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## The heritability of conscientiousness facets and their relationship to IQ and academic achievement

Michelle Luciano<sup>\*</sup>, Mark A. Wainwright, Margaret J. Wright,  
Nicholas G. Martin

*Queensland Institute of Medical Research, PO Royal Brisbane Hospital, Brisbane, QLD 4029, Australia*

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### Abstract

The heritability of conscientiousness has been one of the least explored of the NEO PI domains. Here we focus on the facet scales of the conscientiousness domain, estimating both their heritability and their correlations with measures of IQ and academic achievement (Queensland Core Skills Test; QCST) in a sample of adolescent twins and their non-twin siblings. Our findings confirmed positive associations between IQ and the facets of Competence and Dutifulness (ranging 0.11–0.27), with academic achievement showing correlations of 0.27 and 0.15 with these same facets and 0.15 with Deliberation. All conscientiousness facets were influenced by genes (broad sense heritabilities ranging 0.18–0.49) and unique environment, but common environment was judged unimportant. A multivariate genetic analysis including Competence, Dutifulness, IQ (verbal, performance) and QCST scores showed that common variance was primarily explained by a general additive genetic factor (loadings ranging 0.15–0.84). Future multivariate genetic analysis which incorporates Openness to Experience dimensions may improve the interpretation of these findings.

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*Keywords:* Conscientiousness; IQ; Academic achievement; Twin study; Genetics; NEO PI-R

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<sup>\*</sup> Corresponding author. Tel.: +61 7 3362 0218; fax: +61 7 3362 0101.

E-mail address: [michelle.luciano@qimr.edu.au](mailto:michelle.luciano@qimr.edu.au) (M. Luciano).

## 1. Introduction

Conscientiousness, like other personality traits, is influenced partly by genes. However, there are conflicting findings (e.g., Jang, Livesley, & Vernon, 1996; Loehlin, McCrae, Costa, & John, 1998) on the influence of dominance genes (preferential expression of one parental gene, and including gene by gene interactions) and common environment. The genetic and environmental structure underlying intelligence is, on the other hand, well established, with its variation primarily composed of additive genetic effects (the sum of parental genes in influencing the offspring's trait). The notion that conscientiousness and intelligence may be related is not new (e.g., Pearson, 1906), but the empirical evidence is conflicting, with support for positive and negative correlations between conscientiousness and measures of intelligence (Ackerman & Heggestad, 1997). For academic achievement, positive correlations with conscientiousness have been consistently found (e.g., Busato, Prins, Elshout, & Hamaker, 2000; Lounsbury, Sundstrom, Loveland, & Gibson, 2003). This paper aims to further explore the associations between conscientiousness, IQ, and academic achievement, but within the framework of a classical twin design, which enables the estimation of genetic and environmental contributions to variance and covariance among the measures.

Conscientiousness has a moderate heritability (i.e., the proportion of variance due to genes;  $h^2$ ). Loehlin (1992) analysed biological and adoptive parent–child and sibling/twin correlations reported from previous studies and showed that variation in conscientiousness could be explained by additive genes (0.22), gene by gene interactions (0.16), shared environment (0.07), and unique environment (0.55). The variance in NEO PI conscientiousness scores has been shown to consist of genetic dominance (explaining 29% of variance), shared environment (11%) and unique environment (60%) (Bergeman, Chipuer, Plomin, & Pedersen, 1993). An investigation of the NEO PI-R conscientiousness facet scores supported additive genetic and unique environmental effects for Competence ( $h^2 = 0.44$ ), Dutifulness (0.44) and Achievement-Striving (0.42), while Order, Self-Discipline, and Deliberation were influenced by the common and unique environment (Jang et al., 1996). Although expansion of this study later showed additive genetic influence on Order and Self-Discipline (Jang, McCrae, Angleitner, Riemann, & Livesley, 1998). Furthermore, it was shown that after removing common variance between the facets, specific genetic effects (ranging 0.11–0.28) influenced all facets except Achievement-Striving and Deliberation. A multivariate analysis of facets confirmed the presence of a genetic general factor, a genetic factor loading on all facets but Deliberation, and specific genetic influences on most measures (Jang, Livesley, Angleitner, Riemann, & Vernon, 2002).

While genetic findings support substantial common variance between the diverse facets of the conscientiousness domain, the phenotypic correlations between individual conscientiousness facets and IQ may nevertheless differ. Ackerman and Heggestad's (1997) meta-analysis showed that while the NEO PI conscientiousness domain was positively and negatively, and often non-significantly, correlated with various measures of intelligence, Tellegen's achievement measure (a lower order factor of conscientiousness) demonstrated positive correlations of around 0.12 with almost all intelligence measures. In more recent studies (Moutafi, Furnham, & Crump, 2003, 2004) a negative association (–0.16 and –0.21) between conscientiousness and IQ has been reported, but the source of this association comes from a single NEO-PI facet, Order, and in the case of the Fifteen

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