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## **The Short Dark Tetrad (SD4): Measurement Invariance Across Serbian and Canadian Samples and Further Validation**

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### **Abstract**

This study aimed to test the construct and criterion validity of the Serbian adaptation of the Short Dark Tetrad (SD4). In addition to testing measurement invariance between the Serbian ( $N = 488$ ) and Canadian samples ( $N = 739$ ), the construct validity of the SD4 was also assessed through correlations with more extensive measures of the Dark Tetrad, and criterion validity was evaluated through correlations with variables related to mental health. The results indicated good model fit indices for the SD4 in both samples and partial scalar invariance across samples. Validity correlations with extensive measures confirmed the construct validity of all SD4 scales, with caution noted for the psychopathy scale, which shares similar content with sadism. Profile similarity, based on construct and criterion correlations, revealed substantial dissimilarity between narcissism and the other scales but high similarity among the Machiavellianism, psychopathy, and sadism scales. Regardless of the similarity between the scales, they showed distinctive correlations with emotional distress and positive mental health aspects.

*Keywords:* Dark Tetrad, Dark Triad, dark personality, cross-cultural invariance

## **The Short Dark Tetrad (SD4): Measurement Invariance Across Serbian and Canadian Samples and Further Validation**

After the inclusion of sadism into the Dark Triad constellation, which formed the Dark Tetrad (Chabrol et al., 2009), research on sadism has rapidly grown. The Dark Tetrad consists of psychopathy (characterized by a lack of remorse and guilt, superficial charm, as well as impulsivity and reckless antisocial behavior), narcissism (characterized by beliefs of grandiosity and a sense of entitlement), Machiavellianism (characterized by a preference for strategic manipulation of others), and sadism (characterized by pleasure from others' suffering, see Paulhus, 2014). To measure Dark Tetrad traits, previous researchers typically combined the Dark Triad scales (e.g., Dark Triad Dirty Dozen; Jonason & Webster, 2010, or Short Dark Triad; Jones & Paulhus, 2014) with one of the sadism instruments (e.g., Assessment of Sadistic Personality; Plouffe et al., 2017, or Comprehensive Assessment of Sadistic Tendencies; Buckels, 2023). In response to the need for a concise assessment of the Dark Tetrad, Paulhus et al. (2021) developed the Short Dark Tetrad (SD4). However, evidence of cross-cultural invariance for the SD4 is limited. Therefore, this research aimed to examine the psychometric properties of the SD4 in a sample from Serbia. Samples from Serbia on one side and Canada, where the SD4 was originally proposed and tested, on the other side, reflect substantial cultural differences in dimensions such as individualistic/collectivistic orientation, uncertainty avoidance, power distance, etc. (Hofstede Insights, 2024), which could affect the manifestation of dark traits. Thus, testing cross-cultural invariance is important for the interpretation and comparison of SD4 scores.

### **The Development of the SD4 and Its Validity**

The SD4 represents the first brief Dark Tetrad measure, consisting of 28 items. While based on the SD3, several adjustments facilitated the empirical separation of the Dark Tetrad

traits and strengthened the psychometric properties of the four scales. First, the initial sadism item pool included a variety of sadistic tendencies, including direct physical, direct verbal, and vicarious sadism. However, the direct physical items showed substantial empirical overlap with psychopathy, forcing their removal. The correlation between the final SD4 sadism and psychopathy scales was .51 (Paulhus et al., 2021). The final sadism scale mainly captures vicarious sadism (four items) and verbal sadism (two items), while one item expresses a sentiment that may be common to all varieties of sadism (“Some people deserve to suffer”). Secondly, the authors revised the content of the Machiavellianism scale to include items from the Mach VI scale (Paulhus & Jones, 2015), focusing on less aggressive indicators of Machiavellianism and more on indicators of controlled manipulation. Therefore, the correlation between Machiavellianism and psychopathy scales is lower compared to the correlation obtained with the SD3, which is one of the advantages of the SD4. The correlation between the final SD4 Machiavellianism and psychopathy scales was .32 in Paulhus et al. (2021), which contrasts with the larger .52 average correlation for the corresponding SD3 scales (Vize et al., 2018), showing the improved empirical separation with the development of the SD4. Thirdly, there are no reverse-coded items, but the analysis showed that partialling out the acquiescence index had little effect on the intercorrelations among the scales (Paulhus et al., 2021).

Although the exploratory factor analysis revealed a clear four-factor solution, confirmatory factor analyses on another sample resulted in marginal model fit. However, a model with 12 parcels showed an excellent fit. Further validation indicated a distinction between the scales. Narcissism correlated highly and positively with extraversion, followed by small positive correlations with openness and personal adjustment. In addition, narcissism showed a nonsignificant correlation with agreeableness (Paulhus et al., 2021), suggesting that it captures

more of an agentic rather than an antagonistic aspect of grandiose narcissism. In contrast, Machiavellianism, psychopathy, and sadism showed small to moderate negative correlations with Big Five agreeableness (Paulhus et al., 2021).

In subsequent research, Neumann et al. (2022) demonstrated that the exploratory structural equation model exhibited an acceptable model fit. However, the best model fit was observed in a mini-model consisting of 12 items (three per scale). While the bifactor model displayed marginal fit, the general factor comprised psychopathy and sadism items, which is theoretically questionable. All models were invariant across genders. Men displayed higher scores on all scales, with the largest effect sizes observed for sadism and psychopathy (Neumann et al., 2022), consistent with the original study (Paulhus et al., 2021). Furthermore, the external validity of the scales was confirmed, with psychopathy showing consistent negative relationships with likability, and narcissism and sadism showing associations with sex drive (Neumann et al., 2022).

#### **Cross-Cultural Validity of the SD4**

So far, the SD4 has been adapted into several languages. However, there have been some issues regarding cross-cultural invariance. For instance, the German adaptation showed only configural invariance when compared to the US. However, metric invariance was confirmed when the German sample was restricted to an equal age range (Blötner, Webster, et al., 2023). Furthermore, the German SD4 showed marginal model fit for the four-factor model based on items but an acceptable fit when using parcels (Blötner, Ziegler, et al., 2022), and an acceptable fit for an exploratory structural equation model, although substantial cross-loadings of sadism items on the psychopathy factor were noticeable (Blötner, Webster, et al., 2023). Based on congruence between the hypothesized and observed correlations involving the SD4, the authors

concluded that the narcissism scale assesses both agentic and antagonistic aspects (although the correlation with Big Five agreeableness was nonsignificant, correlations with aggression and antagonism were significant and positive); further concluded that Machiavellianism reflects strategic orientation; sadism captures aggression, dominance, and low empathy; and psychopathy relates to conflicts with others and authorities (Blötner, Ziegler, et al., 2022). However, high-profile similarity was found based on correlations with basic and maladaptive traits, personal values, unified motives, and self-esteem, as well as a moderate-to-high correlation between psychopathy and sadism (.54). Furthermore, the psychopathy scale displayed higher correlations with disinhibition and some aspects of impulsivity, as well as with physical and verbal aggression, compared to sadism. Sadism also showed substantial correlations with physical aggression (Blötner & Mokros, 2023). In addition, sadism items exhibited poor discrimination parameters (Blötner & Beisemann, 2022). Regardless, the SD4 was invariant across gender in the German sample (Blötner, Webster, et al., 2023).

Although the four-factor model best fit the data, the SD4 showed metric noninvariance across Italian, Romanian, and UK samples (Fino et al., 2023). Each scale exhibited several country-based differential item functioning (DIF), especially the Machiavellianism scale (Fino et al., 2023). Large DIF was found in Italian and UK samples compared to the Romanian sample (Fino et al., 2023). Therefore, these results emphasize the need for cultural-specific adaptations that account for variations in both cultures and languages.

After adjusting and replacing some items, Liu et al. (2023) developed a Chinese version of the SD4 and confirmed the validity of each scale. Sadism and psychopathy still showed a moderate-to-high correlation (.50), which is in line with previous findings. In addition, Akhtar et al. (2022) excluded four items (one from each scale) from the English version of the SD4 and

formulated a 24-item version of the SD4, which should be more appropriate for use in Muslim societies. The correlation between sadism and psychopathy was .57.

Four-factor structure was confirmed in Russian (Kornienko et al., 2022), Portuguese (Pechorro et al., 2023), Farsi (Qaderi Bagajan et al., 2024), and Persian (Qaderi Bagajan et al., 2024) languages, but there was no test of measurement invariance. Again, the correlation between sadism and psychopathy was in a range from .55 (Qaderi Bagajan et al., 2024) to .59 (Pechorro et al., 2023). In addition, in the Portuguese sample (Pechorro et al., 2023), although both scales correlated significantly with delinquency and substance abuse, psychopathy showed higher correlations. In the Croatian adaptation, the four-factor model exhibited unsatisfactory-to-marginal fit, but the bifactor model showed marginal fit (Wertag et al., 2023). Once again, as in Neumann et al. (2022), the general factor comprised psychopathy and sadism items, which raises questions about its theoretical validity. Therefore, the four-factor model was retained in the Croatian sample, given the small differences in model fit.

### **The Current Study**

This study aims to further explore the cross-cultural validity of the SD4. Previous research has primarily focused on WEIRD samples (e.g., Canada, USA, UK, Germany, Italy) when investigating the cross-cultural invariance of the SD4. The results have indicated challenges when adapting the SD4 to other languages, as seen in studies such as the German adaptation (Blötner, Webster, et al., 2023; Blötner, Ziegler, et al., 2022) or the Italian and Romanian adaptations (Fino et al., 2023). The noninvariance of the SD4 hinders the ability to compare results across different countries and languages. Although studies have been conducted on non-WEIRD samples (e.g., in China), they have not tested cross-cultural invariance, and in some studies, SD4 modification was suggested. In the same vein, when the English SD4 is

administered to a non-WEIRD sample (Akhtar et al., 2022), the results suggest the need for adjustments to achieve a psychometrically satisfactory measure.

Therefore, in this study, a four-factor correlated model of the SD4 was tested, along with an examination of cross-cultural invariance between the Canadian (in the English language) and the Serbian sample (in the Serbian language). Considering that the SD4 was originally proposed and tested with a Canadian sample, each test of cross-cultural measurement invariance should be conducted in comparison to a sample from this population. According to Holland's cultural dimensions, in comparison to Canadian and American culture, Serbian culture is characterized as more collectivistic and restrained, more normative than pragmatic, with higher power distance, and a very high preference for avoiding uncertainty (Hofstede Insights, 2024). Hence, Serbian culture seems to be more characterized by a slow life history, while Canadian and American culture seems to be more characterized by a fast life history. These differences could be reflected in the expression of dark traits, which are in alignment with the fast life history strategy (Jonason & Webster, 2010).

Previous research has shown that the SD3 had a good model fit in the Serbian sample (Dinić et al., 2018), and this is also true for various sadism measures (Dinić, Bulut Allred, et al., 2020), which might lead us to expect a satisfactory model fit for the SD4. However, there has been no SD4 invariance testing involving Serbian samples, and a large cross-cultural study involving participants from 18 countries showed that the SD3 is not cross-culturally invariant, especially the psychopathy scale (Aluja et al., 2022).

Besides invariance testing, we also tested SD4 construct validity in the Serbian sample via associations with more extensive measures of the Dark Tetrad. In line with previous research (e.g., Neumann et al., 2022; Paulhus et al., 2021), we expected to find high correlations with

these measures of dark traits. Furthermore, criterion validity was tested via associations with variables related to mental health. In line with previous research (e.g., Dinić, Sadiković, et al., 2020; Paulhus et al., 2021), we expected that narcissism would correlate with personal adjustment measures (i.e., positive with positive mental health and negative with distress symptoms), while other dark traits would not. Narcissism is the ‘lightest’ trait among dark traits and it shows some adaptive aspects, like agentic ones (Cai & Luo, 2018), which are dominant in the SD4 narcissism scale. By including more extensive measures of the Dark Tetrad and relevant criteria, we aimed not only to provide validity evidence for the Serbian SD4 adaptation but also to offer insight into the distinct manifestations of the Dark Tetrad traits in a non-WEIRD country.

## **Method**

### **Participants and Procedure**

#### ***Canadian Sample***

The Canadian sample included 775 undergraduate students, 36 of whom had missing SD4 data and was excluded (4.6%), resulting in a final sample of 739 participants, of which 78.2% were women, and 0.8% had missing data regarding gender. The participants had a mean age of 20.23 ( $SD = 4.75$ ), with an age range from 17 to 60. These individuals completed the SD4 as part of a larger online survey in exchange for partial course credit. The study on the Canadian sample was approved by the University Human Research Ethics Board at the University of Winnipeg, Canada.

#### ***Serbian Sample***

The Serbian sample consisted of 488 participants, with 55.3% women and 0.4% missing data regarding gender. The participants had an average age of 34.95 ( $SD = 12.26$ ), with ages ranging from 18 to 81. This sample was obtained through a convenient online collection method,

primarily using social networks. The study on the Serbian sample was a part of a larger study approved by the Ethical Committee of the Faculty of Philosophy, University of Novi Sad, Serbia.

### **Measures**

The translation of the SD4 into Serbian was carried out by the first author, followed by a back-translation conducted by a professional English teacher. The original and back-translated SD4 versions were then compared and adjusted for equivalence through a consensus between the first author and D. L. Paulhus, one of the original authors. In the Serbian sample, besides SD4, the Serbian adaptations of several measures were used:

- 1) 18-item Narcissistic Admiration and Rivalry (NARQ; Back et al., 2013, for Serbian adaptation see Dinić et al., 2023), measuring two aspects of grandiose narcissism: admiration and rivalry;
- 2) 20-item Mach-IV (Christie & Geis, 1970, for Serbian adaptation see Međedović & Petrović, 2015) measuring Machiavellianism;
- 3) 28-item Levenson Self-Report Psychopathy Scale (LSRP; Levenson et al., 1995, for Serbian adaptation see Dinić, Wertag, et al., 2020) measuring primary and secondary psychopathy;
- 4) 9-item Assessment of Sadistic Personality (ASP; Plouffe et al., 2017, for Serbian adaptation see Dinić, Bulut Allred, et al., 2020) measuring subclinical sadism;
- 5) 21-item Depression, Anxiety, Stress Scale (DASS-12; Osman et al., 2012, for Serbian adaptation see <http://www2.psy.unsw.edu.au/dass/Serbian/Serbian.htm>) measuring three aspects of psychological distress: depression, anxiety, and stress; and
- 6) 9-item Positive Mental Health Scale (PMH; Lukat et al., 2016, for Serbian adaptation see <https://fbz-bochum.de/pmh-positive-mental-health-skala>).

NARQ has a 6-point Likert scale (1 = *not agree at all*, 6 = *agree completely*), DASS-21 has a 4-point scale (0 = *did not apply to me at all*, 3 = *applied to me very much, or most of the time*) as well as PMH (0 = *do not agree*, 3 = *agree*), while the rest of the measures have a 5-point Likert scale (1 = *not agree at all*, 5 = *agree completely*). Alpha reliabilities are presented in Table 2.

### **Data Analysis**

A four-factor model with correlated SD4 factors was tested via confirmatory factor analysis. Model fit was evaluated via values  $\geq .90$  for comparative fit index (CFI) and Tucker-Lewis index (TLI), as well as  $\leq .08$  for root mean square error of approximation (RMSEA) and standardized root mean square residual (SRMR), which refer to acceptable model fit (Hu & Bentler, 1999). For measurement invariance, configural (equal factor structure), metric (equal loadings), and scalar invariance (equal thresholds) were tested. A difference in CFI ( $\Delta\text{CFI} \leq .01$ ) and a difference in RMSEA ( $\Delta\text{RMSEA} \leq -.015$ ) were considered indicative of negligible differences between the models (Cheung & Rensvold, 2002). All models were tested using the R package “lavaan” (Rosseel, 2012) and “semTools” (Jorgensen et al., 2022), with a diagonally weighted least squares (DWLS) estimator. Profile (dis)similarity between the SD4 scales, based on correlations with validity variables, was calculated using Cronbach and Gleser’s (1953)  $D$  statistic. Lower  $D$  values indicate smaller distances and higher similarity.  $D$  could be interpreted in terms of Cohen’s  $d$  as an effect size measure. Data are available at <https://osf.io/gqf6v/>.

### **Results**

#### ***Factor Structure of the SD4 and Cross-Cultural Invariance***

The four-factor model in the Canadian sample demonstrated good model fit (Table 1). Loadings ranged from .40 to .89 (see Table A in the Online Supplement). Correlations between the latent factors ranged from .32 (between narcissism and sadism) to .59 (between psychopathy and sadism). In the Serbian sample, the four-factor model also showed good model fit (Table 1). Loadings were in the range of .36 to .91 (see Table B in the Online Supplement), and correlations between the latent factors ranged from .41 (between Machiavellianism and psychopathy) to .76 (between psychopathy and sadism).

The results of the measurement invariance analysis indicated configural and metric, but not scalar invariance (Table 1). To achieve partial scalar invariance, 12 thresholds with the highest  $\chi^2$  test were released (which represents 1.07% of the total 112 thresholds) until the model fit fell within the recommended range of  $\Delta$ CFI and  $\Delta$ RMSEA. Released thresholds included items from the Machiavellianism (1, 5, 2), psychopathy (16, 18), and sadism scales (26, 28).

#### ***Descriptives, Alpha Reliabilities, and Validity Correlations of the Serbian SD4***

The alpha and omega reliabilities of the Serbian SD4 scales were satisfactory (Table 2). Regarding construct-validity correlations, the SD4 Machiavellianism scale showed the highest correlations with Mach-IV and primary psychopathy; the SD4 narcissism scale showed a remarkably high correlation with narcissistic admiration; the SD4 sadism and psychopathy scales showed the highest correlation with ASP, followed by primary psychopathy (Table 2). The correlation between the SD4 sadism and ASP scales was stronger than the correlation between SD4 psychopathy and ASP ( $z = 2.84, p = .005$ ), although the difference in correlations is rather small. All SD4 scales, except narcissism, were uncorrelated with positive mental health; however, they had weak positive correlations with depression, anxiety, and stress (Table 2). The

narcissism scale displayed a contrasting pattern of correlations, with the highest negative correlations with distress aspects and a positive correlation with positive mental health.

Profile similarity between SD4 psychopathy and sadism (0.11), Machiavellianism and psychopathy (0.14), and Machiavellianism and sadism (0.17) indicated a high similarity between the scales. In contrast, there was substantial dissimilarity between narcissism and the rest of the scales, with values of 0.89 for Machiavellianism, 0.99 for psychopathy, and 0.99 for sadism.

## **Discussion**

This study aimed to explore the psychometric properties of the SD4 in Serbian culture. The results indicated partial scalar invariance of the SD4 when comparing the Serbian sample to the Canadian sample. Therefore, the results generally showed that the SD4 scores in these samples refer to the same constructs, that is, Dark Tetrad traits and that they were measured in the same way. This means that there is no need for culture-specific adaptation and changes in the SD4, at least when the Serbian adaptation is in question. However, considering that *partial* scalar invariance is achieved, caution should be exercised when comparing some scores between the two samples. This result is partially consistent with previous cross-cultural comparisons of the SD4 (Blötner, Webster, et al., 2023; Fino et al., 2023), which have highlighted cultural variations in the expression of dark traits measured by the SD4. The caution for comparison applies to all scales except the narcissism scale. Previous research has shown scalar measurement invariance in narcissism scales across Serbian and US samples (Dinić & Vujić, 2020). Hence, cross-cultural differences in individualism, short-term orientation, indulgence, and uncertainty avoidance, which reflect self-centeredness and a fast life history strategy as characteristics of dark traits (e.g., Blötner, Webster, et al., 2023), could account for possible reasons for the different expressions of ‘darker’ dark traits, such as Machiavellianism, psychopathy, and sadism.

Despite the partial scalar invariance, the Serbian adaptation of the SD4 exhibited good model fit indices for the originally proposed four-factor solution with correlated factors. Furthermore, alpha reliabilities were adequate and consistent with previous studies (e.g., Blötner, Webster, et al., 2023; Paulhus et al., 2021). Construct-validity correlations with extensive dark trait measures confirmed the construct validity of each scale and provided a better understanding of their content. For instance, the SD4 narcissism scale predominantly captures the adaptive and agentic aspects of grandiose narcissism, as opposed to the antagonistic aspects, which aligns with the original study by Paulhus et al. (2021) but contrasts with conclusions drawn from the German adaptation (Blötner, Ziegler, et al., 2022). In addition, criterion-validity correlations showed that narcissism had a positive correlation with positive mental health and negative correlations with emotional distress, which is in line with previous research on the SD4 (Paulhus et al., 2021).

The correlation between the SD4 Machiavellianism and psychopathy scales was too low to suggest redundancy (.30). This lower correlation is one of the advantages of the SD4 compared to the SD3. Close inspection of the validity correlations revealed that Machiavellianism overlaps more strongly with primary psychopathy than secondary psychopathy. The SD4 psychopathy scale's emphasis on secondary psychopathy indicators (i.e., lack of behavioral control and risky behaviors) likely contributes to its lower correlation with Machiavellianism. Nevertheless, the Machiavellianism and psychopathy scales showed high-profile similarity in this study. Given that the Machiavellianism scale mostly encompasses a preference for strategic manipulation, the lack of validity measures assessing planfulness and cautious deliberation (vs. impulsivity and recklessness) might explain such high-profile similarity. Although high profile similarity between Machiavellianism and psychopathy measures

is highlighted in Miller et al. (2017), evidence of distinctiveness requires criterion variables that should, theoretically, display different associations with these overlapping traits.

One possible validity issue for the Serbian SD4 measure involves the psychopathy scale, which shares similar content with sadism. Previous research also pointed out high agreement between the nomological networks of psychopathy and sadism measures (Blötner & Mokros, 2023). Cross-construct correlations between SD4 psychopathy and SD4/ASP sadism were higher than the correlations with primary and secondary psychopathy. Although this pattern suggests weak construct validity, there may be alternative explanations. For instance, there may be a mismatch between the narrow bandwidth SD4 psychopathy scale and the broad bandwidth LSRP. As a broadband measure, the LSRP encroaches on the territory of the other dark traits. For example, the LSRP item, “I tell other people what they want to hear so that they will do what I want them to do,” may be better classified as Machiavellianism content. In contrast, the SD4 psychopathy measure was designed to reduce overlap between the traits. Its narrow focus on the unique aspects of psychopathy may reduce associations with traditional broadband measures. At the same time, the modest correlations between the SD4 psychopathy and LSRP scales (.40 and .34 for primary and secondary psychopathy, respectively) are surprising, considering their similar content. These correlations contrast with higher correlations between the Serbian SD3 and LSRP primary (.66) and secondary psychopathy scales (.49, see Dinić, Sadiković, et al., 2020). The differences may be attributed to the revised content of the SD4 psychopathy scale, sampling variation, or a combination of both.

In support of its construct validity, SD4 sadism showed the highest correlation with ASP, followed by primary psychopathy. Blötner and Beisemann (2022) pointed out issues with the SD4 sadism scale. In the case of the Serbian adaptation, those validity issues may have shifted to

the psychopathy scale. A meta-analysis of forensic samples showed that sadism had small correlations with psychopathy (.25–.26, O’Connell & Marcus, 2019); however, in the general population, it is higher (.58, Bonfá-Araujo et al., 2022). One of the key distinctions between psychopathy and sadism is in emotional functioning, with psychopathy showing deficits in emotion perception ability and issues with appropriately generating negative emotions as a response to violence, while sadism showed a positive contribution to the identification of emotional expressions and positive reactivity to violence (Bulut, 2020). The results of our study showed that differences could be discerned based on emotional distress, which is unrelated to sadism and positively related to psychopathy. This result aligns with Paulhus et al. (2021), showing no significant correlation between sadism and personal adjustment but a significant negative correlation between psychopathy and personal adjustment. However, it is a challenge to create self-report items that optimally distinguish between sadism (enjoying others’ pain and suffering) and psychopathy (indifference to others’ emotions). Currently, the SD4 provides the best empirical separation of these traits, yet the profile similarity between the sadism and psychopathy scales, as well as all SD4 scales, except narcissism, still indicates their strong interrelation.

There are several limitations to this study. First, the recruitment procedure limited the generalizability of conclusions to the population of the respective countries. Additionally, there is an imbalance in the mean age across samples, with the Serbian sample consisting of older adults. While Blötner, Webster, et al. (2023) achieved metric invariance when matching the age of the samples, in our preliminary analysis, this strategy did not contribute to the scalar invariance. The same strategy was not adequate for gender matching due to the small subsample of men in the Canadian sample. Therefore, gender imbalance could contribute to the invariance of some item

thresholds, especially considering that these items capture ‘darker’ dark traits. Second, gender and age invariance were not tested, considering their imbalance in both samples. Third, some of the validity scales showed lower alphas ( $< .70$ ), although omegas were adequate. Therefore, conclusions based on correlations with these scales should be taken with caution. Future replications should include more balanced samples regarding demographic characteristics and incorporate a greater variety of construct measures, especially psychopathy measures.

Despite these limitations, the results of this study underscore possible cross-cultural differences in the expression of dark traits, as reflected in the lack of threshold invariance for some items across the Serbian and Canadian samples. Conclusions gleaned from the measurement invariance analysis enhance this study’s research contributions, which go beyond the development and validation of the Serbian SD4 adaptation. Our findings advance knowledge by offering psychometric information necessary for valid cross-cultural comparisons and documenting association patterns with a sample that is culturally different from the SD4’s originating countries (Canada and the US). The Serbian SD4 associations with criterion variables like personal adjustment align with those from Western samples (e.g., Paulhus et al., 2021), which suggests that cross-cultural similarities may outweigh the differences. Previous research (e.g., Aluja et al., 2022) has raised questions about the cross-cultural invariance of dark trait measures among non-WEIRD samples, but achieving even weak/metric invariance was challenging in those cases. Therefore, the results of our study support the partial scalar invariance across the investigated samples and the meaningful nomological network of the Serbian adaptation of the SD4.

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**Table 1***Model fit indices for the four-factor SD4 model and cross-cultural measurement-invariance*

	DWLS $\chi^2(df)$	CFI	$\Delta$ CFI	TLI	RMSEA (90% CI)	$\Delta$ RMSEA	SRMR
Canada	2016.685(344)	.951		.946	.081 (.078-.085)		.079
Serbia	1016.563(344)	.953		.948	.063 (.059-.068)		.080
Canada–Serbia							
Configural	3033.248(688)	.951		.946	.075 (.072-.077)		.080
Metric	3337.524(712)	.945	.006	.942	.078 (.075-.080)	-.003	.084
Scalar	5449.402(792)	.903	.042	.908	.098 (.096-.100)	-.020	.084
Partial scalar	3909.913(780)	.935	.010	.937	.081 (.078-.083)	-.003	.082

*Note:* all  $\chi^2$  were significant at  $p < .001$ .

**Table 2***Descriptives, alphas, and validity correlations of the SD4 Serbian adaptation (N = 488)*

	SD4 Machiavellianism	SD4 Narcissism	SD4 Psychopathy	SD4 Sadism	<i>M(SD)</i>	$\alpha$	$\omega$
SD4 Machiavellianism	1				3.15(0.77)	.72	.73
SD4 Narcissism	.32	1			2.44(0.87)	.81	.81
SD4 Psychopathy	.30	.44	1		1.84(0.67)	.73	.73
SD4 Sadism	.38	.36	.58	1	1.72(0.70)	.74	.70
Mach-IV Machiavellianism	.54	.10	.32	.42	2.77(0.53)	.62	.78
NARQ Narcissistic admiration	.25	.73	.27	.22	3.13(1.03)	.70	.85
NARQ Narcissistic rivalry	.38	.23	.32	.43	1.96(0.81)	.60	.80
LSRP Primary psychopathy	.50	.32	.40	.51	1.90(0.61)	.61	.83
LSRP Secondary psychopathy	.18	-.06	.34	.21	2.41(0.69)	.63	.73
ASP Sadism	.27	.26	.54	.63	1.42(0.54)	.64	.78
DAS-12 Depression	.13	-.20	.11	.06	0.92(0.86)	.79	.88
DAS-12 Anxiety	.07	-.08	.13	.04	0.79(0.74)	.86	.80
DAS-12 Stress	.11	-.11	.10	.06	1.43(0.86)	.86	.87
PMH Positive mental health	-.02	.32	.02	.03	1.89(0.72)	.92	.92

*Note:* Correlations  $\geq \pm .11$  are significant at  $p < .01$ . Scale range for SD4, Mach-IV, LSRP, and ASP is 1-5, for NARQ is 1-6, and for DAS-12 and PMH is 0-3.

## Acknowledgements

### Conflicts of Interest

The authors declare they have no conflict of interest. Informed consent was obtained from all participants included in the study in line with ethical approval.

### Publication Ethics

All procedures performed in studies involving human participants were by the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The study on the Serbian sample was a part of a larger study approved by the Ethical Committee of the Faculty of Philosophy, University of Novi Sad, Serbia. The study on the Canadian sample was approved by the University Human Research Ethics Board at the University of Winnipeg, Canada.

### Authorship

Bojana M. Dinić, Conceptualization, methodology, data analysis, writing – original draft, writing – review and editing. Erin Buckels, Data collection, writing – review and editing. Nataša Kovačević, Methodology, data collection.

### Open Science

We report all analyses including all tested models. Since this study is part of a larger project, in addition to the listed instruments, the Coping Inventory for Stressful Situations and the Patient Health Questionnaire-15 (additional 36 items) were used for another research purpose. If we use inferential tests, we report exact *p*-values, effect sizes, and 95% confidence or credible intervals. We did not conduct a priori sample size calculation because our research objectives focused on maximizing sample size to improve the stability and reliability of the results. The achievement of these objectives did not necessitate conducting any confirmatory analysis for a specific effect, thereby precluding the need for a prior power analysis. We report

all data exclusions. The inclusion/exclusion criteria were established prior to data analysis.

Open Data: We confirm that there is sufficient information for an independent researcher to reproduce all of the reported results, including codebook. The data for the main analyses are available at <https://osf.io/gqf6v/> (Dinić, 2024).

Open Materials: We confirm that there is sufficient information for an independent researcher to reproduce all of the reported methodology. The measures are available at <https://osf.io/gqf6v/> (Dinić, 2024).

Preregistration of Studies and Analysis Plans: This study was not preregistered.

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