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ARTICLE

The Association Between Five Factor Model Personality Traits and Verbal and Numeric Reasoning

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ABSTRACT

Five-factor model (FFM) personality traits are related to basic cognitive functions and risk of cognitive impairment in late life. The present study addresses whether FFM traits are also associated with a more complex cognitive function, reasoning, across adulthood. We used seven samples to examine the relation between personality and verbal (total *N*= 39,177) and numeric (total *N*= 76,388) reasoning. A meta-analysis indicated higher Neuroticism was associated modestly with worse performance on verbal and numeric reasoning tasks. Openness was associated with better verbal reasoning and was unrelated to numeric reasoning. Surprisingly, Extraversion was associated modestly with worse performance in both domains, and Conscientiousness was essentially unrelated to reasoning. Agreeableness was unrelated to reasoning. There was significant heterogeneity across the samples but only limited evidence for moderation by age or sex. Consistent with other cognitive domains, the results suggested that Neuroticism is related to worse performance globally, whereas Openness tends to be associated with better verbal abilities. Among the unexpected findings was the better reasoning of introverts. The pattern also suggests that the common positive association between Conscientiousness and cognition does not extend to reasoning and suggests that Conscientiousness may support healthier cognitive aging through basic cognitive functions rather than through complex functions like reasoning.

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KEYWORDS
Reasoning; verbal abilities; personality traits; numeric reasoning; meta-analysis

Five-factor model (FFM; McCrae & John, 1992) personality traits have been associated with aspects of cognitive function (Curtis et al., 2015). Individuals who score higher in Neuroticism (a general tendency toward negative emotionality and vulnerability to stress) perform worse on measures of episodic memory and verbal fluency, whereas individuals who score higher in Conscientiousness (a general tendency toward organization, discipline, and responsibility) perform better on tasks that measure these two aspects of cognition (Luchetti et al., 2016; Sutin, Stephan, Damian et al., 2019a). Higher Neuroticism and lower Conscientiousness are also the traits implicated most consistently in risk of severe cognitive impairment in older adulthood (Segerstrom, 2020). The other

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three FFM traits – Extraversion (a general tendency toward sociability and positive emotionality), Openness (a general tendency toward imagination and creativity), and Agreeableness (a general tendency toward altruism and cooperation) tend to have more domain-specific associations with cognition (Curtis et al., 2015). The literature on personality and cognition in adulthood has focused primarily on either specific cognitive functions, such as episodic memory and processing speed (Chapman et al., 2017), or on clinically relevant outcomes, such as Alzheimer's disease (Terracciano et al., 2014) and other significant cognitive impairments (Terracciano et al., 2017). Less work has addressed the relation between personality traits and more complex cognitive processes that involve the integration of multiple basic functions, such as reasoning.

Reasoning is the ability to identify the relation between two or more objects and/or concepts. It is essential for problem solving and is a cornerstone of human learning (Gentner & Maravilla, 2018). It has been described as inference based on knowledge (Oaksford & Chater, 2019) and as the integration of multiple cognitive functions, including working memory, inhibition, and set shifting (Krawczyk, 2012). Reasoning can occur in any cognitive domain; verbal and numeric are the two most common domains. Verbal reasoning refers to the relation between words and is typically measured with tasks such as analogies, whereas numeric reasoning refers to the relation between numbers and is typically measured with tasks such as number series.

Evidence that personality may be related to reasoning comes from work on personality and aptitude tests like the Scholastic Achievement Test (SAT) in adolescence and reasoning tasks administered in adulthood. Of the five traits, Openness tends to have the most consistent associations with better verbal reasoning skills in adolescence, as assessed by the SATs (Noftle & Robins, 2007). The association between this trait and the quantitative section of the SATs is more mixed, and the other four traits are not associated consistently with either section of the SATs (Noftle & Robins, 2007). In a set of studies on high school students that combined measures of reasoning across verbal, numeric and visuospatial domains, Openness again had the most replicable association with higher reasoning, whereas the other four traits were not associated consistently with it (Bergold & Steinmayr, 2018).

The pattern of associations between personality and reasoning is somewhat different in adulthood. In a large sample of adults, for example, higher Neuroticism was associated with lower scores in verbal reasoning (the other four traits were not assessed and neither was numeric reasoning; Olivo et al., 2019). In a relatively small sample of adults (N= 154), Neuroticism and Extraversion were both associated with lower scores on a numeric reasoning task, whereas the other three traits were unrelated to it (Graham & Lachman, 2014). In a moderately large sample of older adults from the Health and Retirement Study (HRS; N= 2,865), there was a similar negative association between Neuroticism and numeric reasoning, a positive association between Conscientiousness and numeric reasoning, and no linear association with the other three traits (Sutin, Stephan, Luchetti et al., 2019b). In the HRS sample, Neuroticism and Conscientiousness were likewise associated with visuospatial reasoning, and, in addition, there were positive associations with Openness and Agreeableness (Sutin, Stephan, Damian et al., 2019b).

This body of literature thus suggests Openness should be associated with reasoning in younger adulthood, whereas Neuroticism should be associated with reasoning in middle and older adulthood. Related work on verbal fluency (Sutin, Stephan, Damian et al., 2019a), however, suggests that Openness, Extraversion, and Conscientiousness might also play a role in verbal ability across adulthood. That is, these traits are associated with better verbal ability, measured as fluency. These positive associations may extend to verbal reasoning, another component of verbal abilities. Further, the broader literature on personality and cognition indicates that Conscientiousness supports better cognitive function into older adulthood (Wilson et al., 2007), with some evidence that its protective effect extends to reasoning (Sutin, Stephan, Damian et al., 2019b). The basic processes associated with these traits may contribute to the association with reasoning performance. For example, the tendency to feel distressed and anxious that is characteristic of Neuroticism may interfere with the ability to reason. The organization and disciplined approach associated with Conscientiousness may support better reasoning. And the cognitive flexibility that is one of the defining characteristics of Openness may support better reasoning skills.

The present research takes a systematic approach to the relation between personality traits and verbal and numeric reasoning by examining a total of seven publicly available datasets (see below). Based on the literature on personality and cognition in adulthood and the literature on personality and reasoning in both adolescence and adulthood, we made the following pre-registered hypotheses: Higher Neuroticism will be associated with lower scores on tasks that measure verbal and numeric reasoning. Higher Conscientiousness and higher Openness will be associated with higher scores on tasks that measure verbal and numeric reasoning. Higher Extraversion will be associated with higher scores on verbal reasoning and be unrelated to performance on numeric reasoning tasks. Agreeableness will not be related to either type of reasoning. We further examined whether the associations vary by age or gender (exploratory analyses).

Method

We took an Integrative Data Analysis (IDA) approach in this research. Hofer and Piccinin (Hofer & Piccinin, 2009, 2010) have advocated for such an approach to increase replicability, reproducibility, and rigor. One IDA approach is to estimate the associations separately within each sample and then combine them using meta-analysis (Hofer & Piccinin, 2010; Weston et al., 2020). IDA approaches have become popular for identifying replicable associations between personality and health-related outcomes (Graham et al., 2017; Jokela et al., 2013). We searched the Interuniversity Consortium for Political and Social Research (ICPSR), the Gateway to Global Aging, and the UK Data Service, as well as our knowledge of other cohort studies, to identify publicly available datasets for download that included a validated measure of FFM traits and standard measures of verbal and/or numeric reasoning. We identified six cohorts (seven samples) with a measure of verbal reasoning and seven cohorts (seven samples) with a measure of numeric reasoning (four cohorts included a measure of both types of reasoning). Several of these cohorts overlap with our previous research on personality and verbal fluency (Sutin, Stephan, Damian et al., 2019a). Although related, verbal fluency and reasoning are distinct cognitive domains that are only modestly correlated (Graham & Lachman, 2014). In most samples, personality and reasoning were measured at the same time, except where noted below. Participants who had valid data on all five personality traits, reasoning, and demographic covariates were selected into the analytic sample for each cohort. Participants were not excluded for any reason other than missing data on key variables. The preregistration for this study can be found at https://osf.io/qp6mf/. Note that the ELSA sample was not part of our preregistration. Subsequent to preregistration, we became aware that ELSA administered a numeric reasoning task at the wave after the first personality assessment. We included it in our analysis, following the same analytic strategy as described for the other cohorts in the preregistration.

Participants and procedure

HRS. The Health and Retirement Study (HRS) is a longitudinal study of Americans aged 50 years and older and their spouse (regardless of age). An FFM measure of personality has been included in the Leave-Behind Questionnaire since 2006. In 2006, a random half of HRS participants were selected for an enhanced face-to-face interview that included this questionnaire; the other half of the sample completed it in 2008. Participants repeat this assessment at alternating waves, every four years. The measure of numeric reasoning was administered to all participants in 2012, and the measure of verbal reasoning was administered to all participants in 2014. We thus used the corresponding personality assessments from these waves (the 2012/2014 Leave-Behind Questionnaire). A total of 13,398 participants had valid data on personality, verbal reasoning, and the sociodemographic characteristics, and a total of 12,476 participants had valid data on personality, numeric reasoning, and the sociodemographic characteristics. See http://hrsonline.isr.umich.edu/for more information about HRS and to access the data and measures.

UAS. The Understanding America Study (UAS) is an internet panel administered by the University of Southern California. Participants complete short surveys regularly through a device of their choice (e.g., computer, phone, tablet, etc.). Participants recruited into the study who did not have a device and/or internet access were provided with the equipment needed to participate. UAS was initiated in 2014. Personality was first assessed at UAS1 in 2014. Numeric reasoning was assessed in UAS42, and verbal reasoning was assessed in UAS44, both administered in June 2016. A total of 5,800 participants had valid data on personality, verbal reasoning, and the sociodemographic characteristics, and a total of 6,025 participants had valid data on personality, numeric reasoning, and the sociodemographic characteristics. See http://uasdata.usc.edu/ for more information about UAS and to access the data and measures.

CogUSA. Cognition in the USA (CogUSA) is a three-wave longitudinal study of age-related changes in cognition. Data collection occurred for CogUSA between 2007 and 2009. Personality and the reasoning tests were administered at wave 2 in 2007–2008. A total of 1,204 and 1,212 participants had valid data on verbal reasoning (similarities and analogies, respectively; see below), personality, and the sociodemographic characteristics, and a total of 1,207 participants had valid data on personality, numeric reasoning, and the sociodemographic characteristics. See https://www.icpsr.umich.edu/icpsrweb/NACDA/studies/36053 for more information about CogUSA and to access the data and measures.

CFAS. The Cognitive Function and Aging Study in Wales (CFAS) is a longitudinal study of cognitive function of older adults in Wales that was initiated in 2011. Personality and a measure of verbal reasoning were available from the wave 2 assessment completed in 2016. A total of 2,092 participants had valid data on personality, verbal reasoning, and the relevant sociodemographic characteristics. See https://beta.ukdataservice.ac.uk/datacata logue/studies/study?id=8281 for more information about CFAS and to access the data and measures.

WLS. The Wisconsin Longitudinal Study is a set of two samples, the Graduate sample (WLSG) and the Sibling sample (WLSS). The WLSG was recruited as a random sample of individuals who graduated from a Wisconsin high school in 1957. The WLSS is a selected sibling of the graduates. Participants in both samples completed measures of personality and verbal reasoning in 2011. A total of 5,924 and 3,120 participants from the WLSG and WLSS, respectively, had valid data on personality, verbal reasoning, and the relevant sociodemographic characteristics. See http://www.ssc.wisc.edu/wlsresearch/ more information about WLS and to access the data and measures.

PSID. The Panel Study of Income Dynamics (PSID) started in 1968. The original participants and their descendants continue to be assessed. In 2016, PSID administered an online Well-Being and Daily Life supplement that included a personality measure and measures of verbal and numeric reasoning. A total of 7,734 participants had valid data on personality, verbal reasoning, and the sociodemographic characteristics, and a total of 7,631 participants had valid data on personality, numeric reasoning, and the sociodemographic characteristics. Most participants completed this assessment online (76%), but a subset of participants was administered the measures either on paper (23%) or over the phone (1%). See http://www.psidonline.isr.umich.edu for more information about PSID and to access the data and measures.

MIDUS. Initiated in 1994–1995, the Midlife in the United States (MIDUS) is a longitudinal study that currently has three waves of data. At the second assessment (MIDUS II), participants completed a measure of numeric reasoning as part of the cognitive function battery between 2004 and 2006. The personality assessment was included in the self-administered questionnaire at this wave. A total of 3,622 participants had valid data on personality, numeric reasoning, and the relevant sociodemographic characteristics. The association between personality and numeric reasoning has been published previously (Graham & Lachman, 2012) using a different analytic strategy and different inclusion criteria that may have led to some differences in the reported associations in the current analysis. See http://www.midus.wisc.edu/ for more information about MIDUS and to access the data and measures.

US. Understanding Society (US) is a large-scale longitudinal study of the health and well-being of households in the United Kingdom. A numeric reasoning task was included in the cognitive battery administered at Wave 3, collected between 2011 and 2013. Personality traits were included in a self-completion questionnaire at this wave. A total of 38,315 participants had valid data on personality, numeric reasoning, and the relevant sociodemographic characteristics. See https://www.understandingsociety.ac.uk/for more information about US and to access the data and measures.

ELSA. Initiated in 2002, the English Longitudinal Study of Aging (ELSA) is a longitudinal study of the English population aged 50 years and older. A measure of numeric reasoning was included in the Wave 6 assessment in 2012; personality traits were assessed at the previous wave in 2010. A total of 7,112 participants had valid data on personality, numeric reasoning, and the relevant sociodemographic characteristics. See http://www.elsa-project.ac.uk/for more information about ELSA and to access the data and measures.

Measures

Personality. In each cohort, personality traits were assessed with a validated measure of FFM traits and scored in the direction of the trait label. Participants in the HRS, MIDUS, and ELSA completed the Midlife Development Inventory (MIDI; Lachman & Weaver, 1997). The MIDI included 26 items that measured Neuroticism (e.g., moody), Extraversion (e.g., talkative), Openness (e.g., creative), Agreeableness (e.g., helpful), and Conscientiousness (e.g., organized). Items were rated on a scale from 1 (*a lot*) to 4 (*not at all*).

Participants in US, PSID, both WLS samples, CogUSA, and UAS completed versions of the Big Five Inventory (BFI; John et al., 2008). Participants rated items that finish the sentence stem, "I see myself as someone who . . . " on a scale from 1 (*does not apply to me at all*) to 7 (*applies to me perfectly*) that measured Neuroticism (e.g., worries a lot), Extraversion (e.g., is talkative), Openness (e.g., is original), Agreeableness (e.g., has a forgiving nature), and Conscientiousness (e.g., does a thorough job). Participants in US and PSID completed a 15-item version of the BFI, participants in both WLS samples completed a 29-item version of this scale, and participants in CogUSA and UAS completed the original 44-item version.

Participants in the CFAS completed the Ten-Item Personality Inventory (TIPI; Gosling et al., 2003). Participants were asked to "Please indicate the extent to which you agree or disagree with each statement, on a scale of 1–7 where 1 is the lowest agreement and 7 the highest. You should rate the extent to which the pair of traits applies to you, even if one characteristic applies more strongly than the other." Response options ranged from 1 (*Disagree strongly*) to 7 (*Agree strongly*). Participants rated two items for each trait: Neuroticism (anxious, easily upset), Extraversion (extraverted, enthusiastic), Openness (open to new experiences, complex), Agreeableness (sympathetic, warm), and Conscientiousness (dependable, self-disciplined).

Verbal reasoning. Verbal reasoning was measured with three different tasks across the cohort studies. Verbal reasoning was measured with an analogies task in the HRS, UAS, and CogUSA. In the analogies task, participants were given two words that were related. Participants then had to complete a second pair of words using the same relation as the first pair of words (e.g., "Mother is to Daughter as Father is to . . . " [answer = Son]). The task is adaptive in that participants were first given a block of three analogies and then a second block determined by how well the participant did on the first block (i.e., the second block was easier if the participant missed some on the first block and harder if the participant got all of the first block correct). HRS developed a scoring system in which a participant's score is weighted by the difficulty of the second block. This score is a standardized score referred to as a *W*-score that is derived from the difficulty parameters from an item response theory (IRT) model (see Fisher et al., 2013 for detailed information about how scoring was developed in HRS). The same scoring metric was used in CogUSA. In UAS, verbal reasoning was expressed as an IRT score based on item difficulty.

A similarities task was administered in CogUSA and the WLS. Specifically, participants were asked how two words were similar. For each item, responses were coded on a scale from 0 (not correct) to 2 (more abstract). An example item is, "In what way are an orange and a banana alike?" A two-point response is "fruit," a one-point response is "things to eat," and zero points would be given for a response that did not indicate how the words were similar. Scores in CogUSA are expressed as T-scores and scores in WLS are expressed as the sum of points across the items.

Participants in PSID completed a 6-item sentence completion task. Participants were given a sentence with one word missing and were told to choose one of five words that "makes the best, truest, or most sensible complete sentence" (e.g., "Lemons are sour but sugar is ..." [answer = sweet]). The score was the sum of correct answers.

Numeric reasoning. In all studies, a number series task was used as a measure of numeric reasoning. Participants were given a series of numbers and were asked to fill in one missing number in the series (e.g., 17 __ 12 8 [answer = 15]). In HRS, CogUSA, ELSA, US, and PSID, participants completed the first block and then a second block. The difficulty of the second block varied by how well the participant did on the first block. Similar to the analogies task, HRS developed a scoring system in which a participant's score is weighted by the difficulty of the second block that is expressed as a *W*-score (Fisher et al., 2013). In UAS, numeric reasoning was also expressed as an IRT score based on item difficulty. Numeric reasoning was the sum of correct responses to five items in MIDUS and PSID.

Covariates. All covariates were self-identified and self-reported in each study. Age in years was reported by participants in years. Gender was dummy-coded as 1 for woman and 0 for man. Race was dummy-coded into African American/Black (US, HRS, CogUSA, PSID, UAS, MIDUS), Asian (US), Biracial (US, MIDUS) and other/unknown (US, HRS, CogUSA, PSID, UAS, MIDUS) and contrasted against white as the reference group (1 for the comparison group, 0 for the reference group). In HRS, both WLS samples, CogUSA, PSID, UAS, and CFAS education were reported in years. Education was reported as a range from 1 (no qualification) to 6 (degree) in US, from 1 (no qualification) to 7 (degree) in ELSA, and from 1 (no school) to 12 (advanced degree) in MIDUS. Study-specific covariates were year of personality assessment in HRS (2012 versus 2014) and mode of administration in PSID (paper and phone versus web).

Analytic strategy

Linear regression was used to test the association between each personality trait and both types of reasoning (verbal, numeric), controlling for age, gender, race, education, and sample-specific covariates where appropriate. We meta-analyzed the results of the individual samples for each trait and each type of reasoning using the metafor package in R (Viechtbauer, 2010). A random-effects meta-analysis was conducted based on the partial correlation and sample size of each cohort to summarize the effects across samples. For verbal reasoning, we did the meta-analysis twice, once with CogUSA analogies and once with CogUSA similarities because we could not include both measures in one meta-analysis since the same participants completed both tasks, and there was not a clear rationale to choose one measure over the other. These analyses were followed up with meta-regressions to identify possible reasons for heterogeneity, including age of sample (mean age above or below 60) and personality measure, grouped by the two most common measures across the samples (BFI versus not BFI and MIDI versus not MIDI). For verbal reasoning, we also tested reasoning measure, grouped as analogies versus not analogies and similarities versus not similarities. In addition, we also tested whether the associations differed when the measures were administered in cross-sectional versus prospective approaches (UAS and ELSA measured reasoning two years after the

Table 1. Descriptive statistics for each sample with verbal Reasoning.

Variable	HRS	UAS	CogUSA	CFAS	WLSG	WLSS	PSID
Age (years)	67.40 (10.70)	47.62 (15.49)	64.54 (10.59)	75.91 (6.48)	64.31 (.68)	63.91 (6.92)	50.05 (14.16)
Age range	18–104	17–98	38–94	67–99	63–67	40–87	30–97
Gender (female)	60%	57%	56%	52%	54%	54%	56%
Education (years)	12.99 (2.94)	11.06 (2.26)	14.26 (2.32)	11.88 (2.79)	13.74 (2.33)	13.52 (2.40)	14.07 (2.22)
Race (white)	76%	82%	89%	100%	100%	100%	66%
Race (African American/Black)	17%	8%	6%	–	–	–	30%
Race (other/unknown)	7%	10%	5%	–	–	–	4%
Verbal Reasoning	503.49 (29.35)[a]	50.46 (8.73)[b]	511.26 (26.76)[a]/54.96 (9.66)[c]	6.65 (1.48)[d]	6.64 (2.36)[d]	6.70 (2.35)[d]	3.88 (1.37)[e]
N	13,398	5,800	1,212	2,092	5,924	3,120	7,631

Note. Numbers are means (standard deviations) or percentages. HRS = Health and Retirement Study. UAS = Understanding America Study. CogUSA = Cognition and Aging in the USA. CFAS = Cognitive Function and Aging Study in Wales. WLSG = Wisconsin Longitudinal Study Graduate sample. WLSS = Wisconsin Longitudinal Study Sibling sample. PSID = Panel Study of Income Dynamics. [a] W-score based on IRT-parameters developed in HRS. [b] IRT score based on difficulty of the items. [c] Expressed as a T-score. [d] Sum of points across items. [e] Sum of correct responses.

Table 2. Descriptive statistics for each sample with numeric reasoning.

Variable	HRS	UAS	CogUSA	MIDUS	US	PSID	ELSA
Age (years)	67.01 (10.55)	47.63 (15.54)	64.42 (10.56)	56.36 (12.31)	46.41 (17.78)	50.05 (14.16)	65.54 (8.98)
Age range	27–99	17–98	38–94	32–84	16–100	30–97	29–99
Gender (female)	60%	57%	55%	55%	56%	56%	55%
Education	13.25 (2.71)[a]	11.68 (9.14)[a]	14.27 (2.33)[a]	7.29 (2.54)[b]	3.87 (1.62)[c]	14.07 (2.22)[a]	4.28 (2.20)[d]
Race (white)	77%	82%	90%	89%	88%	66%	100%
Race (African American/ Black)	16%	8%	5%	3%	3%	30%	–
Race (other/unknown)	7%	10%	5%	4%	3%	4%	–
Race (Asian)	–	–	–	–	6%	–	–
Race (Biracial)	–	–	–	4%	2%	–	–
Numeric Reasoning	521.85 (31.46)[e]	50.68 (9.14)[f]	519.68 (23.27)[e]	2.29 (1.52)[g]	530.50 (31.17)[e]	.70 (.24)[g]	535.76 (27.12)[e]
N	12,476	6,025	1,207	3,622	38,315	7,631	7,112

Note. Numbers are means (standard deviations) or percentages. HRS = Health and Retirement Study. UAS = Understanding America Study. CogUSA = Cognition and Aging in the USA. MIDUS = Midlife in the United States. US = Understanding Society. PSID = Panel Study of Income Dynamics. ELSA = English Longitudinal Study of Aging. [a] Education in years. [b] Education on a scale from 1 (no school) to 12 (advanced or professional degree). [c] Education on a scale from 1 (no qualification) to 6 (degree). [d] Education on a scale from (no qualification) to 7 (degree). [e] W-score based on IRT-parameters developed in HRS. [f] IRT score based on difficulty of the items. [g] Sum of correct responses.

personality assessment), and, for numeric reasoning, whether the associations differed by scoring type (MIDUS and PSID used the sum of correct responses whereas the other studies used an IRT-based score because items were adaptive across the blocks). Neither of these moderators was pre-registered.

Finally, we tested whether the association between personality and each type of reasoning was moderated by age or gender. Within each sample, an interaction between each of the traits and the demographic factors was tested as a predictor of reasoning, in addition to the main effects (all continuous variables were centered within sample prior to analysis). We then meta-analyzed the interaction terms with a random-effects meta-analysis using the same approach as with the main effects. Sample scripts are posted with the OSF registration.

Results

Descriptive statistics for all study variables for each cohort for verbal and numeric reasoning are listed in Tables 1 and table 2, respectively. Table 3 shows the relation between personality and verbal reasoning. Consistent with our hypothesis and the literature on personality and verbal abilities (Noftle & Robins, 2007; Sutin, Stephan, Damian et al., 2019a), Openness had the strongest and most consistent association with performance on verbal reasoning tasks. This positive association was apparent in the meta-analysis and in every sample except for CFAS (which was positive but not statistically significant). Also consistent with our hypothesis, Neuroticism was associated with worse performance on verbal reasoning in the meta-analysis and in every sample except for the analogies task in CogUSA. It was surprising that Extraversion had a negative association with verbal reasoning in the meta-analysis and in most samples (HRS, UAS, WLSS, PSID). More surprising, however, was the inconsistency in the association between Conscientiousness and verbal reasoning. Overall, there was no association between

Table 3. Association between personality traits and verbal reasoning.

Sample	Verbal Reasoning		
	β	95% CI	*p*
		Neuroticism	
HRS (analogies)	−.061	−.075, −.046	<.000
UAS (analogies)	.039	.015, .063	.002
CogUSA (analogies)	.006	−.044, .056	.820
CogUSA (similarities)	−.077	−.124, −.030	.001
WLSG (similarities)	−.046	−.070, −.022	<.000
WLSS (similarities)	−.047	−.080, −.014	.005
CFAS (abstraction)	−.087	−.129, −.046	<.000
PSID (sentence completion)	−.021	−.042, −.001	.042
Meta-analytic partial *r*			
With CogUSA analogies	−.034	−.068, −.001	.046
With CogUSA similarities	−.045	−.080, −.011	.009
Heterogeneity			
Q (CogUSA analogies/ CogUSA similarities)	61.633/ 62.257	–	<.000/ <.000
I^2 (CogUSA analogies/ CogUSA similarities)	90.19/ 90.59	–	–
		Extraversion	
HRS (analogies)	−.028	−.042, −.014	<.000
UAS (analogies)	−.046	−.070, −.023	<.000
CogUSA (analogies)	−.033	−.083, .017	.196
CogUSA (similarities)	.031	−.016, .078	.196
WLSG (similarities)	−.015	−.039, .008	.206
WLSS (similarities)	−.038	−.071, −.006	.020
CFAS (abstraction)	.032	−.009, .074	.127
PSID (sentence completion)	−.042	−.062, −.022	<.000
Meta-analytic partial *r*			
With CogUSA analogies	−.030	−.048, −.013	.001
With CogUSA similarities	−.023	−.046, .001	.058
Heterogeneity			
Q (CogUSA analogies/ CogUSA similarities)	14.442/ 20.193	–	.025/ .004
I^2 (CogUSA analogies/ CogUSA similarities)	63.10/ 78.85	–	–
		Openness	
HRS (analogies)	.056	.041, .071	<.000
UAS (analogies)	.034	.010, .058	.005
CogUSA (analogies)	.107	.054, .159	<.000
CogUSA (similarities)	.140	.090, .189	<.000
WLSG (similarities)	.140	.115, .165	<.000
WLSS (similarities)	.158	.125, .192	<.000
CFAS (abstraction)	.038	−.004, .079	.076
PSID (sentence completion)	.073	.053, .093	<.000
Meta-analytic partial *r*			
With CogUSA analogies	.091	.054, .128	<.000
With CogUSA similarities	.096	.056, .137	<.000
Heterogeneity			
Q (CogUSA analogies/ CogUSA similarities)	64.453/ 70.097	–	<.000/ <.000
I^2 (CogUSA analogies/ CogUSA similarities)	92.05/ 93.33	–	–
		Agreeableness	
HRS (analogies)	.015	.000, .030	.047
UAS (analogies)	−.039	−.063, −.015	.001
CogUSA (analogies)	−.066	−.116, −.015	.011
CogUSA (similarities)	.018	−.030, .066	.457
WLSG (similarities)	−.012	−.036, .013	.348
WLSS (similarities)	−.035	−.069, −.002	.037
CFAS (abstraction)	−.063	−.105, −.021	.004
PSID (sentence completion)	.036	.016, .057	<.000

(*Continued*)

Table 3. (Continued).

Sample	Verbal Reasoning		
	β	95% CI	*p*
		Neuroticism	
Meta-analytic partial *r*			
With CogUSA analogies	−.021	−.051, .010	.188
With CogUSA similarities	−.010	−.039, .018	.482
Heterogeneity			
Q (CogUSA analogies/ CogUSA similarities)	46.382/ 40.837	–	<.000/ <.000
I^2 (CogUSA analogies/ CogUSA similarities)	88.04/ 85.97	–	–
		Conscientiousness	
HRS (analogies)	.031	.016, .045	<.000
UAS (analogies)	−.029	−.053, −.005	.017
CogUSA (analogies)	−.045	−.095, .005	.078
CogUSA (similarities)	−.012	−.059, .035	.616
WLSG (similarities)	−.028	−.051, −.004	.020
WLSS (similarities)	−.051	−.084, −.019	.002
CFAS (abstraction)	.018	−.023, .059	.388
PSID (sentence completion)	.034	.014, .054	.001
Meta-analytic partial *r*			
With CogUSA analogies	−.008	−.039, .022	.585
With CogUSA similarities	−.004	−.033, .024	.763
Heterogeneity			
Q (CogUSA analogies/ CogUSA similarities)	51.737/ 48.349	–	<.000/ <.000
I^2 (CogUSA analogies/ CogUSA similarities)	87.84/ 86.31	–	–

Note. *df* for each meta-analysis = 7. For Q and I^2, coefficients before the "/" are for analogies and coefficients after the "/" are for similarities. Total *N* for the meta-analysis = 39,177/39,169 (analogies/similarities); N = 13,398 for HRS; N = 5,800 for UAS; N = 1,212/1,204 for CogUSA (analogies/similarities); N = 5,924 for WLSG; N = 3,120 for WLSS; N = 2,092 for CFAS; N = 7,631 for PSID. Regression coefficients are standardized betas from a linear regression predicting verbal reasoning from each personality trait, controlling for age, gender, education, and race (and mode of administration in PSID). HRS = Health and Retirement Study. UAS = Understanding America Study. CogUSA = Cognition in the United States. WLSG = Wisconsin Longitudinal Study Graduate sample. WLSS = Wisconsin Longitudinal Study Sibling sample. CFAS = Cognitive Function and Aging Study in Wales. PSID = Panel Study of Income Dynamics.

Conscientiousness and verbal reasoning in the meta-analysis due to inconsistencies across the samples. There was the expected positive association in some cohorts (HRS, PSID) and unexpected null (CogUSA similarities, CFAS) and negative (UAS, CogUSA analogies, WLSG, WLSS) associations in other cohorts. The association between Agreeableness and verbal reasoning was mixed across studies and the overall meta-analytic association was null. Across the five traits, the same pattern was apparent for the meta-analysis with CogUSA analogies and CogUSA similarities.

Table 4 shows the relation between personality and numeric reasoning. As expected, Neuroticism had a negative association with numeric reasoning that was apparent in the meta-analysis and in every cohort except UAS. Although unexpected, Extraversion was associated fairly consistently with lower numeric reasoning: Higher Extraversion was associated with worse performance on the numeric reasoning task in the meta-analysis and in the HRS, MIDUS, and UAS (and a negative association in the other samples, even if not significant). The associations with the other three traits were more varied. The meta-analysis suggested a small positive association between Conscientiousness and numeric reasoning that was apparent in HRS, MIDUS, US, PSID, and ELSA. The associations between both Openness and Agreeableness and numeric reasoning varied across samples and the

Table 4. Association between personality traits and numeric reasoning.

Sample	Numeric Reasoning		
	β	95% CI	*P*
		Neuroticism	
HRS	−.068	−.083, −.053	<.000
UAS	−.007	−.030, .016	.532
CogUSA	−.079	−.123, −.034	<.001
PSID	−.063	−.084, −.042	<.000
MIDUS	−.078	−.107, −.049	<.000
US	−.027	−.037, −.018	<.000
ELSA	−.042	−.064, −.021	<.000
Meta-analytic partial *r*	−.057	−.080, −.033	<.000
Heterogeneity			
Q	48.074	–	<.000
I^2	87.95	–	–
		Extraversion	
HRS	−.031	−.046, −.017	<.000
UAS	−.083	−.105, −.060	<.000
CogUSA	−.028	−.073, .017	.218
PSID	−.016	−.036, .004	.110
MIDUS	−.038	−.067, −.009	.010
US	−.006	−.016, .003	.169
ELSA	−.012	−.033, .009	.269
Meta-analytic partial *r*	−.034	−.057, −.012	.003
Heterogeneity			
Q	44.607	–	<.000
I^2	86.93	–	–
		Openness	
HRS	.040	.025, .055	<.000
UAS	−.017	−.040, .006	.141
CogUSA	.023	−.024, .070	.344
PSID	.003	−.017, .023	.743
MIDUS	.000	−.030, .029	.984
US	.038	.029, .047	<.000
ELSA	.000	−.021, .022	.987
Meta-analytic partial *r*	.015	−.005, .035	.138
Heterogeneity			
Q	36.284	–	<.000
I^2	82.43	–	–
		Agreeableness	
HRS	.008	−.007, .023	.296
UAS	−.026	−.049, −.003	.024
CogUSA	−.038	−.083, .007	.099
PSID	.021	.001, .041	.041
MIDUS	−.043	−.073, −.013	.005
US	−.007	−.016, .003	.167
ELSA	−.033	−.055, −.012	.003
Meta-analytic partial *r*	−.015	−.035, .005	.135
Heterogeneity			
Q	26.770	–	<.000
I^2	83.07	–	–
		Conscientiousness	
HRS	.034	.019, .049	<.000
UAS	−.013	−.035, .010	.282
CogUSA	−.025	−.070, .020	.270
PSID	.028	.008, .048	.006
MIDUS	.031	.002, .060	.034
US	.011	.001, .020	.025
ELSA	.034	.013, .056	.002
Meta-analytic partial *r*	.020	.003, .037	.021
Heterogeneity			
Q	21.810	–	.001
I^2	75.39	–	–

Note. df for each meta-analysis = 7. Total *N* for the meta-analysis = 76,388; N = 12,476 for HRS; N = 6,025 for UAS; N = 1,207 for CogUSA; N = 7,631 for PSID; N = 3,622 for MIDUS; N = 38,315 for US; N = 7,112 for ELSA. Regression coefficients are standardized betas from a linear regression predicting numeric reasoning from each personality trait, controlling for age, gender, education, and race (and mode of administration in PSID). HRS = Health and Retirement Study. UAS = Understanding America Study. CogUSA = Cognition in the United States. PSID = Panel Study of Income Dynamics. MIDUS = Midlife in the United States. US = Understanding Society. ELSA = English Longitudinal Study of Aging.

meta-analysis indicated no overall association between these two traits and numeric reasoning.

The meta-regressions suggested that few associations varied by characteristics of the sample or design for either verbal reasoning (Supplemental Table S1) or numeric reasoning (Supplemental Table S2). For verbal reasoning, the negative association with Neuroticism was stronger in samples over the age of 60 than in samples younger than 60. Moreover, the positive association with Openness was stronger when verbal reasoning was measured with similarities than with other verbal reasoning tasks (although still significant with the other verbal tasks). For numeric reasoning, the association between Conscientiousness and numeric reasoning was stronger for studies that used the MIDI compared to the BFI. Finally, there was a difference between the UAS sample (the sample with personality measured two years prior to the assessment of reasoning) and the other samples for Neuroticism and verbal reasoning, such that the association was positive in this sample and negative across the other samples. There was also a small difference between the prospective studies for Openness and numeric reasoning: the associations were weaker in these prospective studies than the cross-sectional studies. There was not, however, any differences for the other traits for either measure of reasoning. There was also no difference between studies that used an IRT-based score versus raw score for numeric reasoning.

There was likewise not consistent evidence that the associations were moderated by age or gender. In the individual studies, there were few interactions and none that replicated in more than two cohorts for either verbal reasoning (Supplemental Table S3) or numeric reasoning (Supplemental Table S4). There was, however, modest evidence from the meta-analytic results that some of the associations were moderated by sex. Specifically, there was an interaction between sex and Extraversion (meta-analytic partial $r = .014$, 95% CI = .006, .021, $p < .001$) and sex and Openness (meta-analytic partial $r = -.011$, 95% CI = −.018, −.003, $p = .004$) on numeric reasoning that indicated that the associations for these traits were stronger among males than females. For verbal reasoning, the negative association between Extraversion and verbal reasoning, as measured by similarities, was stronger among males than females (meta-analytic partial $r = .024$, 95% CI = .005, .044, $p = .013$). This pattern was seen in the overall meta-analysis for verbal reasoning when CogUSA similarities were included (meta-analytic partial $r = .014$, 95% CI = .000, .028, $p = .043$) but not when CogUSA analogies (meta-analytic partial $r = .011$, 95% CI = −.005, .026, $p = .188$) was included or when the meta-analysis was limited to verbal reasoning measured by analogies (meta-analytic partial $r = -.007$, 95% CI = −.021, .007, $p = .327$). Further, the negative association between Conscientiousness and verbal reasoning was apparent for males but not females for both the meta-analysis with CogUSA analogies (meta-analytic partial $r = .014$, 95% CI = .003, .024, $p = .009$) and CogUSA similarities (meta-analytic partial $r = .016$, 95% CI = .004, .027, $p = .006$) but was only apparent in the meta-analysis on similarities (meta-analytic partial r= .034, 95% CI = .014, .053, p= .001), not analogies (meta-analytic partial r= .006, 95% CI = −.007, .020, p= .356). None of the interactions between the traits and age was significant in the meta-analysis for either verbal or numeric reasoning.

Discussion

The present research examined the association between FFM personality traits and verbal and numeric reasoning in seven samples. Consistent with our hypotheses, higher Neuroticism was associated with lower reasoning in both domains. Partly consistent with our hypotheses, higher Openness was associated with higher verbal reasoning (expected) but was unrelated to numeric reasoning (unexpected). Surprisingly, and inconsistent with our hypotheses, Extraversion was associated with lower reasoning in both domains and, despite a small positive association with numeric reasoning, Conscientiousness was essentially unrelated to reasoning. Finally, as expected, Agreeableness was unrelated to either type of reasoning. These findings inform theoretical models of how personality traits contribute to performance on tasks that measure more complex cognitive skills.

Our pre-registered hypothesis for Neuroticism was that higher Neuroticism would be associated with lower scores on the reasoning tasks. This hypothesis was supported by both verbal and numeric reasoning. Theories of Neuroticism indicate that individuals high on this trait are anxious, self-conscious, and prone to stress (Shiner, 2019) and that there should be downstream associations because of these tendencies (Lahey, 2009). In the context of reasoning, these tendencies may interfere with the ability to perform the tasks. That is, individuals higher in Neuroticism tend to be self-conscious (Costa & McCrae, 1992; Eldesouky & English, 2018) and their performance may suffer when completing tasks with an interviewer. With few exceptions (e.g., UAS), the reasoning task was administered by an interviewer in each study, and the participant was required to verbally answer the items. Anxiety might interfere with the cognitive flexibility required to perform the task well, especially in front of another person. In addition to interfering with task performance, the lifelong tendency to experience more intense negative emotions, poor coping skills, and heightened vulnerability to stress may have detrimental effects on brain health. High Neuroticism, for example, is associated with lower levels of brain-derived neurotropic factor (Terracciano et al., 2011) and with markers of neurodegeneration (Jackson et al., 2011). By undermining brain health, neuroticism is likely to contribute to the individual differences in performance observed in this study. This negative association is also consistent with previous research on verbal (Olivo et al., 2019) and numeric (Sutin, Stephan, Damian et al., 2019b) reasoning, as well as the larger literature on Neuroticism and cognitive function (Curtis et al., 2015). Individuals higher in Neuroticism tend to perform worse on tasks that measure basic cognitive functions (Curtis et al., 2015; Sutin, Stephan, Damian et al., 2019b); the present research indicates that this association extends to more complex cognitive functions, such as reasoning. Overall, the negative association between Neuroticism and both verbal and numeric reasoning support our hypothesis and is consistent with both theoretical accounts of Neuroticism and previous empirical research on this trait.

Our pre-registered hypothesis for Openness was that higher Openness would be associated with higher scores on both verbal and numeric reasoning. Openness is defined within models of personality as mental flexibility, interest in knowledge, and creativity (DeYoung, 2014). Such characteristics may be associated with better performance on reasoning tasks. Support for our hypothesis, however, was mixed: Of the five personality traits, Openness was the trait most strongly associated with verbal reasoning but was unrelated to numeric reasoning. The association with better verbal reasoning is consistent with the broader literature on Openness and verbal abilities (Bergold & Steinmayr, 2018; Noftle & Robins, 2007). The verbal abilities associated with Openness can be seen across the lifespan in the abilities and interests of individuals high in this trait. Elementary school children high in Openness, for example, score higher on tests of verbal abilities and are perceived by their parents and teachers to have higher reading and writing skills (Lamb et al., 2002) and show higher school competency in middle school (Herzhoff & Tackett, 2012). Openness is associated with higher SAT verbal scores in adolescence (Noftle & Robins, 2007), with owning more and varied books and magazines in young adulthood (Gosling et al., 2002), and with more time spent engaged in reading and writing activities in middle and older adulthood (Stephan et al., 2014). This engagement with verbal activities likely supports better verbal reasoning skills across adulthood. In addition, the definition of Openness includes greater cognitive flexibility and ability to manipulate information (Costa & McCrae, 1992) that may support their ability to reason with verbal information. Critically, and contrary to our expectations, this association does not extend to numeric reasoning. Individuals higher in Openness may be particularly adept at using their flexibility for verbal material, an ability that does not apply to the ability to manipulate numbers. This distinction may be critical, as it suggests that individuals higher in Openness do not have the ability to flexibly manipulate all information. Rather, it appears to be more domain specific, specifically for verbal material that individuals higher in Openness may be able to manipulate because they have a lifetime of experience of engagement with this type of information (i.e., reading, writing, etc.). As such, our hypothesis for Openness was supported for verbal reasoning but not for numeric reasoning.

Our pre-registered hypothesis for Extraversion was that higher Extraversion would be associated with higher scores on verbal reasoning and be unrelated to scores on numeric reasoning. This hypothesis was based on the theoretical account of the verbosity associated with this trait: Individuals high on Extraversion talk a lot (Mehl et al., 2006). We had thus expected that this characteristic of Extraversion may translate into better verbal reasoning. This hypothesis was also based on empirical evidence that Extraversion is associated with other aspects of verbal ability, namely verbal fluency (Sutin, Stephan, Damian et al., 2019a): Individuals higher in Extraversion are able to generate more words in verbal fluency tasks than individuals lower on this trait. The positive association with fluency apparently does not extend to reasoning. Individuals high in Extraversion are fast paced (Armon & Shirom, 2011) and tend to talk quickly (Mairesse et al., 2007), which may lead them to respond with the first answer they think of rather than thinking through whether it is correct or not. The pattern with verbal fluency suggests that introverts are slower at producing words, but the slower pace may help them outperform extroverts at analyzing more complex tasks and inferring the correct responses. The negative association between Extraversion and reasoning also extends to numeric reasoning. This consistency may be for similar reasons: Individuals higher in Extraversion may respond quickly without evaluating accuracy for material that is either verbal or numeric. The results of this research thus do not support our hypothesis but do suggest the contours of the relation between Extraversion and verbal abilities: Higher Extraversion is associated with greater ability to produce specific words (i.e., higher verbal fluency) but higher introversion is associated with a better ability to manipulate material (i.e., higher reasoning).

Our pre-registered hypothesis for Conscientiousness was that higher Conscientiousness would be associated with higher scores on both verbal and numeric reasoning. This hypothesis was based on both theoretical accounts of this trait that link it to greater deliberation (McCrae & Costa, 2008; Roberts et al., 2014) and empirical evidence that Conscientiousness tends to be associated with better cognitive function (Chapman et al., 2017; Sutin, Stephan, Damian et al., 2019b). Surprisingly, the pattern of associations for Conscientiousness largely did not support our hypothesis. Reasoning requires both knowledge and flexibility in thought to find connections between concepts (Krawczyk, 2012). Conscientiousness has a certain rigidity that is helpful in some situations (e.g., sticking to an exercise schedule) but not in others (e.g., flexibility in thought) that may impair performance on tasks that require flexibility. Although Conscientiousness tends to be associated with better memory (Chapman et al., 2017) and verbal fluency (Sutin, Stephan, Damian et al., 2019a), as well as a lower risk of cognitive impairment (Duchek et al., 2020; Terracciano et al., 2017), this positive association may not apply to more complex functions that involve flexibility and manipulation of information rather than basic cognitive processes. The protective effect of Conscientiousness on cognitive aging is thus likely due to pathways other than through reasoning. The literature on Conscientiousness and specific cognitive functions is more mixed in younger adulthood (Soubelet & Salthouse, 2011), and it may be the healthy lifestyle and engagement in cognitively stimulating activities that help individuals higher in Conscientiousness maintain better function in older adulthood. The inconsistencies in the association between Conscientiousness and reasoning were more apparent for verbal reasoning than numeric reasoning. The reason for this inconsistency is not clear, as the moderator analysis indicated that the differences were not due to the tasks used to assess verbal reasoning measures or age differences. Individuals higher in Conscientiousness may be less adept at divergent thinking (Puryear et al., 2017) and have less of the ability to think abstractly that is needed for the similarities task. Thus, overall, the results from this study did not support our hypothesis that Conscientiousness would be associated with better performance on reasoning tasks.

There was little evidence of moderators, either from the meta-regressions or the participant-level moderation analysis. There was some evidence of an effect of age on the relation between Neuroticism and verbal reasoning. That is, the negative association was somewhat stronger among samples with a mean age over 60 (meta-regressions). This pattern suggests a cumulative effect where the negative association with reasoning grows stronger with age. Not all samples showed this association, however, and thus this pattern should be interpreted with caution until replicated. There was some indication of differences across personality measures and by type of verbal reasoning measure, but these moderators were not generally apparent across traits. Finally, the interactions tested in the participant-level analyses were few and generally not significant and did not replicate across the samples. This pattern suggests that the associations found between personality and both reasoning tasks are similar across gender and age.

The present study had several strengths, including the inclusion of several large-sample cohorts, validated measures of FFM personality traits in all samples, and tasks that measured reasoning in verbal and numeric domains. There are also some limitations to consider. First, the data are cross-sectional. We could not address temporal associations with such data (e.g., personality may help maintain and increase reasoning ability across adulthood and/or reasoning skills may contribute to personality development across adulthood). Cross-sectional and longitudinal associations may also address slightly different issues related to the nature of the relation between personality and reasoning. Cross-sectional associations, for example, may help to address the importance of personality and verbal reasoning in the case of medication adherence, whereas longitudinal associations can better address how personality-cognitive ability relations unfold over time and across age groups. Second, several tasks were used to measure verbal reasoning, which may have contributed to the heterogeneity across studies. Future work would benefit from using multiple tasks to assess verbal reasoning. Third, our reasoning tasks were limited to verbal and numeric reasoning. Future work could examine the association between personality and reasoning measured with other types of tasks, such as Block design or progressive matrices. Finally, most of the samples were middle aged and older with few that included sufficient numbers of younger adults. Larger sample of younger adults is needed to test whether similar associations emerge in younger adulthood.

Despite these limitations, one strength of the present research is the use of multiple large samples to identify patterns of associations between the five major personality traits and reasoning abilities. With the multiple samples, replicable associations can be separated from associations that may be sample specific and/or chance findings. Even with some variability across studies, there was evidence that higher Neuroticism and higher Extraversion are associated with worse performance on tasks that measure verbal and numeric reasoning and that Openness is associated with better performance on verbal reasoning tasks. And, surprisingly, the protective association of Conscientiousness on cognitive function across adulthood does not extend to reasoning. Future studies need to compare different pathways (e.g., health versus intellectual behaviors) to disentangle the association of conscientiousness with broader versus more complex cognitive abilities.

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