



# The basic psychological need satisfaction and frustration scale (BPNSFS) among Serbian adolescents: testing factor structure and gender measurement invariance

Ognjen Janić<sup>1</sup> · Milica Lazić<sup>2</sup> · Milica Ljevaja<sup>3</sup>

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## Abstract

This study aimed to replicate research on the multidimensionality of basic psychological needs within a Serbian cultural context. Using both traditional (bifactor) confirmatory factor analysis (CFA) and (bifactor) exploratory structural equation modeling (ESEM) frameworks, this study examined the factor structure of the Basic Psychological Needs Satisfaction and Frustration Scale (BPNSFS) and tested measurement invariance across gender in a sample of 413 Serbian high school students (54.2% female;  $M_{age} = 16.62$ ,  $SD_{age} = 0.722$ ). The ESEM model with six specific factors (three satisfaction and three frustration factors for autonomy, competence, and relatedness) demonstrated superior fit indices and measurement quality compared to alternative models. Full scalar invariance of the BPNSFS was supported. Males reported substantially higher competence satisfaction, while females reported higher autonomy frustration. Our findings support the use of BPNSFS as a multidimensional measure of basic psychological needs among adolescents and confirm the usefulness of applying the ESEM framework for evaluating validity aspects of this scale.

**Keywords** Basic Psychological Need Satisfaction and Frustration Scale (BPNSFS) · Confirmatory Factor Analysis (CFA) · Exploratory Structural Equation Modeling (ESEM) · Gender invariance

## Introduction

### The basic psychological needs theory

The Basic Psychological Needs Theory is one of six mini-theories that fall under the umbrella of the comprehensive Self-Determination Theory (SDT; Deci & Ryan, 1985, 2012) – meta-theory of human motivation and personality. At its

core, SDT assumes an organismic view of human nature, proposing that individuals possess a set of innate, universal psychological needs essential for psychological growth, integrity, and well-being (Deci & Ryan, 2012). According to Deci & Ryan (2012) there are three basic psychological needs that drive human behavior and development. The *need for competence* involves the need to establish control and overcome challenges in one's environment; the *need for relatedness* reflects the need to be recognized, respected, and accepted by others; and the *need for autonomy* refers to the need to experience one's behavior as voluntary, i.e., congruent with the authentic self (Deci & Ryan, 2004).

In addition to the organismic nature, the authors also mention the "dialectical nature" of SDT (Deci & Ryan, 2004), which is based on the interaction between the active natural integrating tendencies of human nature and the social context. This means that, on one hand, the person's active intrinsic tendencies exert their influence on the environment, while on the other hand, the environment requires adaptation from the person – that is, it either nurtures or undermines this organismic nature. Thus, if specific

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✉ Ognjen Janić  
ognjen.janic@tims.edu.rs

Milica Lazić  
milica.lazic@ff.uns.ac.rs

Milica Ljevaja  
mljevaja@idn.org.rs

<sup>1</sup> Faculty for Sports and Psychology – Educons University, Novi Sad, Serbia

<sup>2</sup> Faculty of Philosophy, University of Novi Sad, Novi Sad, Serbia

<sup>3</sup> Institute of Social Sciences, Belgrade, Serbia

environmental conditions are provided that support and facilitate the satisfaction of the aforementioned needs, the natural tendencies for growth, integration, and well-being will be actualized. On the other hand, if the fulfillment of these needs is frustrated by environmental factors, these fundamental processes of human nature will be disrupted, leading to unfavorable and maladaptive outcomes (Deci & Ryan, 2004).

## Measuring psychological needs

Basic Psychological Needs Theory has inspired the development of numerous instruments aimed at the empirical operationalization of its constructs (Bartholomew et al., 2011a, b; Sheldon & Hilpert, 2012). However, a study conducted by Chen and colleagues (2015) has garnered particular attention from the research community.

Building on Basic Psychological Needs Theory, Chen et al. (2015) addressed a significant gap in previous research. While earlier studies focused solely on measuring need satisfaction, they recognized that examining both satisfaction and frustration of basic psychological needs would provide a more complete understanding. This approach aimed to better capture how these fundamental needs contribute to psychological functioning, as need satisfaction and frustration can have distinct effects on well-being and development. Moreover, the authors aimed to explore the moderating role of culture in the experience of satisfaction and frustration of basic psychological needs. Their international study resulted in the cross-cultural validation of the Basic Psychological Need Satisfaction and Frustration Scale (BPNSFS) on samples from Belgium, China, the USA, and Peru. Through their research, the authors confirm the cultural universality of basic psychological needs, which aligns with the core tenets of SDT. The aforementioned scale represents a six-factor solution that operationalizes the satisfaction and frustration of the three basic psychological needs.

Previous research findings showing strong correlations between satisfaction and frustration factors provide empirical support for examining need fulfillment as a single continuum (Chen et al., 2015; Cordeiro et al., 2016a, b). On the other side, SDT's distinction between lack of satisfaction and active frustration offers theoretical grounding for a two-factor structure that treats these as separate dimensions (Costa et al., 2015; Vansteenkiste & Ryan, 2013). The identification of autonomy, competence, and relatedness as distinct basic psychological needs within SDT supports investigation of a three-factor model organized around these fundamental needs (Deci & Ryan, 2000; Vansteenkiste et al., 2010). Building on these perspectives, the six-factor model examines satisfaction and frustration as distinct components for each basic need, supported by evidence that satisfaction

and frustration operate independently and uniquely influence psychological functioning across the three psychological needs (Bartholomew et al., 2011a, b).

Psychometric research based on confirmatory factor analysis (CFA) consistently demonstrates that the six-factor model of basic psychological needs fits the data better than alternative models (e.g., Chen et al., 2015; Costa et al., 2017; Rodríguez-Meirinhos et al., 2019). These include models with a single factor representing need fulfillment, two factors distinguishing need satisfaction and need frustration, and three factors representing autonomy, relatedness, and competence. Additionally, the six-factor model outperforms hierarchical models where six first-order factors load onto two higher-order factors: need satisfaction and need frustration (e.g., Cordeiro et al., 2016a, b; Nishimura & Suzuki, 2016).

One of the key limitations of previous research that examined the factor structure of the BPNSFS using CFA is the implicit assumption that items load exclusively on their prescribed target factors, with cross-loadings not being allowed. This is rarely the case for multidimensional constructs (Morin et al., 2016), and neglecting this fact can result in biased parameter estimates. In this regard, Morin and colleagues emphasize the importance of estimating two sources of construct-relevant psychometric multidimensionality (Morin et al., 2016): (a) the hierarchical nature of constructs and (b) the conceptual relatedness of indicators. These authors therefore propose the combined use of Exploratory Structural Equation Modeling (ESEM) (Asparouhov & Muthén, 2009) and hierarchical or bifactor modeling to successfully bridge the methodological and statistical limitations of CFA while retaining its advantages.

To cover both sources of construct-relevant psychometric multidimensionality, it is necessary to account for cross-loadings of items on non-target factors (ESEM), as well as the possibility of a general factor underlying responses to all items on the scale (hierarchical or bifactor models). This bifactor structure suggests that while needs can be conceptualized along a general fulfillment continuum, there remain meaningful distinctions in how each need is uniquely satisfied or frustrated. This integrates competing theoretical perspectives - acknowledging both the interconnected nature of needs (general factor) and their distinctiveness (specific factors). Research utilizing the bifactor ESEM framework in the context of examining the BPNSFS is rare, but the existing studies consistently demonstrate the superiority of the bifactor ESEM model over alternative models (Sánchez-Oliva et al., 2017; Tóth-Király et al., 2017).

Research emphasizes the need to systematically compare CFA, bifactor CFA, ESEM, and bifactor ESEM models (Morin et al., 2016; Sánchez-Oliva et al., 2017) because each model incorporates unmodeled construct-relevant

multidimensionality in different ways. For instance, the CFA model manages unmodeled cross-loadings or a general factor (G) by increasing correlations among factors. The bifactor CFA model, on the other hand, compensates for unmodeled cross-loadings by elevating loadings on the G factor. Meanwhile, the ESEM model addresses unmodeled general factor(s) by increasing both correlations among factors and cross-loadings (Sánchez-Oliva et al., 2017).

## The present study

The aim of this research was to verify the factor structure of the BPNSFS in a high school Serbian population using the bifactor ESEM framework. More precisely, the aim of this study was to replicate Toth-Kiraly et al.'s (2017) research examining the multidimensionality of basic psychological need fulfillment in a Serbian sample. Tóth-Király et al. (2017) proposed the bifactor-ESEM approach as a psychometrically and theoretically robust solution for modeling basic psychological needs. This approach allows for the simultaneous estimation of a global need fulfillment factor and specific need dimensions (autonomy, competence, and relatedness), while accounting for cross-loadings that typically bias estimates in traditional CFA. Their model demonstrated superior fit and construct clarity across two large Hungarian adult samples – one community-based and one nationally representative – demonstrating the model's robustness within that national context. Given these strengths, the bifactor-ESEM framework is particularly useful in culturally sensitive research, such as ours, as it enables the detection of both shared and specific features of need experiences in the Serbian context – providing a nuanced view of how adolescents experience and differentiate between satisfaction and frustration of their basic psychological needs. Following their methodological framework, we will test all 17 proposed measurement models to examine whether the bifactor-ESEM structure of the BPNSFS found in their Hungarian samples generalizes to a Serbian cultural context.

## Method

### Participants and procedures

Prior to the data preparation phase of the analysis, the sample consisted of 434 high school students, with an average age of  $M=16.63$  ( $SD=0.730$ ), of whom 232 (53.5%) were female. Sampling was convenience-based and conducted in high schools across the Vojvodina region in the Republic of Serbia. Participation in the research was anonymous and voluntary, with participants having previously signed

informed consent forms to take part. The scale was administered using a standard paper-and-pencil format. The study was conducted with the approval of the Ethics Committee of the MASKED FOR REVIEW (Approval Code: MASKED FOR REVIEW).

Using the Sample Size Calculator ([https://wnarifin.shinyapps.io/ss\\_sem\\_cfi\\_equal/](https://wnarifin.shinyapps.io/ss_sem_cfi_equal/)), based on a six-factor solution with CFI of 0.90, statistical power of 95%, and considering expected factor loadings and inter-factor correlations, a minimum sample size of 421 participants was sufficient to test the primary aim of this study.

### Instruments.

The Serbian version of the *Basic Psychological Need Satisfaction and Frustration Scale* [BPNSFS, Chen et al., 2015] comprises of 24 items measuring the satisfaction and frustration of three psychological needs (autonomy, relatedness, competence). All six subscales consist of four items that are rated on a five-point Likert scale ranging from 1 („Strongly disagree“) to 5 („Strongly agree“).

## Data analysis

### Data preparation phase

Before the main analyses, the data were examined for potential issues such as outliers and missing values, and then prepared for further analysis. Based on Mahalanobis distances from the data matrix, 21 outliers were identified and removed ( $p<0.001$ ). Missing value analysis showed that less than 2% of data were missing, which were handled using the Full Information Maximum Likelihood (FIML) method. Consequently, the final analysis included 413 participants (54.2% female;  $M_{age}=16.62$ ,  $SD_{age}=0.72$ ).

### Data analysis phase

For data analysis, the statistical software Mplus 8.10 (Muthén & Muthén, 1998–2023) was used. Confirmatory factor analysis (CFA) and exploratory structural equation modeling (ESEM)<sup>1</sup> were employed to test the factor structure. For ordinal data, the Weighted Least Squares Mean and Variance Adjusted (WLSMV) method was applied (Van Zyl & Klooster, 2022). Target oblique rotation was used for ESEM models, while target orthogonal rotation was used for bifactor CFA and ESEM models. Target rotation represents a middle ground between EFA and CFA frameworks.

<sup>1</sup> In CFA models, items are only allowed to load exclusively on their a priori defined (target) factors, while their loadings on other (non-target) factors are constrained to zero (Marsh, 2007). Item correlations are visible only at the factor level. On the other hand, in ESEM models, factors are defined as in CFA models, with the allowance of cross-loadings (on non-target factors), which are constrained to be as close to zero as possible (Van Zyl & Klooster, 2022).

While CFA enforces strict zero loadings, target rotation aims to rotate loadings close to zero based on theoretical expectations. Rather than binary accept/reject decisions in CFA, target rotation allows iterative refinement of target values. This offers more flexibility than CFA while maintaining theoretical guidance that is missing from purely exploratory EFA rotations (Zhang et al., 2019). We tested the following models relying on the comprehensive research done by Tóth-Király et al. (2017), and these models are presented in Table 1.

The fit indices were monitored, encompassing (a) *absolute* (Satorra-Bentler  $\chi^2$  test), (b) *approximate* (Root Mean Square Error of Approximation [RMSEA]), Standardized Root Mean Square Residual [SRMR]), and (c) *incremental* (Comparative Fit Index [CFI] and Tucker-Lewis Index [TLI]) fit indices.

Models were considered to exhibit *good fit* if CFI and TLI values ranged between .96 and .99, SRMR between .01 and .05, and RMSEA between .01 and .05. Conversely, models were considered to demonstrate *acceptable fit* if CFI and TLI values ranged between 0.90 and .95, SRMR between .06 and .08, and RMSEA between .06 and .08 (Hu & Bentler, 1999).

When comparing retained models, preference was given to those demonstrating the best fit: lowest Satorra-Bentler

$\chi^2$  test value, highest CFI ( $\Delta\text{CFI} > .01$ ) and TLI ( $\Delta\text{TLI} > .01$ ) values, and lowest RMSEA ( $\Delta\text{RMSEA} \leq .015$ ) and SRMR ( $\Delta\text{SRMR} \leq .015$ ) values; alongside optimal parametric estimates: standardized factor loadings ( $\lambda > 0.35$ ), cross-loadings, and global  $R^2$  for each item (Van Zyl & Klooster, 2022). The reliability of bifactor models was derived using an Excel calculator specifically designed for bifactor models created by Dueber (Dueber, 2017), while omega ( $\omega$ ) indicators were used to assess the reliability of the factors.

## Measurement invariance

Multi-group CFA was used to test measurement invariance across gender. Due to the use of robust weighted least squares estimation and ordinal data treatment, two levels of measurement invariance were tested: *configural* (factorial structure equivalence across groups) and *scalar* (equivalence of factor loadings and item thresholds across groups). Following recommendations (Millsap & Yun-Tein, 2004), metric measurement invariance does not need separate calculation for ordinal data, as item characteristic curves contain both factor loadings and thresholds, which must be either freed (configural) or fixed (scalar) together. Model comparison used fit indices changes. Following conventional guidelines (Chen, 2007; Cheung & Rensvold, 2002),

**Table 1** Tested models in this study relying on the research done by Tóth-Király et al. (2017)

Models	Factors
<i>CFA models</i>	
Model 1	1 factor (global need fulfillment)
Model 2	2 factors (need satisfaction, need frustration)
Model 3	3 factors (autonomy, relatedness, competence)
Model 4	6 factors (autonomy satisfaction and frustration, competence satisfaction and frustration, relatedness satisfaction and frustration)
<i>Bifactor CFA models</i>	
Model 5	1 G-factor (global need fulfillment), 2 S-factors (need satisfaction and need frustration)
Model 6	1 G-factor (global fulfillment), 3 S-factors (autonomy, competence, relatedness)
Model 7	1 G-factor (global need fulfillment), 6 S-factors (autonomy satisfaction and frustration, competence satisfaction and frustration, relatedness satisfaction and frustration)
Model 8	2 G-factors (need satisfaction, need frustration), 3 S-factors (autonomy, competence, relatedness)
Model 9	2 G-factors (need satisfaction, need frustration), 6 S-factors (autonomy satisfaction and frustration, competence satisfaction and frustration, relatedness satisfaction and frustration)
<i>ESEM models</i>	
Model 10	2 factors (global need satisfaction and frustration)
Model 11	3 factors (global fulfillment of autonomy, relatedness and competence)
Model 12	6 factors (autonomy satisfaction and frustration, competence satisfaction and frustration, relatedness satisfaction and frustration)
<i>Bifactor ESEM models</i>	
Model 13	1 G-factor (global need fulfillment), 2 S-factors (need satisfaction, need frustration)
Model 14	1 G-factor (global need fulfillment), 3 S-factors (autonomy, competence, relatedness)
Model 15	1 G-factor (global need fulfillment), 6 S-factors (autonomy satisfaction and frustration, competence satisfaction and frustration, relatedness satisfaction and frustration)
Model 16	2 G-factors (need satisfaction, need frustration), 3 S-factors (autonomy, competence, relatedness)
Model 17	2 G-factors need satisfaction, need frustration), 6 S-factors (autonomy satisfaction and frustration, competence satisfaction and frustration, relatedness satisfaction and frustration)

a CFI decrease less than 0.01 and RMSEA increase less than 0.015 indicate acceptability of the more restrictive model, confirming the next level of measurement invariance.

## Results

### Model fit indicators

The fit indices for the nine estimated CFA models and eight estimated ESEM models can be found in Table 2. The results indicate that only one of the CFA models, Model 8 exhibits good fit, and four exhibit acceptable fit: Model 4, Model 6, Model 7 and Model 9. On the other side, four ESEM models show a good fit: Model 12, Model 15, Model 16 and Model 17, while three of the ESEM models show an acceptable fit: Model 11, Model 13 and Model 14 (Table 2).

These models were then compared based on their fit indices (Table 3). The results show that Model 4 (*Six-factor CFA model*) and Model 8 (*Bifactor CFA model with two G-factor and three S-factors*) have a significantly better fit than rest of the CFA models. Meanwhile, Model 15 (*Bifactor ESEM model with one G-factor and six S-factors*) and Model 17 (*Bifactor ESEM model with two G-factors and six S-factors*) are showing significant advantage out of the other ESEM models. When comparing these CFA and

ESEM models, we can observe that ESEM models are superior. For example, Model 17 ( $\Delta\chi^2=-352.951$ ;  $\Delta df=-115$ ;  $\Delta CFI=.032$ ;  $\Delta TLI=.032$ ;  $\Delta RMSEA=-.025$  [90% CI -.032, -.021];  $\Delta SRMR=-.030$ ) and Model 15 ( $\Delta\chi^2=-292.516$ ;  $\Delta df=-108$ ;  $\Delta CFI=.025$ ;  $\Delta TLI=.017$ ;  $\Delta RMSEA=-.011$  [90% CI -.015, -.009];  $\Delta SRMR=-.026$ ) fit the data significantly better than Model 4. In the case of comparison between the two ESEM models and Model 8, the data does not yield clear results— Model 17 shows a better fit, but Model 15 is just partially advantageous (in terms of  $\Delta CFI$  and  $\Delta SRMR$ ). Given its good fit indices, solid theoretical grounding, and empirical support, we have decided to retain Model 12 (*Six-factor ESEM model*), despite the results of the model comparison.

In summary, from the total of five CFA and ESEM models that have the best fit, we will exclude Model 4 (*Six-factor CFA model*) that consistently proves to be inferior to ESEM models (with an exception of  $\Delta RMSEA$  in comparison with Model 15). Additionally, its factor correlations are moderately to highly elevated, ranging from .229 to .768, suggesting potential unmodeled cross-loadings or the presence of a general factor, thus providing support for retaining bifactor and ESEM models. Therefore, Model 4 is excluded from further analysis, while we will present and compare the factor loadings and reliability for the remaining four models.

**Table 2** Model fit indices

Model	$\chi^2$ (df)	CFI	TLI	RMSEA (90% CI)	SRMR
<i>Confirmatory factor analytical models</i>					
Model 1	2001.294 <sup>*</sup> (252)	.758	.735	.130 (.124-.135) <sup>*</sup>	.104
Model 2	1599.224 <sup>*</sup> (251)	.814	.795	.114 (.109-.119) <sup>*</sup>	.094
Model 3	1132.441 <sup>*</sup> (249)	.878	.865	.093 (.087-.098) <sup>*</sup>	.079
Model 4	515.267 <sup>*</sup> (237)	.962	.955	.053 (.047-.060)	.048
Model 5	1051.638 <sup>*</sup> (228)	.886	.862	.094 (.088-.099) <sup>*</sup>	.070
Model 6	730.556 <sup>*</sup> (228)	.931	.916	.073 (.067-.079) <sup>*</sup>	.059
Model 7	762.134 <sup>*</sup> (227)	.926	.910	.076 (.070-.082) <sup>*</sup>	.064
Model 8	443.349 <sup>*</sup> (227)	.970	.964	.048 (.041-.055)	.043
Model 9	808.687 <sup>*</sup> (227)	.920	.902	.079 (.073-.085) <sup>*</sup>	.065
<i>Exploratory structural equation models</i>					
Model 10	1436.950 <sup>*</sup> (229)	.833	.799	.113 (.107-.119) <sup>*</sup>	.077
Model 11	742.102 <sup>*</sup> (207)	.926	.901	.079 (.073-.085) <sup>*</sup>	.048
Model 12	277.390 <sup>*</sup> (147)	.982	.966	.046 (.038-.055)	.025
Model 13	742.102 <sup>*</sup> (207)	.926	.901	.079 (.073-.085) <sup>*</sup>	.048
Model 14	413.783 <sup>*</sup> (186)	.969	.953	.054 (.047-.062)	.032
Model 15	222.751 <sup>*</sup> (129)	.987	.972	.042 (.032-.051)	.022
Model 16	352.790 <sup>*</sup> (182)	.976	.964	0.048 (0.040-0.055)	.030
Model 17	162.316 <sup>*</sup> (122)	.994	.987	0.028 (0.015-0.039)	.018

<sup>\*</sup> $p \leq 0.001$ ; Model 1 = One-factor CFA model; Model 2 = Two-factor CFA model; Model 3 = Three-factor CFA model; Model 4 = Six-factor CFA model; Model 5 = Bifactor CFA model with one G-factor and two S-factors; Model 6 = Bifactor CFA model with one G-factor and three S-factors; Model 7 = Bifactor CFA model with one G-factor and six S-factors; Model 8 = Bifactor CFA model with two G-factors and three S-factors; Model 9 = Bifactor CFA model with two G-factors and six S-factors; Model 10 = Two-factor ESEM model; Model 11 = Three-factor ESEM model; Model 12 = Six-factor ESEM model; Model 13 = Bifactor ESEM model with one G-factor and two S-factors; Model 14 = Bifactor ESEM model with one G-factor and three S-factors; Model 15 = Bifactor ESEM model with one G-factor and six S-factors; Model 16 = Bifactor ESEM model with two G-factors and three S-factors; Model 17 = Bifactor ESEM model with two G-factors and six S-factors

**Table 3** Comparing models

	$\Delta\chi^2$	$\Delta df$	$\Delta CFI$	$\Delta TLI$	$\Delta RMSEA$	$\Delta SRMR$
<i>Confirmatory factor analytical (CFA) models</i>						
M8 vs. M4	-71.918	-10	.008	.009	-.005 (-.006 - -.005)	-.005
M8 vs. M6	-287.207	-1	.039	.048	-.025 (-.026 - -.024)	-.016
M8 vs. M7	-318.785	0	.044	.054	-.028 (-.029 - -.027)	-.021
M8 vs. M9	-365.338	0	.050	.062	-.031 (-.032 - -.030)	-.022
<i>Exploratory structural equation models</i>						
M17 vs. M16	-190.474	-60	.018	.023	-.020 (-.025 - -.016)	-.012
M17 vs. M15	-60.435	-7	.007	.015	-.014 (-.017 - -.012)	-.004
M17 vs. M14	-251.467	-64	.025	.034	-.026 (-.032 - -.023)	-.014
M17 vs. M13	-579.786	-85	.068	.086	-.051 (-.058 - -.046)	-.030
M17 vs. M12	-115.074	-25	.012	.021	-.018 (-.031 - -.016)	-.007
M17 vs. M11	-578.786	-85	.068	.086	-.051 (-.058 - -.046)	-.030
<i>CFA vs. ESEM</i>						
M17 vs. M8	-281.033	-105	.024	.023	-.020 (-.026 - -.016)	-.025
M17 vs. M4	-352,951	-115	.032	.032	-.025 (-.032 - -.021)	-.030
M15 vs. M8	-220,598	-98	.017	.008	-.006 (-.009 - -.004)	-.021
M15 vs. M4	-292,516	-108	.025	.017	-.011 (-.015 - -.009)	-.026

*M4* Model 4 (Six-factor CFA model), *M6* Model 6 (Bifactor CFA model with one G-factor and three S-factors), *M7* Model 7 (Bifactor CFA model with one G-factor and six S-factors), *M8* Model 8 (Bifactor CFA model with two G-factors and three S-factors), *M9* Model 9 (Bifactor CFA model with two G-factors and six S-factors), *M11* Model 11 (Three-factor ESEM model), *M12* Model 12 (Six-factor ESEM model), *M13* Model 13 (Bifactor ESEM model with one G-factor and two S-factors), *M14* Model 14 (Bifactor ESEM model with one G-factor and three S-factors), *M15* Model 15 (Bifactor ESEM model with one G-factor and six S-factors), *M16* Model 16 (Bifactor ESEM model with two G-factors and three S-factors), *M17* Model 17 (Bifactor ESEM model with two G-factors and six S-factors)

### Item level parameter estimates and factor reliability

Model 8 (*Bifactor CFA model with two G-factor and three S-factors*) has well-defined general factors ( $p < .001$ ) with item loadings going beyond the threshold value. An average loading for first general factor is  $\lambda_{AS} = .515$  ( $\lambda = .352$  to  $.677$ ), as the second general factor shows an average loading of  $\lambda_{AS} = .589$  ( $\lambda = .374$  to  $.778$ ) for a single item loadings. But it is important to note that the two general factor have an average to high correlation  $r = -.678$ . As for the specific factors, we can observe that loadings are generally going beyond the threshold value ( $\lambda = .35$ ,  $p < .001$ ), with few exceptions, mainly in the case of the autonomy satisfaction where one item (item 9) does not have a significant loading, as four items fail to reach the threshold. This is not so surprising in bifactor models, as those items are saturating the first general factor. The average values of item loadings for specific factors are as follows: autonomy satisfaction -  $\lambda_{AS} = .35$  ( $\lambda = .097$  to  $.617$ ); relatedness satisfaction -  $\lambda_{AS} = .516$  ( $\lambda = .296$  to  $.763$ ); competence satisfaction -  $\lambda_{AS} = .435$  ( $\lambda = .182$  to  $.627$ ).

The reliability results for Model 8 indicate that the omega for the first general factor is  $\omega = .868$  and for the second one  $\omega = .904$ . Among the specific factors, need for relatedness ( $\omega = .820$ ) and need for competence ( $\omega = .808$ ) exceed the .70 threshold, while need for autonomy falls below it ( $\omega = .635$ ).

Model 12 (*Six-factor ESEM model*) has well-defined factors ( $\lambda > .35$ ,  $p < .001$ ), except for two items whose target loadings on relatedness frustration factor fall below the

threshold value. Nonetheless, these loadings are statistically significant ( $p < .001$ ). The average values of item-specific target loadings for specific factors are as follows: autonomy satisfaction -  $\lambda_{AS} = .524$  ( $\lambda = .460$  -  $.554$ ); relatedness satisfaction -  $\lambda_{AS} = .640$  ( $\lambda = .389$  -  $.886$ ); competence satisfaction -  $\lambda_{AS} = .706$  ( $\lambda = .579$  -  $.914$ ); autonomy frustration -  $\lambda_{AS} = .670$  ( $\lambda = .588$  -  $.721$ ); relatedness frustration -  $\lambda_{AS} = .379$  ( $\lambda = .267$  -  $.414$ ); competence frustration -  $\lambda_{AS} = .622$  ( $\lambda = .484$  -  $.731$ ). The  $R^2$  values range from .312 (item 6) to .779 (item 14). From total of 120 cross-loadings (on non-target factors) five items' cross-loadings go beyond  $\lambda > .30$ .

The reliability results for Model 12 indicate that the omega for autonomy satisfaction ( $\omega = .731$ ), relatedness satisfaction ( $\omega = .825$ ), competence satisfaction ( $\omega = .823$ ), autonomy frustration ( $\omega = .815$ ) and competence frustration ( $\omega = .839$ ) exceed the threshold value of .70, while the omega for relatedness frustration is somewhat lower ( $\omega = .634$ ).

Model 15 (*Bifactor ESEM model with one G-factor and six S-factors*) exhibits a well-defined general factor (all items load the general factor well,  $\lambda > .35$ ,  $p < .001$ ) with an average loading of  $\lambda_{AS} = .527$ , while certain item-specific target loadings for specific factors fall below the threshold value. Specifically, although the target loading of a first item on autonomy satisfaction factor is not statistically significant ( $p > .05$ ), it effectively loads onto the general factor ( $p < .001$ ). The average values of item-specific target loadings for specific factors are as follows: autonomy satisfaction -  $\lambda_{AS} = .412$  ( $\lambda = .194$  -  $.676$ ); relatedness satisfaction

-  $\lambda_{AS}=.544$  ( $\lambda=.315$ -.757); competence satisfaction -  $\lambda_{AS}=.526$  ( $\lambda=.430$ -.633); autonomy frustration -  $\lambda_{AS}=.563$  ( $\lambda=.453$ -.646); relatedness frustration -  $\lambda_{AS}=.313$  ( $\lambda=.245$ -.385); competence frustration -  $\lambda_{AS}=.337$  ( $\lambda=.242$ -.411). The range of  $R^2$  values varies from .311 (item 6) to .799 (item 14). From total of 120 cross-loadings (on non-target factors) two items' cross-loadings go beyond  $\lambda>.30$ .

The results indicate that the omega for the general factor is  $\omega=.913$ , demonstrating high reliability. Autonomy satisfaction ( $\omega=.581$ ), relatedness frustration ( $\omega=.444$ ) and competence frustration ( $\omega=.596$ ) show low reliability, while relatedness satisfaction ( $\omega=.763$ ), competence satisfaction ( $\omega=.744$ ), and autonomy frustration ( $\omega=.764$ ) show optimal reliability with  $\omega$  values greater than .70.

Finally, Model 17 (*Bifactor ESEM model with two G-factors and six S-factors*) demonstrates poor factor loadings on both general factors with majority of item loadings failing to reach statistical significance and threshold value ( $p>.001$ ,  $\lambda<.35$ ). The average values of first general factor is  $\lambda_{AS}=.262$  with the range of .066 to .476, as for the second one is  $\lambda_{AS}=.308$  with the range of .065 and .606. Correlation between the two general factors is  $r=-.347$ . The average values of item-specific target loadings for specific factors are as follows: autonomy satisfaction -  $\lambda_{AS}=.53$  ( $\lambda=.434$  to .594), relatedness satisfaction -  $\lambda_{AS}=.483$  ( $\lambda=.252$  to .657), competence satisfaction -  $\lambda_{AS}=.65$  ( $\lambda=.527$  to .747), autonomy frustration -  $\lambda_{AS}=.614$  ( $\lambda=.413$  to .761), relatedness frustration -  $\lambda_{AS}=.483$  ( $\lambda=.252$  to .657), competence frustration -  $\lambda_{AS}=.539$  ( $\lambda=.301$  to .695). From total of 120 cross-loadings (on non-target factors) five items' cross-loadings go beyond  $\lambda>.30$ .

The reliability results for Model 17 indicate that the omega for the first general factor is  $\omega=.675$  and for the second one  $\omega=.763$ . Five of six specific factors (with exception of autonomy frustration) show optimal reliability, with  $\omega$  values greater than .70 ( $\omega_{mean}=.752$ ).

To summarize, models incorporating two G-factors either failed to achieve significant and sufficient factor loadings (*Bifactor ESEM model with two G-factors and six S-factors*) or raised concerns about the discriminant validity of the general factors (*Bifactor CFA model with two G-factors and three S-factors*). Additionally, the *Six-Factor Bifactor ESEM model*, although including a reliable general factor and fewer cross-loadings, exhibited below-threshold loadings and poor reliability for three specific factors, rendering it inadequate for representing basic psychological needs.

In contrast, the *Six-Factor ESEM model* demonstrated well-defined and highly reliable specific factors (with relatedness frustration falling slightly below the threshold). Given its alignment with theoretical expectations and empirical findings, as well as its superior performance in representing multidimensional constructs, the *Six-Factor*

*ESEM model* emerged as the most reliable and valid solution for capturing basic psychological needs in Serbian high school students.

Factor loadings and reliability estimates for the *Six-Factor ESEM model*, identified as the most optimal model, are presented in Table 4. Details for the other three models are provided in the Supplementary Material.

## Measurement invariance across gender and latent mean differences

The *Six-factor ESEM model* of the BPNSFS provided a good fit to the data both among females and males. Configural invariance of the ESEM model across gender was supported ( $\chi^2_{(294)}=441.094$ , CFI=.980, TLI=.963, RMSEA=.049, 90% CI=.039,.058). Scalar model also provided good fit indices ( $\chi^2_{(467)}=593.504$ , CFI=.983, TLI=.980, RMSEA=.036, 90% CI=.027,.045), and changes in fit indices between configural and scalar measurement invariance are within acceptable ranges ( $\Delta CFI<.01$ ,  $\Delta RMSEA<.015$ ). This suggests that the BPNSFS scale measures the same constructs in the same way regardless of gender.

The comparison of latent means (males were the reference group with latent means fixed to zero) showed that females reported higher levels of autonomy frustration (standardized estimate=.321, SE=.150,  $p<.05$ ), whereas males reported higher levels of competence satisfaction (standardized estimate=-.370, SE=.140,  $p<.01$ ). No significant gender differences were found for other factors of BPNSFS.

## Discussion and conclusion

The aim of this study was to replicate Tóth-Király et al.'s (2017) research on the multidimensionality of basic psychological need fulfillment in a Serbian sample. Specifically, we sought to empirically test whether the bifactor-ESEM structure of the BPNSFS identified in their Hungarian sample generalizes to a Serbian cultural context. Building on Tóth-Király et al.'s (2017) research, we compared 17 models in total: 9 CFA models and 8 ESEM models, encompassing both simple first-order and bifactor configurations.

After testing these models (Table 1), two CFA models stood out - Model 4 (*Six-factor CFA model*) and Model 8 (*Bifactor CFA model with two G-factors and three S-factors*) - as having significantly better fit than the rest of the CFA models. Meanwhile, Model 15 (*Bifactor ESEM model with one G-factor and six S-factors*) and Model 17 (*Bifactor ESEM model with two G-factors and six S-factors*) showed significant advantages over the other ESEM models. Additionally, Model 12 (*Six-factor ESEM model*) was retained as

**Table 4** Standardized factor loadings,  $R^2$ ,  $p$ -values and omega: ESEM model with six S-factors

Item	$R^2$	F1 (AS)	F2 (RS)	F3 (CS)	F4 (AF)	F5 (RF)	F6 (CF)
1	.358	<b>.460</b> ***	-.001	.066	-.282***	.048	.052
2	.421	<b>.537</b> ***	.128*	.046	-.217***	.230***	.094
9	.466	<b>.554</b> ***	.080	.082	.064	.019	-.163*
17	.461	<b>.544</b> ***	.154**	.028	.183***	.062	-.226***
3	.647	.022	-.136*	.092	<b>.660</b> ***	-.346	.288***
10	.590	-.099*	.178***	-.045	<b>.721</b> ***	.236	-.143*
11	.555	.009	.153**	-.092	<b>.588</b> ***	.359	-.011
18	.630	-.113*	-.069	-.003	<b>.711</b> ***	-.034	.078
4	.637	.074	<b>.795</b> ***	.085	-.002	-.018	.136*
12	.768	-.033	<b>.886</b> ***	.008	.019	-.051	.097
19	.621	.261***	<b>.489</b> ***	0.055	.095*	-.307***	-.048
20	.478	.244***	<b>.389</b> ***	-.091	-.001	-.396***	.030
5	.514	.108	-.276***	-.056	.173***	<b>.323</b> ***	.268***
6	.312	.121	-.202**	.142	.189	<b>.267</b> ***	.244**
13	.640	.037	-.257***	-.052	.105**	<b>.515</b> ***	.214***
21	.596	.105	-.363***	-.055	.089	<b>.414</b> ***	.193**
7	.495	.041	.047	<b>.684</b> ***	-.079	.054	.044
14	.779	-.066	.053	<b>.914</b> ***	-.014	-.002	.023
15	.521	.072	-.053	<b>.648</b> ***	.050	.059	-.107
22	.652	.120*	.063	<b>.579</b> ***	.069	-.007	-.232***
8	.586	-.115*	-.014	-.084	.274***	.041	<b>.484</b> ***
16	.673	.013	.103*	-.298***	.075	.135**	<b>.564</b> ***
23	.700	-.050	.078	-.139*	.008	.128*	<b>.708</b> ***
24	.727	-.168***	.085*	-.034	.032	.144**	<b>.731</b> ***
Omega ( $\omega$ )		.734	.825	.823	.815	.634	.839

$p \leq 0.001$  \*\*\*;  $p \leq 0.01$  \*\*;  $p \leq 0.05$  \*; item-specific target loadings are put in bold; AS Autonomy satisfaction, RS Relatedness satisfaction, CS Competence satisfaction, AF Autonomy frustration, RF Relatedness frustration, CF Competence frustration

well due to its good fit indices as well as strong theoretical and empirical grounding.

After comparing the retained CFA and ESEM models, we observed that the ESEM models were superior, particularly in relation to *Six-factor CFA model*, which consistently showed a poorer fit than the ESEM models. Additionally, by analyzing the correlations between factors of *Six-factor CFA model*, we observed moderately high to high inter-factor correlations, raising suspicions about the possibility of unmodeled cross-loadings or the presence of a general factor (Morin et al., 2016; Sánchez-Oliva et al., 2017). These findings confirmed the rationale for including ESEM and bifactor models for further analysis to examine the multidimensionality of the construct under investigation. Consequently, we excluded *Six-factor CFA model* from further analysis and compared the four remaining models (*Bifactor CFA model with two G-factors and three S-factors*, *Six-factor ESEM model*, *Bifactor ESEM model with one G-factor and six S-factors*, and *Bifactor ESEM model with two G-factors and six S-factors*) in relation to their item level parameters and reliability.

Firstly, the analysis revealed that *Bifactor ESEM model with two G-factors and six S-factors*, while having well-defined specific factors, had poor factor loadings on both

general factors that failed to reach statistical significance and threshold value. In contrast, the *Bifactor CFA model with two G-factors and three S-factors* had well-defined both specific and general factors. However, this model showed elevated correlations between the general factors, raising concerns about their discriminant validity. These findings, concerning the models incorporating two G-factors, align with the research findings of Tóth-Király et al. (2017).

Both the *Six-Factor ESEM model* and the *Six-Factor Bifactor ESEM model* demonstrate good fit indices. While the *Six-Factor Bifactor ESEM model* includes a clearly defined and highly reliable G-factor with fewer cross-loadings compared to the *Six-Factor ESEM model*, it exhibits below-threshold factor loadings and poor reliability for three specific factors: autonomy satisfaction, relatedness frustration, and competence frustration. These limitations render the *Six-Factor Bifactor ESEM model* an inadequate psychometric representation of basic psychological needs and inconsistent with prior validation studies using the bifactor ESEM framework (Sánchez-Oliva et al., 2017; Tóth-Király et al., 2017).

In contrast, the *Six-Factor ESEM model* features well-defined and highly reliable specific factors, with relatedness frustration being the only exception, failing to meet the

threshold value. Previous psychometric studies of this scale (Chen et al., 2015; Rodríguez-Meirinhos et al., 2019; Šakan, 2022) have similarly shown lower reliability for some factors, including relatedness frustration, so this finding was to be expected. With this in mind, and supported by Šakan's (2022) findings, we conclude that the *Six-Factor ESEM model* is the most suitable representation of basic psychological needs in a sample of Serbian high school students, making it the best psychometric solution.

The presence of cross-loadings (ESEM model) highlights the multidimensional nature or conceptual interrelatedness of the indicators that constitute basic psychological needs. Cross-loadings suggest that certain item ratings simultaneously capture aspects of both the satisfaction and frustration of multiple basic psychological needs. This suggests that for example positive environmental conditions designed to fulfill one need (e.g., autonomy) may create a spillover effect, positively influencing the satisfaction of other needs (e.g., competence, relatedness). However, these interconnections do not undermine the distinctiveness of each need, nor do they suggest an underlying general factor, in line with Tóth-Király et al.'s (2017) findings. In conclusion, specific factors remain crucial for understanding the unique contributions of autonomy, competence, and relatedness to individual outcomes, consistent with SDT and the extensive empirical evidence supporting it.

Additionally, the results of tested measurement invariance provide strong support for the psychometric robustness of the *Six-factor ESEM model* of the BPNSFS across gender. The configural invariance results confirm that the factor structure of the scale is consistent for both males and females, indicating that the same underlying constructs are being measured in both groups. Moreover, the scalar invariance findings suggest that item loadings and thresholds are equivalent across gender, allowing for meaningful comparisons of latent means. These results underscore the suitability of the BPNSFS for examining gender differences in basic psychological needs.

The comparison of latent means revealed interesting gender-specific patterns in our sample. Females reported significantly higher levels of autonomy frustration, suggesting they might experience more obstacles in feeling attuned to their authentic self in their daily lives. Conversely, males reported significantly higher levels of competence satisfaction, indicating they may feel more capable and effective in achieving desired outcomes.

These findings reflect broader societal and cultural norms that shape the psychological needs of males and females. Serbia, like many other countries, features a complex interplay of traditional gender roles and evolving cultural expectations (Ćeriman et al., 2011; Jarić, 2013) that may influence how adolescents experience and express their psychological needs. Girls are often socialized to prioritize relationships

over individual goals, which may frustrate their sense of autonomy (UNICEF Serbia, 2020). In contrast, boys in Serbia are more encouraged to assert themselves in competitive and achievement-oriented environments, such as school or extracurricular activities. This socialization pattern may lead to higher competence satisfaction among boys, as they are more likely to receive recognition and validation for their accomplishments (Schweder & Raufelder, 2021). Conversely, girls may face different expectations, where success is measured differently, and they may not receive the same level of support in pursuing individual achievements.

## Limitations

Despite its strengths, the conducted research also has some limitations. Primarily, although this study aimed to validate an instrument addressing basic psychological needs—considering them universal—it focused on a sample of high school students from the Republic of Serbia. Another important limitation is the use of a convenience sample, which might not reflect the psychological needs of students from smaller rural areas not included in the study. Additionally, the study did not assess measurement invariance across other relevant characteristics, such as age, which could provide deeper insights into the instrument's applicability across subgroups. Furthermore, the absence of repeated measurements prevented the evaluation of test–retest reliability.

Future research should consider employing the bifactor ESEM framework to explore the factor structure of BPNSFS across diverse developmental contexts and minority groups within the Republic of Serbia. Studies conducted in different cultural settings are also encouraged, as they can further support the generalizability of the results.

## Conclusion

This study provided a comprehensive examination of the Basic Psychological Need Satisfaction and Frustration Scale (BPNSFS) within a Serbian adolescent sample, confirming the multidimensional nature of basic psychological needs and the scale's psychometric robustness. By employing both CFA and ESEM frameworks, the findings highlight the superiority of *Six-factor ESEM model* in capturing the satisfaction and frustration of three psychological needs—autonomy, competence, and relatedness. Full scalar invariance across genders further supports the scale's applicability for diverse groups, with gender differences reflecting subtle cultural dynamics. These results endorse the BPNSFS as a reliable tool for assessing psychological needs in Serbian adolescents and emphasize the importance of advanced modeling techniques like ESEM for nuanced construct validation.

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**Authors' contribution** All authors listed on this submission have made significant contributions to the acquisition, analysis, or interpretation of the data and have approved the version for publication. Additionally, all authors agree to take responsibility for all aspects of the work, ensuring that any questions regarding the accuracy or integrity of any part are properly investigated and resolved.

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**Data availability** The data used to support the findings of this study are available and posted on the Open Science Framework (OSF) platform ([https://osf.io/tx6n2/?view\\_only=21741716ea8b474093ec119415dbfd25](https://osf.io/tx6n2/?view_only=21741716ea8b474093ec119415dbfd25); the link is anonymous until the manuscript is accepted).

## Declarations

**Ethics approval** The study was conducted with the approval of the Ethics Committee of the MASKED FOR REVIEW (Approval Code: MASKED FOR REVIEW).

**Consent to participate and publish** Informed consent was obtained from all individual participants included in the study.

**Conflict of interest** On behalf of all authors, the corresponding author states that there is no conflict of interest.

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