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Personality and Individual Differences 40 (2006) 909–917
PERSONALITY AND INDIVIDUAL DIFFERENCES
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Personality level on the big five and the structure of intelligence

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Received 13 June 2005; received in revised form 1 September 2005; accepted 12 September 2005
Available online 21 November 2005

Abstract

Research about changes in the structure of intelligence has generally not focused on the possible role played by personality traits. However, previous findings suggest that some personality traits (especially Neuroticism) could affect the structure of intelligence. Recently, there is a renewed interest in developing links between personality and intelligence. This interest calls for a theoretical integration of ability and non-ability traits. From this standpoint, the relationships between ability and non-ability traits at the structural level should be investigated. The NEO-FFI and three cognitive tests (PMA-V, PMA-E, and PMA-R) were administered to 569 university students. Samples were divided into three groups according to personality scores. This division was conducted separately for every personality trait. Further, the *g* factor was extracted in every group. Results show no change in the importance of the *g* factor across personality level groups. This pattern is replicated for the Big-Five. Therefore, it is concluded that personality traits play no role in the changes in the structure of intelligence. Possible explanations for this lack of differences between personality level groups, and future directions are discussed.

Keywords: Differentiation hypothesis; Structure of intelligence; Personality; Big-Five; PMA cognitive battery

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doi:10.1016/j.paid.2005.09.013

1. Introduction

The changes in the structure of cognitive abilities have become a central topic in the current research on human intelligence (Deary et al., 1996; Juan-Espinosa, 1997). Such structural changes have usually been investigated under the following hypotheses: ability-level differentiation, age-differentiation, and age-dedifferentiation. The first hypothesis is related to the role of ability-level, and states that the higher the level of *g*, the less the amount of variance accounted for by *g* (Abad, Colom, Juan-Espinosa, & García, 2004; Detterman & Daniel, 1989). The second and the third hypotheses are related to the role of age variables. The age-differentiation hypothesis states that from childhood ages to early maturity, the structure of intelligence changes from a unified, general ability to a set of abilities (Garrett, 1946; Juan-Espinosa, García, Colom, & Abad, 2000). However, from early maturity to late adulthood, the reverse phenomenon (designated as the age-dedifferentiation hypothesis) is postulated. So, an increase of the variance accounted for by *g*, as well as a reduction in the number of specific abilities would be expected (Balinsky, 1941; Juan-Espinosa et al., 2002).

These hypotheses have dominated the research on variations in the structure of intelligence. However, other variables have been hypothesized to affect the structure of intelligence. In this sense, personality traits have deserved some attention. Thus, in the sixties, it was found that extraverted, neurotic and subjects with a clinical disorder had a less differentiated cognitive structure than introverted, emotionally stable and subjects without a clinical disorder, respectively (Balzert, 1968; Lienert, 1963). Also, Lienert (1966) found that the structure of cognitive abilities was less differentiated in the group of students who answered psychological tests under the effects of LSD. However, other authors were not able to replicate those results (Cohen & Witteman, 1967).

Further, Austin, Deary, and Gibson (1997) divided a sample of Scottish farmers ($N = 210$) by using the mean in the corresponding personality scale as the cut-off point. They hypothesised that cognitive abilities had a different structure at low and high levels of neuroticism, with less ability differentiation in high-*N* groups. This hypothesis received tentative support from the demonstration of an increase in the correlation between a verbal test named National Adult Reading Test (NART), and the Raven test with increasing *N*. In agreement with Austin et al. (1997), Austin, Hofer, Deary, and Eber (2000) found that the correlation between two ability measures (The intelligence sub-scale of the 16-PF and the Cattell's Culture Fair Intelligence Test) varies with level of neuroticism, the correlations for the high-*N* groups being larger. This finding was consistent across two extremely large sub-samples (more than 15,000 subjects each one). However, conclusions derived from both studies were based on simple correlations between two cognitive tests and, as Austin et al. (1997) emphasised, further work using a wider range of ability tests, allowing more detailed factor-analytic studies, would be necessary.

Austin et al. (1997) also investigated the impact of the Openness factor on the correlations between the NART and the Raven. This last analysis is sustained by the relationships between Openness and cognitive abilities as knowledge achievement or creative thinking (McCrae, 1987). From this view, individual differences on Openness would be related to intelligence. In fact, correlations found between Openness and intelligence measures are usually around 0.30 (Costa & McCrae, 1992). The meta-analytic study by Ackerman and Heggestad (1997) concluded that the

strongest relationship between psychometric intelligence and personality traits is found for the broad trait of Openness (also named culture or intellect; Goldberg, 1992). Austin et al. (1997) found tentative support for an effect of the O level on cognitive structure.

All previous studies have been focused on Neuroticism, Extraversion, and more recently, on Openness to Experience. But currently, there is some consensus in considering the Five-Factor Model (FFM) as the dominant paradigm in personality research (Brody & Ehrlichman, 1998; Matthews, 1998). Following the FFM, Neuroticism, Extraversion, Openness to Experience, Agreeableness, and Conscientiousness are the basic traits of temperament. In spite of the possible role played by those five basic traits, no study has investigated the role of Agreeableness and Conscientiousness on variations in the structure of intelligence. Although this lack of concern could be due to the absence of relationships between such factors and cognitive abilities (Ackerman & Heggestad, 1997), the impact of those domains over the cognitive structure should be tested before discarding them definitively.

Another point is the trend of the relationship; it has been suggested that personality could affect the structure of intelligence in a non-linear way, showing similar distribution effects for low and high groups, but not for the central part (Austin et al., 1997; Eysenck & White, 1964). This effect could explain previous contradictory results observed in the sixties, and should be taken into account. In fact, Austin et al. (1997) found a non-linear effect for the Neuroticism and the Openness factors, this trend being weaker for O than for N.

Relationships between personality and intelligence at the structural level have been mostly guided by the personality differentiation hypothesis (Austin et al., 2000; Brand, Egan, & Deary, 1994). It seems that fewer personality dimensions are required to explain the variance on self-report personality questionnaires in low-ability than in high-ability groups. According to this proposal, the size of correlations among the personality factors decreases with increasing mental abilities (Allik, Laidra, Realo, & Pullmann, 2004). The personality differentiation hypothesis assumes that ability-level has an effect on personality structure. Note that the present article is focused on the inverse view, i.e., on the effect of personality level on the structure of intelligence.

Considering Austin et al.'s (1997) suggestion about the convenience of adopting a factor-analytic approach, and that only a few studies have analysed the role of personality traits on the structure of intelligence, the aims of the present article were: (a) using a factor-analytic approach to replicate previous findings about the effect of Neuroticism, Extraversion, and Openness to Experience on the structure of intelligence, (b) extending these analyses to Agreeableness and Conscientiousness, and (c) investigating if these relationships are non-linear.

2. Method

2.1. Subjects

The sample was composed of 569 Spanish college students, 77 of which were males and 492 were females. Age mean was 19.62 years (SD 1.61). Participants were recruited as volunteers from upper division undergraduate courses at the autonomous University of Madrid. All questionnaires were collectively applied in classrooms of around 60 subjects each.

2.2. Measures

2.2.1. Personality

The Spanish version of the NEO Five-Factor Inventory (NEO-FFI; Costa & McCrae, 1999) was used. This is a sixty-item self-report questionnaire which allows scores to be obtained on the five personality dimensions of Neuroticism (N), Extraversion (E), Openness (O), Agreeableness (A) and Conscientiousness (C). The answer format is a five-point Likert-type scale, ranging from "Strongly disagree" (0) to "Strongly agree" (4). There are twelve questions for each dimension; the range of possible scores on each dimension being from 0 to 48. The alpha reliability coefficients for Neuroticism, Extraversion, Openness, Agreeableness and Conscientiousness in the Spanish population were 0.82, 0.78, 0.71, 0.71, and 0.83, respectively.

2.2.2. Cognitive abilities

The three cognitive tests were taken from the well-known Primary Mental Abilities (PMA; Thurstone & Thurstone, 1984), Battery: Vocabulary (Split-half reliability = 0.91), Spatial Rotation (Test–retest reliability = 0.73) and Inductive Reasoning (Split-Half reliability = 0.92).

2.3. Analysis

Austin et al. (1997) divided their sample into two groups taking the mean as the cut-off point. In the present study, the sample was divided into three groups in order to test a possible non-linear trend. So, subjects with a standardized score below −0.5, between −0.5 and +0.5 and higher than +0.5 were assigned to a low, medium, and high group, respectively. These groups were formed for each personality trait.

Later, a principal axis extraction method was conducted separately for each group. In all cases, one factor was explicitly requested. According to Jensen and Weng (1994), the percentage of variance accounted for by the first unrotated principal factor is a good estimate of the *g* factor, especially when the nature of tests is diverse (Jensen, 1998). Congruence coefficients between *g* vectors were computed with the objective of assuring that personality groups were comparable (Cattell, 1978). Also, the absence of differences in variability and the presence of normal distributions must be shown before any analysis was conducted (Deary et al., 1996). Finally, significance of differences between low/medium, low/high and medium/high groups was tested through the *F* ratio of eigenvalues. This analysis informs us about the significance of the changes in the percentage of variance since the eigenvalue is the standardized variance accounted for by the cognitive factors (Jensen, 2003).

3. Results

Table 1 shows the descriptive statistics of the total sample. When reported means for adolescent and adult standardization samples of the Spanish NEO-FFI (Costa & McCrae, 1999) are combined, we obtained the following means for the Neuroticism, Extraversion, Openness, Agreeableness and Conscientiousness scales, respectively (standard deviation between parenthesis): 18.98 (7.46), 33.81 (6.79), 29.17 (6.59), 30.67 (5.85), and 32.18 (6.52). Also, observed were means for

Table 1
Descriptive statistics for the total sample

	Mean	Standard deviation	Asymmetry	Kurtosis
Vocabulary	28.32	7.00	.185	−.325
Spatial Rotation	24.22	10.12	.367	−.008
Inductive Reasoning	19.70	4.66	−.451	.630
Neuroticism	24.48	7.56	−.041	.172
Extraversion	31.62	6.48	−.132	.204
Openness	31.70	6.25	−.113	.172
Agreeableness	29.10	4.86	−.288	.656
Conscientiousness	28.89	6.31	−.185	.487

Vocabulary, Spatial Rotation, and Inductive Reasoning tests in an extremely large Spanish sample ($N = 10{,}257$) of similar age (Escorial, García, Juan-Espinosa, Rebollo, & Colom, 2003) were (standard deviation between parenthesis): 27.70 (7.03), 28.38 (11.54), and 19.19 (11.84), respectively. Note that the only remarkable differences between those means and the reported ones in Table 1 were found for Neuroticism and Spatial Rotation. The high percentage of females in this sample can explain observed differences on Neuroticism (Costa, Terracciano, & McCrae, 2001), and Spatial Rotation (Voyer, Voyer, & Bryden, 1995), but, in general, reported means and standard deviations were considerably similar to population values for personality and cognitive measures, and the asymmetry and kurtosis indexes suggested the presence of a normal distribution in every case.

Table 2 shows the descriptive statistics of the cognitive tests by personality trait and group. No remarkable difference in the standard deviations of the cognitive tests was found among the three

Table 2
Descriptive statistics (Mean, Standard deviation [SD], Asymmetry [A], and Kurtosis [K]) by personality trait and group

			Vocabulary				Spatial Rotation				Inductive Reasoning			
	Groups	N	Mean	SD	A	K	Mean	SD	A	K	Mean	SD	A	K
Neuroticism	Low	169	29.48	7.29	−.017	−.489	25.52	10.66	.363	−.326	20.51	4.86	−.616	.798
	Medium	238	27.43	6.39	.166	−.238	23.05	9.35	.305	.317	19.07	4.49	−.294	.559
	High	162	28.43	7.38	.296	−.270	24.58	10.49	.340	−.122	19.77	4.59	−.609	1.009
Extraversion	Low	185	28.45	6.37	.210	−.125	23.86	10.35	.427	−.341	19.38	4.51	−.371	.793
	Medium	195	27.26	7.31	.143	−.589	23.58	10.13	.388	.403	19.47	4.35	−.355	−.173
	High	189	29.29	7.14	.263	−.311	25.23	9.84	.312	.027	20.24	5.08	−.655	1.093
Openness	Low	187	27.24	7.05	.398	−.059	23.72	10.48	.466	.062	19.34	4.65	−.348	.345
	Medium	187	28.13	6.98	.128	−.492	23.90	9.93	.252	−.104	20.21	4.19	−.272	−.185
	High	195	29.54	6.82	.071	−.199	25.01	9.95	.390	.055	19.55	5.07	−.570	1.013
Agreeableness	Low	143	29.20	6.95	.083	.013	25.43	10.45	.248	−.150	19.77	4.56	−.211	−.247
	Medium	270	27.40	7.03	.282	−.395	23.26	9.77	.264	.035	19.48	4.62	−.456	.964
	High	156	29.11	6.83	.154	−.324	24.79	10.30	.597	.009	20.01	4.84	−.656	.914
Conscientiousness	Low	146	29.20	7.00	.027	.027	24.22	9.99	.329	−.035	19.80	4.91	−.718	1.288
	Medium	278	27.50	6.76	.230	−.267	24.32	10.25	.326	.005	19.63	4.41	−.276	.242
	High	145	29.01	7.31	.211	−.646	24.04	10.06	.493	.078	19.72	4.90	−.449	.505

Table 3
Number of subjects (N), eigenvalue (λ), and percentage of variance accounted for by the g factor (%) by personality trait and group

		N	λ	%
Neuroticism	Low	169	1.249	41.62
	Medium	238	1.160	38.68
	High	162	1.204	40.12
Extraversion	Low	185	1.049	34.95
	Medium	195	1.190	39.66
	High	189	1.342	44.74
Openness	Low	187	1.350	44.99
	Medium	187	1.095	36.49
	High	195	1.205	40.15
Agreeableness	Low	143	1.189	39.64
	Medium	270	1.181	39.35
	High	156	1.296	43.21
Conscientiousness	Low	146	1.174	39.12
	Medium	278	1.216	40.53
	High	145	1.262	42.06

groups in the five traits. Also, asymmetry and kurtosis indexes suggest the presence of a normal distribution. So, differences on variability or distribution will not explain possible differences in the cognitive structure across personality groups.

Table 3 show percentages of variance accounted for by the g factor by personality trait and group. Congruence coefficients were higher than 0.90 in all cases, so factors can be properly compared. The largest difference between two groups was around 3, 10, 8, 4, and 3% for Neuroticism, Extraversion, Openness, Agreeableness, and Conscientiousness, respectively. However, the F ratio of the eigenvalues was not significant in all cases, even for the comparison between low and high Extraversion groups ($F = 0.78$; $p > 0.05$).

4. Discussion

Results show no role of personality traits on the structure of intelligence. A factor-analytic approach does not replicate findings reported by Austin et al. (1997), and Austin et al. (2000). In fact, the percentage of variance accounted for by g was lower for the low than for the high Neuroticism group. However, the tendency with Extraversion is the same to the one reported by Balzert (1968), although the difference was not significant.

Thus, the theoretical interpretation of the relationships between Neuroticism and cognitive structure in terms of the higher degree of general temporal trait variability in subjects scoring high on Neuroticism (Brand et al., 1994), or the idea that greater degrees of cognitive organisation (i.e. a more differentiated structure) could be linked to some personality patterns are not supported. On the other hand, the existence of non-linear relationships between personality traits and cognitive structure is also rejected.

A possible explanation for the lack of differences between personality level groups is the absence of mean differences. As can be seen in Table 2, means in the three cognitive tests were strongly similar across groups. An Univariate ANOVA shows significant differences in Vocabulary, Spatial Rotation, and Inductive Reasoning between low and medium Neuroticism groups, and in Vocabulary for Extraversion (medium Vs high groups), Openness (low Vs high), Agreeableness (low Vs medium), and Conscientiousness (low Vs medium). However, the largest absolute difference (2.47) is observed for Vocabulary between low and medium Neuroticism groups, being the associated effect size of 0.25. Note that this effect size can not be considered large since it is lower than 0.50 (Cohen, 1969). This fact suggests that previous supporting evidence of the impact of the personality level on the structure of intelligence could be due to differences on the ability-level between personality groups, not to a real effect of the independent variable considered, i.e., personality traits.

Recently, it has been argued that the increase in the number of studies examining empirical links between personality and intelligence calls for a theoretical integration of ability and non-ability traits (Chamorro-Premuzic & Furnham, 2004). From this perspective, it is time to ask whether personality traits have any different effect on the performance of cognitive tests, or on the development of intellectual skills. In their recent, review, Zeidner and Matthews (2000) concluded that although performance on cognitive tests could be influenced by non-cognitive factors such as personality traits and states, ability and personality are orthogonal constructs at the level of latent constructs. Results from the present paper support this point of view.

Although this study is the first effort in the study of relationships between personality and cognitive structure using a factor-analytic approach, more cognitive tests should be incorporated in future studies. This increment in the number of cognitive tests would imply two major improvements. The first one would come from the possibility of analyzing other cognitive factors. Although the diversity of tests applied in the present paper is optimal to analyse the most important and general cognitive ability (g), the lack of more cognitive tests precludes the extraction of factors different from g. Those analyses are especially relevant since it is expected that non-ability variables, such as personality traits, had a stronger impact on cognitive factors developed through learning, experience, and cultural opportunities (Ackerman, 1996; Cattell, 1987). In fact, the invariant pattern found in the present study could be explained because the g factor is closer to fluid than to crystallized intelligence (Carroll, 1993). Results reported by Abad et al. (2004) reinforce this idea, since they found that a battery with a crystallised bias presented a stronger ability-level differentiation effect than a battery with a fluid bias. Therefore, cognitive batteries which cover a wider range of cognitive factors should be desirable in future studies.

The second improvement is related to the use of structural equation modelling techniques. Testing the equivalence of factor structures calls for the employment of such techniques (Bollen, 1989), allowing for more stringent statistical criteria (Vassend & Skrondal, 1997). Unfortunately, the present paper analyses three cognitive tests only. A model including one latent factor and three observed variables is completely identified and obtains a perfect fit, so competing models can not be properly compared. The inclusion of more cognitive tests would also be desirable in order to incorporate structural equation modelling approaches to analyse this topic.

This study has two limitations. Firstly, the sample is a university sample and not from the general population. It is interesting to note, however, that the sample has lower conscientiousness scores compared to the normative statistics reported for the Spanish population (see Table 1).

Typically, university students would be characterized as conscientious. Secondly, the ability range in the student sample is restricted. Non-linear intelligence/personality associations (if they exist) are more likely to be found if there is a wide range of both intelligence and personality trait scores. More research is required to eliminate these limitations.

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