Personality and Individual Differences 192 (2022) 111605

Contents lists available at ScienceDirect

Personality and Individual Differences

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

Short Communication

The five factor model of personality and heritability: Evidence from Denmark

Aaron Weinschenk [a], Stig Hebbelstrup Rye Rasmussen [c,*], Kaare Christensen [b], Christopher Dawes [d], Robert Klemmensen [b]

[a] University of Wisconsin-Green Bay, United States of America
[b] University of Southern Denmark, Denmark
[c] University of Aarhus, Denmark
[d] New York University, United States of America

ARTICLE INFO

Keywords:
Five factor model
Heritability
Replication
Twin studies

ABSTRACT

While previous studies have shown that the traits in the FFM are moderately heritable, it is important to examine whether earlier results hold across different contexts. To date, few studies from the Scandinavian context have estimated the heritability of the FFM. We remedy this shortcoming by making use of a large sample of Danish twins who completed a 60-item personality inventory. Our results confirm that previous findings regarding the heritability of personality traits hold in the Danish context. We find that there are differences in mean levels and heritability estimates of personality traits across gender, though the differences in heritability estimates are not statistically significant. We find a significant common environment component for several of the personality traits, which indicates that the rearing environment of Danish twins may influence the development of some personality traits.

All scripts for the analyses in this paper will be made available on OSF upon publication. This study's design and its analysis were not pre-registered. We are not allowed to share or post the Danish Twin Registry data used in this paper. However, information on the requirements for getting access to data and how to apply for data can be located here: https://www.sdu.dk/en/om_sdu/institutter_centre/ist_sundhedstjenesteforsk/centre/dtr/researcher/guidelines. We note that data used for this research was provided by the Danish Twin Registry, University of Southern Denmark. The findings, opinions and recommendations expressed therein are those of the author(s) and are not necessarily those of the Danish Twin Research Center. The Danish Twin Registry has been approved by SDU RIO (SDU Legal Services) and the Committee on Health Research Ethics. The participants were enrolled by informed consent. The Danish Twin Registry, SDU RIO notification no. 10.585.

We have a conflict of interest with Pete Hatemi and Brad Verhulst because of this publication: Ludeke, S. G. & Rasmussen, S. H. R. (2016). Personality correlates of sociopolitical attitudes in the Big Five and Eysenckian models. Personality and Individual Differences, 98, 30–36.

1. Introduction

While it has been established that personality traits are partially heritable, with studies consistently showing that 40% to 60% of individual differences in personality are due to genetic influences (Vukasović & Bratko, 2015), few studies have tested the heritability of personality traits in the Scandinavian context and most of the existing studies from this area have not examined the Five Factor Model (FFM). Given the importance and dominance of the FFM model within psychology (John, 2021), the growing use of this model in other disciplines such as political science (Gerber, Huber, Doherty, Dowling, & Ha, 2010) and economics (Heckman, Jagelka, & Kautz, 2021), and recent research in psychology showing that many new measures of personality essentially reduce to the FFM model (Bainbridge, Smillie, & Ludeke, 2021), it is important to examine the model in as many contexts as possible.

In a recent meta-analysis of the heritability of personality traits, Vukasović and Bratko (2015) identified 134 studies that have estimated

* Corresponding author.
E-mail address: stighj@hotmail.com (S.H.R. Rasmussen).

https://doi.org/10.1016/j.paid.2022.111605
Received 1 February 2022; Received in revised form 4 March 2022; Accepted 7 March 2022

the heritability of various personality models. According to their analyses, the majority of studies on the heritability of personality have been conducted in the United States and Australia and only seven studies have been conducted in Scandinavian countries.[1] Interestingly, all seven of those studies measured personality using the Eysenck model (Eysenck, 1952), which focuses on Neuroticism, Extraversion, and Psychoticism, rather than the FFM (McCrae & Costa, 1999), which focuses on Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism. In this paper, we add to the literature by providing a well-powered twin study of the heritability of the FFM in the Danish context.

2. Methods, data & measures

We have used *Mplus* version 8 for all analyses and tests concerning heritability estimates and all biometric models control for age.[2] Before running the analyses, we conducted tests to investigate whether the variance across gender could be constrained to equality for each personality trait. Only for Neuroticism could we rule out that the variance was not equal across genders (see Table 4 supplementary materials).

Our data come from the Danish Twin Registry at the University of Southern Denmark, which is one of the oldest twin registries in the world with data on more than 75,000 twin pairs born in Denmark over the last 130 years. In 2012, a questionnaire that included the 60-item NEO-BFI (translated into Danish) was distributed by the Danish Twin Registry to 6596 individuals. We note that the Danish translation that we use here has been validated (Skovdahl Hansen & Mortensen, 2004). As a brief overview, the 60 item NEO-BFI inventory we use here measures personality by asking 12 items per trait.[3] Many previous studies have relied on short measurement batteries to capture personality traits and assess heritability, but it is generally preferable to use longer batteries due to increased reliability. To construct overall measures of each the Big Five traits, we created scales based on the 12 items included for each trait. Overall, our personality measures are quite reliable. The alpha scores for the traits were as follows: Extraversion (0.82), Openness (0.71), Agreeableness (0.73), Conscientiousness (0.78), and Neuroticism (0.83). We note that while previous research has examined the measurement properties of the FFM in Denmark, finding that it is reliable and valid (e.g., Vedel et al., 2020), such studies were not based on twin samples and were therefore unable to examine the heritability of the model in Denmark. Our questionnaire was in the field starting October 12, 2012 and was completed by the last respondent on March 27, 2013. With a total of 2468 participants in the final sample of respondents, the response rate for the survey was 37%, which included 650 complete twin pairs (277 monozygotic pairs, 224 same-sex dizygotic pairs and 149 opposite-sex dizygotic pairs). Due to missing data for some measures, our sample size is 1758 for the biometric analyses reported below.

3. Descriptive statistics

Table 1 in the supplementary materials shows descriptive statistics for our sample as well as the mean differences in personality traits for men and women.[4] We examine personality by gender given that some previous studies have found mean differences in personality (Lippa, 2010) and heritability (Matteson, McGue, & Iacono, 2013) by gender, though we note that not all studies have reported significant gender differences (Vukasović & Bratko, 2015). The table shows that there are statistically significant ($p < .05$) mean differences between men and women for Openness, Conscientiousness, Agreeableness and Neuroticism. For each trait, we report Cohen's *d*, which provides the standardized effect size for each gender comparison. Overall, the values for Cohen's *d* indicate that the differences in personality between men and women are small to moderate for most traits.

Indeed, Cohen's *d* is below 0.30 for Openness, Conscientiousness, and Extraversion and just under 0.50 for Neuroticism. Only Agreeableness has a Cohen's *d* of over 0.50 ($d = 0.748$). Our findings are largely consistent with Lippa (2010), who found that gender differences in personality are generally small, and that Agreeableness and Neuroticism are the personality traits with the largest gender differences. As we noted above, we conducted tests to investigate whether the variance across gender could be constrained to equality for each personality trait, which we could only rule out for Neuroticism (see Table 4 in supplementary materials).

Table 1
Variance explained for Big Five, Women and Men.

Personality trait	A	C	E
	Women		
Openness	0.419	0.097	0.484
	[0.151;0.823]*	[0.000;0.588]	[0.383;0.596]*
Conscientiousness	0.256	0.133	0.612
	[0.015;0.790]*	[0.000;0.672]	[0.498;0.734]*
Extraversion	0.307	0.246	0.448
	[0.076;0.692]*	[0.052;0.581]*	[0.356;0.548]*
Agreeableness	0.309	0.000	0.691
	[0.199;0.444]*	[0.000;0.000]	[0.575;0.817]*
Neuroticism	0.144	0.260	0.596
	[0.000;0.789]	[0.036;0.689]*	[0.479;0.726]*
	Men		
Openness	0.490	0.000	0.510
	[0.342;0.664]*	[0.000;0.000]	[0.362;0.684]*
Conscientiousness	0.452	0.000	0.549
	[0.308;0.621]*	[0.000;0.000]	[0.403;0.716]*
Extraversion	0.500	0.000	0.500
	[0.368;0.651]*	[0.364;0.364]	[0.368;0.651]*
Agreeableness	0.154	0.266	0.581
	[0.000;0.978]	[0.026;0.762]*	[0.423;0.762]*
Neuroticism	0.558	0.000	0.442
	[0.437;0.692]*	[0.000;0.000]	[0.324;0.579]*

Note: Coefficients are standardized. * $p < .05$.

4. Heritability estimates

In Table 1, we present the heritability estimates derived from structural equation models. Again, we show the estimates for men and women separately. Entries in the tables indicate the amount variance explained expressed as a percentage of the total variance. A number of important findings stand out. First, the tables show that there is a significant heritable component to most of the personality traits for both genders. Only two of the heritability estimates are not statistically significant (the Neuroticism estimate for women and the Agreeableness estimate for men).[5]

For females, the heritability estimates range from about 0.144 for Neuroticism (and not significant (95% CI [0.000;0.789]) to about 0.42 for Openness. When it comes to men, we again find that most of the traits have a moderate heritable component. The heritability estimates range from 0.56 for Neuroticism to 0.15 for Agreeableness (which is not significant (95% CI [0.000;0.978]).

[1] The number of participants in these twin studies ranges from 38 to 4542 for all studies and between 95 and 2717 for the studies conducted in Scandinavian countries (the countries with twin studies of personality were Finland, Sweden, and Norway). The heritability estimates for the different personality dimensions typically range between 40% and 60%.

[2] See supplementary materials for additional details on age.

[3] In this study, possible responses to each trait were as follows: Completely agree, Partially agree, Partially disagree, Completely disagree.

[4] Table 3 in supplementary materials provides a correlation matrix showing the relationships among the five traits.

[5] Table 2 in supplementary materials provides the MZ and DZ correlations (separately for males and females) for each personality trait.

Second, our results suggest that although there are some differences in the levels of heritability across gender (i.e., the heritability estimates are larger for men than women for most traits), tests of whether the heritability levels for each trait are significantly different when comparing men and women indicate that they are not (see Table 5 in supplementary materials).[6] Thus, the finding reported by South, Jarnecke, and Vize (2018) that there can be significant mean differences by gender for some personality traits, while differences in the magnitude of heritability estimates across gender are often statistically insignificant, replicate in this sample.

The total number of pairs for MZ males, MZ females, DZ males and DZ females are 225, 383, 278, 378 (i.e., 1264 pairs in total). We use full information maximum likelihood estimation to estimate the missing values within pairs.

Third, the table shows that the common environment component is significant for several traits. For example, there is a significant common environment estimate for women for Extraversion and Neuroticism and a significant common environment estimate for Agreeableness for men. This provides evidence that the rearing environment of Danish twins influences some of their personality traits. This is an interesting finding given that many previous studies on the underpinnings of the Big Five personality traits have found that shared environmental influences account for a negligible amount of the variance in personality (Matteson et al., 2013). As we mentioned at the outset, there have been a limited number of studies on the heritability of personality in Scandinavia, however some scholars have found evidence of common environmental influences on personality in this context. Rose, Koskenvuo, Kaprio, Sarna, and Langinvainio (1988) examined the heritability of Extraversion and Neuroticism (using measures from the Eysenck model) using data on Finnish twins and found evidence of significant common environment influences. Bergeman et al. (1993) found a significant common environment estimate for Agreeableness in Swedish sample. It is worth noting, as Uchiyama, Spicer, and Muthukrishna (2021) have recently pointed out, that genetic and environmental estimates are contingent on cultural practices. Ultimately, conducting more studies within the Scandinavian context (and across a wide range of other contexts) will be useful in helping to better understand the role of common environmental influences in personality formation.

5. Discussion and conclusion

Our results suggest that there are sizeable heritability components in personality as measured by the FFM and that previous results showing that personality is partially heritable extend to the Danish context. We also found that there are several differences in mean personality scores across gender. While heritability estimates differ when comparing men and women, the differences are not statistically significant.

We also found significant C components for several personality traits in the FFM. Interestingly, there were differences in which traits were influenced by common environmental factors when comparing men and women (i.e., Extraversion and Neuroticism were influenced by C for women but not men and Agreeableness was influenced by C for men but not women). This finding is potentially important if replicated in other samples and contexts because it suggests that different mechanisms may be responsible for the development of personality across gender.

Overall, the results in this study suggest a number of possible avenues for future research. It would be useful to examine the heritability of the FFM using other measurement batteries. There are a variety of other measures that can be used to assess the FFM. It would be useful to make sure that similar results are obtained across a variety of different measures (e.g., 44 item measure, 120 item measure, etc.). In addition, we hope that researchers will measure the FFM and examine the heritability of the traits in the model in other contexts within Scandinavia. Additional studies would help put the findings from this paper and other analyses of the heritability of the FFM into a more comparative context. Additional studies will also be important given our finding regarding a significant common environment influence for some of the personality traits in the FFM. Most studies on the genetic and environmental basis of the FFM do not find evidence of significant common environmental influence. Thus, it will be important to examine whether this pattern persists across additional samples and contexts.

CRediT authorship contribution statement

Aaron Weinschenk took the lead on witting the manuscript.

Stig Hebbelstrup Rye Rasmussen took the lead on statistical modelling.

Kaare Christensen, Christopher Dawes and Robert Klemmensen provided comments on various drafts of the work.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.paid.2022.111605.

References

Bainbridge, T., Smillie, L., & Ludeke, S. (2021). *Evaluating the Big Five as an organizing framework for commonly used psychological trait scales*.

Bergeman, C. S., Chlpuer, H. M., Plomin, R., Pedersen, N. L., McClearn, G. E., Nesselroade, J. R., Costa Jr, P. T., & McCrae, R. R. (1993). Genetic and environmental effects on openness to experience, agreeableness, and conscientiousness: An adoption/twin study. *Journal of Personality, 61*(2), 159–179.

Eysenck, H. J. (1952). *The scientific study of personality*. Macmillan.

Gerber, A., Huber, G., Doherty, D., Dowling, C., & Ha, S. (2010). Personality and political attitudes: Relationships across issue domains and political contexts. *American Political Science Review, 104*(1), 111–133.

Heckman, J. J., Jagelka, T., & Kautz, T. (2021). *Some contributions of economics to the study of personality*.

John, O. P. (2021). *History, measurement, and conceptual elaboration of the Big-Five trait taxonomy: The paradigm matures*.

Lippa, R. A. (2010). Gender differences in personality and interests: When, where, and why? *Social and Personality Psychology Compass, 4*(11), 1098–1110.

Matteson, L. K., McGue, M., & Iacono, W. G. (2013). Shared environmental influences on personality: A combined twin and adoption approach. *Behavior Genetics, 43*(6), 491–504.

McCrae, R., & Costa, P. (1999). A five factor theory of personality. In L. A. Pervin, & O. P. John (Eds.), *Handbook of personality: Theory and research* (pp. 139–153). New York: Guliford Press.

Rose, R. J., Koskenvuo, M., Kaprio, J., Sarna, S., & Langinvainio, H. (1988). Shared genes, shared experiences, and similarity of personality: Data from 14288 adult Finnish co-twins. *Journal of Personality and Social Psychology, 54*(1), 161–171.

Skovdahl Hansen, H., & Mortensen, E. L. (2004). Dokumentation for den danske udgave af NEO PI-R og NEO PI-R Kort Version [Documentation for the Danish version of NEO PI-R and NEO PI-R Short Version]. In P. T. Costa, & R. R. McCrae (Eds.), *NEO PI-R. Manual - klinisk [NEO PI-R. Manual -clinical]* (pp. 53–86). København, Denmark: Psykologisk Forlag A/S.

South, S. C., Jarnecke, A. M., & Vize, C. E. (2018). Sex differences in the Big Five model personality traits: A behavior genetics exploration. *Journal of Research in Personality, 74*, 158–165.

Uchiyama, R., Spicer, R., & Muthukrishna, M. (2021). Cultural evolution of genetic heritability. *Behavioral and Brain Sciences*, 1–147. https://doi.org/10.1017/S0140525X21000893

Vedel, A., Wellnitz, K., Ludeke, S., Soto, C., John, O., & Andersen, S. (2020). Development and Validation of the Danish Big Five Inventory-2: Domain-and Facet-Level Structure, Construct Validity, and Reliability. *European Journal of Psychological Assessment, 37*(March), 1–10.

Vukasović, T., & Bratko, D. (2015). Heritability of personality: A meta-analysis of behavior genetic studies. *Psychological Bulletin, 141*(4), 769.

[6] In the supplementary materials, we examine the power to detect differences between genders (i.e., post hoc power analysis). We find that for most differences in variance explained, the power is quite high.