Personality and Individual Differences 100 (2016) 73–78

Contents lists available at ScienceDirect

Personality and Individual Differences

journal homepage: www.elsevier.com/locate/paid

# Personality differentiation by cognitive ability: An application of the moderated factor model☆

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ARTICLE INFO

*Article history:*
Received 30 June 2015
Received in revised form 25 February 2016
Accepted 30 March 2016
Available online 8 April 2016

*Keywords:*
Personality differentiation
Personality structure
Intelligence
Cognitive ability

ABSTRACT

The personality differentiation hypothesis holds that at higher levels of intellectual ability, personality structure is more differentiated. We tested differentiation at the primary and global factor levels in the US standardisation sample of the 16PF5 (n = 10,261; 5124 male; mean age = 32.69 years (SD = 12.83 years). We used a novel combined item response theory and moderated factor model approach that overcomes many of the limitations of previous tests. We found moderation of latent factor variances in five of the fifteen primary personality traits of the 16PF. At the domain level, we found no evidence of personality differentiation in Extraversion, Self-Control, or Independence. We found evidence of moderated factor loadings consistent with the personality differentiation for Anxiety, and moderated factor loadings consistent with anti-differentiation for Tough-Mindedness. As differentiation was restricted to a few personality factors with small effect sizes, we conclude that there is only very limited support for the personality differentiation hypothesis.



## 1. Introduction

Whilst very many studies have investigated the relation between intellectual ability and personality trait levels (e.g. Bartels et al., 2012; Chamorro-Premuzic et al., 2005; Murray et al., 2014), much less attention has been paid to the relation between intellectual ability and personality trait structure. An exception has been the work in the personality differentiation framework. The personality differentiation hypothesis originated with Brand, Egan and Deary (1994) who proposed that at higher levels of intellectual ability, personality structure is more differentiated. The authors proposed the hypothesis by way of analogy with the 'intelligence differentiation' hypothesis in cognitive ability (Spearman, 1927) and was based on the idea that more intelligent individuals have more specialised skills and interests which in turn become reflected in more differentiated personality structures.

Empirical studies have largely operationalised differentiation statistically as personality constructs having smaller variances and larger inter-correlations in individuals of lower cognitive ability. Several studies have reported a tendency for larger facet (Austin, Hofer, Deary & Eber, 2000; Harris, Vernon & Jang, 2005) or dimension variance (Austin, Deary & Gibson, 1997; De Fruyt, Aluja, García, Rolland, & Jung, 2006; Harris et al., 2005; Harris, Steinmayr, & Amelang, 2006; Myers & McCaulley, 1985; Shure & Rogers, 1963) in higher ability groups. Likewise, with the exception of only a few samples (e.g. Austin et al., 1997) or traits within studies, dimension inter-correlations have tended to decrease with ability level (Austin et al., 2002; De Fruyt et al., 2006; Blas & Carraro, 2011; Harris et al., 2006; Mõttus et al., 2007) though the effects are not large nor always statistically significant. This past work has led to a general perception that there is at least some support for the personality differentiation hypothesis.

In interpreting the above-mentioned evidence, it is important to consider the possibility that cognitive ability may not produce true differences in latent personality structure, but differences in the manner in which individuals interpret, understand and respond to personality items which could, in turn, impact on observed structure (Allik & McCrae, 2004;Watson, Deary & Austin, 2007). If, for example, personality items show differential reliability across the range of cognitive ability due to these or other measurement issues, then this could mask or mimic differentiation effects. That is, observed personality differentiation could be a measurement phenomenon rather than a latent structure phenomenon (e.g. see Murray, Dixon & Johnson, 2013).

The majority of previous personality studies has utilised observed scores which conflate trait and error variances making it difficult to differentiate between effects (or the absence of effects) due to differential measurement properties and differential latent structure across the range of cognitive ability. Although Brand et al., (1994) did not explicitly lay out any predictions regarding how personality differentiation should manifest in the latent variable models now commonly used to model and test hypotheses regarding personality

☆ This article is a Special issue article – "Young researcher award 2015".

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http://dx.doi.org/10.1016/j.paid.2016.03.094
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structure, it would be reasonable to assume some parallels between personality differentiation and the intelligence differentiation hypotheses which served as its inspiration. The intelligence differentiation hypothesis proposes that *g* is less influential at higher levels of intellectual ability. This has been operationalized in factor models of intelligence as smaller factor loadings of specific intellectual skills (usually measured by subtest scores) for higher levels of *g* (Tucker-Drob, 2009; Molenaar, Dolan, & Verhelst, 2010). In personality, considering the relations between items and facets and between facets and global factors, this translates into the prediction that personality factor loadings will be reduced at higher levels of intellectual ability. That is, the personality factors interact with intellectual ability.

To ensure that any differences in factor loadings to not merely reflect differential reliability, one solution is to utilise a moderated factor model which allows moderation of item residuals to be modelled and thus explicitly models the differential reliability that might otherwise be mistaken for personality differentiation (Molenaar, Dolan, Wicherts, & van der Maas, 2010). The moderated factor model proposed by Molenaar et al. (2010) can be used to test for personality differentiation by evaluating whether the loadings in a factor model of personality are moderated by intelligence. The approach is conceptually similar to the multi-group CFA (MG-CFA) approaches to testing personality differentiation (see DeFruyt et al., 2006; McLarnon & Carswell, 2013) but it has the advantage that it allows intellectual ability to be modelled continuously rather than across discrete groups created using artificial dichotomisation. Further, the moderated factor model provides more easily interpretable indices of moderation because it directly estimates 'moderation parameters'. These parameters represent the linear change in loadings with a cognitive ability level. In spite of these advantages, the moderated factor model approach is yet to be applied to the personality differentiation. It was, therefore, the aim of the present study to apply the moderated factor model to evaluate personality differentiation in a large population representative sample of individuals who had completed an omnibus personality inventory, the Sixteen Personality Factor Questionnaire, Version 5 (16PF5) (Conn & Reike, 1994).

## 2. Methods

### 2.1. Sample & measure

We use the American standardisation sample of the 16PF5 (N = 10,261).[1] The standardisation sample was reviewed in 2002 based on the US census in 2000 to ensure it remained a representative of the general population of the USA with respect to a number of demographic variables including sex (5124 males, 49.9%), ethnicity (77.9% white, 10.8% black, 3.6% Asian), age (mean age = 32.69 years, SD = 12.83 years, range = 16 to 82) and geographic region. Conn and Rieke (1994) note that the educational level and years in education of the sample are greater than that of the US population.

#### 2.1.1. Personality measures

In its current form, the 16PF5 comprises 15 personality scales, structured into five second order global factors, namely Extraversion (Self-Reliance (Q2), Warmth(A), Liveliness(F), Privateness(N), Social Boldness(H)); Anxiety (Tension(Q4), Apprehension(O), Emotional Stability(C), Vigilance(L)); Tough-Mindedness (Sensitivity(I), Openness to Change(Q1), Warmth(A), Abstractness(M)); Independence (Dominance(E), Social Boldness(H), Vigilance(L), Openness to Change(Q1)); and finally Self-Control (Abstractness(M), Rule Consciousness(G), Perfectionism(Q3), Liveliness(F)). Each of the primary personality scales consists of between 10 and 14 items with a three point response format, "No", "?" and "Yes", scored as 0, 1 and 2 respectively.

#### 2.1.2. Intelligence measure (moderator)

In addition, the 16PF5 contains a 15 item Reasoning scale: a short cognitive ability measure assumed to tap verbal, numerical and logical abilities. It is designed to provide a quick measure of intelligence and correlates at $r = .61$ the Information Inventory (Altus, 1948) and at $r = .51$ with the Form A, Scale 2 Culture Fair Intelligence Test (CFIT; IPAT 1973a, 1973b). The test manual reports a Cronbach's alpha of .80 for the scale with 2 week and 2 month test–retest reliabilities of .71 and .70 respectively. Based on a sample of 2500 respondents, the Reasoning scale has been shown to have correlations with the primary factors of the 16PF ranging from r = −.27 (L: Vigilance) to r = .20 (Q1: Openness to Change) (Conn & Rieke, 1994, Appendix 5B). Investigations of differential item functioning by gender and ethnicity found no biasing by race or gender the exception of one item that functioned differently in a Hispanic sample (Conn & Rieke, 1994).

### 2.2. Analysis strategy

#### 2.2.1. Overview

Given the 3-level hierarchical structure of the 16PF5 (items, primary factors, global factors) the statistically most sound analysis would have been to fit a second-order moderated factor model to the item level personality data (i.e., a second-order item response theory model or discrete factor model subject to moderation). However, such a model has not yet been developed. In addition, for the present undertaking fitting such a model will be numerically challenging due to the large number of items (40 to 51 across global models), the large sample size, and the high dimensionality of the 16PF5. We therefore test for moderation at the primary and global factor level separately.

#### 2.2.2. Primary factor level

As the primary factor level consists of item level categorical data, we adopted an item response theory approach. Our choice for a specific IRT model was guided by the recurrent finding that the middle '?' option of the 16PF response scale does not consistently perform as a middle response option (Murray, Booth & Molenaar, 2015; Stark, Chernyshenko, Drasgow & Williams, 2006). As tests on interaction effects in general (Loftus, 1978) and differentiation effects in particular (Murray et al., 2013) are sensitive to scaling of the measurement, we wanted to explicitly take the ordering of the response options (including '?') into account. Therefore, we adopted Bock's Nominal Response Model (NRM; Bock, 1972). In this model, each item category is associated with a loading parameter, unlike the discrete factor model where each *item* has a loading. This complicates the operationalisation of the differentiation effect in terms of moderated factor loadings. We therefore introduced the differentiation effect on the variance of the primary factor. That is, by making the primary factor variance an exponential function of the intelligence moderator, we could investigate whether the variance decreased for increasing levels of intelligence. Note that moderation of the factor variance has been proposed as an alternative but a comparable method to test for differentiation (Molenaar et al., 2010).

#### 2.2.3. Global factor level

To assess differentiation at the global factor level, we used a two-step approach. First, we estimated factor scores for the primary factors using the NRM discussed above. Next, we fit a moderated first-order factor model to each of the global factors. Within this model, personality differentiation was operationalised as decreasing primary factor loadings at increasing levels of intellectual ability. Note that if the primary factors are differentiated (as tested using the methods discussed above), the primary factor scores will incorporate this effect.

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