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Basic cognition in adulthood: Combined effects of sex and personality

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ABSTRACT

This study was designed to explore the relationships between sex, personality, and basic cognitive processes. Using a representative adult sample of 245 participants (M age = 47.80 years) with processing speed and short-term memory (STM) as the dependent variables, sex, and personality traits were entered into multiple regression analyses. Sex (female) and personality (high Extraversion) positively predicted processing speeds (final βs = .25 and .24, respectively). In addition, there was a Sex X Conscientiousness interaction for processing speed in which females high in Conscientiousness were significantly faster than males high in Conscientiousness; low Conscientiousness scores were non-discriminatory between the sexes. Sex (male) and personality (high Extraversion, low Conscientiousness) were predictive of STM (final βs = −.17, .16, and −.19, respectively). Differences in cognitive styles or motivation levels in low conscientious and high conscientious men and women may account for these differences.

1. Introduction

The literature on personality and cognition is considerably complex and is fraught with inconsistencies. Although less contradictory, the research on sex differences in cognition is also quite complicated. This research has shown both sex and personality to be related to basic performance-based cognition in varying degrees and directions (e.g. Lynn & Irwing, 2008; Meinz & Salthouse, 1998). Given that there are often sex differences on personality traits (e.g. Schmitt, Realo, & Allik, 2008), a question arises as to whether sex, personality, or a combination of the two contribute to the individual differences in cognition. The goals of the current study are to further clarify the relationship between sex and personality and cognition in a representative sample of adults.

1.1. Sex differences in cognitive performance

One extensive line of individual differences research in cognitive psychology has focused on sex differences in basic cognition, including in speed-of-processing and short-term memory. Females have often been found to have an advantage in processing speed (Burns & Nettelbeck, 2005; Meinz & Salthouse, 1998). In their meta-analysis, Meinz and Salthouse (1998) found that across the lifespan, females tended to have faster processing speeds than males, although the magnitude of this difference was small (r = .05).

Research on sex differences in verbal short-term memory (STM) has found less clear results. The Meinz and Salthouse meta-analysis (1998) found that males have an advantage in working memory (r = .07). Other studies, however, have shown no sex differences (e.g. Goldstein et al., 2005) or female advantage (e.g. Van der Elst, Van Boxtel, Van Breukelen, & Jolles, 2008: β = .10) in STM.

1.2. Personality differences in cognitive performance

Many studies have found significant personality–cognition relations (e.g. Ackerman & Heggestad, 1997; Lieberman, 2000). The patterns and strength of associations vary by cognitive factors and personality traits being measured. The majority of published findings on personality–cognition relationships have examined the link between processing speed and Extraversion (e.g., Ackerman & Heggestad, 1997; Baker & Bichsel, 2006; Humphreys & Revelle, 1984; Lieberman, 2000). Eysenck's (1967) original theory hypothesized that because extraverts have lower states of arousal, they generally perform quicker than introverts on speeded tasks. Indeed, many studies have confirmed that high levels of Extraversion are related to quicker speed-of-processing (e.g. Ackerman & Heggestad, 1997; Baker & Bichsel, 2006).

There have only been a few studies examining Neuroticism and processing speed. It appears as though Neuroticism may not affect inspection time (Bates & Rock, 2004) but may affect discrimination and choice reaction times (Socor & Bucik, 1998). Findings relating Openness, Conscientiousness, and Agreeableness to processing speed are sparse or non-existent.

Findings on personality predictors of STM are also mixed (Baker & Bichsel, 2006; Humphreys & Revelle, 1984; Lieberman, 2000). For instance, Lieberman (2000) found that extraverts had better STM than introverts but suggested that this was merely due to

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the faster processing speed of extraverts. However, in the Baker and Bichsel (2006) study, it was reported that the personality factors of both Conscientiousness and Openness (but not Extraversion or Neuroticism) predicted STM. These divisive findings in the literature suggest a need for further studies of STM and personality.

1.3. Sex–personality interaction

While there is no published research examining sex by personality interactions in understanding basic cognition in adults, there are several lines of research that suggest that males and females with different personality types may behave differently in certain circumstances. For instance, Terrell, Hill, and Nagoshi (2008) found that women and men acted aggressively in competitive situations based on their personality types. Travis, McKenzie, Wiley, and Kahn (1988) found that gender interacted with both locus of control and type of achievement domain in predicting motivation for success. This study, in particular, suggests that men and women may have different motivational levels for different types of tasks.

1.4. Current study

Because both personality and sex have been shown to be predictive of basic cognitive processes, it is unknown if one or both of these factors are contributing to performance differences. Exploring both personality and sex predictors is, therefore, an important next step in establishing a better understanding of, not only the separate contributions of these factors, but also their potential interplay in cognitive performance. The specific goals of this study are to examine the relationship of both personality and sex with two basic cognitive processes (processing speed and STM) in a representative adult sample. In addition to examining the sex–cognition and personality–cognition relationships, an exploration of potential sex by personality interactions on the cognitive variables will be conducted.

The hypotheses are as follows:

1. Sex (female) and personality (high Extraversion, low Neuroticism) will predict faster processing speed.
2. Sex (male) and personality (high Extraversion, high Openness) will predict better STM.

Relationships of the other personality variables with speed and STM, along with sex by personality interactions in these relationships, will be included as exploratory analyses.

2. Method

2.1. Participants

The data were obtained from a substudy of the national study, Midlife in the United States (MIDUS), which was conducted by the John D. and Catherine T. MacArthur Foundation Network on Successful Midlife Development. The MIDUS data is a nationally representative sample and this substudy consisted of an intentional oversample using random digit dialing of adults in the greater Boston area. Of the original 302 participants, 245 had complete data, absence of stroke, and spoke English as their primary language. Further description of this sample can be found in Miller and Lachman (2000). The mean age of the sample was 47.80 (SD = 13.21) years. The sample was 58% male. Forty-six percent of the sample had a bachelor's degree or higher.

2.2. Measures

2.2.1. Cognition

Two aspects of cognition were assessed (processing speed and short-term memory). These factors have been described previously in Miller and Lachman (2000). Speed of processing was measured using the standardized means of the letter comparison task (Salthouse & Babcock, 1991) and the digit symbol substitution test from the Wechsler Adult Intelligence Scale (WAIS; Wechsler, 1981). Short-term memory was assessed using the standardized mean of Forward and Backward Digit Span from the Wechsler Adult Intelligence Scale-Revised (WAIS-R; Wechsler, 1981) and a counting backwards task which required participants to count backwards by sevens from a three digit number. The age differences on the objective cognitive factors have been reported previously (see Miller & Lachman, 2000) and will not be explored in this study. From both cognitive factor scores, I created a standardized residual score controlling for both age and education which were then used as the dependent variables in all subsequent analyses.

2.2.2. Personality

The Big Five personality constructs (Neuroticism, Extraversion, Openness to experience, and Conscientiousness) were examined through a list of descriptive attributes (Lachman & Weaver, 1998). These scores correlate highly with alternative measures of personality traits, such as those based on the NEO-PI (Costa & McCrae, 1992). These scales have good internal consistency (alphas ranging from .58 to .80: Lachman & Weaver, 1998). Each scale consists of several items asking participants to indicate how much each item is characteristic of themselves (1 = not at all; 4 = a lot). Higher scores on each construct indicate higher reported levels of that trait.

2.3. Procedures

This substudy of the larger MIDUS study consisted of two times of measurement over a one to two year period. At Time 1, participants were mailed a series of questionnaires, including the personality scale. At Time 2, approximately 6 months to a year later, cognitive tests were administered at each participant's home.

T-tests were used to examine sex differences on the personality traits. To examine personality and sex predictors of cognition, hierarchical regression analyses were conducted for both dependent (cognitive) variables. For each dependent variable, sex was entered in the first step, the five personality variables were entered in the second step, and interactions were examined in the final step.

3. Results

Means, standard deviations, and zero-order correlation coefficients are listed in Table 1. There were significant sex differences on Agreeableness ($t(244) = -3.29$, $p < .001$) and Conscientiousness ($t(244) = -2.49$, $p < .05$), such that females were more agreeable and more conscientious than males. Of note, there were no age differences between males and females ($t(244) = 1.31$, $p = .20$).

3.1. Prediction of objective cognition

3.1.1. Speed

The overall regression for speed of processing yielded several main effects and one interaction accounting for a total of 15% of the variance (Table 2). Sex was entered in Step 1 and accounted for 7% of the total variance, $F(1, 243) = 18.72$, $p < .001$, such that females were faster than males. The addition of the personality variables added an additional 6% of the variance in speed,

Table 1
Zero-order correlations, means (M), and standard deviations (SD) of study variables.

								Males (n = 143)		Females (n = 102)	
		1	2	3	4	5	6	M	SD	M	SD
1.	Speed	–						−.19	.84	.35[a]	.91
2.	Short-term memory	.30**	–					.18	.80	−.23[a]	.68
3.	Neuroticism	−.08	.00	–				2.20	.67	2.24	.61
4.	Extraversion	.21**	.06	−.10	–			3.21	.53	3.27	.48
5.	Openness	−.02	.03	−.16*	.44**	–		3.14	.48	3.03	.50
6.	Agreeableness	.11	−.10	−.04	.52**	.32**	–	3.35	.59	3.59[a]	.44
7.	Conscientiousness	.05	−.19*	−.29**	.25**	.26**	.30**	3.37	.47	3.51[a]	.40

Note: Both cognitive factors are adjusted for age and education.
[a] Test for mean between-group differences significant at $p < .05$.
* $p \leqslant .05$.
** $p \leqslant .01$.

Table 2
Summary of significant final regression coefficients.

Cognitive factor	Predictor	*B*	SEB	*β*
Processing speed	Sex	.50	.13	.25***
	Extraversion	.48	.15	.24**
	Sex X Conscientiousness	.71	.29	.15*
Short-term memory	Sex	−.35	.13	−.17**
	Extraversion	.31	.15	.16*
	Conscientiousness	−.42	.15	−.19**

Note: Both cognitive factors are adjusted for age and education. Sex is coded 1 = males and 2 = females.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

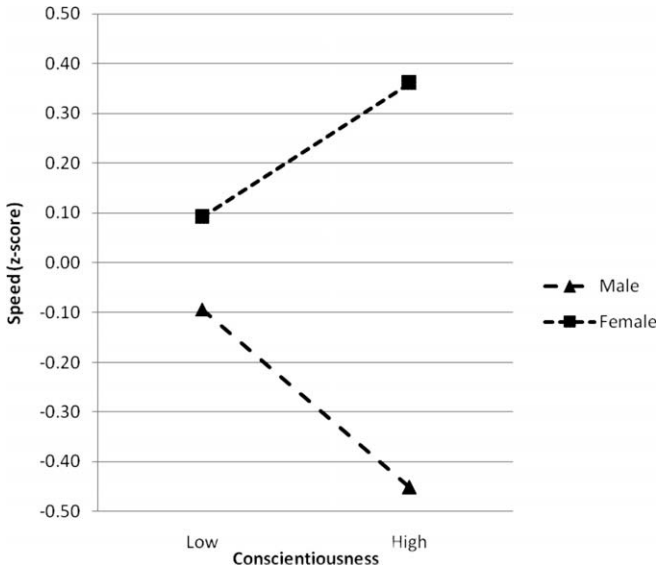

Fig. 1. Speed-of-processing interaction. Note: speed is adjusted for age and education. Low Conscientiousness = M − 1 SD. High Conscientiousness = M + 1 SD. Men higher in Conscientiousness were significantly slower than all women and men lower in Conscientiousness. Women higher in Conscientiousness were significantly faster than all men and women lower in Conscientiousness.

$F(5, 238) = 3.13$, $p < .01$. Only Extraversion was a unique predictor with more extraverted participants having quicker processing speeds. Finally, there was a Sex X Conscientiousness interaction (see Fig. 1) which added an additional 2% of variance, $F(1, 237) = 6.11$, $p < .01$. Males that were high in Conscientiousness had the slowest speed scores, whereas the high Conscientiousness females had the quickest speed scores. Low Conscientiousness scores were non-discriminatory between the sexes.

3.1.2. Short-term memory

The overall regression for STM yielded a couple of main effects which accounted for a total of 9% of the variance (Table 2). Sex was entered in Step 1 and accounted for 5% of the variance, $F(1, 243) = 12.26$, $p < .01$, with the males having a STM advantage over females. The addition of the personality variables accounted for an additional 5% of the variance $F(5, 238) = 2.43$, $p < .05$. Extraversion and Conscientiousness were the only two significant personality predictors of STM. Similar to speed, participants that were high in Extraversion had an STM advantage. Interestingly, participants that were more Conscientiousness scored lower on the STM tasks. There were no significant interactions.

4. Discussion

Many previous studies have investigated the role of personality *or* sex on cognition, intelligence, and/or memory (e.g. Ackerman & Heggestad, 1997; Baker & Bichsel, 2006; Burns & Nettelbeck, 2005; Herlitz & Rehnman, 2008; Meinz & Salthouse, 1998). What is missing from these previous studies is an examination of combination of both personality *and* sex differences. Given the often found sex differences on several of the personality variables (Agreeableness and Conscientiousness in the current study), it is important to try to disentangle the effects of both sex and personality on cognitive performance. The current study demonstrates that *both* sex and personality separately affect cognition in adulthood. Furthermore, in this study, sex and Conscientiousness interacted to predict processing speed.

4.1. Sex and cognition

As predicted, sex predicted processing speed. The accumulation of data, including this study, consistently suggests that females have a slight advantage over men on speeded tasks (see also Burns & Nettelbeck, 2005; Meinz & Salthouse, 1998). The source of this female advantage is yet unknown. Females may, in general, be

more efficient on these types of tasks. It may, however, be parallel to the female advantage on verbal episodic memory tasks (de Frias, Nilsson, & Herlitz, 2006; Herlitz, Nilsson, & Bäckman, 1997). Because the speeded tasks used in this study (digit symbol and letter comparison) both have verbal components, it is possible that the real female advantage here was not necessarily in processing speed but in verbal ability. Females may have used the strategy of verbally encoding stimuli (e.g. "the number one is a dash") which led to quicker speeds.

As hypothesized, males outperformed females on verbal STM. Interestingly, in their sample of younger adults (mean age = 32), Goldstein et al. (2005) found no sex differences in actual performance on a verbal STM task but did find sex differences on the brain regions used during those tasks. That is, they found that the right superior parietal lobe was activated during males' STM performance and the left dorsolateral prefrontal cortex and the right orbitofrontal cortex were activated during females' STM performance. If it is the case that young females use their frontal and prefrontal cortex for STM tasks, whereas young males rely more on their parietal lobe, then it stands to reason that the known age-related degradation of the prefrontal cortex (see Hillary, Geneva, Chiaravalloti, Rypma, & DeLuca, 2006) may lead females to have more difficulty on STM with each passing year. Given that the current sample was significantly older overall than the Goldstein sample, it stands to reason that, although there were no age differences on STM (from Miller & Lachman, 2000), there were sex differences.

Another possibility for understanding the sex differences on STM relates to the nature of the tasks used in this study. Many STM tasks (including digit span and backwards subtraction) involve numbers, which may put males at an advantage. Therefore, the sex differences on the current STM tasks may be due more to differences in both actual and perceived numeric ability as opposed to short-term memory ability. The biological viewpoint suggests that males are superior to females on numerical tasks due to evolution and brain structure, but it has also been suggested that female difficulties with mathematical concepts are due to the differing socialization and education patterns of males and females. Indeed, several studies have shown that the use of numbers in tasks may set up stereotype threat situations in which the women respond with anxiety due to an implicit fear of math tests (e.g. Steele, 1997).

The finding of a male advantage on STM (current study) and visuospatial tasks (see de Frias et al., 2006) provides an interesting contrast with the female advantage on processing speed (current study) and verbal episodic memory (see Herlitz & Rehnman, 2008) which deserves further exploration.

4.2. Personality and cognition

Many of the previous studies on personality and cognition have focused exclusively on Extraversion (e.g. Lieberman, 2000; Stahl & Rammsayer, 2008). As predicted, Extraversion was significantly related to both speed and STM. Studies examining the Extraversion–speed link have found that extraverts have a quicker motor response than introverts both in terms of performance measures and psychophysiological responsivity (Doucet & Stelmack, 2000; Lieberman, 2000). Introverts tend to have higher basal levels of arousal which in term may lead them to modulate their responses so as to prevent over-arousal (Eysenck, 1967; Stelmack, 1997). Furthermore, Extraversion is positively related to activity in the prefrontal cortex and parietal lobe (Canli, 2004; Eisenberger, Lieberman, & Satpute, 2005) as is processing speed (Peers et al., 2005; Rypma, Eldreth, & Rebbechi, 2007). Similarly, Gray and Braver (2002) found that behavioral approach sensitivity, an affective dimension similar to Extraversion, was related to better working memory performance in an adult sample. They linked this association with neural activity in the caudal anterior cingulate cortex which is a brain region important in cognitive control and performance. Although work is needed to further understand this brain–Extraversion–performance link, it appears as though the resting arousal levels and the subsequent cortical activity of extraverts are related to both their faster processing speed and better STM.

Contrary to the predictions, Conscientiousness was predictive of STM in this sample. Furthermore, this relationship was negative, such that people who were higher in Conscientiousness performed worse on the STM tasks. This finding is in line with previous research which found that people lower in Conscientiousness tend to score higher on general ability measures (Moutafi, Furnham, & Crump, 2006). It has even been suggested that some adolescents and younger adults actually develop higher levels of Conscientiousness when they enter secondary school or college as a means of coping with a lower overall ability level (Moutafi, Furnham, & Crump, 2003).

These Conscientiousness findings, however, are contrary to the Baker and Bichsel (2006) study, which found Conscientiousness to be a predictor of STM only in "cognitively superior" older adults (a distinction I did not make). Both cross-sectional and longitudinal studies have shown that adults, on average, become more conscientious with advancing age (Roberts & Mroczek, 2008). One possible reason for this change is that age-related changes in cognition force people to initiate more structure on their lives, thereby increasing self-ratings of Conscientiousness. Perhaps in older adulthood, the people that are best able adapt to age-related cognitive changes could be categorizes as successful cognitive agers ("cognitive superiority") like in Baker and Bichsel (2006). Because the current study did not include any adaptation-type measures or longitudinal data, I am unable to test this possibility and further clarify this relationship. Nevertheless, it is clear from both the current study and the Baker and Bichsel (2006) study that Conscientiousness is linked to STM across the lifespan.

It is interesting that neither of the cognitive variables were related to Openness to Experience which has repeatedly been shown to be an important personality factor in intelligence and cognition (e.g. Baker & Bichsel, 2006; Schaie, Willis, & Caskie, 2004). I believe this lack of finding is probably due to the dependent (cognitive) variables being controlled for age and education, both of which are strongly related to Openness (Ashton, Lee, Vernon, & Jang, 2000; McCrae et al., 2004). Contrary to the hypothesis, Neuroticism was also not related to processing speed. I believe one potential reason for this is that the tasks used to measure speed in this study were non-discriminatory between inspection time and response time. Socor and Bucik (1998) found that participants that were more emotionally stable were quicker on choice reaction time (but not on inspection time) tasks and argued that this effect was due to less efficient processing by those high in Neuroticism.

4.3. Sex–personality interaction

In addition to the main effects of sex and personality, I also found an interesting sex by personality interaction. Specifically, high levels of Conscientiousness had differing effects for men and women on processing speed. Females with high levels of Conscientiousness had significantly faster processing speeds than the rest of the sample, and males with high Conscientiousness were significantly slower than the rest of the sample. I hypothesize that these differences may be accountable to differences in cognitive styles in low conscientious and high conscientious men and women (Dickman & Meyer, 1988; Quiroga, Hernández, Rubio, Shih, & Santacreu, 2007). Quiroga et al. (2007) found that some people solve cognitive tasks using their basic abilities while others are more influenced by their cognitive styles (fast-accurate, slow-inaccurate, impulsive,

and reflexive). I suggest that cognitive styles of high and low conscientious men and women may have influenced speeded performance similarly. That is, males high in Conscientiousness may be more deliberate and cautious (reflexive) in the speeded tasks (trading speed for accuracy), whereas females high in Conscientiousness may not have to make such a trade-off because of higher baseline levels of competence on speeded tasks (fast-accurate).

Another potential way to understand this interaction may be that males and females with varying Conscientiousness levels have different levels of motivation. As mentioned previously, Travis and colleagues (1988) found that gender interacted with type of achievement domain being tested and with locus of control in predicting levels of motivation on tasks. Therefore, perhaps males and females with varying levels of Conscientiousness differ in levels of task motivation. These differing levels of motivation may lead directly to the performance differential. For instance, perhaps high conscientious females are indeed highly motivated to do well on these tasks and are, therefore, quicker and more accurate. Measuring motivation levels and task importance would be helpful in furthering our understanding of this relationship.

4.4. Study limitations

This study has several limitations. Although some of the measures were collected at different time points, I am still combining the data and running non-longitudinal analyses. Nevertheless, it is important to keep in mind that the personality tasks were given over a year prior to the cognitive measures and I still found significant personality–cognition links. A 10-year follow-up of this study is in the final stages of completion which means that future studies can include both cross-sectional comparisons and longitudinal examinations of change in personality and cognition. Another possible limitation is one that was mentioned earlier in the discussion: the use of purely numeric short-term memory tasks and highly verbal speeded tasks. To really understand and explain the underlying sex differences, a larger set of more diverse basic cognitive tasks are needed. Finally, this study did not include imaging or physiological arousal measurements which could have further clarified the nature of some of the findings.

5. Conclusions

This study, which used a representative sample of adults aged 25–75, showed that personality and sex are both predictive speed-of-processing and STM. There was an interesting interaction (sex–Conscientiousness) that has not previously been reported in the literature. This better characterization of the role of sex and personality in adult cognition furthers our understanding of individual difference variables involved in cognition and adds additional questions to be addressed in future studies. The role of brain development, motivation, and socialization may be potential areas for understanding these personality and sex differences.

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