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Predicting interest in and attitudes toward science from personality and need for cognition

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ABSTRACT

One important task for psychologists of science is to examine the psychological factors (such as personality or cognition) that underlie who becomes interested in science and what kind of attitudes people develop toward science. Those were the primary questions addressed by the present study in a sample of 655 college undergraduates. We predicted that the personality dimensions of openness to experience, conscientiousness, and introversion as well as the cognitive style need for cognition would each predict level of interest in science. Results confirmed these predictions, although the effect sizes tended to be small. Further analyses revealed that need for cognition explained variance in interest in science over and above variance explained by personality.

1. Introduction

Science is one of the most influential forces in modern culture: few aspects of contemporary life are outside its reach. Ever since the Sputnik era of the 1950s there have been national calls for training our best and brightest minds for a life of science. But if young talented minds are to gravitate to a life of science, they first must have a positive attitude toward and develop an interest in science. Two important questions, therefore, are: (1) what kind of attitudes do people in general have toward science? and (2) who develops an interest in science?

The focus of this study is to understand who becomes interested in science. From psychological, social, and economic perspectives the question of how and when interest in and talent for science develops is of tremendous import (Park, Lubinski, & Benbow, 2008; Subotnik & Steiner, 1994). Indeed, disciplines that study science from historical, philosophical, and sociological perspectives are well established as seen by the fact that departments of study, graduate degrees, societies, and conferences are offered. The study of science from a psychological perspective (psychology of science), however, is still in its infancy: until 2006, no formal society exists and until 2008 no peer reviewed journal existed (see Feist, 2006; Feist & Gorman, 1998 for reviews of the field). Psychology, more than other studies of science, has the theoretical and methodological tools for answering questions of how attitudes toward and interest in science develops (Feist, 2006; Simonton, 2009).

Moreover, what kind of attitude non-scientists have toward science is tremendously important in shaping science's relationship with society. Recent surveys show that the American public still maintains a very favorable view toward science. In a 2009 survey of more than 2000 adults, 84% said that science's effect on society has been mostly positive, and scientists ranked only behind the military and teachers in professions that contribute to society's well being (Public Praises Science, 2009).

And yet, given a relatively positive view toward science, in most industrialized countries fewer and fewer people are obtaining degrees—both at the undergraduate and graduate levels—in science and technology. For instance, a study by Organization for Economic Cooperation and Development (OECD) between 1993 and 2003 revealed decreases in percentage of students earning bachelors' degrees in science and technology in 12 of the 16 countries and in the percentage of students earning PhDs in 13 of the 16 countries (Organization for Economic Cooperation, 2006). If fewer people are obtaining science and technology degrees, interest in these topics must be waning.

What light can the psychology of science shed on the psychology of scientific interest in general? The current study does not examine longitudinal changes in scientific interest, but does examine two important psychological factors behind interest in science, namely personality and need for cognition in a sample of 655 college undergraduates. By investigating the psychological influences of scientific interest and attitudes, we shed light on why certain individuals become interested in science in the first place, which in turn may provide clues as to how these interests and attitudes get translated into choosing a career (Holland, 1992).

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2. Personality and interest in and attitudes toward science

Research on the personality traits associated with scientists has existed for more than 125 years. In 1874 the British statistician and psychologist, Francis Galton (Darwin's first cousin) published the first scientific investigation of the psychological characteristics of geniuses, including scientists (Galton, 1874). He collected qualitative self-report data from 180 English men of science and found that they were distinguished by their high levels of energy, physical health, perseverance, good memories, and remarkable need for independence.

Since the 1950s, however, more systematic work has focused on the personalities of scientists, with "scientists" being defined as any sample that consisted of either professionals or students of science (physical, biological, and social), engineering, or technology (Feist, 1998, 2006, 2010; Feist & Gorman, 1998). The literature on personality and science has advanced to the point that a quantitative review (meta-analysis) has now been published (Feist, 1998). The following conclusions are the summaries from the meta-analysis conducted on the 26 published studies comparing personality traits of nearly 5000 scientists or science-oriented students to non-scientists.

2.1. Conscientiousness

One of the more robust if not terribly surprising findings from the research on scientists' personalities is their high level of conscientiousness, that is, desire for order, organization, and punctuality (Albert & Runco, 1987; Bachtold, 1976; Kline & Lapham, 1992; Wilson & Jackson, 1994). From the meta-analysis of 26 studies, the overall effect size on conscientiousness was .51, meaning that scientists on average are about a half a standard deviation higher than non-scientists on conscientiousness (Feist, 1998). In short, being high on conscientiousness lowers one's threshold for being interested in or having a career in science.

2.2. Openness

In the meta-analysis of 26 studies, the effect size for openness was consistent but small (median $d = .11$; see Cohen, 1988) comparing scientists to non-scientists (Feist, 1998). Openness to experience is made up of traits such as "aesthetic," "creative," "curious," "flexible," "imaginative," and "intelligent." Previous research focusing more on the "intelligence" component of openness, however, has reported a positive association between dispositional intelligence and being a scientist (Barton, Modgil, & Cattell, 1973). I from a theoretical perspective (Ackerman, 1996; Ackerman & Beier, 2003), developed an integrative model of personality traits, career interests, and intelligence in which openness to experience is part of the intellectual/cultural trait complex, but shares variance with the math/science complex.

Yet when comparing creative scientists to less creative scientists openness to experience is a large discriminator. The effect size is about a third of a standard deviation, meaning creative scientists are a third of a standard deviation higher on openness than less creative scientists (Feist, 1998). The open person seeks out new experiences, is curious about the world, and is relatively flexible in his or her ideas. One cannot be too set in one's ways in science, because nature has a way of humbling even the best of ideas. Additionally, one must be able to attack problems from different angles if one is to solve problems others have not.

2.3. Introversion and independence

Scientists, relative to non-scientists, do prefer to be alone and are somewhat less social and less affiliative (Bachtold, 1976; Eiduson, 1962; Roe, 1952; Wilson & Jackson, 1994). Results from the meta-analysis revealed a small to medium effect size between science and introversion (median $d = .28$; Feist, 1998). Such a finding is somewhat more true of physical scientists and mathematicians than social scientists. Scientists seem to have relatively low thresholds for social stimulation, and therefore prefer somewhat solitary activity or small group interactions. As Eysenck (1997) theory and empirical research has demonstrated, introverts have lower thresholds for arousal than extraverts and therefore find social stimulation overwhelming. Social stimulation can and often will interfere with the reflection needed to solve problems.

Similarly, research points to a connection between some forms of science, math, and engineering and a predisposition toward Asperger syndrome, a syndrome of disorders involving impaired social interest and interaction, stereotyped and repetitive behaviors, but without the delayed cognitive or language development that is seen in full-fledged autism (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001; Baron-Cohen, Wheelwright, Stone, & Rutherford, 1999). The combination of impaired social interest and stereotyped behaviors is most likely to be found in physical scientists, engineers, and mathematicians. This orientation toward non-social objects compared with people is sometimes referred to as a "thing orientation" as opposed to a "people orientation" (Feist, 2006; Graziano, Habashi, & Woodcock, 2011; Prediger, 1982) or an "empathizing or systemizing" style. Empathizing involves an interest and capacity in understanding other people's emotions and states of mind (people orientation), whereas systemizing involves constructing relationships between and understanding non-social entities (thing orientation). Science students are much more likely to have a systemizing cognitive style, whereas humanities students are much more likely to have an empathizing cognitive style (Billington, Baron-Cohen, & Wheelwright, 2007; Focquaert, Steven, Wolford, Colden, & Gazzaniga, 2007; Nettle, 2007).

Research into the connection between personality and interest in and attitudes toward science by non-scientists is much less well developed than the research on the personality of scientists. One study by Barton, Modgil and R.B. Cattell reported that particular personality traits of 13-year olds who attended public schools in the United Kingdom predicted interest in science. In particular, three traits from the Cattell's 16 Personality Factor (16PF) Inventory—Intelligent, Imaginative, and Self-Sufficient—each positively predicted interest in science as measured by an attitude survey. To map the 16PF traits on to the Five-Factor Model, Intelligent and Imaginative are both related to Openness, whereas Self-Sufficient is related to Extraversion (Feist, 1998). The current study was conducted to fill in the gap in this literature and to determine whether these patterns between personality and scientific interest and attitudes from the 1970s still hold true in the 2000s.

3. Need for cognition and interest in and attitudes toward science

In addition and related to personality as a predictor of scientific interest, the need for cognition should also predict who is interested in science and who is not. Cohen, Stotland, and Wolfe (1955, p. 291) first described need for cognition as "a need to structure relevant situations in meaningful, integrated ways. It is a need to understand and make reasonable the experiential world." Science in general involves understanding and making reasonable our experience of our world. More recently, Cacioppo and colleagues defined the need for cognition as "an individual's tendency to engage in and enjoy effortful cognitive endeavors." (Cacioppo, Petty & Kao, 1984, p. 306). Need for cognition, therefore, should be associated with interest in science, because the latter begins with wonder, questioning, and curiosity about how the world operates (Feist, 2006).

No research to date has established a direct connection between scientific interest, scientific reasoning, or scientific ability and the need for cognition. Numerous studies, however, have reported a direct association between the need for cognition and other aspects of reasoning connected to science, such as critical thinking and rational thinking (Cacioppo, Petty, & Morris, 1983; Kardash & Scholes, 1996). For example, West, Toplak, and Stanovich (2008) reported that need for cognition and open-minded thinking predicted critical thinking ability even after cognitive ability (SAT scores) had been held constant. In other words, need for cognition and open-minded thinking explain variance in critical thinking ability over and above cognitive ability. The current study, therefore predicts there will be a direct link between need for cognition and interest in science.

In order to further investigate the relationship between interest in and attitudes toward science and personality and the need for cognition, we conducted a study at a selective public liberal arts college. Specifically, given the research on personality and scientific interest, we predicted that openness to experience, conscientiousness, and introversion would be related to interest in science. In addition, given the conceptual connection between need for cognition, curiosity and interest in science, we predicted that those students who have the strongest need for cognition would be most interested in science.

4. Methods

4.1. Participants

Participants were 655 undergraduates enrolled in introductory psychology courses at a small public liberal arts college in Virginia. There were 271 men and 384 women and the sample as a whole had a mean age of 18.9. Eighty-four percent were of European-American ethnicity, 6% were of Asian-American ethnicity, and 2.3% were of African-American ethnicity.

4.2. Materials

Interest in and attitudes toward science: scientific attitude inventory. The measure of scientific interest was the Scientific Attitude Inventory-II (SAI-II; Moore & Foy, 1997). The SAI-II is a 40-item self-report scale that consists of 4 subscales with a 5-point Likert rating scale (5 = strongly agree; 3 = neutral/undecided; 1 = strongly disagree). The Science as Limited (alpha = .58) consists of six items, including "Anything we need to know can be found out through science," (reverse-scored, R), and "Some questions cannot be answered by science." The Science as Critical Thinking scale (alpha = .67) consisted of 6 items, including "Good scientists are willing to change their ideas," and "If one scientist says an idea is true, all other scientists will believe it," (R). The Need for Public Understanding of Science scale (alpha = .64) consisted of 6 items, including "Only highly trained scientists can understand science," (R) and "Most people can understand science." It is the last subscale, the Science as Interesting scale (alpha = .89) that will be of particular import to the present investigation. It consisted of 10 items, such as "I would like to work with other scientists to solve scientific problems," "I would like to be a scientist," and "Scientific work would be too hard for me" (R).

4.2.1. Personality: Big-Five Inventory (BFI)

The Big-Five Inventory (John, Donahue, & Kentle, 1991) was administered as a short measure of each of the Big-Five personality dimensions. The measure consists of 44-items (8 items each for Extraversion and Neuroticism; 9 items each for Agreeableness and Conscientiousness; and 10 items for Openness). Each item is rated on a 5-point Likert scale (1 = "disagree strongly" 3 = "neither agree nor disagree" and 5 = "agree strongly"). Reliability and validity information concerning the BFI is quite good (e.g., internal reliabilities ranging from .79 to .88 for the 5 scales; and corrected pairwise convergent validities ranging from .85 to .99) and can be found in John and Srivastava (1999).

4.2.2. Personality: NEO-Openness

Colleagues of the author were interested in openness for a separate study and wanted to add a second measure of openness. Therefore, we also included Costa and McCrae's NEO-PI-Revised Openness scale (Costa & McCrae, 1992). The NEO-PI-R Openness scale consists of 12 items, rated on a 5-point Likert scale (1 = strongly disagree, 3 = neutral; and 5 = strongly agree). The O scale has adequate reliability and validity (Costa & McCrae, 1992).

4.2.3. Need for cognition

Need for cognition was assessed via the short version (18 item) Need for Cognition Scale (Cacioppo et al., 1984). The inter-correlation between the 18 item and original 34-item scale approached the upper limits of reliability (r = .95) and its alpha-coefficient was .90 (Cacioppo et al., 1984). As was the case with other measures, items were rated on a 5-point Likert scale (1 = strongly disagree, 3 = neutral; and 5 = strongly agree).

4.3. Procedures

Data were collected in three separate classes of Introduction to Psychology, each of which averaged about 220 students. Another researcher was screening students on openness to experience and wanted multiple measures of the construct, hence our assessing openness with two distinct measures. The measures were administered in paper format and were mostly completed in class. Some students who could not complete the battery in the allotted 30 min time period were allowed to complete it outside of class and return it during the next class period. Course credit was provided to participants upon completion of their participation.

5. Results

To test the prediction that personality would be associated with interest in science, we conducted a series of zero-order correlation coefficients. The results confirmed the prediction that openness to experience is related to believing that science is interesting (see Table 1). People who are open and interested in novel experiences and ideas are most likely to be interested in science. Open individuals are also more likely to see the limits of science, to believe that science consists of critical thinking, and to argue for the public's need to understand science.

Extraversion was negatively related to interest in science ($r = -.10$), meaning that introverted students tend to be more interested in science than extraverted students (see Table 1). Additionally, students high in conscientiousness tend to find science slightly more interesting than those low in conscientiousness, but the effect size is quite small (r = .08).

The prediction that NFC would correlate with scientific interest was also supported. The zero-order correlation coefficient between overall need for cognition and finding science to be interesting was .27 (see Table 1). Students with the highest need for cognition were more likely to view science as having limits and requiring critical thinking, and to believe that the public should understand the fundamentals of science.

Table 1
Zero-order correlations between personality dimensions and scientific attitude scales (N = 655).

	Scientific attitude scale (SAI-II): science as				
	Limited	Critical thinking	Requiring public understanding	Interesting	Total SAI
Personality					
NEO-Openness	.19***	.29***	.26***	**.16******	.35***
BFI-Openness	.12**	.20***	.20***	**.14******	.26***
BFI-Extraversion	−.11**	−.07	−.07	**−.10****	−.14***
BFI-Agreeableness	.03	−.01	.09*	**.06**	.04
BFI-Conscientiousness	−.01	−.01	.11**	**.08***	.06
BFI-Neuroticism	.05	.00	.04	**−.04**	.02
Need for cognition	.09*	.25***	.25***	**.27******	.36***

Note: NEO = NEO-Personality Inventory; BFI = Big-Five Inventory; bold text for emphasis.
* $p \leqslant .05$.
** $p \leqslant .01$.
*** $p \leqslant .001$.

Given the relatively large sample size, the correlations, while small, are relatively robust (Cohen, 1988). Moreover, zero-order correlation coefficients merely tell us how strongly two variables correlate with each other, but they do not provide a hint about how much variance a set of variables as a whole explain in scientific interest or whether one predictor or set of predictors explains variance in an outcome over and above the variance of another predictor.

Multiple regression in general and setwise multiple regression in particular addresses these limitations. Results of the setwise multiple regression, with personality as the first set and need for cognition as the second set are presented in Table 2 (Cohen, Cohen, West, & Aiken, 2003). All together, the four personality variables (BFI-Openness, NEO-Openness, BFI-Conscientiousness and BFI-Extraversion) correlate .24 with believing science is interesting, which explains 6% of the variance ($R = .24$, $F = 9.66$, $p < .001$; see Table 2). Partialling shared variance between the predictors out of the equation, we see that BFI-E explains about 2% ($sr^2 = .018$), BFI-C and BFI-O each about 1%, and NEO-O less than 1% of the unique variance in believing science is interesting.

Entering NFC as the second step in the setwise regression equation functionally holds personality variance constant and addresses the question of whether NFC explains variance over and above personality. The answer is, yes, it does ($R^2 = .09$, R^2 change = .03; $F = 22.96$, $p < .001$). In other words, need for cognition explains 3% variance in science as interesting, once personality variance is held constant. Together, personality and need for cognition explain 9% of the variance in science as interesting ($R^2 = .088$, $F = 12.58$, $p < .001$).

6. Discussion

Personality and need for cognition both influence students' level of interest in and attitudes toward science. Of the Big-Five dimensions of personality, Openness to Experience, Introversion (opposite pole of Extraversion), and Conscientiousness are significantly correlated with interest in science. Examining the zero-order correlations, Openness appears to be the most consistently related to interest in science. Yet, when one filters out shared variance among the personality dimensions, Introversion explains a little more of the unique variance in scientific interest than either Openness or Conscientiousness.

These findings have both theoretical and practical import. They are consistent with and partially support Ackerman's theory of intellectual development known as the process, personality, interest, and knowledge (PPIK) theory (Ackerman, 1996; Ackerman & Beier, 2003). In short, PPIK argues that "ability (or intelligence-as-process) is directed by personality and interest traits toward specific domains" (Ackerman & Beier, 2003, p. 211). Scientific ability is directed by individual differences in openness, introversion and conscientiousness as well as need for cognition. Openness to experiences shares variance with the "math/science trait" complex, but in Ackerman's model is more centrally located in the "intellectual/cultural" trait complex. In addition, conscientiousness in Ackerman's model is located in the "clerical/conventional" complex and extraversion is in the "social" trait complex. The current findings, therefore, also challenge some portions of Ackerman's model and support other parts of it.

In addition, given the definition of openness and the one already discussed of the need for cognition (i.e., an individual's tendency to engage in and enjoy effortful cognitive activity), it is not surprising that these two dimensions are related to each other and associated with interest in science. Science, most everyone would agree, involves "effortful cognitive activity" and hence people disposed toward such activity would also tend toward a life of science, or at least be interested in it. Indeed, research on the need for cognition and personality consistently reports a moderately strong correlation between the two constructs, with effect sizes being approximately .50 (Woo, Harms, & Kuncel, 2007).

Moreover, a negative relationship between extraversion and scientific interest was confirmed. Students who are more intro-

Table 2
Setwise multiple regression: personality and need for cognition as predictors of scientific interest (SAI-interest scale).

Set	Predictor(s)	sr^2	t	R	$R^2\Delta$	Cum. R^2	df	F
1	BFI-Conscientiousness	.012	2.91**	.24	.056		4,653	9.66***
	BFI-Extraversion	.018	−3.52***					
	BFI-Openness	.005	1.81					
	NEO-Openness	.001	2.60**					
2	Need for cognition	.036	4.79***	.30	.032		1,652	22.96***
All variables						.088	5,652	12.58***

Note: BFI = Big Five Inventory; NEO = NEO Personality Inventory.
** $p \leqslant .01$.
*** $p \leqslant .001$.

verted are a bit more likely to be interested in science than those who are extraverted. One possible reason for the small effect size ($r = .08$), however, might involve the way interest in science was measured, that is, it did not distinguish between the different domains of science. As Feist (2006) has argued elsewhere, physical scientists and engineers will probably be somewhat introverted, whereas social scientists will probably be most extraverted. Future research should explicitly explore whether domain of science moderates the relationship between science and introversion.

Another interesting result from the current study was the fact that need for cognition explained variance in scientific interest even once variance due to personality was held constant. This implies that need for cognition is not merely a personality dimension, but rather also a unique cognitive style construct. Although some authors consider need for cognition to be a personality dimension (Woo et al., 2007), the current results suggest it is related to, yet distinct from, personality.

Finally, another set of studies on systemizing (or thing-oriented) cognitive style offer a bridge that may link scientific interest with personality and cognitive style. First, recent studies have reported that the systemizing cognitive style is related to interest in science and engineering (Billington et al., 2007; Focquaert et al., 2007). Another study of more than 250 adults (mean age = 31) reported that systematizing is moderately and positively related to the personality dimensions of Conscientiousness and Openness (Nettle, 2007).

Lastly, taken together these findings suggest that the open, somewhat introverted, and mildly conscientious person who likes cognitive puzzles and problems is most primed to be interested in science. That interest is the starting point for career interest. Career counselors could add this profile to their list when advising students into careers that fit their personality and interest. In short, personality and cognition are but two of the pieces in the puzzle of what makes for interest and success in science.

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