Five-Factor Model Personality Traits and Verbal Fluency in 10 Cohorts

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Personality traits, such as Neuroticism and Conscientiousness, are associated with cognitive outcomes across the life span, including cognitive function in young adulthood and risk of cognitive impairment and dementia in old age. Research on personality and age-related cognition has focused primarily on memory-related tasks and outcomes. The purpose of this research is to address the relation between Five Factor Model personality traits and another critical marker of cognitive function that has received less attention—verbal fluency. We examine this relation across adulthood in 10 cohorts (11 samples) that totaled more than 90,000 participants (age range 16–101). Participants in all samples reported on their personality traits and completed at least one fluency task (semantic and/or letter). A meta-analysis of semantic fluency ($N = 86,044$) indicated that participants who scored lower in Neuroticism, and higher in Extraversion, Openness, and Conscientiousness, retrieved more words, independent of age, gender, and education. These associations generally replicated for the letter fluency task (3 samples; $N = 11,551$). Moderation analysis indicated that the associations between personality and semantic fluency were stronger in older samples (except for Openness) and among individuals with lower education. This pattern suggests that these associations are stronger in groups vulnerable to severe cognitive impairment. Personality traits have pervasive associations with fluency tasks that are replicable across samples and age groups.

Keywords: semantic fluency, letter fluency, cognition, Big Five, nuances

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Life Span models of personality and health recognize that the processes associated with personality traits start early in life and unfold across the life span (Friedman, Kern, Hampson, & Duckworth, 2014). These processes contribute to engagement in health-related behaviors and physiological regulation that can either promote or harm health with age. Childhood Conscientiousness, for example is theoretically predicted to promote healthier behaviors, such as more frequent physical activity and reduced risk of smoking in young adulthood, which in turn predict better health outcomes in middle adulthood and, ultimately, greater longevity (Hampson, Edmonds, Goldberg, Dubanoski, & Hillier, 2013; Hampson, Goldberg, Vogt, & Dubanoski, 2006). Although often referred to in the context of longevity, life span models of personality and health are relevant for other important outcomes, including cognition. One important step toward life span models of personality and health in the context of cognition is to examine intermediate markers of cognitive function to better understand the role of personality traits as risk factors for significant cognitive impairments. Theoretical models of personality and dementia suggest that individual differences in personality may predispose an individual to Alzheimer's disease and related dementias (Segerstrom, 2018). This association between personality and cognition is theorized to be apparent across the life span and culminate in dementia risk in old age.

Cognitive function tends to follow a normative trajectory across the life span (Salthouse, 2010). In adulthood, functions related to speed tend to decline the most, whereas functions that tap in to crystalized functions tend to remain intact into older adulthood (Salthouse, 2018). These trajectories are, in part, due to normative changes that occur naturally in the brain with age. Theories of cognitive aging, however, also suggest that decline is not inevitable: Individuals may develop compensatory processes that help offset brain-related deficits that undermine performance (Baltes, Lindenberger, & Staudinger, 2006). Inherent in this argument is the notion that there are individual differences in the rate of cognitive decline and individual differences in how and how well individuals compensate for these losses. This perspective suggests that factors other than brain aging may contribute to individual differences in cognitive function, with effects that accumulate over the life span. We integrate these two theories to take an individual differences approach that seeks to identify how relatively stable individual differences in Five Factor Model (FFM; McCrae & John, 1992) personality traits are associated with performance on a specific cognitive task (verbal fluency) across adulthood and whether these associations become stronger with age.

Empirically, FFM personality traits are associated consistently with significant cognitive impairments in older adulthood, including Alzheimer's disease (Duberstein et al., 2011; Terracciano et al., 2014; Wilson, Schneider, Arnold, Bienias, & Bennett, 2007) and other dementias (Sutin, Stephan, & Terracciano, 2018; Terracciano, Stephan, Luchetti, Albanese, & Sutin, 2017). Even before dementia, personality is associated with several aspects of cognitive function. Individuals who score higher in Conscientiousness, the tendency to be organized, disciplined, and responsible, tend to perform better on objective memory tasks and have better subjective memory than individuals who score lower on this trait (Hülür, Hertzog, Pearman, & Gerstorf, 2015). In contrast, individuals higher in Neuroticism, the tendency to experience negative emotions and vulnerability to stress, tend to perform worse on tasks that measure cognition (Graham & Lachman, 2014; Munoz,

Sliwinski, Smyth, Almeida, & King, 2013; Wettstein, Tauber, Kuźma, & Wahl, 2017). Openness (the tendency to be creative and unconventional) tends to be associated with better performance on a range of cognitive tasks, such as verbal and spatial ability (Sharp, Reynolds, Pedersen, & Gatz, 2010), whereas the association between Extraversion (the tendency to be sociable) and specific cognitive functions tends to be mixed (Curtis, Windsor, & Soubelet, 2015). Agreeableness (the tendency to be trusting and compassionate) tends to be unrelated to cognition.

The relation between personality and cognition with age tends to be most studied in the context of either significant cognitive impairment (Kaup, Harmell, & Yaffe, 2019) or tasks that measure a specific domain, such as memory (Allen, Laborde, & Walter, 2019). Cognitive tasks that require the integration of multiple cognitive functions may be particularly important to study as a marker of cognitive aging because they may help identify individuals who are at risk of poor cognitive outcomes earlier in adulthood before the onset of impairment. Such integrative tasks are critical for life span models of personality and cognition because they tend to change more with age and may thus provide an intermediate marker for risk for cognitive impairment. Verbal fluency, the ability to produce correct examples from a specific category, is such a task. It is among the most common cognitive tasks used in research and clinical settings (Lezak, 2004). The task typically used to measure fluency is simple to administer (e.g., the number of words retrieved from a specific category such as animals or letters such as "s") but requires activation of a number of cognitive processes to complete (Troyer, Moscovitch, & Winocur, 1997). First, individuals rely on their verbal knowledge to produce numerous examples of a given category. Second, individuals must inhibit similar words that are from different semantic categories. Third, individuals must monitor and remember the words that they already said to not repeat themselves. Finally, this process must be done quickly to produce as many correct words as possible within a short period of time.

Verbal fluency follows a normative trajectory across the adult life span. Performance typically increases from adolescence through middle adulthood and then starts to decline in early old age (Buczylowska & Petermann, 2016). In addition to the patterns associated with normal aging, some research has documented deficits in fluency with Alzheimer's disease (Henry, Crawford, & Phillips, 2004) and Parkinson's disease (McDowd et al., 2011), and fluency is also used sometimes to help differentiate between types of dementia (Yoon, Lee, Yong, Moon, & Lee, 2014). Performance on a verbal fluency task is also predictive of incident dementia among individuals with no cognitive impairment at baseline (Sutin, Stephan, & Terracciano, 2019). As such, this task is a useful marker of cognitive function across the life span and is predictive of critical aging outcomes in older adulthood. And, since it includes an element of verbal ability, performance on it should be more susceptible to factors other than biology.

Based on the Five Factor Theory (McCrae & Costa, 2003), the basic tendencies associated with the traits may contribute to performance on the verbal fluency task. Individuals higher in Neuroticism, for example, tend to be self-conscious and anxious about how they are evaluated by others (Eldesouky & English, 2018), which may be heightened by having to perform for the tester administering the fluency task. This self-monitoring may slow performance and lead to a negative association between this trait and fluency. Extraversion, in contrast, is a trait defined, in part, by

verbosity: Individuals high in Extraversion talk a lot (Mehl, Gosling, & Pennebaker, 2006). This verbal ease may contribute to a positive association between this trait and fluency. Cognitive exploration is a core part of Openness (DeYoung, 2014), and this tendency toward exploration helps build the verbal knowledge needed to perform well on the fluency task. Finally, individuals high in Conscientiousness tend to be more organized in their thoughts as well as in their belongings than individuals low on this trait (McCrae & Costa, 2003). Such organization may help to perform well on this task since both successful production and inhibition are necessary for the task. These traits may also act through behavioral and physiological pathways. Higher Conscientiousness, Extraversion, and Openness, and lower Neuroticism, for example, are associated with health-promoting behaviors, such as physical activity (Artese, Ehley, Sutin, & Terracciano, 2017; Sutin et al., 2016) and cardiovascular fitness (Terracciano et al., 2013), which are beneficial for cognition (Hötting & Röder, 2013). Higher Conscientiousness is also associated with healthier weight across the life span (Sutin et al., 2018) that may help promote healthier cognitive outcomes in old age (Kivimäki et al., 2018). There is no clear reason why Agreeableness should be associated with verbal fluency.

We previously investigated the relation between personality traits and verbal fluency in a large sample of rural Italians ($N = 4,790$; Sutin et al., 2011). Consistent with the association between Neuroticism and worse cognitive performance and risk of cognitive decline (Luchetti, Terracciano, Stephan, & Sutin, 2016), individuals who scored higher on Neuroticism retrieved fewer words. In addition, individuals who scored higher in Extraversion or higher in Openness were able to produce more words. There was no association with Conscientiousness, which was surprising given that individuals who score higher in Conscientiousness tend to perform better on some cognitive tasks (Hülür et al., 2015). There was evidence, however, that this association was moderated by education. Specifically, Conscientiousness had a positive association with fluency at lower levels of education that was not apparent at higher levels of education. This pattern suggests that Conscientiousness may help compensate for a vulnerable educational background, which is consistent with previous findings on a representative sample of more than 80,000 individuals in the United States (Damian, Su, Shanahan, Trautwein, & Roberts, 2015) and broadly consistent with the idea that psychological processes can compensate for vulnerability to poor cognitive outcomes.

Subsequent studies that have included measures of personality and fluency have found somewhat mixed results. In a small sample of a young adults ($N = 182$), for example, the negative association with Neuroticism and the positive association with Openness replicated, but there was no association with Extraversion (Murdock, Oddi, & Bridgett, 2013). In another small sample of undergraduate students ($N = 103$), there were no relations between any of the traits and fluency (Buchanan, 2016). Furthermore, in older adulthood, one study ($N = 179$) found the expected positive association with Openness and Conscientiousness and the expected negative association with Neuroticism, but no relation with Extraversion (Chapman et al., 2017). These differences may be due, in part, to small sample sizes and/or the composition of the samples (e.g., age).

Through integration of models of personality and health and cognitive aging, the present study examines the association between personality traits and verbal fluency in 11 samples from 10 cohorts that collectively have >90,000 participants who range in age from 16 to 101. All samples are from large-scale longitudinal studies with public data. Use of such data in an Integrative Data Analysis (IDA) has been called for to increase replicability, reproducibility, and rigor in research (Hofer & Piccinin, 2009, 2010). Pooled analysis is one IDA approach, similar to coordinated analysis, in which effects are estimated separately within each sample and then synthesized using meta-analytic techniques (Hofer & Piccinin, 2010). Such an approach has been used successfully for identifying replicable associations between personality and mortality (Graham et al., 2017; Jokela et al., 2013). In the present research, we summarize age differences in verbal fluency, test the association between personality and fluency individually in each sample, and synthesize the results for semantic fluency in a meta-analysis. In each sample, we also test whether the associations between personality and semantic fluency are moderated by demographic characteristics. Specifically, we test age as a moderator because of differences in the relation between personality and fluency across younger (Buchanan, 2016) and older (Chapman et al., 2017) samples and gender as a moderator because of gender differences in both fluency (Weiss et al., 2006) and personality (Costa, Terracciano, & McCrae, 2001). Furthermore, we test education as a moderator because the resource substitution hypothesis suggests that individual differences are stronger predictors of achievement outcomes at lower socioeconomic status (Damian et al., 2015; Shanahan, Bauldry, Roberts, Macmillan, & Russo, 2014); we extend this hypothesis to personality and examine whether it is a stronger predictor of verbal fluency at lower levels of education.

Method

Participants were from 11 samples drawn from 10 large-scale cohort studies with data that are publicly available (see below). Each cohort included a validated measure of FFM personality traits and had a standard measure of verbal fluency (see below). All participants who had the necessary data available were included in the analysis in each study. The Institutional Review Board at the Florida State University approved this research (protocol #IRB00000446, "Secondary Data Analysis of Public Health Databases"). In each sample, we selected participants who had relevant and valid data on personality, verbal fluency, and the demographic covariates. There were no exclusion criteria. Except where noted in the study descriptions below (the SOEP sample), personality and verbal fluency were assessed in the same wave in each sample. As such, the analyses across the samples were cross-sectional, with the exception of a 1-year prospective analysis. Descriptive statistics for study variables for each sample are shown in Table 1.

Participants and Procedure

US. Understanding Society (US) is a large-scale longitudinal study of the health and well-being of households in the United Kingdom. Participants aged 16 and older were administered the verbal fluency task and filled out a self-completion questionnaire

Table 1

Demographic Characteristics of Each Sample

Characteristic	US	HRS	ELSA	WLSG	WLSS	NCDS	CogUSA	SOEP	NSHAP	MIDUS	CFAS
Age (years)	46.79 (17.94)	66.66 (11.13)	66.23(9.35)	71.17 (.90)	63.84 (6.96)	58	64.53 (10.60)	51.82(16.77)	72.89 (7.24)	56.39 (12.31)	75.94 (6.49)
Age range	16–100	27–101	29,90	70–74	44–92	58	38–94	17–95	62–91	32–84	67–99
Gender (female)	56%	59%	56%	54%	54%		56%		53%	56%	52%
Education	3.81 (1.65)[b]	12.91 (2.98)[a]	4.12 (2.24)[c]	13.88 (2.38)[a]	13.54 (2.41)[a]	2.39 (1.76)[d]	14.26 (2.32)[a]	11.86 (2.66)[a]	2.70 (1.03)[e]	7.29 (2.54)[e]	11.85 (2.78)[a]
Race (white)	85%	77%	100%	100%	100%	100%	89%	100%	82%	90%	100%
Race (African American/ Black)	4%	16%	—	—	—	—	6%	—	12%	3%	—
Race (other/unknown)	3%	7%	—	—	—	—	5%	—	—	3%	—
Race (Asian)	6%	—	—	—	—	—	—	—	6%	—	—
Race (Biracial)	2%	—	—	—	—	—	—	—	—	4%	—
Hispanic ethnicity	—	11%	—	—	—	—	1%	—	9%	3%	—
Verbal Fluency (Category)	21.85 (6.80)	17.50 (7.22)	21.19 (6.66)	19.88 (5.94)[g]	19.80 (5.89)[h]	22.61 (6.24)	25.90 (8.95)[i]	15.27 (10.79)	.49 (.50)	18.85 (6.16)	17.06 (5.51)
Verbal Fluency (Letter)	—	—	—	11.38 (4.14)	11.74 (4.51)	—	—	—	—	—	12.56 (5.18)
$r_{category\ fluency.age}$	−.17**	−.31**	−.30**	—	−.19**	—	−.37**	−.19**	−.14**	−.31**	−.31**
N	40,076	14,851	8,778	4,412	2,455	7,894	1,223	3,998	2,547	3,626	2,139

Note. Numbers are means (standard deviations) or percentages. US = Understanding Society; HRS = Health and Retirement Study; ELSA = English Longitudinal Study of Ageing; WLSG = Wisconsin Longitudinal Study Graduate sample; WLSS = Wisconsin Longitudinal Study Sibling sample; NCDS = National Child Development Study; CogUSA = Cognition and Aging in the USA; SOEP = German Socio-Economic Panel Study; NSHAP = National Social Life Health and Aging Project; MIDUS = Midlife in the United States; CFAS = Cognitive Function and Ageing Study in Wales.
[a] Education in years. [b] Education on a scale from 1 (no qualification) to 6 (degree). [c] Education on a scale from 1 (no qualification) to 7 (degree). [d] Education on a scale from 1 (no qualification) to 6 (higher degree). [e] Education on a scale from 1 (less than high school) to 4 (bachelor's or more). [f] Education on a scale from 1 (no school) to 12 (advanced or professor degree). [g] n = 2,204. [h] n = 1,255. [i] Performance reported as a p-score.
** $p < .01$.

that included a measure of personality at Wave 3 (collected between 2011 and 2013). Information on US and how to access the data can be found at https://www.understandingsociety.ac.uk/. A total of 40,076 participants had valid data on personality, verbal fluency, and the relevant demographic characteristics.

HRS. The Health and Retirement Study (HRS) is a longitudinal study of Americans aged 50 years and older and their spouse (regardless of age). Starting in 2006, a measure of FFM personality traits was included in the Leave-Behind Questionnaire. A random half of the HRS participants first completed the Leave-Behind Questionnaire in 2006; the other half completed it in 2008. Subsequently, participants completed the measure every four years. Verbal fluency was assessed at the 2010 and 2012 waves of HRS. Personality measured in the concurrent Leave-Behind Questionnaire in 2010 and 2012 was used in the analysis. Information on HRS and how to access the data can be found at http://hrsonline.isr.umich.edu/. Across the 2010 and 2012 waves of HRS, a total of 14,851 participants had valid data on personality, verbal fluency, and the relevant demographic characteristics.

ELSA. The English Longitudinal Study of Aging (ELSA) is a longitudinal study of the English population aged 50 years and older. Participants are reassessed every two years on a variety of measures of health and well-being. Personality traits and verbal fluency were assessed in ELSA at Wave 5 in 2010. Information on ELSA and how to access the data can be found at http://www.elsa-project.ac.uk/. A total of 8,778 participants had valid data on personality, verbal fluency, and the relevant demographic characteristics.

WLS. The Wisconsin Longitudinal Study was initiated with a random sample of individuals who graduated from a Wisconsin high school in 1957. This sample is referred to as the WLS-Graduate (WLSG) sample. In addition to the Graduate sample, a selected sibling of many of the graduates was recruited into the study. This sample is referred to as the WLS-Sibling (WLSS) sample. More information about both WLS samples and how to access the data can be found at http://www.ssc.wisc.edu/wlsresearch/. In both WLS samples, participants were administered up to two fluency tasks (letter, category; see below). In 2011, all participants in both samples were administered the letter fluency task, and a random 50% of both samples were also administered the category task. A total of 4,412 and 2,204 participants from the WLSG completed the letter task and the fluency task, respectively, and had valid data on personality and the relevant demographic characteristics available. A total of 2,455 and 1,255 participants from the WLSS completed the letter task and the category task, respectively, and had valid data on personality and the relevant demographic characteristics available.

NCDS. The National Child Development Study (NCDS) is a longitudinal study of people born during a single week in 1958 in England, Scotland, and Wales. Participants have been followed up nine times from birth through age 55. Personality traits and verbal fluency were both assessed in 2008 when participants were 50 years old. More information about the NCDS and how to access the data can be found at http://www.cls.ioe.ac.uk. A total of 7,894 participants had valid data on personality, verbal fluency, and the relevant demographic characteristics.

MIDUS. Midlife in the United States (MIDUS) is a longitudinal study that was initiated in 1994–1995. Currently there are three waves of data in MIDUS. Verbal fluency was assessed as part of the cognitive function battery during the MIDUS 2 assessment between 2004 and 2006. Personality was assessed in MIDUS 2 through the self-administered questionnaire at this wave. More information about MIDUS and how to access the data can be found at http://www.midus.wisc.edu/. A total of 3,626 participants had valid data on personality, verbal fluency, and the relevant demographic characteristics.

SOEP. The German Socio-Economic Panel Survey (SOEP) is a longitudinal study of households in Germany that started in 1984. Participants are reinterviewed every year. Personality was first measured in 2005, and verbal fluency was assessed on a subsample of SOEP participants the following year in 2006. More information about SOEP and how to access the data can be found at http://www.diw.de/en/soep. A total of 3,998 participants had valid data on personality, verbal fluency, and the relevant demographic characteristics.

CogUSA. Cognition in the U.S.A. (CogUSA) is a longitudinal study of age-related changes in cognition. CogUSA has three waves of data collected between 2007 and 2009. The second wave occurred one week after the first wave and included both personality and verbal fluency. Data for the second wave were collected in 2007–2008. More information about CogUSA and how to access the data can be found at https://www.icpsr.umich.edu/icpsrweb/NACDA/studies/36053. A total of 1,223 participants had valid data on personality, verbal fluency, and the relevant demographic characteristics.

CFAS. The Cognitive Function and Ageing Study in Wales (CFAS) is a longitudinal study of cognitive function of older adults in Wales. The first wave of CFAS was initiated in 2011, and the second wave was completed in 2016. Both verbal fluency and personality were available at Wave 2. More information about CFAS and how to access the data can be found at https://beta.ukdataservice.ac.uk/datacatalogue/studies/study?id = 8281. A total of 2,137 participants had valid data on personality, verbal fluency, and the relevant demographic characteristics.

NSHAP. The National Social life, Health, and Aging Project (NSHAP) is a longitudinal study of the health of older adults. There are currently three waves of data available. Personality and verbal fluency were available in Wave 2 collected in 2010–2011. More information about NSHAP and how to access the data can be found at http://www.norc.org/Research/Projects/Pages/national-social-life-health-and-aging-project.aspx. A total of 2,547 participants had valid data on personality, verbal fluency, and the relevant demographic characteristics.

Measures

Personality. Participants in the HRS, ELSA, MIDUS, and NSHAP completed the Midlife Development Inventory (MIDI; Lachman & Weaver, 1997), a measure of FFM personality traits. For HRS, ELSA, and MIDUS, 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 that ranged from 1 (*a lot*) to 4 (*not at all*). Items were reverse scored when necessary in the direction of the label of the trait. NSHAP participants completed a 21-item version of the MIDI on the same response scale.

Participants in US, both WLS samples, SOEP, and CogUSA completed versions of the Big Five Inventory (BFI; John, Naumann, & Soto, 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 SOEP 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 completed the original 44-item version.

Participants in the NCDS completed the 50-item version of the International Personality Item Pool (Goldberg et al., 2006). Participants were asked to "Please use the rating scale to describe how accurately these phrases describe you." Response options ranged from 1 (*Very inaccurate*) to 5 (*Very accurate*). Participants rated 10 items for Neuroticism (e.g., I get stressed out easily), Extraversion (e.g., I am the life of the party), Openness (e.g., I have a vivid imagination), Agreeableness (e.g., I sympathize with others' feelings), and Conscientiousness (e.g., I pay attention to details).

Participants in the CFAS completed the Ten-Item Personality Inventory (TIPI; Gosling, Rentfrow, & Swann, 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).

Fluency. Participants in US, HRS, ELSA, both WLS samples, NCDS, CogUSA, MIDUS, and CFAS were given 60 seconds to name as many animals as possible. Fluency was the total number of animals named in 60 seconds. In SOEP, participants were given up to 90 seconds to respond. The number of animals said at the 60 second mark, however, was recorded and used in this research to be consistent with the other samples. For CogUSA, the total is expressed as a p-score (the raw total was not available). For the category task in the WLS, participants were instructed to name as many examples as they could of either animals or foods (participants responded to one category or the other). In all WLS analyses, a dummy-coded variable was included to control for the different versions of the category task (animals vs. foods).

In the WLS and CFAS samples, participants were also administered a letter verbal fluency task. For the letter task, participants were instructed to name as many words as they could that started with either "f" or "l" (participants responded to one letter or the other). Participants were given 60 seconds to name as many words as they could. In all WLS analyses, a dummy-coded variable was included to control for the different versions of the letter task ("f" vs. "l"). Participants in CFAS were instructed to name as many words that start with the letter "s" that they could in one minute. Finally, in NSHAP, participants were instructed to name as many words that start with the letter "f" as possible in 60 seconds. For NSHAP only, verbal fluency was recorded as a dichotomous measure, with a value of 1 given for participants who listed 11 or more words correctly and a 0 for participants who listed less than 11 words. There was not a measure of category fluency in NSHAP.

Covariates. In each study, all covariates were self-reported. Participants reported their age in years and self-identified their gender and race/ethnicity. Age was included in the analyses in years. Gender was dummy-coded as 1 for female and 0 for male. Race was dummy-coded into variables that contrasted African American/Black (US, HRS, CogUSA, NSHAP, and MIDUS), Asian (US, NSHAP), Biracial (US, MIDUS), and other/unknown (US, HRS, CogUSA, MIDUS) against White as the reference group (with 1 for the comparison group and 0 for the reference group). Groupings were made based on the availability of the data. Hispanic ethnicity was coded as 1 for Hispanic and 0 for not-Hispanic (HRS, CogUSA, NSHAP, MIDUS). Education self-reported years of education in HRS, both WLS samples, CogUSA, SOEP, and CFAS, as a range in US, ELSA, and NCDS, from 1 (no qualification) to 6 (degree) in US, from 0 (no qualification) to 7 (degree) in ELSA, from 1 (high school) to 4 (bachelor's degree or higher) in NSHAP, and from 1 (no school) to 12 (advanced degree) in MIDUS.

Analytic Strategy

We ran a zero-order correlation between age and category fluency in each of the samples to examine the relation between age and fluency. All variables were standardized within cohort before analysis. Linear regression was used to test the association between personality and verbal fluency. Verbal fluency was the dependent variable and was predicted from each personality trait, controlling for age, gender, education, and race/ethnicity when relevant (and task version in the WLS samples). Comprehensive meta-analysis software was used to meta-analyze the results from 10 samples from 9 cohorts with category fluency (i.e., all samples but NSHAP, which only had letter fluency). To summarize the effects across the 10 samples with category fluency, a random-effects meta-analysis was done based on the partial correlation and sample size of each cohort. We followed up these analyses with metaregressions to identify reasons for heterogeneity, including age of sample (mean age above or below 60), sample location (US vs. Europe), and personality measure, grouped by the two most common measures across the samples (i.e., BFI vs. not BFI and MIDI vs. not MIDI).

Finally, we also tested whether the association between personality and category fluency was moderated by age, gender, or education. Within each sample, an interaction between each of the traits and the demographic factors was tested as a predictor of verbal fluency, in addition to the main effects. When there was evidence of at least one replicated interaction in the same direction (i.e., at least two significant effects), we followed up with a meta-analysis of the interactions terms across all samples to summarize the effect.

Results

There was a negative association between age and fluency in each of the samples (see Table 1) that indicated that fluency declines with age. The US sample was unique in that it was a large sample that ranged in age from 16 to 100. The pattern of age differences in verbal fluency in this sample was clear (see Figure 1): The mean for fluency
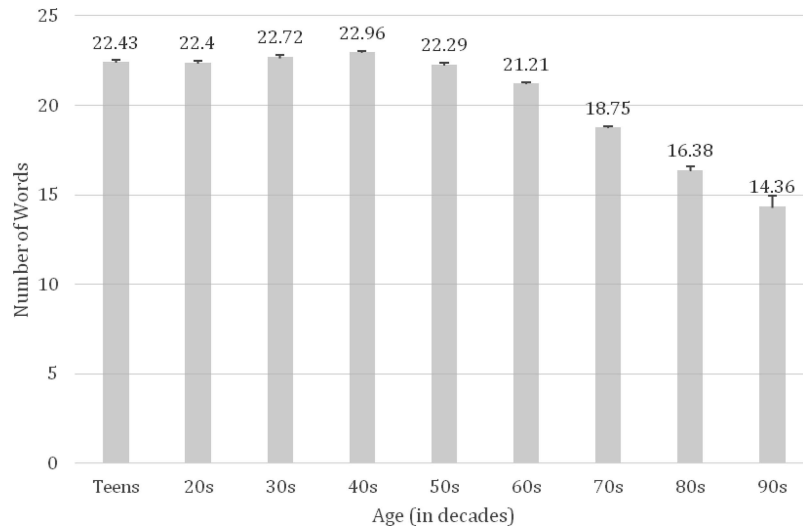
Figure 1. Mean and standard error by decade of age in category fluency in Understanding Society.

was higher in each decade from adolescence to the 40s and then was lower in each decade starting in the 50s and across the rest of the life span, which is consistent with previous research on age differences in fluency across the adult life span in smaller samples (e.g., Buczylowska & Petermann, 2016).

The results of the regression analyses of the relation between personality and fluency are shown in Tables 2 and 3. For verbal fluency based on category, there were very consistent associations across the 10 samples with this task (see Table 2): The meta-analysis indicated that participants higher in Neuroticism retrieved fewer words, whereas participants higher in Extraversion, Conscientiousness, and especially Openness retrieved more words. The meta-analysis indicated that Agreeableness was unrelated to fluency. In the individual samples, all of the associations between Neuroticism and fluency were negative except for one (SOEP), and all of the associations between Extraversion, Openness, and Conscientiousness were positive (although not necessarily all significant). The associations for Agreeableness were mixed across the 10 samples. Finally, the pattern of associations replicated across the second measure of fluency—letter fluency—with the strongest and most consistent associations found for Neuroticism, Extraversion, and Openness (see Table 3).

The meta-analysis indicated significant heterogeneity for all of the traits. The sample-level moderator analyses suggested that age might be one factor in this heterogeneity (Supplementary Table 1). Specifically, the associations between Neuroticism, Extraversion, and Conscientiousness and fluency were stronger in samples with a mean age older than 60 than younger than 60. None of the associations varied by sample location (US vs. Europe). Only one effect emerged for the personality measure: The association between Agreeableness and fluency was weaker when the personality measure was the BFI.

In addition to the sample-level moderators, we also tested for moderators within each sample. The interaction terms for the moderation analysis by gender, age, and education in the individual samples are listed in Table 2 in the online supplemental materials. There was little evidence that age or gender moderated the association between the traits and verbal fluency, with no

interaction that replicated in the same direction across samples. Although not apparent in every sample, there was some evidence for moderation by education. A meta-analysis of the interaction terms revealed significant moderation for four out of the five traits, with the strongest effect for Conscientiousness: The association between Conscientiousness and category fluency was slightly stronger among individuals with less education (meta-analytic partial $r = -.026$, 95% CI [$-.040$, $-.013$], $p < .001$). This pattern was similar, but weaker, for Neuroticism (meta-analytic partial $r = .012$, 95% CI [.002, .021], $p = .014$), Extraversion (meta-analytic partial $r = -.012$, 95% CI [$-.023$, $-.001$], $p = .034$), and Agreeableness (meta-analytic partial $r = -.016$, 95% CI [$-.027$, $-.005$], $p = .005$). The interaction term was not significant in the meta-analysis for Openness (meta-analytic partial $r = -.023$, 95% CI [$-.047$, $.001$], $p = .064$).

Discussion

Life Span models of personality and health posit that traits contribute to health across the life span (Friedman et al., 2014). Life Span models of cognition likewise posit that individual differences contribute to cognitive outcomes and especially shape performance in old age (Baltes et al., 2006). The present research integrated and applied these perspectives to one marker of cognitive aging—verbal fluency—that is sensitive to both age and critical cognitive outcomes in older adulthood (Henry et al., 2004; Sutin et al., 2019; Yoon et al., 2014). These characteristics make it a useful measure of cognitive function to place in a life span context with personality. Consistent with theories of cognitive aging, verbal fluency follows a normative trajectory (Buczylowska & Petermann, 2016), but less is known about factors associated with it across adulthood and whether the associations vary by age. Such information is needed to help promote healthier cognitive aging into older adulthood. In the present research, across 11 samples that totaled more than 90,000 participants between the ages of 16 and 101, consistent associations emerged between personality traits and verbal fluency: Individuals who were more

Table 2

Association Between Personality Traits and Category Fluency

Sample	Verbal fluency		
	β	95% CI	p
		Neuroticism	
US	−.028	[−.038, −.019]	.000
HRS	−.050	[−.064, −.035]	.000
ELSA	−.043	[−.062, −.023]	.000
WLSG	−.070	[−.110, −.031]	.001
WLSS	−.041	[−.093, .012]	.129
NCDS	−.052	[−.074, −.031]	.000
CogUSA	−.077	[−.127, −.027]	.003
SOEP	.008	[−.023, .039]	.602
MIDUS	−.020	[−.050, .010]	.192
CFAS	−.108	[−.147, −.068]	.000
Meta-analytic partial *r*	−.048	[−.065, −.031]	.000
Heterogeneity			
Q	41.0	—	.000
I²	78%	—	—
		Extraversion	
US	.051	[.042, .060]	.000
HRS	.057	[.042, .071]	.000
ELSA	.072	[.052, .091]	.000
WLSG	.108	[.069, .147]	.000
WLSS	.132	[.080, .183]	.000
NCDS	.080	[.059, .101]	.000
CogUSA	.112	[.062, .161]	.000
SOEP	.064	[.034, .094]	.000
MIDUS	.015	[−.014, .044]	.312
CFAS	.062	[.022, .102]	.002
Meta-analytic partial *r*	.074	[.058, .091]	.000
Heterogeneity			
Q	37.6	—	.000
I²	76%	—	—
		Openness	
US	.112	[.103, .122]	.000
HRS	.107	[.092, .121]	.000
ELSA	.107	[.087, .127]	.000
WLSG	.098	[.056, .140]	.000
WLSS	.096	[.041, .151]	.001
NCDS	.167	[.145, .190]	.000
CogUSA	.127	[.075, .180]	.000
SOEP	.088	[.057, .119]	.000
MIDUS	.082	[.052, .112]	.000
CFAS	.096	[.056, .136]	.000
Meta-analytic partial *r*	.113	[.098, .128]	.000
Heterogeneity			
Q	31.8	—	.000
I²	71.7%	—	—
		Agreeableness	
US	−.005	[−.014, .004]	.295
HRS	.046	[.031, .061]	.000
ELSA	.024	[.004, .044]	.019
WLSG	.011	[−.030, .051]	.608
WLSS	.006	[−.046, .058]	.816
NCDS	.058	[.035, .081]	.000
CogUSA	.000	[−.051, .05]0	.985
SOEP	.026	[−.005, .056]	.099
MIDUS	.002	[−.029, .033]	.890
CFAS	−.011	[−.051, .030]	.611
Meta-analytic partial *r*	.017	[−.001, .036]	.065
Heterogeneity			
Q	47.1	—	.000
I²	80.9%	—	—

Sample	Verbal fluency		
	β	95% CI	p
		Conscientiousness	
US	.035	[.026, .045]	.000
HRS	.040	[.025, .054]	.000
ELSA	.065	[.045, .084]	.000
WLSG	.078	[.038, .117]	.000
WLSS	.085	[.034, .137]	.001
NCDS	.016	[−.005, .038]	.130
CogUSA	.007	[−.043, .057]	.783
SOEP	.024	[−.006, .054]	.118
MIDUS	.010	[−.019, .040]	.483
CFAS	.049	[.009, .088]	.015
Meta-analytic partial *r*	.042	[.028, .056]	.000
Heterogeneity			
Q	26.7	—	.002
I²	66.3%	—	—

Note. df for each meta-analysis = 9. Total *N* for the meta-analysis = 86,044; *N* = 40,076 for US; *N* = 14,851 for HRS; *N* = 8,778 for ELSA; *N* = 2,204 for WLSG; *N* = 1,255 for WLSS; *N* = 7,894 for NCDS; *N* = 1,223 for CogUSA; *N* = 3,998 for SOEP; *N* = 3,626 for MIDUS; *N* = 2,139 for CFAS. Regression coefficients are from a linear regression predicting verbal fluency from each personality trait, controlling for age, gender, education, race, and ethnicity. US = Understanding Society; HRS = Health and Retirement Study; ELSA = English Longitudinal Study of Ageing; WLSG = Wisconsin Longitudinal Study Graduate sample; WLSS = Wisconsin Longitudinal Study Sibling sample; NCDS = National Childhood Development Study; CogUSA = Cognition in the United States; SOEP = Socioeconomic Panel Survey; MIDUS = Midlife in the United States Study; CFAS = Cognitive Function and Ageing Study in Wales.

emotionally stable, extraverted, open, and conscientious retrieved more words than individuals who scored lower on these traits. These associations were not dependent on the type of fluency task administered; similar associations emerged across category and letter fluency.

Of the five traits, Openness had the strongest association with verbal fluency. Individuals higher in Openness tend to achieve more education (Sutin, Luchetti, Stephan, Robins, & Terracciano, 2017), and education, in turn, contributes to better fluency (Kempler, Teng, Dick, Taussig, & Davis, 1998). It is of note, then, that the association between Openness and fluency was independent of education. That is, there is a relatively strong association between Openness and fluency even after adjusting for educational attainment. This association is likely due in part to the greater verbal abilities associated with Openness, an association that starts in childhood. Openness measured at age 10, for example, is associated with greater intrinsic motivation to read and interest in challenging reading material (Medford & McGeown, 2012). This interest in reading may contribute to the greater verbal abilities associated with this trait, as indexed by scores on the verbal section of the SATs (Noftle & Robins, 2007). Individuals higher in Openness may continue to develop their verbal abilities across adulthood in part through the activities they choose during their leisure time, such as reading (Stephan, Boiché, Canada, & Terracciano, 2014). The present research suggests that one outcome of this verbal interest and ability is higher fluency across adolescence and adulthood.

After Openness, Extraversion had the strongest association with verbal fluency. Individuals high in Extraversion do not necessarily

Table 3

Association Between Personality Traits and Letter Fluency in WLSG, WLSS, CFAS, and NSHAP

Sample	β	95% CI	p
		Letter fluency	
		Neuroticism	
WLSG	−.030	[−.059, −.002]	.035
WLSS	−.034	[−.072, .003]	.073
CFAS	−.075	[−.117, −.034]	.000
NSHAP	−.051	[−.044, −.007]	.007
		Extraversion	
WLSG	.098	[.070, .126]	.000
WLSS	.091	[.054, .129]	.000
CFAS	.091	[.050, .133]	.000
NSHAP	.059	[.011, .048]	.002
		Openness	
WLSG	.145	[.115, .175]	.000
WLSS	.124	[.085, .164]	.000
CFAS	.118	[.076, .159]	.000
NSHAP	.055	[.009, .046]	.004
		Agreeableness	
WLSG	.054	[.025, .082]	.000
WLSS	.004	[−.034, .041]	.853
CFAS	.032	[−.011, .075]	.140
NSHAP	.051	[.006, .044]	.009
		Conscientiousness	
WLSG	.055	[.027, .083]	.000
WLSS	.020	[−.018, .057]	.308
CFAS	−.006	[−.047, .036]	.793
NSHAP	.040	[.002, .039]	.033

Note. N = 4,412 for WLSG; N = 2,455 for WLSS; N = 2,137 for CFAS; N = 2,547 for NSHAP. Regression coefficients are from a linear regression predicting verbal fluency from each personality trait, controlling for age, gender, and education. WLSG = Wisconsin Longitudinal Study Graduate sample; WLSS = Wisconsin Longitudinal Study Sibling sample; CFAS = Cognitive Function and Ageing Study in Wales; NSHAP = National Social Life, Health, and Aging Project.

have the verbal abilities of those high in Openness—Extraversion tends to be unrelated to SAT verbal scores, for example (Noftle & Robins, 2007)—but this trait does have a strong verbal component to it. Talkativeness, for example, is one of the defining features of Extraversion (McCrae & Costa, 2010). It is thus not that surprising that individuals who are extraverted would be able to produce a lot of words quickly. The association with fluency indicates that individuals high on this trait can focus their verbosity to produce many words from a specific category.

In contrast to traits like Openness and Extraversion, Conscientiousness may be more likely to be related to verbal fluency through cognitive functions other than verbal ability. Conscientiousness tends to be unrelated to verbal interest and abilities, as measured by motivation and interest in reading at age 10 (Medford & McGeown, 2012) or by SAT verbal scores in adolescence (Noftle & Robins, 2007). It is, however, related to better academic outcomes (Noftle & Robins, 2007), memory (Hülür et al., 2015), and organizational skills (McCrae & Costa, 2010). The relation between Conscientiousness and measures of executive function, however, is not clear. While some find that Conscientiousness is

unrelated to executive function (Buchanan, 2016), others find that it is related to specific aspects of it, such as mental set shifting (Fleming, Heintzelman, & Bartholow, 2016). Still other evidence suggests that it is either unrelated to working memory (Fleming et al., 2016) or even related negatively to it (Waris, Soveri, Lukasik, Lehtonen, & Laine, 2018). It may be the better ability to shift back and forth between the requirements of the task that increases ability to perform well.

Finally, the expected negative association between Neuroticism and fluency was apparent across most of the samples: Individuals who score higher in Neuroticism produce fewer words. This association is consistent with previous work on Neuroticism and cognition, which generally finds a negative association between this trait and cognitive function (Luchetti et al., 2016). Individuals higher in Neuroticism tend to perform worse on cognitive tasks and have more complaints about their cognitive function (Steinberg et al., 2013). Individuals higher in Neuroticism tend to be nervous (Costa & McCrae, 1992), and this trait tendency related to anxiety may interfere with performance. Arousal and performance are known to follow an inverted U, with greater arousal improving performance until a tipping point past which it harms performance (Cohen, 2011). Individuals who score higher in Neuroticism tend to have excessive self-presentational concerns (Eldesouky & English, 2018) that may interfere with performance, especially in front of other people.

There was, however, significant heterogeneity in the associations across the samples in the meta-analysis. The sample-level moderators gave some insight into some of the reasons for the heterogeneity. Sample age, in particular, moderated the association between Neuroticism, Extraversion, and Conscientiousness and fluency. Consistent with theories of cognitive aging (Baltes et al., 2006), this pattern (i.e., a stronger association at older ages between lower Neuroticism and higher Extraversion and Conscientiousness and higher verbal fluency) suggests a cumulative effect across the life span of the benefits associated with personality traits that helps to preserve cognitive function at older ages. That is, the healthier lifestyle and health status associated with the traits that help to preserve cognition should lead to stronger associations at older ages. Conscientiousness, for example, is associated with health-promoting behaviors, such as physical activity (Artese et al., 2017) and healthier weight (Sutin et al., 2018), which may cumulate across the life span to better cognition in old age. Conscientiousness is also associated with better cardiovascular health (Hampson et al., 2013; Jokela, Pulkki-Råback, Elovainio, & Kivimäki, 2014), which also plays a significant role in cognitive function in older adulthood (Kaffashian et al., 2011; Norton, Matthews, Barnes, Yaffe, & Brayne, 2014). Neuroticism, in contrast, is related to health-risk behaviors, such as being sedentary (Sutin et al., 2016), that may culminate in poor health and ultimately lower cognition in old age. Finally, the frequent social interactions of extraverted individuals may support better fluency across the life span. Overall, the stronger associations at older ages may reflect compensatory mechanisms (Baltes et al., 2006), with personality-related processes stepping up in the face of normative cognitive decline. Of note, age did not consistently moderate the association with fluency in the individual samples, which may be due to differences in the age range and composition of the samples, and highlights the importance of using multiple data sets to address this question. Other than age, there was only one other sample-

level moderator: The relation between Agreeableness and fluency was weaker when the Agreeableness was measured with the BFI, which may be due to the presence of reverse-scored items on the BFI. It is of note that location also did not moderate any of the associations, which indicated similar associations across two slightly different cultural contexts (United States and Europe).

Of the demographic factors, the strongest evidence of moderation was for education. The interaction between personality and education emerged in several samples, and a meta-analysis of the interaction terms indicated that the association between four of the traits and fluency was stronger at lower education, with the strongest meta-analytic effect for Conscientiousness. The interaction between Conscientiousness and education replicates our previous study using a large Italian sample (Sutin et al., 2011). This pattern is consistent with the resource substitution hypothesis, whereby individual differences are stronger predictors of attainment at lower levels of socioeconomic status (Damian et al., 2015; Shanahan et al., 2014). Emotional stability, Extraversion, and Agreeableness were likewise slightly more beneficial for fluency at lower levels of education. Given the difficulty to find and replicate interactions, however, these results should be interpreted with caution. Still, reporting such associations is necessary to help build an evidence base for potential demographic differences in the relation between personality and cognition.

There are both theoretical and practical implications of this research. From a theoretical perspective, the findings broadly support life span models of both personality and cognition and implicate verbal fluency as an intermediate marker of cognitive health that can be a useful outcome in research on personality and cognition. It further shows which traits associations are most replicated and suggests that these associations are apparent across diverse populations, with some relations stronger in specific populations (e.g., stronger associations in older than younger cohorts; stronger associations in populations with relatively less than more education). There are also practical implications. For example, traits may be used to identify individuals most at risk for cognitive impairment. Early identification can help with early intervention to promote healthier cognitive aging. There is also now evidence that maladaptive aspects of personality can be changed through intervention (Roberts et al., 2017). One downstream consequence of such intervention may be improved cognitive function. Finally, these findings may also be used in the context of personalized interventions that may improve the efficacy of the intervention by tailoring it to the individual's personality (Conrod et al., 2013; Rouch et al., 2018).

The present research had several strengths, including 11 samples from 10 cohorts that totaled more than 90,000 participants, a staff-assessed verbal fluency task, and validated FFM measures of the traits in all samples. The findings were robust despite differences in study design, age, nationality, and measures of fluency and personality. The use of multiple data sets helps to improve the generalizability and overall robustness of findings because it points to replicable findings and reduces the possibility that identified associations are due to chance. Such an approach is well-recognized as critical to building a robust literature on aging (Hofer & Piccinin, 2009, 2010). This study also had some limitations. First, we could not examine the association between personality and the specific cognitive functions that are thought to underlie fluency performance (e.g., verbal abilities, working memory, processing speed). As such, we could not identify which specific cognitive aspect of fluency was driving the associations with personality. Second, the measure of personality in each of the samples was brief. Third, the data were cross-sectional. Finally, we did not include health status in the analyses. Future research could test both verbal fluency and the more specific cognitive functions that contribute to fluency performance and facets of personality and whether these associations are independent of health status. In addition, future research could repeat these measurements in a longitudinal framework to address the interrelations between personality and fluency over time and the potential for patterns of personality plasticity to contribute to cognitive function (Graham & Lachman, 2012). Despite these limitations, the present research provides evidence of replicable associations between personality and verbal fluency that are apparent from adolescence to older adulthood.

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