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Genetic and Environmental Contribution to Social Dominance Orientation and its Overlap with HEXACO Personality Traits: A Twin Study

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Abstract

Social dominance orientation (SDO), i.e. the preference toward egalitarian or hierarchically arranged relations within a society may be studied from social/contextual, but also dispositional perspective. The aim of the present study was to explore genetic and environmental contribution to the individual differences in SDO, and its overlap with HEXACO personality traits, both at phenotypic and latent genetic and environmental levels. The sample consisted of 830 Croatian twins aged 19 to 28 years who filled-in the self-report measures. Data analyses indicated the heritability of SDO was over 40%, with no evidence for the common environmental influences. SDO phenotypic variance substantially overlapped with Honesty-Humility, Emotionality, and Openness domains. Numerous significant correlations were found at the facet level, with the highest phenotypic overlap for the "interstitial" altruism facet. However, incremental predictive power of personality (over age and sex) was moderate: 13% and 19% of the phenotypic SDO variance was predicted by HEXACO traits at the domains and facet levels, respectively. Multivariate behavioural genetic analysis indicated that 19% and 3% of the genetic and unique environmental variance of SDO overlapped with the genetic and unique environmental variance of personality, respectively. Substantial genetic correlations of SDO with Honesty-Humility and Openness domains were found, while marginal unique environmental correlation was found for Openness domain only. The etiological overlap between SDO and personality represents an argument in favour of taking dispositional along with social/contextual perspective in explaining social behaviour.

Keywords: social dominance orientation (SDO), HEXACO, personality, heritability, genetics, twin study

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Introduction

To ensure a better understanding of its complexity, social behaviour should be considered from both social/contextual and dispositional perspectives. For example, in the recent synthesis of the aetiology of prejudice, Hodson and Dhont (2015) presented arguments that affirmed dispositional perspective onto social behaviour as equally valuable and complementary to the more recognized social/contextual approach. The authors adverted evidence that demonstrated the predictive power of individual differences for a wide range of social outcomes and social behaviours as comparable to, and in some cases, even larger than the one of social/contextual factors.

Social Dominance Orientation

Social dominance orientation (SDO) plays a pivotal role in the mechanism underlying the association of dispositions and social appraisal. It represents preference toward egalitarian or hierarchically arranged group relations within a certain society (Pratto et al., 1994). In its origins, SDO was conceived as a personality trait. However, due to its partly malleable nature (Guimond et al., 2003; Reynolds et al., 2001; Sibley & Duckitt, 2008), it appears to be more accurately defined as the ideological attitude rather than the core trait (e.g. Bergh et al., 2016; Duckitt & Sibley, 2017). Individuals high in SDO tend to value power, hierarchy and dominance over other social groups. They incline toward being interpersonally cold and unpleasant, conservative, pro-army, pro extreme right-wing options, and contra different social welfare programs (Duckitt, 2005; Guimond et al., 2003; Pratto & Lemieux, 2001; Pratto et al., 1994). There is abundant empirical evidence on the association of high SDO and unfavourable attitudes toward different unprivileged and/or minority groups (e.g. Akrami et al., 2009; Bäckström & Björklund, 2007; Cohrs & Stelzl, 2010; Costello & Hodson, 2014; Guimond et al., 2003; Zakrisson, 2005), as well as the meta-analytical finding disclosing SDO as one of the most powerful antecedents of prejudice (r = .55, N = 2 479, k = 9; Sibley & Duckitt, 2008; for longitudinal evidence, see Asbrock et al., 2010; Kteily et al., 2011; Perry & Sibley, 2012; Sibley & Duckitt, 2010).

SDO was initially described as a trait whose expression is influenced by both temperament and socialization (Pratto et al., 1994). Along these lines, Altemeyer (1998) stated both genetic underpinnings and environmental influences as relevant in shaping SDO. The analysis of the aetiology of individual differences in SDO and its relations with other dispositions could further help us to understand its nature.

Aetiology of Individual Differences: A Behavioural Genetics Perspective

Individual differences in some phenotype, i.e. in some observable characteristic can be attributed to two main sources: genetic and/or environmental variations

between individuals. Scientific field that is focused on detecting the degree to which these two sources shape individual differences in behavioural phenotypes is called behaviour genetics. The main statistic parameter in behaviour genetics research is heritability (h^2), which refers to the proportion of the phenotypic variance that is accounted for by genetic differences among individuals within some population (Knopik et al., 2017). It can range from 0 to 1, i.e. from 0% to 100%. Furthermore, the genetic variance can be decomposed into additive genetic influences (A), which are passed on from parents to their offspring, and non-additive genetic influences (D), which include non-linear combinations of the genetic effects that theoretically may not contribute to the similarity of parents and offspring (Bratko et al., 2017). Environmental variance can also be divided into two main categories: common environment or effects that are shared within members of the same family (C), and unique or non-shared effects (E), which are specific for every individual. Therefore, the total phenotypic variance can be divided into four different types of influences (A, D, C, E). The relative contribution of different sources of variation can be estimated through specific study designs that are using genetically informative samples, or via molecular genetic approach. Classical twin design is one of the most popular behavioural genetic designs. The logic of the twin study lays in the fact that there are two types of twins – monozygotic (MZ), that share 100% of all genetic influences and 100% of shared environmental influences, while dizygotic (DZ), on average share only 50% of additive genetic, 25% of non-additive genetic and 100% of shared environmental influences. Therefore, the basic idea is to compare similarities between groups of MZ and DZ twins reared together in some phenotype and to build a model which explains these phenotypic similarities. If MZ twins are significantly more similar in some trait than DZ twins, that implies the measured trait is heritable to some degree.

Behavioural Genetic Studies of Social Behaviour

Rather recently, the number of behavioural genetic studies of different manifestations of social behaviour has increased. This shed light on substantial genetic contributions to the various socio-political phenomena, like political orientation, conservativism, nationalism, in-group favouritism, right-wing authoritarianism (RWA), ethnocentrism and prejudice (e.g. Barlow et al., 2017; Kandler et al., 2016; Kandler et al., 2015; Koenig & Bouchard, 2006; Lewis & Bates, 2010, 2014; Lewis et al., 2014; Ludeke & Krueger, 2013; McCourt et al., 1999; Orey & Park, 2012; Oskarsson et al., 2015). According to Lewis et al. (2014), heritable effects account for 25-50% of phenotypic variance of different social attitudes (see also Kandler et al., 2016; Ludeke & Krueger, 2013), which stands in sharp contrast with credentials of many psychologists, sociologists and even geneticists who believed that the transmission of social attitudes was entirely cultural (Koenig & Bouchard, 2006). In McCourt et al.'s study (1999), for example, the correlation of RWA of MZ twins raised separately was as high as .69, clearly indicating the

heritability of that phenotype. The authors found that the covariance of RWA in the twin sample can best be described by the model encompassing 50% of additive genetic variance, 16% of shared environmental variance and 34% of non-shared environmental variance. When assortative mating (the effect of spouse similarity) was taken into account, the model accounting for 64% of additive genetic variance and 36% of non-shared environmental variance demonstrated the best fit to the data (for comparable results, see Lewis & Bates, 2014). Similar conclusions were derived using the data from the Jena Twin Study of Social Attitudes (Stößel et al., 2006). Substantial additive genetic influences – 41% and 64% for RWA and conservativism, respectively – and no reliable effects of the common environment were found. Stößel et al. (2006) also reported the basic conclusions of what could easily be the first genetic investigation of SDO, stating smaller genetic effects for SDO self-reports compared to other related constructs. Effects of the non-shared environment explained about 70% of the phenotypic variance of SDO in the Jena study. This conclusion was elaborated by Kandler et al. (2015) who performed analyses on the same sample. They reported that, while genetic influences contributed to the 50% of variance in RWA and 43% of variance in xenophobia, genetic effects to the variance in SDO were rather low (7%) and non-significant. In a subsequent paper based on the same sample, Kandler et al. (2016) reported SDO to be largely attributable to environmental sources shared and non-shared by twins. Hence, according to the Jena study findings, genetic effects appear to be non-significant source of the variation of SDO. Kandler et al. (2015, p.194) provide rationale for these findings by emphasizing context-sensitive nature of SDO that gets "heated up in the face of conflict or competition between own and out-group". Despite the given rationale, the Jena study conclusions on the heritability of SDO should be taken with a grain of salt and more studies using independent samples from different populations are needed. To our knowledge, the only other examination of the heritability of SDO is Kleppestø et al.'s (2019) study on a large Norwegian twin sample. They reported a moderate heritability of two SDO facets: 37% of variance of SDO-dominance and 24% of variance of SDO-egalitarianism were attributable to genetic influences. Kleppestø et al. (2019) contrasted their conclusions to those arising from the Jena study and stated several reasons that increase confidence in the robustness of their findings. Firstly, Kleppestø et al.'s (2019) study was employed on a considerably larger twin sample. Secondly, their sample was of a markedly older age, which is relevant as heritability estimates tend to increase with age. Finally, the authors noted that it is possible that the heritability estimates of SDO in the Norwegian sample differ from the German sample because of the contextual factors (e.g. social desirability effects) and gene-environment interactions (Kleppestø et al., 2019).

SDO and Personality

Studies investigating associations between SDO and personality mainly used models that define five basic personality domains. Meta-analysis by Sibley and Duckitt (2008) revealed moderate negative correlation of SDO with Big Five Agreeableness (r = -.29, N = 11 669, k = 31) and weak negative correlation of SDO with Big Five Openness to Experience (r = -.16, N = 11 319, k = 30). These findings were corroborated in subsequent research (e.g. for SDO-Agreeableness association, see Cohrs et al., 2012; Heaven et al., 2011; Hodson et al., 2009; Matić et al., 2019; Perry & Sibley, 2012; Sibley & Duckitt, 2010; for SDO-Openness association, see Cohrs et al., 2012; Heaven et al., 2011; Matić et al., 2019; Sibley & Duckitt, 2010). The association of SDO with Big Five Neuroticism, Conscientiousness and Extraversion appeared to be insignificant (for meta-analytical evidence, see Sibley & Duckitt, 2008). These findings are greatly aligned with the theoretical predictions of the dual-process motivational approach of ideology and prejudice (Duckitt, 2001, 2005; Duckitt & Sibley, 2017), positing that SDO arises from the underlying personality dimension of tough-mindedness which corresponds to low Agreeableness. As Sibley and Duckitt (2008, p. 250) noted, "people high in tough-mindedness are more likely to view the world as a ruthlessly competitive jungle in which the strong win and the weak lose, which makes salient the motivational goals or values of power, dominance, and intergroup superiority expressed in high SDO."

Recently, the facet-level focus on personality traits has been advocated as a promising perspective in exploring personality correlates of social attitudes (Leone, Chirumbolo et al., 2012; Leone, Desimoni et al., 2012). Within the Five-factor model (Costa & McCrae, 1992) framework, all the Agreeableness facets (trust, straightforwardness, altruism, compliance, modesty, tender-mindedness) and five of six Openness facets (values, feelings, fantasy, aesthetics, actions) were found to negatively correlate with SDO (Akrami & Ekehammar, 2006). The authors also found negative association of SDO and warmth, a Big Five Extraversion facet, attributing it to the conceptual proximity with the Agreeableness domain (see also Ekehammar & Akrami, 2007). The highest bivariate correlations were obtained for the tender-mindedness and values facets (r = -.60 and r = -.43, respectively). This greatly corresponds to the conclusion of Heaven and Bucci (2001) who analyzed the association of SDO with IPIP personality facets. They found SDO individuals to be low on sympathy (equivalent to tender-mindedness), cooperation (i.e. compliance), morality (i.e. straightforwardness), dutifulness and artistic interests (i.e. aesthetics). The prediction of SDO by personality showed to be significantly more successful if facets instead of domains scores are used (Akrami & Ekehammar, 2006).

The HEXACO Model of Personality

Although there is a significant support for five-factor taxonomies of personality, there has been growth in research using the alternative six-factor model. Namely,

results of lexical studies in several languages showed that personality can be better captured with a similar set of six, not five basic domains (Ashton & Lee, 2001). Therefore, the new HEXACO personality model was conceptualized, defining six broad domains: Honesty-Humility (H), Emotionality (E), Extraversion (X), Agreeableness (A), Conscientiousness (C), and Openness to Experience (O) (Ashton et al., 2004).

The HEXACO has some similarities, but also substantial differences from the five-factor personality models. Extraversion, Conscientiousness, and Openness are quite similar, regarding the trait content, as their Big Five namesakes. On the other hand, remaining domains outline the key differences between HEXACO and other structural models of personality. The crucial difference is the identification of the sixth factor named Honesty-Humility. Although there are objections that Honesty-Humility is only extracted content from Big Five Agreeableness, studies showed that different five-factor measures do not capture well the Honesty-Humility scale variance (Ashton & Lee, 2019, 2020). Moreover, HEXACO Agreeableness and Emotionality cannot be equated with Agreeableness and Neuroticism/Emotional stability from five-factor models. Namely, Emotionality includes anxiety, dependent behaviours, and sentimentality, but does not cover content related to depression or anger, traits that are usually important parts of Neuroticism/Emotional stability. However, anger, or irritability, is presented in HEXACO model, but it indicates low Agreeableness. The main traits of HEXACO Agreeableness are calmness, patience, and tolerance. Therefore, it is not entirely compliant with the same-named Big Five domain since it also excludes the sentimentality, which is part of Emotionality. Those shifts of anger and sentimentality between Agreeableness and Emotionality domains in HEXACO are the reason why those traits can be considered as the rotated variants of the Big Five Emotional Stability and Agreeableness axes (Ashton & Lee, 2007). The HEXACO model is hierarchically organized so that each of the six domains consists of four facets. Additionally, the 25. "interstitial" facet named altruism is operationalized, which loads across Honesty-Humility, Emotionality, and Agreeableness domains.

The association of SDO and personality conceptualised within the HEXACO framework is still under-researched and only tentative conclusions can be driven based on the results of a small number of individual studies. However, there is now accumulated evidence of a prominent role of Honesty-Humility domain. This domain encompasses the dispositions that are crucial in shaping preference for equal vs. hierarchical social relations, and those that appear influential in fostering social relations based on trust and reciprocity. Also, it is generally characterized by the lack of desire for high status (Leone, Chirumbolo et al., 2012; Leone, Desimoni et al., 2012). Moderate to strong correlations of low HEXACO Honesty-Humility with SDO (or higher-order constructs, e.g. desire for power; Lee et al., 2013) were found in Lee et al. (2010, 2013), Leone, Chirumbolo et al. (2012), Leone, Desimoni et al. (2012), Sibley (2011) and Sibley et al. (2010). Low to moderate negative associations

of SDO with HEXACO Openness and Emotionality were also consistently found (Lee et al., 2010, 2013; Leone, Chirumbolo et al., 2012; Leone, Desimoni et al., 2012; Sibley et al., 2010). The facet-level analysis by Leone, Desimoni et al. (2012) shed light onto consistent low to moderate negative associations of SDO and the following HEXACO narrow trait components: honesty (i.e., sincerity and fairness), humility (i.e., greed avoidance and modesty), openness-curiosity (i.e., aesthetic appreciation and unconventionality) and openness-culture (i.e., inquisitiveness and creativity), with other narrow trait components excluded from the analysis. On the other hand, Leone, Chirumbolo et al. (2012) revealed that only humility component (rather than honesty component) of HEXACO Honesty-Humility domain significantly related to SDO. Empirical studies examining the association of SDO and other HEXACO domains (Extraversion, Conscientiousness, and Agreeableness) yielded mixed results mostly spanning from non-significant to marginal negative coefficients. In sum, compared to the results using Big Five conceptualization, there are two prominent differences that appear when the association of SDO and personality is analysed under the HEXACO framework (Sibley et al., 2010); i) the association of SDO with HEXACO Emotionality seems to be more substantial than the association of SDO with Big Five Neuroticism; and ii) the association of SDO with HEXACO Agreeableness seems to be marginal, in contrast to the established moderate association of SDO with Big Five Agreeableness (Sibley & Duckitt, 2008; however, see Lee et al., 2010, 2013 and Leone, Chirumbolo et al., 2012 for non-marginal correlations between SDO and HEXACO Agreeableness).

Aetiological Overlap between SDO and Personality

SDO is under-researched phenotype in the behavioural genetic literature. However, there is rich evidence that personality is substantially heritable. Recent meta-analyses indicate that heritability of personality traits is around 40%, and that common environmental influence is negligible for that phenotype (Bratko et al., 2017; Vukasović & Bratko, 2015; see also Kandler et al. (2020) for developmental shifts of the HEXACO personality traits across the life-span). However, family/adoption design typically resulted with the heritability estimates around 20-30% (see Bratko & Marušić, 1997; Bratko et al., 2014), while the estimates from the twin design approached 50% (Polderman et al., 2015; see also Bratko & Butković, 2007 for the estimate in Croatian population).

Apart from the information on the aetiology of the construct itself, behavioural genetic studies offer insight into the nature of the association of two or more constructs. For example, Lewis and Bates (2014) found that the genetic influences underlying traditionalism moderately overlapped with the genetic influences inherent in intragroup bias, while the genetic contributions to RWA completely overlapped with the genetic influences underlying intragroup bias. Moreover, they observed that Big Five Openness shared common genetic underpinnings with both RWA and in-group favouritism. Kleppestø et al. (2019) revealed high genetic

correlation between SDO and political attitudes. In the Jena study, genetic influences on personality traits explained approximately one-third of the genetic effects on RWA, conservatism and SDO (Stößel et al., 2006).

The Present Study

The present study is, to our knowledge, the first behavioural genetic study of SDO within the HEXACO personality framework. We had three general goals. The first goal was to perform univariate behavioural genetic analysis using a classical twin design and to estimate the quantitative genetic parameters for SDO. Although previous studies yielded mixed results, we believe it is reasonable to expect moderate heritability of SDO, as well as the common and unique environmental influences. The second goal was to explore the phenotypic relations between SDO and HEXACO personality traits, both on the broad domains and the narrow facet levels. We expect substantial correlation of SDO with Honesty-Humility, Emotionality and Openness domains and facets, and possibly marginal correlations with Agreeableness domain and its facets. Also, we find it reasonable to expect substantial correlation of SDO and the interstitial facet of altruism, as it captures the variance of Honesty-Humility, Emotionality, and Agreeableness domains. Additionally, we were interested in estimating the total amount of SDO variance explainable by HEXACO domains and facets. The third goal was to explore the aetiological overlap between SDO and personality. It is quite possible that phenotypic correlations between personality and SDO are genetically and/or environmentally mediated, so we approach this goal exploratory.

Method

Participants and Procedure

The sample consisted of 830 twins aged 19 to 28 years (M = 22.92; SD = 1.82). The initial sample of 2649 individual twins was contacted and asked for a written consent to participate in the study. The 836 twins (31.6%) agreed to participate voluntary, without any monetary compensation. Valid data was collected for 415 twin pairs: 147 MZ, 146 same-sex DZ, and 122 opposite-sex DZ twin pairs. In total, there were 306 male and 524 female participants. Data was collected through questionnaires sent by mail. Participants also received an additional empty, stamped and return-addressed envelope. They were instructed to fill-in the assigned measures and return them to the first author of this study. The procedure and the used questionnaires were approved by the Ethical Committee of the Department of Psychology, Faculty of Humanities and Social Sciences of the University of Zagreb.

Measures

Zygosity

Zygosity was diagnosed via questionnaire comparing physical similarity and the frequency of confusion of the twins. The questionnaire was constructed and used in the previous research on Croatian population (e.g. Bratko et al., 2012). It consists of eleven items that evaluate physical similarity, e.g. facial appearance, hair colour, height, weight or skin colour, and five items that assess twin confusion by parents, other family members, teachers, casual friends and strangers. These items were shown to be valid indicators of zygosity in a number of studies (e.g., Gao et al., 2006; Price et al., 2000) with zygosity determination being accurate around 95% (Reed et al., 2005; Spitz et al., 1996), using DNA similarity of the twins as criteria.

Social Dominance Orientation

SDO was assessed with the adapted version of the SDO_5 questionnaire (Sidanius & Pratto, 1999). The adapted scale consists of 13 items (e.g., 'Some groups of people are simply not equals to others.') with an accompanying 5-point Likert-type scale. During the translation and adaptation of this scale for the Croatian context, Skokandić (2013) excluded the item '10. Equality.' from the original 14-item scale, considering it largely redundant with other statements in the scale. Additionally, the order of the items was changed to ensure the alternating order of pro- and con-trait items, and the format of the scale was modified, from the original 7-point to 5-point scale. Skokandić's (2013) version of Sidanius and Pratto's (1999) SDO_5 scale functioned adequately in previous studies on a large representative Croatian sample (Matić et al., 2019). The Cronbach's Alpha coefficient of the scale in the present study was .74.

HEXACO Personality Inventory-Revised

Personality was measured with the 100-item HEXACO personality inventory (Lee & Ashton, 2018), i.e. with its Croatian version (Babarović & Šverko, 2013). The inventory measures six broad HEXACO domains and 25 facets (four facets per each domain and interstitial altruism facet). Each of the broad domains is assessed with 16 items, while each of the facets is assessed with four items. The inventory has a five-point Likert scale for responding (1 = *strongly disagree*; 5 = *strongly agree*). The Croatian version of HEXACO-100 showed satisfactory psychometric properties (Babarović & Šverko, 2013). The Cronbach's Alpha coefficients of the Honesty-Humility, Emotionality, Extraversion, Agreeableness, Conscientiousness, and Openness scales in the present study were .81, .83, .86, .81, .81, and .84, respectively. Same indices at the facet level varied between .48 and .79, with a median of .68.

Preliminary Analyses and Data Analytic Strategy

Prior to main analyses, a preliminary check and some data transformations were performed. Due to the large sample and to the multiple statistical procedures, we set the risk ratio for the preliminary analyses and hypotheses testing to 1%. However, for the parameter estimates in behavioural genetic analyses we adopted the conventional 95% confidence interval criteria, and significance level of 5% as indication of trends. Firstly, the planned analyses require a roughly normal distribution of the variables. Kolmogorov-Smirnov tests indicated that all of the variable distributions departed from normality. However, that was due to the relatively large sample. Therefore, skewness and kurtosis of the distributions were examined. These indices were very low. Skewness and kurtosis for the SDO scale were .33 and .12, respectively. Maximal skewness and kurtosis of the HEXACO domains were -.43 and .35, respectively, while the highest of these indices at the facet level were -.58 and -.65, respectively. Therefore, the distributions of the scores were considered acceptable for parametric statistics. Secondly, it is very important for the variances within MZ and DZ groups to be similar, because there is no reason to expect differences between these two groups. Eventual observed differences in MZ and DZ variances may bias the covariance estimates, and may indicate the selective rejection of participation. However, thirty-two Levene's tests (25 HEXACO facets, 6 HEXACO domains, and SDO) revealed no significant differences between MZ and DZ variances. Thirdly, since twins within a pair have same age and, in case of the same-sex twins which constitutes more than 70% of the sample, same sex as well – the within pair correlations may be biased due to the age and sex differences in the observed variables. Partly due to the narrow age range, the correlations of age with the SDO, HEXACO domains and facets were very low (the highest being r = -.11). The correlations of sex were much higher, up to .51 for the Emotionality domain. Therefore, prior to genetic modelling we corrected data for age, sex, and their interaction, controlling for the linear effects using the McGue and Bouchard (1984) regression approach.

Our data analytic strategy was the following. Firstly, we performed correlational analysis of SDO and calculated the intraclass correlations within MZ and DZ twin pairs. Then we ran several univariate behavioural genetic models to the variance/covariance SDO matrices within MZ and DZ twin groups in order to estimate the behavioural genetic parameters. We first tested the full ACE model. We then tested several nested models to see if exclusion of A or C parameters would yield the significant worsening of fit. The DE model, checking for the non-additive nature of the genetic influence, was also tested. The heritability was estimated from the full ACE and the best-fitting model.

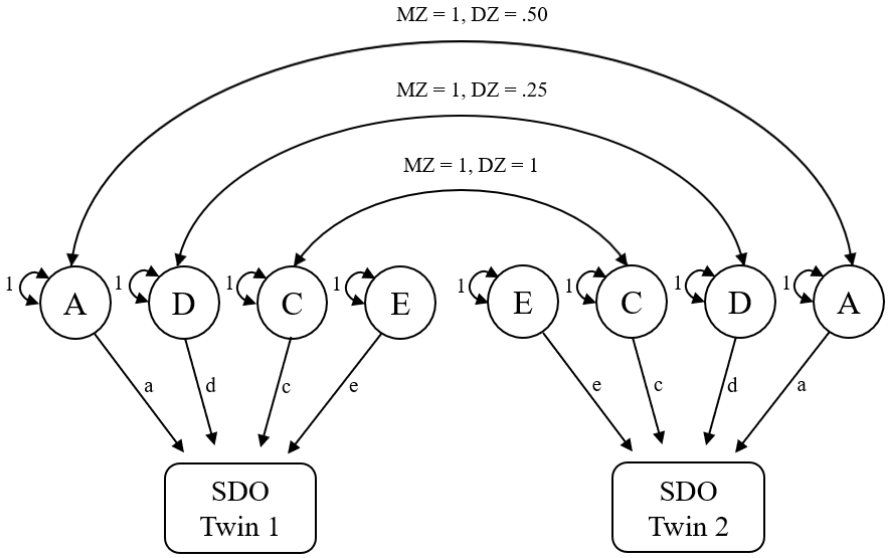
After estimating its heritability, the phenotypic position of SDO within HEXACO personality space was examined. The correlations of SDO with HEXACO domains and facets were calculated, followed by hierarchical regressions with SDO

as criterion and traits as predictors, separately for domains and facets, with age and sex effects controlled in the first step. Since twin scores within pairs are correlated and do not represent the random sampling, the degrees of freedom associated with significance tests were based on the number of independent pairs rather than individuals.

Finally, the multivariate behavioural genetics analysis at domain level was performed in order to examine the aetiological overlap between SDO and those HEXACO domains which predicted SDO in the regression analysis. To reduce complexity of the models and to increase the statistical power, only selected domains – those with significant ($p < .01$) and non-marginal beta ponders (criteria set to $\beta > .10$) were included in the multivariate genetic modelling. Since previous univariate analysis of the HEXACO traits showed that the best-fitting was AE model (Kandler et al., 2020), and that C effect for personality is negligible (see Vukasović & Bratko, 2015), the multivariate analysis was based on the AE models for all included variables. That model also, using Akaike index as criteria, fitted data best in a series of univariate behavioural genetic models for the variables which were included in the multivariate modelling. For the multivariate behavioural genetic analysis, the Cholesky decomposition was used. Cholesky decomposition is the behavioural genetic extension of a diagonal factor analysis in which the first extracted factor equals to the first variables and the paths to other variables of that factor are estimated. Second extracted factor equals to the residual variance of the second variables and the residual paths to the other variables are estimated. We finish with as many factors as there are variables in the analysis with the progressively less unexplained variance. Cholesky decomposition is very sensitive to order of the variables which are included in the analysis. We used two strategies and related models: i) model A, in which we entered the SDO variable first, and therefore examined its overlap with the personality through the maximal likelihood estimates of the first genetic and environmental factor; and ii) model B, in which we entered SDO as the last variable, and therefore estimated its total specific genetic and environmental variance, i.e. variance that is not related to personality. Genetic and environmental correlations were estimated from the better of these two models using the triangulation procedure. All phenotypic analyses were done in SPSS and genetic model-fittings were performed using LISREL. Graphical representations of the used univariate and multivariate behavioural genetic models are presented in the Figures 1 and 2.

Figure 1

The Representation of the Twin Univariate Model in the Present Study

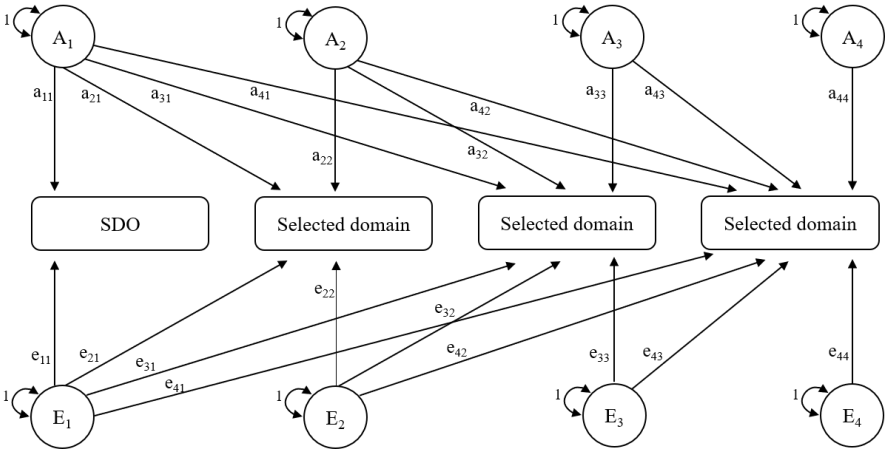


Note. A = additive genetic influences; D = non-additive genetic influences; C = common environmental effects; E = unique enviromental effects.

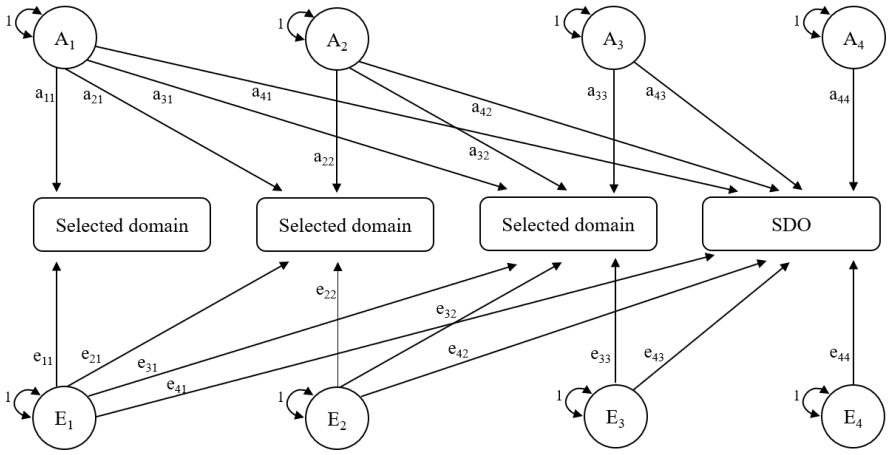
Figure 2

The Representation of the Two Tested Models (Model A and Model B) for the Multivariate Cholesky Decomposition

Model A



Model B



Note. A1-A4 = additive genetic effect; E1-E4 = unique enviromental effects; a_{11}-a_{44} = genetic path coefficients; e_{11}-e_{44} = enviromental path coefficients.

Results

Univariate Behavioural Genetic Analysis of SDO

The intraclass correlations within subgroups of MZ and DZ twins for the SDO scale, both for raw data and the data corrected for age, sex and their interaction, are presented in Table 1. Both MZ and DZ correlations were statistically significant (all $p < .01$), and the MZ correlations substantially exceeded the DZ correlations, indicating plausibility of the genetic hypothesis. The pattern of the MZ/DZ correlations is much closer to the 2:1 ratio than to the 4:1 ratio, indicating that additive rather than non-additive genetic mechanism was involved (see Knopik et al., 2017). The observed pattern of correlations suggested that the presence of the common environmental influence was implausible. However, the pattern of the possible influences on the individual differences in SDO was explicitly tested in a series of the univariate behavioural genetic models.

First, we ran the full ACE model, which fitted the data well ($\chi^2 = 4.06$, $df = 3$, $p = .25$; RMSEA = .04, CFI = .97). The A, C, and E components of the total variance estimates were .46, .00, and .54, respectively. Then we ran the nested AE model which should be preferred because it has the similar fit with the smaller number of parameters ($\chi^2 = 4.06$, $df = 4$, $p = .40$; RMSEA = .01, CFI = .99), with the same parameter estimates for A and E. Changing the A parameter with D yielded poorer model-fit ($\chi^2 = 7.23$, $df = 4$, $p = .12$; RMSEA = .06, CFI = .92). Likewise, excluding the A parameter from the full ACE model worsened the fit substantially ($\chi^2 = 11.68$, $df = 4$, $p = .02$; RMSEA = .09, CFI = .81). Therefore, the model which included

additive genetic and unique environmental influences had the best fit to the data, and the heritability of SDO was estimated at 46%, without any evidence for the common environmental influence. Thus, our first hypothesis was partly supported as we found evidence for the genetic and unique environmental influences, but not for the common environmental influences on SDO.

Table 1

Twin Intraclass Correlations and the Results of the Univariate Analysis for the SDO Scale on the Data Corrected for Age, Sex, and Age x Sex Interaction

r_{MZ}	r_{DZ}	Model	h^2	c^2	e^2	$\chi^2(df)$	p	RMSEA	CFI
.42** (.48**)	.23** (.19**)	ACE	**.46** [.38 - .54]	**.00** [-1.00 - 1.00]	**.54** [.51 - .57]	4.06(3)	.25	.04	.97
		AE	**.46** [.38 - .54]		**.54** [.51 - .57]	4.06(4)	.40	.01	.99
		DE				7.23(4)	.12	.06	.92
		CE				11.68(4)	.02	.09	.81

Note. N = 147 MZ and 268 DZ pairs; ** = $p < .01$; h^2 = narrow-sense heritability; c^2 = shared environmental effects; e^2 = non-shared environmental effects; RMSEA = root mean square error of approximation; CFI = comparative fit index. Numbers in parenthesis represent twin correlation coefficients on raw data, 95% confidence intervals for parameter estimates, and associated degrees of freedom.

Phenotypic Relations between SDO and HEXACO Personality Traits

The zero-order correlations between SDO, HEXACO facets and domains are presented in Table 2. Table 3 presents the results of the hierarchical regression analysis at the domain level, while Table 4 presents the results of the same analysis at the facet level. At the domain level, the substantial correlations of SDO with Honesty-Humility, Emotionality, and Openness were obtained, while correlation with Conscientiousness was significant but marginal. At the facet level, SDO significantly correlated with all Honesty-Humility facets, three Emotionality and Openness facets, and one of the Extraversion, Agreeableness, and Conscientiousness facets. The highest correlation (r = -.34) was obtained for the interstitial altruism facet. Besides that, the correlations larger than -.20 were obtained for sentimentality, modesty, fairness, aesthetic appreciation, and greed-avoidance facets. Therefore, the hypotheses regarding the phenotypic relations between SDO and personality were also partly confirmed, since we found no evidence of the significant SDO-Agreeableness association.

Table 2

Zero-Order Correlations between SDO, HEXACO Facets and Domains (N = 830)

	H1	H2	H3	H4	E1	E2	E3	E4	X1	X2	X3	X4	A1	A2	A3	A4	C1	C2	C3	C4	O1	O2	O3	O4	I	H	E	X	A	C	O
SDO	**-.19**	**-.24**	**-.22**	**-.26**	-.11	**-.13**	**-.17**	**-.27**	-.03	-.02	**-.13**	-.03	-.09	**-.17**	-.05	-.04	-.09	**-.13**	-.12	-.10	**-.23**	-.06	**-.15**	**-.18**	**-.34**	**-.32**	**-.23**	-.06	-.11	**-.15**	**-.21**
H1	1	**.24**	**.39**	**.26**	-.11	-.03	-.04	.04	.03	-.04	-.06	-.02	.08	.07	-.01	.05	.05	.08	.08	.07	.09	.04	.07	.06	**.14**	**.64**	-.05	-.03	.06	.09	.09
H2		1	**.40**	**.26**	**.15**	-.01	**.15**	**.24**	**.16**	.02	**.15**	.09	**.16**	**.17**	.10	.07	**.21**	**.21**	**.18**	**.24**	.09	.02	.03	-.05	**.33**	**.71**	**.18**	**.13**	**.17**	**.29**	.04
H3			1	**.46**	.05	-.00	.04	**.19**	-.01	-.05	-.02	-.00	**.24**	**.19**	.12	**.15**	.10	.09	.05	**.13**	**.18**	.04	.07	.12	**.25**	**.80**	.09	-.03	**.24**	**.13**	**.14**
H4				1	.06	-.01	.04	**.22**	-.10	-.10	.08	.03	**.17**	**.26**	.10	.09	.04	-.07	-.10	-.02	.01	-.11	-.07	-.02	**.19**	**.67**	.11	-.03	**.20**	-.04	-.07
E1					1	**.35**	**.43**	**.39**	-.15	**.23**	.02	**-.24**	-.08	-.04	.01	**-.29**	.05	-.10	-.02	**-.15**	.06	**-.17**	-.05	-.11	**.17**	.06	**.75**	**-.20**	**-.16**	-.07	.09
E2						1	**.24**	**.30**	**-.31**	**-.22**	-.05	**-.36**	**-.14**	-.04	-.10	**-.26**	.06	.03	**.17**	**-.15**	**.17**	-.02	.06	.07	**.15**	-.02	**.64**	**-.31**	**-.20**	.03	.09
E3							1	**.50**	.02	.07	**.27**	.03	-.00	-.05	-.04	**-.30**	.06	**.13**	.10	-.11	.07	-.12	.05	-.04	**.29**	.08	**.77**	.12	**-.15**	.06	-.01
E4								1	.07	.05	**.31**	**.13**	.09	.12	.02	-.10	**.14**	**.20**	.12	-.09	**.18**	-.10	.12	-.03	**.56**	**.25**	**.75**	**.17**	.03	.12	.06
X1									1	**.38**	**.37**	**.57**	.08	.09	.07	**.13**	**.24**	**.34**	.12	**.25**	-.07	.03	.07	-.12	**.23**	.04	-.12	**.74**	**.13**	**.32**	-.02
X2										1	**.48**	**.44**	.05	-.09	-.08	.04	.07	**.27**	.02	.06	.03	.12	**.16**	.05	.11	-.06	-.11	**.78**	-.02	**.14**	**.13**
X3											1	**.47**	.09	**.13**	.01	.02	.11	**.25**	.04	-.02	.01	-.04	.07	-.06	**.31**	.06	**.19**	**.75**	.08	**.13**	-.00
X4												1	**.15**	**.16**	.04	**.21**	.12	**.34**	.07	.06	-.02	.03	.14	-.08	**.23**	.04	**-.15**	**.81**	**.20**	**.19**	.03
A1													1	**.31**	**.30**	**.41**	.01	.02	-.11	.06	.06	-.00	.01	.04	**.24**	**.23**	-.04	.12	**.69**	-.00	.04
A2														1	**.38**	**.44**	.02	-.04	-.05	.08	.01	-.04	.01	.01	**.34**	**.24**	-.01	.09	**.70**	.01	-.01
A3															1	**.44**	.08	.02	-.06	**.23**	.05	.04	-.01	-.01	**.20**	.11	-.04	.01	**.71**	.10	.03
A4																1	.02	.04	-.01	**.22**	.03	.05	.07	.10	**.16**	**.13**	**-.33**	**.13**	**.82**	.09	.08
C1																	1	**.43**	**.38**	**.37**	.01	.03	.02	-.11	**.20**	**.15**	.10	**.17**	.04	**.78**	-.01
C2																		1	**.47**	**.35**	**.17**	**.18**	**.20**	.05	**.26**	.12	.09	**.39**	.02	**.75**	**.21**
C3																			1	**.29**	**.20**	**.18**	**.25**	.12	**.16**	.09	**.13**	.07	-.08	**.70**	**.25**
C4																				1	.08	**.14**	.03	.02	.10	**.17**	**-.17**	.11	**.21**	**.69**	.10
O1																					1	**.36**	**.49**	**.50**	.11	**.13**	**.16**	-.01	.05	**.15**	**.79**
O2																						1	**.31**	**.36**	-.06	.00	**-.14**	.05	.02	**.17**	**.70**
O3																							1	**.49**	.12	.04	.06	**.15**	.04	**.16**	**.77**
O4																								1	-.01	.04	-.04	-.06	.06	.02	**.76**
I																									1	**.33**	**.40**	**.28**	**.31**	**.25**	.06
H																										1	.12	.02	**.24**	**.19**	.07
E																											1	-.07	**-.16**	.05	.02
X																												1	.12	**.25**	.05
A																													1	.07	.05
C																														1	**.18**
O																															1

Note. SDO = social dominance orientation; H1 = sincerity; H2 = fairness; H3 = greed-avoidance; H4 = modesty; E1 = fearfulness; E2 = anxiety; E3 = dependence; E4 = sentimentality; X1 = social self-esteem; X2 = social boldness; X3 = sociability; X4 = liveliness; A1 = forgiveness; A2 = gentleness; A3 = flexibility; A4 = patience; C1 = organization; C2 = diligence; C3 = perfectionism; C4 = prudence; O1 = aesthetic appreciation; O2 = inquisitiveness; O3 = creativity; O4 = unconventionality; I = interstitial altruism facet; H = Honesty-Humility; E = Emotionality; X = Extraversion; A = Agreeableness; C = Conscientiousness; O = Openness to Experience.
$|r| > .13$ are statistically significant at $p < .01$, with degrees of freedom calculated based on $N = 415$. Significant correlations are shown in bold.

In the first hierarchical regression analysis that used domains as predictors, the control variables of age and sex were entered into the first step, accounting for 7% of the total SDO variance. In the second step, HEXACO domains were entered, explaining additional 13% of the variance. Significant beta coefficients were obtained for Honesty-Humility (β = -.23, t = -6.87, p < .01), Openness (β = -.16, t = -5.02, p < .01), and Emotionality (β = -.15, t = -4.03, p < .01). In the second regression analysis, the 25 HEXACO facets were included in the second step, which explained additional 19% of the total SDO variance. The beta coefficients were significant for altruism (β = -.22, t = -5.02, p < .01), modesty (β = -.20, t = -5.21, p < .01), and unconventionality (β = -.13, t = -3.22, p < .01).

Table 3

The Results of the Hierarchical Regression Analysis Predicting SDO with HEXACO Domains (N = 830)

Predictor	Step 1		Step 2	
	β	*t*	β	*t*
Block 1				
Sex	.27	7.83**	.14	3.67**
Age	.01	.34	-.02	-.69
Block 2				
Honesty-Humility			-.23	-6.87**
Emotionality			-.15	-4.03**
Extraversion			-.05	-1.47
Agreeableness			-.08	-2.48
Conscientiousness			-.05	-1.39
Openness			-.16	-5.02**
R^2 (F)	.07 (30.93)**		.20 (25.01)**	
ΔR^2 (ΔF)			.13 (21.60)**	

**p < .01.

Table 4

The Results of the Hierarchical Regression Analysis Predicting SDO With HEXACO Facets (N = 830)

Predictor	Step 1		Step 2	
	β	*t*	β	*t*
Block 1				
Sex	.27	7.83**	.18	4.48**
Age	.01	.34	-.03	-.97
Block 2				
H1: sincerity			-.09	-2.61
H2: fairness			-.05	-1.41
H3: greed-avoidance			.06	1.53

Predictor	Step 1		Step 2	
	β	*t*	β	*t*
H4: modesty			-.20	-5.21**
E1: fearfulness			.00	.02
E2: anxiety			-.01	-.36
E3: dependence			-.06	-1.60
E4: sentimentality			.00	.06
X1: social self-esteem			-.01	-.12
X2: social boldness			-.04	-.91
X3: sociability			-.02	-.53
X4: liveliness			.05	1.10
A1: forgiveness			.01	.31
A2: gentleness			-.06	-1.47
A3: flexibility			.04	1.16
A4: patience			-.03	-.76
C1: organization			.02	.57
C2: diligence			.00	.01
C3: perfectionism			-.02	-.64
C4: prudence			-.08	-2.18
O1: aesthetic appreciation			-.06	-1.41
O2: inquisitiveness			-.05	-1.30
O3: creativity			.01	.12
O4: unconventionality			-.13	-3.22**
I: altruism			-.22	-5.02**
R^2 (F)	.07 (30.93)**		.26 (10.23)**	
ΔR^2 (ΔF)			.19 (8.04)**	

** $p < .01$.

Multivariate Behavioural Genetic Analysis of SDO and Personality

Following the results of the hierarchical regression (Table 3), the multivariate genetic analysis included Honesty-Humility, Emotionality, and Openness domains in addition to SDO. The analysis was based on the models which included A and E latent variables for all included variables. First, we ran the Cholesky model with, in the following order, SDO, Honesty-Humility, Emotionality, and Openness as observed, and additive-genetic and unique environmental factors as latent variables. That model included four A and four E latent variables and significantly differed from the observed data ($\chi^2 = 125.97$, $df = 52$, $p < .01$; RMSEA = .06, CFI = .83). However, the model in which SDO was entered into the regression last fitted data better and did not differ from the observed variance/covariance matrices ($\chi^2 = 65.10$, $df = 52$, $p = .10$; RMSEA = .03, CFI = .96). Therefore, the parameters were estimated from that model. These estimates, accompanied with associated standard errors and t-values, are presented in the Table 5. The heritability and environmentality of SDO, estimated from the best-fitting multivariate model, were .41 and .59, respectively. The majority (81%) of genetic variance of SDO was specific, i.e., not shared with

the selected personality domains. However, 19% of the variance overlapped with the total genetic variance of three personality domains included into analysis. Genetic correlations, which estimate the magnitude of the genetic overlap, were substantial for Honesty-Humility (r_g = -.31, p < .01), and Openness (r_g = -.30, p < .01), while genetic correlation for Emotionality was non-significant (r_g = -.09, p > .05). The environmental variance of SDO was almost completely specific. Only 3% of the environmental variance of SDO overlapped with personality domains included in the model. The environmental correlations between SDO and personality were -.05, -.09, and -.15 for the Honesty-Humility, Emotionality, and Openness domains, respectively. These correlations were non-significant at the previously set criteria (p < .01). However, the marginal environmental correlation of SDO with Openness would reach the significance level at the p < .05 criteria.

Table 5

Unstandardized Parameter Estimates of Cholesky Factors from the Best-Fitting Model and Maximum Likelihood Estimates of Genetic and Environmental Correlations of SDO with Honesty-Humility, Emotionality, and Openness

	ML path estimates of genetic factors (standard errors)				ML path estimates of environmental factors (standard errors)				r_g of SDO with	r_e of SDO with
	I	II	III	IV	I	II	III	IV	Selected domains	
Honesty-Humility	.38** (.024)				.39 (.018)				**-.31****	-.05
Emotionality	.02 (.028)	.35** (.022)			-.01 (.022)	.34** (.017)			-.09	-.09
Openness	.01 (.037)	-.01 (.041)	.58** (.020)		-.06** (.024)	-.00 (.027)	.36** (.020)		**-.30****	**-.15***
SDO	**-.09**** (.024)	-.03 (.029)	**-.09**** (.021)	**-.26**** (.022)	-.02 (.021)	-.03 (.025)	**-.05*** (.029)	**.34**** (.016)		

Note. Model fit indices are: χ^2 = 65.10, df = 52, p = .10; RMSEA = .03, CFI = .96. Significant parameter estimates of genetic and environmental Cholesky factors on SDO and estimates of genetic (r_g) and unique environmental correlations (r_e) are given in bold. They are estimated from the model estimates on five decimals. $^{*}p$ < .05; $^{**}p$ < .01. Significance of genetic and environmental correlations are estimated from the 99% (**) or 95% (*) confidence intervals.

Discussion

Heritability of SDO

The first aim of this study was to estimate the aetiology of individual differences in SDO. Results of the univariate behavioural genetic analysis confirmed the hypothesis about substantial genetic contribution to SDO, with heritability estimate

of 46% from the univariate ACE and AE models, and 41% from the best-fitting multivariate model. Having in mind that correlation of MZ twins (r = .42) represents the upper-limit of heritability, it is reasonable to conclude that SDO heritability is around 40%. That is in line with the results of extensive meta-analysis (Polderman et al., 2015) which reported that average heritability in twin studies of different phenotypes is .49, as well as with the heritability estimates of different social attitudes that range between 25 and 50% (see Lewis et al., 2014), with mean heritability around 30% (see Polderman et al., 2015 for the results on attitudes domain). The heritability of SDO does not imply neither its immutability nor biological determination in a causal sense. However, it is consistent with the conceptualization of SDO as a disposition and encourages research that would explore its position within a nomological network of other dispositions, as well as its etiology. Surprisingly, we did not find any evidence of the shared environmental influence. Therefore, our results indicate that aetiology of individual differences in SDO, usually conceptualised as an ideological attitude, mirror the aetiology of personality (with typical findings failing to recognize common environmental effect) closer than the aetiology of attitudes (with relatively high common environmental effect, at least in twin design, e.g., 20% in Polderman et al., 2015).

Our findings differ from those obtained in the Jena study (Kandler et al., 2016, 2015), where small and non-significant genetic effect for SDO was found, and are more similar to the heritability of SDO's sibling in the dual-process model - RWA, whose heritability estimate in the Jena study was 50%. At the same time, our results largely corroborate the findings of the Norwegian twin study (Kleppestø et al., 2019), though our heritability estimate is somewhat larger. It is possible that obtained differences reflect stable cultural differences between the samples in these studies, but different estimates may also reflect the specific processes in each society which are related to the measurement time-point, e.g. processes related to the economic or migrant crisis, historical or political processes, or any other processes related to the SDO variance.

Phenotypic Relations between SDO and HEXACO Personality Traits

As hypothesized, we found negative phenotypic correlations of SDO with Honesty-Humility, Emotionality and Openness domains of the HEXACO personality taxonomy. These findings were further consolidated in regression analysis. We also obtained an unexpected marginal bivariate correlation of SDO and Conscientiousness. All correlations were low to moderate in size, as it was true for the correlations of SDO and relevant Big Five domains (see meta-analysis by Sibley & Duckitt, 2008). Instead of hypothesized marginal correlation, we found no evidence for the significant association of SDO and HEXACO Agreeableness. Therefore, our conclusions corroborate previous findings on HEXACO personality-SDO relationship, especially for the more robust SDO correlates - Honesty-Humility, Emotionality and Openness (cf. Lee et al., 2010, 2013; Leone, Chirumbolo et al.,

2012; Leone, Desimoni et al., 2012; Sibley, 2011; Sibley et al., 2010). When contrasted to the conclusions pertaining to five-factor personality conceptualizations, present findings can be summarized in four points: i) as a domain encompassing content that is absent or poorly represented in five-factor space, Honesty-Humility plays a prominent role in explaining SDO; ii) Emotionality appears to be more vital SDO correlate than Big Five Emotional Stability; iii) Big Five and HEXACO Extraversion, Conscientiousness and Openness have comparable associations with SDO; and iv) HEXACO Agreeableness is less prominent SDO correlate than its Big Five namesake. The extension to the HEXACO personality resonates well with the dual-process motivational framework for the study of ideology and prejudice (for the empirical test and more thorough discussion on findings, see Sibley et al., 2010).

As predicted, SDO had significant low to moderate associations with all Honesty-Humility facets (sincerity, fairness, greed-avoidance, modesty), three Emotionality facets (anxiety, dependence, sentimentality), three Openness facets (aesthetic appreciation, creativity, unconventionality) and one Agreeableness facet (gentleness). Furthermore, altruism, an interstitial facet that captures variance of Honesty-Humility, Emotionality and Agreeableness domains, held the highest zero-order correlation with SDO across the spectrum of facets and domains. We also found unpredicted associations of SDO and one Extraversion (sociability) and one Conscientiousness facet (diligence). In regression analysis, only altruism, modesty and unconventionality appeared to be significant facet-level predictors of SDO. However, though modesty stood out in the analysis, there is a considerable shared variance between the Honesty-Humility facets, as largely comparable bivariate correlations with SDO across the facets suggest. Similar can be said for unconventionality and other Openness facets. Our findings on the association of SDO with Honesty-Humility and Openness facets mostly correspond to the existing evidence, with somewhat more pronounced association of honesty component in our sample compared to Leone, Chirumbolo et al. (2012) and less pronounced association of inquisitiveness, an Openness facet, in our sample compared to Leone, Desimoni et al. (2012).

Thus far, Agreeableness was considered to be rather important antecedent, not only of SDO but also of various other social behaviours (e.g. prejudice). However, the lack of substantial SDO - HEXACO Agreeableness association is not that surprising. Namely, the content of Big Five Agreeableness is in the HEXACO taxonomy split between its counterpart Agreeableness, Honesty-Humility and Emotionality domains, as well as altruism facet. Hence, a large portion of the content relevant to social behaviour does not belong to HEXACO conceptualization of Agreeableness. A similar effect of the "instability" of Agreeableness' association to relevant social outcomes was noticed in some five-factor personality conceptualizations. For example, it was evident in some studies administering Big Five Inventory that contains rather short Agreeableness measure that does not cover all possible nuances that longer instruments do, especially with respect to the

Honesty-Humility content (Miller et al., 2011). Bergh and Akrami (2016; see also Bergh et al., 2016; Hodson et al., 2009) explored the "fragility" of the association of Agreeableness and prejudice, with HEXACO Honesty-Humility, the interstitial altruism facet and/or the Dark Triad variables (Machiavellianism, narcissism, psychopathy, whose latent factor represents an antipode to Agreeableness) included in the regression. In these regressions, the authors found non-significant relationship between HEXACO Agreeableness and prejudice. They also proved that the association of five-factor Agreeableness and prejudice depends on the choice of the measure, i.e. the precision with which it measures relevant Agreeableness facets. Though some are not referring specifically to SDO but to prejudice instead, we believe these arguments say much about the relationship of Agreeableness and SDO, one of the strongest prejudice antecedents. Likewise, they illustrate the importance of considering facet-level data in revealing association between personality and other constructs. The role of Agreeableness as an antecedent of various social outcomes remains an intriguing point for many contemporary researchers (e.g. Crawford & Brandt, 2019). With the growing number of individual studies on the relationship of SDO (and related constructs) and personality conceptualized beyond the five-factor taxonomies, more insight into the (in)stability of Agreeableness effects dependent on the trait conceptualization could be expected.

In accordance with earlier evidence (e.g. Akrami & Ekehammar, 2006), we found the prediction of SDO to be more successful if facet instead of domain personality scores were used. This reflects that there are more predictors in regression analysis on the facet than on the domain level, however, it might also be potentiated by the fact that only facet-level (and not domain-level) analyses take altruism into the equation. Nonetheless, it should be noted here that the total amount of variance of SDO explainable by HEXACO domains and facets remained rather modest. Only about one fifth when domains were used and one-fourth of SDO variance when facets were used was accountable by HEXACO personality traits. Other relevant variables, both dispositional (e.g. cognitive ability) and contextual (e.g. perceived threat) should be considered to enable a better understanding of the SDO complex nature. Our findings speak in favour of taking multiple perspectives when considering different aspects of social behaviour.

Genetic and Environmental Overlap Between SDO and Personality

The final aim of our study was to investigate the etiological overlap between SDO and HEXACO domains, in order to examine the level of genetic and environmental mediation of their phenotypic associations. For that purpose, we ran a multivariate behaviour genetic analysis with SDO and HEXACO domains with a substantial predictive power in predicting SDO. It is important to note that due to our sample size, the number of variables that could be used in multivariate analysis with a reasonable statistical power was restricted. Therefore, we set an a priori criterion that only those domains which are significant and substantial SDO predictors

($\beta > .10$, $p < .01$; see Table 3) would be included in the analysis. We compared the results of two multivariate models and the parameters were estimated from the model with the better fit. Results of the multivariate Cholesky decomposition showed that SDO shared genetic variance with Honesty-Humility and Openness, while overlap with Emotionality did not reach the significance level. Genetic correlations of SDO with Honesty-Humility and Openness were substantial, while unique environmental correlation was only marginally significant for Openness domain. Since genetic and unique environmental variance for personality are around 50%, the obvious conclusion is that obtained phenotypic correlations between SDO and analysed personality traits reflect, at least for Honesty-Humility and Openness, the overlap of their genetic rather than environmental effects. That finding is also consistent with one of the common interpretations, borrowed from the multivariate behaviour genetics studies of cognitive abilities, which refers to the "generalist genes" hypothesis (Plomin & Kovas, 2005). This hypothesis predicts that covariation of different traits is mostly due to the overlapping genetic effects, while environmental effects are mostly unique for examined phenotypes. However, small unique environmental overlap between SDO and Openness, which ought to be replicated in future research, may also be important. Obviously, SDO genetic and environmental variance is largely independent from that of personality domains. Our findings about the shared aetiology of SDO and personality support the idea that explanatory models of individual differences in SDO should encompass personality domain. Nonetheless, since obtained effect sizes are rather modest, other variables which were not included in our study may also play an important role.

Limitations and Conclusions

The reported study is subject to some limitations. Twin design which was used is very powerful in revealing the total genetic effects. However, the statistical power in estimating non-additive genetic and common environmental influences is limited, especially for the phenotypes in which both of them are present. Besides that, the eventual effect of assortative mating, which is very common for the variables related to social behaviours, including SDO (e.g. Kandler et al., 2016), was not controlled in our study and may have biased the parameter estimates. Our sample size is relatively large considering the size of the population from which it was derived. However, in order to obtain precise parameter estimates larger sample would be welcomed, and the ratio between MZ and DZ twins should be more balanced. The fact that exclusively self-report measures in only one measurement point were used can justifiably be stated to be a limitation of the study as well. However, we feel that our study yielded a few important findings and resulted in several key conclusions. Firstly, it provided strong evidence for the substantial heritability of SDO, and no evidence for the common environmental influence. We estimated its heritability to the above 40%, with the rest of the variance attributable to the unique environmental effect. Secondly, there are substantial phenotypic correlations between individual

differences in SDO and the HEXACO model traits, both at the domain and facet levels. Substantial correlations were obtained for Honesty-Humility, Emotionality and Openness domains, and significant correlations were found for numerous facets. Thirdly, multivariate genetic modelling indicated substantial overlap of genetic influence on SDO with the genetic influences on Honesty-Humility and Openness, while the overlap of environmental influence on SDO was only marginally significant for Openness domain. The etiological overlap of SDO and personality is, in our view, an additional argument for recognizing dispositional approach in explaining social behaviour as useful and complementary to the widely used social/contextual perspective.

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