factor correlations vary across groups. As

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noted above, participants completed one of two subsets of Big Five items, meaning we can observe four possible factor inter-correlations: Agreeableness-Openness, Extraversion-Conscientiousness, Extraversion-Neuroticism, and Conscientiousness-Neuroticism. We will assess structural invariance by examining changes in fit due to constraining these correlations to be equal across groups, as well as by examining the magnitude of group estimates of each available correlation.

Big Five and SES Indicators (H2)

We will test for the positive associations of SES with conscientiousness, extraversion, and agreeableness, and the negative association with neuroticism, through a series of bivariate correlations. We will calculate the correlations between the four measured indicators of SES and the Big Five scale scores, resulting in twenty bivariate correlations of interest. We will conduct this analysis using the psych package in R (version $\geq 1.8.12$; Revelle, 2018). In addition, we will regress each Big Five scale on education, self-reported income, and occupational prestige to assess the distinctive contribution of each variable. Because occupational income and occupational prestige are both based on the same item and are collinear in the exploratory data, we will not use occupational income and occupational prestige together in the same regression analyses.

Age Trends by Socioeconomic Strata (H3)

The H3 analyses will be conducted using linear regression models. We will analyze one Big Five trait and one SES indicator at a time, resulting in 20 different models. Each model will have a single Big Five trait regressed on age (mean-centered), an SES indicator (mean-centered), and an age-by-SES interaction term.

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The results of these models will include estimates of the main effect of age on personality, a main effect of SES on personality, and an interaction effect between age and SES on personality. We will report the main effects of age on personality and later discuss if the observed age trends, controlling for SES, are consistent with previous findings. The main outcome of interest in this analysis is the coefficient of the interaction term. A significant effect for the interaction term will be interpreted as indicating that age trends in development for that trait vary as a function of SES.

Missing Data Approach

The planned missingness design of the AIID study resulted in no participants responding to all Big Five measures. Instead, participants were randomly assigned to one of 20 individual difference measures. For participants assigned to Big Five measures, some provided responses to two trait measures, agreeableness and openness, and others to three trait measures, extraversion, conscientiousness, and neuroticism. We will calculate observed scales scores across completed items and include participants who made one or more responses to trait items for any subsequent analysis which includes that trait, unless they are excluded for other reasons. In addition, to address missing data in the measurement invariance analysis (H1) we will estimate the models using full information maximum likelihood (fiml).

For the correlation analysis (H2), we will use pairwise deletion. Although this approach is generally not recommended it is acceptable if, as in this case due to the planned missingness design, the data is missing at random (MAR; Rubin, 1976). For the correlation analyses in H2 we will use listwise deletion. For the age trends analysis, we will exclude participants who did not provide a response to the dependent variable of interest for each regression model. This may result in participants being excluded from one analysis and included in another. For example, if

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an individual provided information about their income but not their education, they would be included in the age trends regression model predicting income but not the model predicting education.

Sample Size Considerations

The data for this study have already been collected. Due to the planned missingness design, the subsets of the data that will be used for this analysis are considerably smaller than the total AIID sample size. We will use all available data (after exclusions discussed earlier) for each analysis, resulting in different sample sizes for each analysis.

In addition to the exploratory dataset, we had access to a masked version of the confirmatory dataset that replaced all nonmissing responses with the number 1. Because of uncertainty regarding whether the data underlying the 1s in the masked data would meet exclusion criteria, we cannot calculate an exact sample size for each analysis based on currently available information. However, estimating the sample sizes in the masked confirmatory data for each analysis suggests that they will be sufficient for valid inferences. We detail these considerations below:

H1 analyses. For the measurement invariance analyses, we used the masked confirmatory data (all responses replaced in the data with a 1) to estimate the final sample size for each analysis. Across all the SES indicators for each Big five trait, the estimated number of participants in each group ranges from $N = 227$ to $N = 1681$ (see Tables 1 – 4 for specific anticipated sample sizes and demographics for each analysis). Sample-size planning in structural equation modeling (SEM), like that used in the measurement invariance analysis, is notably complex. However, for this analysis, the fit measure we will use to assess invariance, MFI, is robust to sample sizes larger than 100 (Kang et al., 2016) and the d_{MACS} effect size, the metric we

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will use to construct invariant scales, is relatively stable in smaller samples (>250; Nye et al., 2019), supporting that we will have enough data to draw valid inferences.

Table 1

Sample Sizes and Demographics for HI Measurement Invariance Analysis Across Occupational Prestige

Trait	N	Age (SD)	% female	% white	High Occupational Prestige	Low Occupational Prestige	Medium Occupational Prestige
extra	2288	35.03 (11.93)	.67	.76	299	308	1681
agree	2322	34.71 (11.95)	.66	.76	323	364	1635
open	2307	34.68 (11.93)	.66	.76	322	359	1626
consc	2284	34.97 (11.88)	.67	.76	301	311	1672
neuro	2279	35 (11.89)	.67	.76	299	309	1671

Note. The values in the Occupational Prestige categories reflects the *N* for each category.

Table 2

Sample Sizes and Demographics for HI Measurement Invariance Analysis Across Occupational Income

Trait	N	Age (SD)	% female	% white	High Occupational Income	Low Occupational Income	Medium Occupational Income
extra	2611	35.35 (11.88)	.67	.76	477	462	1672
agree	2631	35.01 (11.85)	.66	.77	468	525	1638
open	2617	34.98 (11.84)	.66	.77	468	520	1629
consc	2609	35.31 (11.83)	.67	.76	481	464	1664
neuro	2602	35.33 (11.83)	.67	.76	478	460	1664

Note. The values in the occupational income categories reflects the *N* for each category

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Table 3*Sample Sizes and Demographics for H1 Measurement Invariance Analysis Across Income*

Trait	N	Age (SD)	% female	% white	< 25	25 - 50	50 - 75	75 – 150	> 150
extra	3032	34.3 (12.49)	.66	.76	537	761	580	820	334
agree	3033	33.91 (12.45)	.66	.77	526	741	639	816	311
open	3013	33.88 (12.43)	.66	.77	516	738	634	811	314
consc	3036	34.23 (12.45)	.66	.76	536	762	581	821	336
neuro	3025	34.25 (12.45)	.66	.76	533	762	579	814	337

Note. Income is in thousands of dollars. The values in the income categories reflects the *N* for each category.

Table 4*Sample Sizes and Demographics for H1 Measurement Invariance Analysis Across Education*

Trait	N	Age (SD)	% female	% white	No college	Some college or AA	Bachelor's degree	Graduate degree
extra	3393	33.29 (12.7)	.67	.75	227	1228	1096	842
agree	3454	32.82 (12.6)	.67	.76	278	1225	1057	894
open	3434	32.79 (12.59)	.67	.76	275	1218	1051	890
consc	3393	33.25 (12.67)	.67	.75	227	1230	1095	841
neuro	3389	33.25 (12.67)	.67	.75	229	1226	1093	841

Note. The values in the education categories reflects the *N* for each category.

H2 analyses. For the correlation and regression analysis for H2, we anticipate there will be from $N = 1763$ to $N = 2192$ participants per pairwise observations for each of our 20 planned bivariate correlations, and between $N = 1692$ and $N = 1714$ participants (see Table 5) for each of the 5 regression analyses. Correlations stabilize at ~250 observations (Schönbrodt & Perugini, 2013) and thus we anticipate that this analysis will afford adequate precision. We also conducted

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a sensitivity analysis in G*Power (Faul, Erdfelder, Buchner, & Lang, 2009) to determine the smallest effect the planned analyses could detect. The results indicated that a fixed linear multiple regression model with three predictors (corresponding to 3 SES predictors), a sample size of 1692, desired power of 95%, and an alpha level of .05 can detect a small effect ($f^2 = .01$, or approximately $R = .10$). Based on this sensitivity analysis, we concluded that the proposed analysis are adequately sensitive to detect effects at the smaller end of the range of those previously reported in the literature.

Table 5

Sample Sizes and Demographics for H2 Regression Analysis

Trait	N	Age (SD)	% female	% white
extra	1694	38.94 (10.53)	.66	.76
agree	1692	38.85 (10.49)	.66	.76
open	1714	38.36 (10.76)	.66	.77
consc	1692	38.85 (10.49)	.66	.76
neuro	1686	38.89 (10.48)	.66	.76

H3 analyses. For the age trends in personality moderated by SES analysis, we anticipate there will be from $N = 1758$ to $N = 2191$ participants (see Table 6) for each linear regression model. A sensitivity analysis for a fixed linear multiple regression model, conducted in G*Power (Faul, Erdfelder, Buchner, & Lang, 2009), indicated that a model with a sample size of 2096, desired power of 95%, and an alpha of .05 could detect a small interaction effect ($f^2 = 0.007$; equivalent to a $\Delta R^2 = .007$ when adding the interaction term to the model). This demonstrates that the planned analyses will be sensitive to detect interaction effects of meaningful size.

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Table 6*Sample Sizes and Demographics for H3 Age Trends Moderated by SES Analysis*

Trait	SES Indicator	N	Age (SD)	% female	% white
extra	Occ Prestige	1765	39.04 (10.59)	.67	.76
extra	Occ Income	2053	39.12 (10.56)	.67	.76
extra	Income	2213	39.16 (11.16)	.66	.76
extra	Education	2306	39.2 (11.21)	.66	.76
agree	Occ Prestige	1821	38.42 (10.81)	.66	.77
agree	Occ Income	2095	38.52 (10.7)	.66	.78
agree	Income	2225	38.62 (11.22)	.65	.79
agree	Education	2346	38.61 (11.24)	.66	.78
open	Occ Prestige	1809	38.38 (10.79)	.66	.77
open	Occ Income	2084	38.48 (10.7)	.66	.78
open	Income	2211	38.59 (11.21)	.65	.79
open	Education	2331	38.59 (11.24)	.66	.78
consc	Occ Prestige	1763	38.96 (10.55)	.66	.76
consc	Occ Income	2053	39.05 (10.53)	.67	.76
consc	Income	2214	39.07 (11.13)	.66	.76
consc	Education	2308	39.13 (11.17)	.66	.76
neuro	Occ Prestige	1758	39 (10.55)	.66	.76
neuro	Occ Income	2047	39.08 (10.51)	.67	.76
neuro	Income	2207	39.09 (11.12)	.66	.76
neuro	Education	2302	39.16 (11.17)	.66	.76

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Timeline

Pending in-principle acceptance, the anticipated timeline for completing stage two of the registered report is 4 months. This reflects the time to receive the full dataset from the AIID study team, run analyses, and write the results and discussion sections of the manuscript.

Exploratory Data

The complete AIID dataset was split into two datasets, one exploratory (~15%) and one confirmatory (~85%). The purpose of this split was to provide researchers an opportunity to use the exploratory data to generate hypotheses that they will subsequently test in the confirmatory data set. However, the hypotheses proposed in this manuscript and that we will test in the confirmatory data were not generated through exploratory analysis of the data, but were instead based on prevailing, but mostly untested, hypotheses in the personality literature.

We used the exploratory data to visually inspect the distribution of SES indicators and to determine the categories of occupational prestige and occupational income for use in the measurement invariance analysis. The proposed analyses were also run in the exploratory data to test for model convergence and fit. We do not report the results from these analyses here because they did not inform our substantive hypotheses, were not preregistered, and are in a smaller sample. However, we will make them available with the final report in supplemental material for interested readers. We will consider the final analyses in the confirmatory data to be the substantively informative ones.

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Contributions

Contributed to conception and design: BTH, CC, JP, PR, CBP, RML, SS

Contributed to analysis and interpretation of data: BTH, CC, JP, PR, CBP, RML, SS

Drafted and/or revised the article: BTH, CC, JP, PR, RML, CBP, JP, SS

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Competing interests

The authors have no competing interests.

Data accessibility statement

The AIID study data is managed by other researchers and we do not have control over its public release.