A New Look on the Representation and Criterion Validity of Need Fulfillment: Application of the Bifactor Exploratory Structural Equation Modeling Framework

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Abstract

The present study re-investigated whether need satisfaction and frustration are better represented as two opposite ends of the same continuum or two distinct constructs through the application of the bifactor exploratory structural equation modeling (bifactor-ESEM) framework. Also, the criterion-related validity of the final representation was tested in relation to indicators of wellbeing. Using a sample of 774 participants (501 females, M_{age} = 27.86, SD_{age} = 9.52), several alternative models were contrasted. The results supported the multidimensional bifactor-ESEM representation including one global factor of need fulfillment and the six specific factors being the combination of satisfaction and frustration with autonomy, competence, and relatedness. Most items tapped into meaningful specificity once the global factor was accounted for. Finally, the global factor was substantially and positively related to positive affect and negatively to negative affect. Competence satisfaction further predicted positive affect, while competence and relatedness frustration predicted negative affect.

Keywords: bifactor exploratory structural equation modeling (bifactor ESEM); need fulfillment; need satisfaction and frustration; positive and negative affect; self-determination theory (SDT); wellbeing

Introduction

Self-Determination Theory (SDT; Deci and Ryan 2000; Ryan and Deci 2017) is an organismic macro-theory of human motivation, personality, and development. One of its central tenets proposes that humans have a basic tendency toward growth and development which is necessary for optimal functioning. It is also posited that growth and wellbeing are intimately linked to the satisfaction of three basic psychological needs of autonomy, competence, and relatedness. While previous need conceptualizations emphasized the differentiation of need satisfaction and need frustration (e.g., Krijgsman et al. 2017; Vansteenkiste and Ryan 2013), a more recent investigation (Tóth-Király et al. 2018) provided initial support for the need fulfillment hypothesis; that is, apart from the six specific factors (satisfaction and frustration × autonomy, competence, and relatedness), on the global level, need satisfaction and need frustration are better represented by an underlying continuum of need fulfillment (with satisfaction and frustration being at the opposite extremes) as opposed to being two distinct dimensions (i.e., their levels do not vary independently from one another within the same person). However, despite the promising findings, more studies should be conducted to test the criterion-related validity of this improved representation which, at the same time, could provide a more precise definition of the factors. Thus, the present study sought to test alternative representations of need fulfillment and to investigate the criterion-related validity of the most appropriate representation in relation to outcomes of wellbeing.

The Theory of Basic Psychological Needs

SDT rests on the assumption that basic psychological needs are nutrients that are necessary and essential conditions for growth, health, and integrity (Deci and Ryan 2000). More specifically, the three needs are autonomy (i.e., the experience of choice, volition, and personal control), competence (i.e., the experience of effectiveness, mastery, and a sense of accomplishment) and relatedness (i.e., the experience of closeness, reciprocal care, and connection with others). The application of these needs has been considered universal, and their satisfaction have been associated with relevant outcomes in several different life domains, including work (Deci et al. 2001), education (Cox and Williams 2008) or sport (Adie et al. 2008). Within these domains, the fulfillment of the three needs was positively associated with indicators of wellbeing and optimal functioning such as vitality, positive affect, effort, intrinsic motivation, job performance, and better sleep quality, and was negatively associated with indicators of ill-being and maladaptive functioning such as depression, negative affect, somatization, anxiety, daytime dysfunction, burnout, turnover intentions, and problematic online behaviors (Baard et al. 2004; Campbell et al. 2015; Chen et al. 2015; Cordeiro et al. 2016; Gillet et al. 2017; Gunnell et al. 2014; Krijgsman et al. 2017; Landry et al. 2016; Schultz et al. 2015). These findings were valid in cases when need fulfillment was measured as a global construct (e.g., Chen et al. 2015; Gillet et al. 2017) and even when the three needs were separately measured (e.g., Costa et al. 2016; Landry et al. 2016), suggesting that all three are important from the perspective of outcomes such as wellbeing.

Within SDT literature, there is an ongoing discussion about the dimensionality and representation of basic psychological needs. With the recent empirical differentiation of need satisfaction and need frustration (Vansteenkiste and Ryan 2013), some researchers have argued that need frustration goes beyond the lack of satisfaction and is directly influenced by the need thwarting environment, suggesting that the two dimensions should be considered distinct. Subsequent psychometric investigations (e.g., Chen et al. 2015; Cordeiro et al. 2016) initially supported a six-factor representation (satisfaction and frustration × autonomy, competence, and relatedness), while others (e.g., Campbell et al. 2017; Krijgsman et al. 2017) relied on the incorporation of general need satisfaction and frustration dimensions as well. However, one limitation of these representations is that

they did not simultaneously take into account the presence of construct-relevant psychometric multidimensionality that is often present in the case of multidimensional constructs.

The Bifactor Exploratory Structural Equation Modeling Framework

One limitation of the studies mentioned above is that they failed to take into account two potential sources of construct-relevant multidimensionality that is expected to be present in the data and that, when not explicitly accounted for, could result in biased estimates and erroneous conclusions (Morin et al. 2016a; 2016b). Typically, confirmatory factor analysis (CFA) has been the most commonly used approach to examine the representation of different psychological constructs. However, an important limitation of CFA is rooted in its independent cluster assumption; that is, scale indicators reflect scores on a single factor only. This assumption was shown to be unrealistic and overly strict for instruments measuring complex multidimensional constructs (Marsh et al. 2014).

The first source of construct-relevant multidimensionality refers to the assessment of conceptually-related constructs. This source stems from the fact that scale indicators are naturally fallible in psychological research and are often associated with other conceptually-related non-target constructs over and above their target factors. For instance, levels of competence satisfaction may influence responses to items measuring one's level of competence frustration. CFA forces these meaningful associations to zero, resulting in biased estimates (i.e., substantially increased factor correlations) and erroneous conclusions (Marsh et al. 2014). When one is suspect of this source of multidimensionality, exploratory structural equation modeling (ESEM; Asparouhov and Muthén 2009; Marsh et al. 2014) could be used as an alternative to CFA as ESEM allows the expression of association between indicators and the conceptually-related non-target construct in the form of cross-loadings. Review of statistical evidence also highlighted that even small cross-loadings need to be expressed to avoid biased measurement models and parameter estimates (Asparouhov et al. 2015). The added value of ESEM has already been highlighted in previous studies inside (e.g., Guay et al. 2015; Litalien et al. 2015; Tóth-Király et al. 2017c) and outside (e.g., Arens and Morin, 2016; Neff et al. 2018; Tóth-Király et al. 2017a) the field of SDT.

The second source of construct-relevant multidimensionality refers to the hypothesized co-existence of global (need satisfaction/frustration) and specific constructs (autonomy, competence, and relatedness). This source has typically been investigated in the form of higher-order models where indicators are associated with first-order factors which themselves are associated with higher-order factors. More precisely, higher-order models assume that the associations between the indicators and the higher-order factors are indirect and fully mediated by the first-order factors. In addition, higher-order models also assume that the ratio of variance explained by the global versus specific factors is forced to be the same for all items related to the specific first-order factor (Gignac 2016; Reise 2012). As argued, however, this assumption is extremely stringent and is rarely verified (Gignac 2016; Morin et al. 2016a). Conversely, bifactor modeling approaches have been suggested as viable alternatives as these models are not constrained by this unrealistic assumption (Reise 2012; Rodriguez et al. 2016). With bifactor models, a general/global construct (i.e., a G-factor underlying responses to all items) and specific constructs (i.e., S-factors providing specificities not accounted for by the G-factor) are extracted at the same time which are orthogonal to one another, facilitating interpretation. Previous studies of bifactor modeling have demonstrated its value in relation to need satisfaction (Brunet et al. 2016), need frustration (Myers et al. 2014), and motivations (Gunnel and Gaudreau 2015) in that, when hypothesized, one should consider the global and specific factors.

As an integrative approach, the bifactor-ESEM framework (Morin et al. 2016a, 2016b) has been proposed that accounts for both relevant sources of psychometric multidimensionality. While there are only a few studies that applied the bifactor-ESEM framework inside SDT (Howard et al. 2017; Litalien et al. 2017), these findings underscored its importance. More specifically, these studies

were able to identify a G-factor representing a self-determination continuum pertaining to work and education, respectively, as well as several theoretically and empirically meaningful S-factors that co-exist with the G-factor. Furthermore, all these factors were uniquely related to relevant outcomes (e.g., commitment, vitality or ill-being). Of particular relevance to the present study, Tóth-Király et al. (2018) investigated the multidimensionality of need fulfillment and concluded that it is better represented by the co-existence of the six specific factors and an overarching need fulfillment continuum with the latter encompassing need satisfaction and need frustration as the endpoints of the said continuum. Sánchez-Oliva et al. (2017) also identified a global need satisfaction factor, as well as three S-factors, in a work context. Moreover, need satisfaction and the specific factors of autonomy, competence, and relatedness differentially predicted outcomes of burnout and professional efficacy.

The Present Study

The first aim of this study was to provide further investigation of the representation of need fulfillment through the bifactor-ESEM framework to assess its replicability. We contrasted six alternative representations: (1a-b) six-factor CFA and six-factor ESEM; (2a-b) bifactor-CFA and bifactor-ESEM including one G-factor and six S-factors; and (3a-b) bifactor-CFA and bifactor-ESEM including two G-factors and six S-factors. We expected the bifactor ESEM solution (2b) to be superior relative to other alternative solutions. A second aim of this study was to test the criterion-related validity of the final solution to better document its meaningfulness by including variables of wellbeing in the form of positive and negative affect. We expected the need fulfillment G-factor to be positively and negatively related to positive and negative affect, respectively. However, while we did not have clear a priori expectations about the associations between the S-factors and the correlates, we expected that at least some of them would be related to the outcomes over and above the G-factor.

Methods

Procedure and Participants

The study was conducted in accordance with the Declaration of Helsinki and with the approval of the University Research Ethics Committee. Participants were invited via general websites, online forums, and mailing lists to complete an online questionnaire set. They were first informed about the aim of the study and ensured about their anonymity. They had to indicate their willingness to participate by checking a box; otherwise, they were excluded.

The final sample consisted of 774 Hungarian respondents (501 females, 64.7%) who were aged between 18 and 73 (M = 27.86, SD = 9.52). Participants reported their place of residence as the capital city (43.3%), county capital (13.8%), city (27.0%), and country (15.9%); their level of education as primary (6.6%), secondary (65.1%), and higher (28.3%) and their status of employment as full-time (32.7%), part-time (14.2%), occasional (12.7%), and unemployed (40.4%).

Measures

Basic Psychological Need Satisfaction and Frustration Scale (BPNSFS). To assess need satisfaction and frustration, the BPNSFS was administered (Chen et al. 2015). It is a 24-item measure comprised of six factors (each represented by four items): autonomy satisfaction (α = .750; e.g., “I feel that my decisions reflect what I really want.”) and frustration (α = .677; e.g., “Most of the things I do feel like ‘I have to’.”), relatedness satisfaction (α = .807; e.g., “I feel connected with people who care for me, and for whom I care.”) and frustration (α = .795; e.g., “I feel that people who are important to me are cold and distant towards me.”), and competence satisfaction (α = .820; e.g., “I feel capable at what I do.”) and frustration (α = .827; e.g., “I have serious doubts about whether I can do things well.”). Participants rated the items of a five-point scale (1 = not true at all for me; 5 = very true for

me). The results of Tóth-Király et al. (2018) provided support for the factorial validity, generalizability and the scale score reliability of the Hungarian version.

Positive and Negative Affect Scale (PANAS). To measure hedonic wellbeing, the 10-item Hungarian version (Gyollai et al. 2011) of the PANAS was used (Thompson 2007; Watson et al. 1988) which is a 10-item scale measuring general dimension of positive (α = .762; e.g., "alert, inspired, determined, attentive, and active") and negative (α = .712; e.g., upset, hostile, ashamed, nervous, and afraid) affect with five items each. Participants were asked to rate the extent to which they experienced each emotion in general (1 = very slightly or not at all; 5 = very much). Previous studies (e.g., Gyollai et al., 2011; Simor et al., 2018) tended to support its reliability and factorial structure.

Statistical Analyses

All analyses were performed in Mplus 8 (Muthén and Muthén 1998-2017) and models were estimated with the robust maximum likelihood (MLR) estimator as it provides tests of model fit and standard errors that are robust to the non-normality of the data. The analyses were conducted in two phases. In the first phase, six alternative models were tested and compared (Morin et al. 2016a, 2016b; Tóth-Király et al. 2018): six-factor first-order CFA and ESEM (Model 1a, 1b), bifactor-CFA and bifactor-ESEM including one G-factor and six S-factors (Model 2a, 2b) and bifactor-CFA and bifactor-ESEM including two G-factors and six S-factors (Model 3a, 3b). Following previous applications (e.g., Morin et al. 2016c; Tóth-Király et al. 2017b), all models were specified with the target rotation procedure (Browne 2001). More details are provided in the online supplementary documents about model estimation (see Appendix 1). In the second phase, to investigate the criterion-related validity of the retained representation, the latent CFA model of the PANAS was incorporated into the final solution. For additive effects, standardized regression coefficients (β) and the percentage of explained variance (R^2) were compared.

In model evaluation, the following indices were examined: the chi-square test (χ^2), the comparative fit index (CFI), the Tucker-Lewis Index (TLI), and the root mean square error of approximation (RMSEA). Following common interpretation guidelines (Hu and Bentler 1999; Marsh et al. 2004, 2005), CFI and TLI were considered acceptable and adequate with values over .90 and .95, respectively, while values below .08 and .06 are indicative of acceptable and good fit for RMSEA. Finally, model-based omega coefficient of composite reliability (ω) was also calculated based on the formula of McDonald (1970) to investigate the reliability of the final factors. Relative to Cronbach's alpha, this index has the advantage of taking into account the strength of the association between the factors and items and the measurement errors specific to the items (Dunn et al. 2014; Sijtsma 2009).

Based on the guidelines of Morin et al. (2016a, 2016b, 2018), selection of the most optimal model should not be based solely on fit indices, but should be coupled with the evaluation of theoretical conformity of the models and the inspection of key parameter estimates (i.e., factor loadings, factor correlations). First, the correlations and the factor loadings of the first-order CFA and ESEM model should be compared. The latter solution should be retained as long as factor definitions are reasonably good and the correlations are reduced compared to the CFA solution, given that ESEM provides more exact parameter estimates (Asparouhov et al., 2015). Second, the retained CFA or ESEM model should be compared to its bifactor counterpart and the bifactor model should be preferred as a final solution when it has a well-defined G-factor and at least some well-defined S-factors. When comparing the different bifactor models with one or two G-factors, it is important to put a special emphasis on the association of the factors and the definition of the two G-factors. If the (1) correlations are too large or (2) the factors are weakly defined by the target factor loadings, then the model with one G-factor should be preferred.

Results

Structural Analyses of Need Fulfillment

Goodness-of-fit indices for the six tested models is presented in Table 1. Starting with the comparison the first-order CFA (1a) and ESEM (1b) solutions, while both had adequate fit to the data, the ESEM solution yielded substantially better fit (ΔCFI = +.030; ΔTLI = +.019; ΔRMSEA = -.008). The examination of standardized parameter estimates (see Table S1 and Table S2 of the online supplementary document) associated with each model revealed well-defined factors (CFA: |λ| = .266 to .829, *M* = .695; ESEM: |λ| = .297 to .884, *M* = .583) and reduced inter-factor correlations in the ESEM solution (|r| = .241 to .647, *M* = .425) compared to the CFA solution (|r| = .401 to .802, *M* = .588). Additionally, the ESEM solution also highlighted several statistically significant and relatively low cross-loadings (|λ| = .001 to .365, *M* = .078) which indicate that these items tap into more than one source of psychometric multidimensionality. Based on the available theoretical and statistical information, the ESEM solution was retained.

--- Table 1 should be inserted about here ---

In the following step, a general need fulfillment factor was incorporated into the ESEM solution (2b) which also revealed substantially better fit relative to the bifactor-CFA with one G-factor (2a, see Table S3 of the online supplementary documents for the parameter estimates of this model) model (ΔCFI = +.075; ΔTLI = +.080; ΔRMSEA = -.028) and the first-order ESEM model (ΔCFI = +.010; ΔTLI = +.016; ΔRMSEA = -.007). The alternative models including two G-factors (3a, 3b) also had acceptable fit (see Table 1). In this case, the examination of parameter estimates could be informative. In the bifactor-CFA solution with two G-factors (3a, see Table S4 of the online supplementary documents), although the two satisfaction and frustration G-factors were relatively well-defined (satisfaction: |λ| = .404 to .703, *M* = .560; frustration: |λ| = .140 to .721, *M* = .546), the association between them was so high that it questions the discriminant validity of the factors (*r* = -.880, *p* < .001). While this correlation was reduced in the bifactor-ESEM model with two G-factors (3b, *r* = .348, *p* = .301), these G-factors were weakly defined by their respective factor loadings (satisfaction: |λ| = .144 to .681, *M* = .328; frustration: |λ| = .022 to .451, *M* = .190, see Table S5 of the online supplementary documents), suggesting that it is not necessary to include a second G-factor and suggest the superiority of the bifactor-ESEM model with one G-factor representing need fulfillment.

This bifactor-ESEM model is also of great theoretical importance due to the fact that it provides a direct estimate of the global need fulfillment dimension. Standardized parameter estimates for this final model, which support the underlying continuum identified by Tóth-Király et al. (2018), are reported in Table 2. The G-factor was well-defined (|λ| = .141 to .764, *M* = .538, ω = .909) by all scale items with the positive and the negative items contributing to the same degree. Apart from the G-factor, most S-factor retained a moderate degree of specificity (relatedness satisfaction: |λ| = .389 to .678, *M* = .539, ω = .627[1]; competence satisfaction: |λ| = .260 to .579, *M* = .409, ω = .449; autonomy frustration: |λ| = .260 to .517, *M* = .407, ω = .445; relatedness frustration: |λ| = .366 to .548, *M* = .443, ω = .495; competence frustration: |λ| = .289 to .469, *M* = .399, ω = .433) with the exception of the autonomy satisfaction S-factor (|λ| = .007 to .650, *M* = .217, ω = .174), suggesting that the latter does not tap into any meaningful specificity once the variance explained by the G-factor is accounted for. Finally, the magnitude of the cross-loadings also decreased (|λ| = .000 to .295, *M* = .074) compared to the first-order ESEM model. Overall, on the basis of better model fit and theoretical representation, the bifactor-ESEM solution was retained for the subsequent analyses.

--- Table 2 should be inserted about here ---

[1] In the case of omega indices for the bifactor-ESEM model, it has to be noted that the reliability of the S-factors in this particular model is generally lower than in the case of first-order model. Also, the lower levels of reliability are less problematic due to the use of fully latent variables which are controlled for measurement errors.

Criterion Validity of Need Fulfillment

Finally, the bifactor-ESEM model was re-expressed with the ESEM-within-CFA (EwC) method (Morin et al. 2013) to investigate the predictive effect of the need fulfillment G-factor and the S-factors on positive and negative affect which were incorporated as latent CFA models[2] (see Table 1 Model 4 for goodness-of-fit indices and Table 3 for standardized estimates). The results revealed that the need fulfillment G-factor predicted the two outcomes in the reasonable direction when it was the sole predictor. Additionally, when the S-factors were also entered into the predictive model, the proportion of explained variance increased by a substantial amount both for positive affect (ΔR^2 = .066) and negative affect (ΔR^2 = .108). The G-factor's effects remained stable and competence satisfaction predicted positive affect, whereas relatedness and competence frustration predicted negative affect over and above the G-factor (see Figure 1 for a schematic overview of the results).

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Discussion

The present study—grounded in the well-established SDT (Ryan and Deci 2017)—re-examined the representation of need fulfillment; that is, whether the satisfaction and frustration of the three basic psychological needs of autonomy, competence, and relatedness are better represented as two extremes of the same underlying continuum or rather as two distinct elements that are related to one another. Our results supported the former hypothesis and replicated the results of Tóth-Király et al. (2018). Additionally, we also tested how this representation relates to positive and negative affect as indicators of wellbeing, respectively. While the global level of need fulfillment was a strong predictor of both positive and negative affect, the specific factors also had unique contributions: while competence satisfaction predicted positive affect, relatedness and competence frustration predicted negative affect over and above the G-factor. A number of interesting findings emerged.

First, one of the key findings of the present investigation is that in accordance with the proposition of Tóth-Király et al. (2018), the existence of an underlying need fulfillment dimension was further supported by taking into account the two sources of construct-relevant psychometric multidimensionality via the bifactor-ESEM framework (Morin et al. 2016a, 2016b). Both the ESEM and the bifactor-ESEM solutions were superior to their CFA counterparts (both in terms of improved model fit and more precise parameter estimates), suggesting that this statistical method could be used to account for the association between items and non-target conceptually-related factors. Furthermore, a G-factor could also be incorporated into this solution, which in the present case resulted in a well-defined global factor representing the participants' general level of need fulfillment. These findings are in line with previous findings (Brunet et al. 2016; Garn et al. 2018; Myers et al. 2014; Sánchez-Oliva et al. 2017) where a global need satisfaction or frustration dimension was identified. Moreover, a recent daily diary study also corroborated that need satisfaction and frustration mirror one another (Bidee et al. 2016) which also supported the notion of the need fulfillment continuum.

In the field of motivations, the usefulness of the bifactor-ESEM framework was also supported as SDT-based motivations were better represented by a general self-determination factor and specific factors both in the context of work (Howard et al. 2017) and education (Litalien et al. 2017). Indeed, when one suspects the presence of both conceptually-related and hierarchically-ordered constructs, this methodological framework could be suitable such as in the current investigation where apart from the global factor, six co-existing specific factors were also identified. While the alternative models

[2] The fit of the PANAS model was adequate (χ^2 = 141.216, df = 32, p < .001; CFI = .930; TLI = .902; RMSEA = .066 [90% CI .055-.078]) and included two correlated uniquenesses between items 3-5 and 2-8. The two factors also showed adequate model-based reliabilities ($\omega_{positive}$ = .740; $\omega_{negative}$ = .696)

with two general factors representing need satisfaction and frustration also had satisfactory fit to the data, the examination of parameter estimates revealed that these are not adequate alternatives and the two G-factors do not vary independently from one another within the same individual. At the same time, these results reinforce that key parameter estimates should also be examined as well as the model fit and theoretical conformity of the proposed model as suggested by Morin et al. (2016a, 2016b).

Additionally, apart from the G-factor, several S-factors were extracted, representing the combination of need satisfaction and frustration with the basic psychological needs of autonomy, competence, and relatedness. Almost all S-factors were well-defined once the G-factor was extracted, suggesting that each tap into meaningful and unique specificity over and above the G-factor. For instance, the relatedness satisfaction S-factor taps into the participants' satisfaction with their relationships with other with the global level of need fulfillment being removed. In contrast, the autonomy satisfaction S-factor, which was also less reliable for Sánchez-Oliva et al. (2017), appeared to retain almost no meaningful specificity with the presence of the G-factor. This finding does not mean that these items (and factor) are redundant and do not tap into a key component of need fulfillment. Rather, it simply suggests that these items only reflect participants' global need fulfillment with no specific variance being left once the global level of need fulfillment is accounted for. This result is in line with Fadda et al. (2017) where not all wellbeing factors retained a high degree of specificity after the global level of eudaimonic wellbeing was taken into account. Finally, one has to remember that the S-factors of a first-order model are interpreted differently than the S-factors in the bifactor-ESEM model (see Litalien et al. 2017), thus both the global and specific components should be interpreted in relation to correlates and other variables of interest.

Findings related to the investigation of criterion validity, similar to Howard et al. (2017) and Litalien et al. (2017), also supported the importance of considering both the G- and S-factors as apparent by the regression coefficients and higher proportion of explained variance in said covariates. Results suggested that respondents' positive and negative affect was greatly predicted by their overall level of need fulfillment; more precisely, whereas need fulfillment was positively associated with more frequent experiences of positive affect, it was negatively related to the frequency of negative affect. This is in line with the assertion of SDT in that global need fulfillment is associated with increased wellbeing and decreased ill-being (Ryan and Deci 2017).

Once the effect of this global need fulfillment factor was considered, the specific factors added to these predictions: competence satisfaction was related to positive affect, indicating that experiencing mastery, effectiveness, and a sense of accomplishment during everyday tasks and exercises could further increase hedonic wellbeing (as measured by the PANAS). In the context of work, apart from the G-factor, the competence satisfaction S-factor was also a unique contributor to the outcomes of professional efficacy and depersonalization (Sánchez-Oliva et al. 2017). In a similar vein, when examined separately in the form of six specific factors (i.e., first-order model), competence satisfaction was also associated with positive affect (Longo et al. 2018). When the need for competence is satisfied, the individual feels effective in interacting with the environment (Ryan and Deci 2017) and if this interaction is continuous (e.g., in a work context where one spends a significant amount of time in a day or in an educational context, during learning for an exam), then the feelings of constant development may be experienced. Being competent in, for instance, one's work might be associated with result achievement (e.g., Quiroga, Janosz, Bisset, and Morin, 2013); consequently, when we are competent, we may achieve good results and positive feedback, potentially leading to feelings of success (e.g., Gilman and Huebner, 2006) which, in turn, may be interpreted as a form of happiness. This phenomenon could manifest in non-obligatory situations as well, such as when one is performing altruistic acts and is contributing to the community: in such a setting, people might experience a sense of competence as they are able to help others (Ryan et al. 2008) which might also contribute to their own positive affective experiences. Apart from these findings, diary studies (e.g.,

Reis, Shledon, Gable, Roscoe, and Ryan 2000; Sheldon, Ryan, and Reis 1996) also showed that, when considering the three needs separately, competence also contributed to individuals' daily wellbeing and happiness. Interestingly, the other S-factors did not contribute to this outcome, suggesting that when general fulfillment does not underlie the S-factors (such as in the case of first-order models where the S-factors contain both the global and specific components), then the associations between these S-factors and the outcomes become more nuanced.

In the case of negative affect, relatedness frustration and competence frustration had additional effects over and above the G-factor. Previous studies demonstrated that need satisfaction and need frustration are distinctly related to different correlates such as stress or academic motivations (Campbell et al. 2017; Krijgsman et al. 2017). While the distinctness of need satisfaction and need frustration G-factors was not supported, the specific frustration factors indeed uniquely predicted negative affect as proposed previously (Vansteenkiste and Ryan 2013). That is, the experience of being rejected by others (i.e., relatedness frustration) or perceiving oneself as a failure (i.e., competence frustration) comes hand in hand with more frequent experiences of negative affect. Previous studies have already highlighted that being lonely and isolated (i.e., frustrated need for relatedness) is related to decreased wellbeing and a handful of maladaptive outcomes (e.g., Kim et al. 2009; Mellor et al. 2008). To counter the experiences of need frustration, future studies might employ social belonging interventions which has positive academic- and health-related outcomes (Walton and Cohen 2011).

Competence appears to be a "double-edged sword" as its satisfaction is related to increased wellbeing, whereas its frustration is related to decreased wellbeing. Cultural characteristics might influence the unique role of competence. For instance, a cross-cultural study (Deci et al. 2001) found that all three needs were related to general self-esteem (i.e., an index of wellbeing reflecting self-acceptance and self-worth; Ryff 1989) in highly similar direction and magnitude in a Bulgarian sample. On the other hand, competence had the strongest association with self-esteem in the US sample, autonomy only weakly correlated with it, and relatedness was not associated with self-esteem. The differences might stem from the individualistic-collectivistic nature of the countries: Bulgaria is identified as a collectivistic society where an emphasis is put on the groups, while the US (and Hungary) are individualistic where an emphasis is put on the individuals themselves (Hofstede 2001; Hofstede, Hostede, and Minkov 2010) and competence/performance might be more important for progress and advancement in individualistic settings. Other studies (e.g., Chen et al. 2015) also highlighted that there might be some variation in the unique role of each needs regardless of cross-cultural equivalence. Future cross-cultural studies should aim to address these questions. Nevertheless, the current study adds to the literature of SDT by demonstrating that specific aspects of need satisfaction and frustration (i.e., the G-factor of need fulfillment and the S-factors of satisfaction and frustration × autonomy, competence, and relatedness) play a critical and important role in relation to wellbeing.

Limitations and Future Directions

Some limitations of the present study should be remembered when interpreting the results. First, data was obtained through self-reported cross-sectional measures which preclude directional or causal inferences; to circumvent these issues, more sophisticated longitudinal, experimental or intervention studies would be necessary. The findings should be replicated in other cultural contexts as well to assess their generalizability. While the sample was relatively large, it was not as comprehensive as in the case of Tóth-Király et al. (2018), thus more diverse and heterogeneous samples are needed to investigate the relations between basic psychological needs and outcomes. The reliability of the S-factors also remained moderate, emphasizing the need of relying on latent variables, such as the ones in the present case, which are controlled for measurement error. Future

studies should also re-assess the criterion-related validity of this representation by using different measures of wellbeing (e.g., eudaimonic wellbeing) and ill-being (e.g., depression, anxiety) or other indicators of adaptive functioning (e.g., motivations). Additionally, it would also be interesting to examine the interplay of this representation of need fulfillment and outcomes of wellbeing and ill-being across different levels of generality (i.e., situational level, contextual level, and global level) as proposed by the hierarchical model of Vallerand (1997).

Conclusions

Taken together, by relying on the bifactor-ESEM framework, need fulfillment was identified again as a multidimensional construct characterized by a global continuum component representing need fulfillment with need satisfaction and need frustration being at the opposite ends. Additionally, the specific combinations of satisfaction and frustration with autonomy, competence, and relatedness are also co-existent in this representation as measured by the BPNSFS. While the global need fulfillment factor was substantially related to the outcomes of wellbeing, the specific factors also had unique contributions: competence satisfaction was related to positive affect, while relatedness frustration and competence frustration was related to negative affect besides the global factor. In sum, the present study also underscores that, for a more detailed picture of the need fulfillment representation and of relations between basic psychological needs and covariates, both the global and the specific factors should simultaneously be taken into account.

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Table 1

Goodness-of-Fit Statistics for the Estimated Models on the Basic Psychological Need Satisfaction and Frustration Scale

Model	χ^2	df	CFI	TLI	RMSEA	RMSEA 90% CI
Model 1a. Six-factor CFA	541.647*	237	.949	.941	.041	.036-.045
Model 1b. Six-factor ESEM	273.978*	147	.979	.960	.033	.027-.039
Model 2a. Bifactor CFA (1 G-factor and 6 S-factors)	743.917*	228	.914	.896	.054	.050-.058
Model 2b. Bifactor ESEM (1 G-factor and 6 S-factors)	196.624*	129	.989	.976	.026	.018-.033
Model 3a. Bifactor CFA (2 G-factors and 6 S-factors)	720.609*	227	.918	.900	.053	.049-.057
Model 3b. Bifactor ESEM (2 G-factors and 6 S-factors)	187.986*	122	.989	.975	.026	.019-.034
Model 4. Criterion validity	793.856*	408	.955	.939	.035	.031-.039

Note. CFA: Confirmatory factor analysis; ESEM: Exploratory structural equation modeling; B: Bifactor model; χ^2: Robust chi-square test of exact fit; df: Degrees of freedom; CFI: Comparative fit index; TLI: Tucker-Lewis index; RMSEA: Root mean square error of approximation; 90% CI: 90% confidence interval of the RMSEA; *$p < 0.01$.

Table 2

Standardized Parameter Estimates (with Standard Errors in Parentheses) of the Bifactor-ESEM Model Including One G-Factor and Six S-Factors (Model 2b)

	Fu (λ)	A-S (λ)	R-S (λ)	C-S (λ)	A-Fr (λ)	R-Fr (λ)	C-Fr (λ)	δ
Autonomy satisfaction (A-S)								
Item 1	**.497(.042)****	**.106(.155)**	-.048(.047)	.094(.053)	-.162(.057)**	.100(.050)*	.200(.051)**	.345
Item 7	**.725(.041)****	**.103(.180)**	-.070(.044)	-.034(.051)	.101(.053)	.168(.047)**	.162(.043)**	.608
Item 13	**.764(.036)****	**.007(.175)**	-.040(.039)	-.032(.055)	.094(.046)*	.258(.044)**	.158(.050)**	.686
Item 19	**.516(.076)****	**.650(.251)****	.055(.052)	.039(.067)	-.133(.069)	.025(.062)	.026(.067)	.713
Relatedness satisfaction (R-S)								
Item 3	**.435(.038)****	.025(.039)	**.411(.044)****	-.131(.043)**	.007(.049)	-.183(.051)**	-.011(.048)	.410
Item 9	**.447(.033)****	.000(.033)	**.677(.047)****	.010(.034)	-.010(.034)	-.089(.047)	.036(.034)	.668
Item 15	**.488(.033)****	-.029(.030)	**.678(.051)****	.004(.030)	.087(.030)**	-.115(.045)*	.052(.038)	.722
Item 21	**.481(.036)****	.124(.083)	**.389(.053)****	-.002(.052)	-.027(.047)	-.214(.059)**	.115(.064)	.458
Competence satisfaction (C-S)								
Item 5	**.581(.041)****	-.082(.056)	-.041(.033)	**.579(.079)****	.042(.041)	.081(.037)*	-.075(.080)	.695
Item 11	**.583(.034)****	.125(.060)*	.000(.040)	**.380(.049)****	.126(.037)**	.093(.042)*	-.125(.040)**	.540
Item 17	**.643(.039)****	.182(.144)	-.034(.038)	**.260(.055)****	.049(.048)	.030(.043)	-.038(.057)	.521
Item 23	**.590(.035)****	-.010(.084)	-.030(.035)	**.416(.070)****	.037(.047)	.082(.040)*	-.158(.042)**	.555
Autonomy frustration (A-Fr)								
Item 2	**-.141(.042)****	-.027(.063)	-.013(.042)	.083(.049)	**.260(.062)****	.000(.049)	.003(.055)	.095
Item 8	**-.507(.033)****	-.119(.091)	.022(.035)	.078(.038)*	**.517(.067)****	.067(.043)	.005(.044)	.549
Item 14	**-.538(.035)****	.041(.038)	.115(.035)**	.046(.038)	**.429(.059)****	-.015(.050)	.070(.059)	.496
Item 20	**-.492(.038)****	-.194(.075)*	-.031(.042)	.043(.048)	**.421(.055)****	.104(.047)	.056(.053)	.474
Relatedness frustration (R-Fr)								
Item 4	**-.504(.036)****	.010(.067)	-.046(.044)	.045(.045)	.019(.054)	**.433(.066)****	.089(.061)	.454
Item 10	**-.520(.042)****	.067(.045)	-.216(.050)**	.101(.047)*	.047(.043)	**.425(.076)****	.061(.055)	.518
Item 16	**-.533(.036)****	.005(.038)	-.173(.041)**	.056(.035)	.036(.038)	**.548(.067)****	.075(.047)	.625
Item 22	**-.494(.037)****	.049(.046)	-.248(.041)**	.087(.050)	.066(.045)	**.366(.058)****	.050(.051)	.456
Competence frustration (C-Fr)								
Item 6	**-.547(.048)****	.134(.113)	.071(.047)	-.295(.044)**	.053(.041)	.111(.056)*	**.289(.077)****	.508
Item 12	**-.648(.038)****	.055(.060)	.062(.037)	-.056(.044)	.018(.036)	.045(.044)	**.469(.080)****	.651
Item 18	**-.587(.035)****	-.023(.057)	.122(.035)**	-.123(.051)*	-.020(.040)	.082(.045)	**.396(.054)****	.540
Item 24	**-.651(.031)****	.020(.037)	.006(.032)	-.015(.041)	.092(.034)**	.086(.041)*	**.443(.055)****	.637

Note. Fu: Global (G-Factor) representing need fulfillment; S-Factors: Specific factors from the bifactor model; S: Need satisfaction; Fr: Need frustration; A: Need for autonomy; C: Need for competence; R: Need for relatedness; λ: Factor loading; δ: Item uniqueness; Target factor loadings are in bold.; **p* < .05; ***p* < .01;

Table 3

Relations between the bifactor-ESEM factors and the outcomes of positive and negative affect

	Positive affect		Negative affect	
	G only	G+S	G only	G+S
Need fulfillment	.765(.029)**	.734(.036)**	-.777(.032)**	-.729(.033)**
Autonomy satisfaction		.164(.211)		-.011(.068)
Relatedness satisfaction		.046(.052)		-.086(.059)
Competence satisfaction		.263(.098)**		-.054(.066)
Autonomy frustration		.076(.097)		.124(.065)
Relatedness frustration		.051(.071)		.248(.071)**
Competence frustration		-.079(.132)		.304(.068)**
R^2	.586	.652	.604	.712

Note. Numbers represent standardized regression coefficients with standard errors in parentheses; G-factor: global need fulfillment factor; S-factor: specific need fulfillment factors; R^2: proportion of explained variance.; *$p < .05$; **$p < .01$.

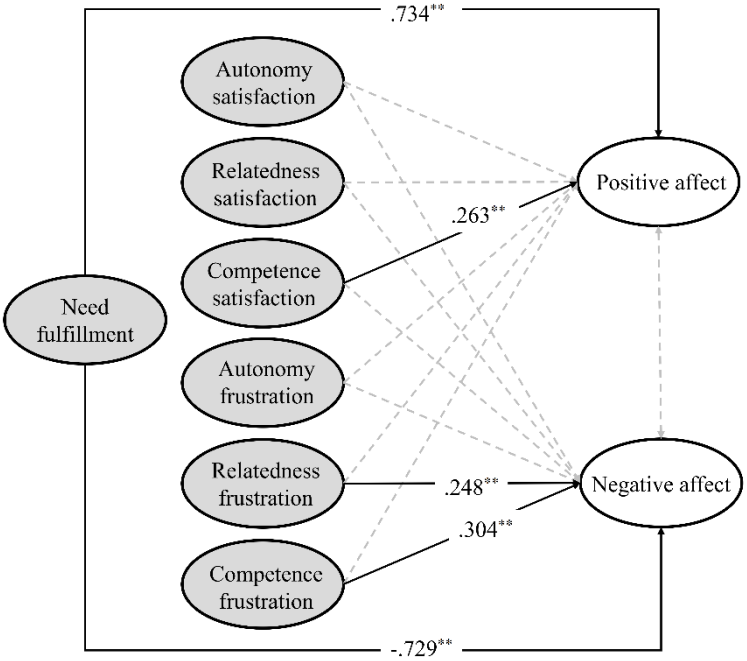

Figure 1
Schematic representation of the associations between need fulfillment and indicators of wellbeing

Note. For the sake of simplicity, only latent variables are shown. Variables in grayscale are part of the same bifactor-ESEM model. One-headed arrows represent regression paths. All parameters are standardized. **p* < .05, ***p* < .01.

Online Supplements for:

A New Look on the Representation and Criterion Validity of Need Fulfillment: Application of the Bifactor Exploratory Structural Equation Modeling Framework

Table of Contents:

Appendix 1: Model Estimation

In first-order six-factor CFA model (1a), scale items were forced to load on the a priori hypothesized factors and the correlation between the factors were freely estimated, but item-level cross-loadings were explicitly forced to be zero. In the corresponding ESEM model (1b), apart from the same CFA specifications, cross-loadings were freely estimated, but "targeted" to be close to zero following theoretical (Browne, 2001) and applied (Morin, Boudrias, Marsh, Madore, & Desrumaux, 2016; Tóth-Király, Bőthe, Rigó, & Orosz, 2017) guidelines to achieve a confirmatory setup. In the bifactor-CFA model with one general factor (2a), scale items simultaneously loaded one general factor (i.e., need fulfillment) and one specific factor. Moreover, these specific factors were forced to be orthogonal to the general factor and to each other as well as per standard bifactor specifications so that they were not allowed to correlate with one another (Morin, Arens, et al., 2016a; Reise, 2012). In the bifactor-ESEM model with one general factor (2b), besides the bifactor-CFA specifications, items were allowed to cross-load on the non-target factors, but "targeted" to be close to zero as in the previous models. In the two-bifactor models (3a and 3b), the two general factors were allowed to correlate with each other (need satisfaction and need frustration, respectively), but not with the specific factors (same as in Tóth-Király, Morin, Bőthe, Orosz, & Rigó, 2018), while the rest of the specifications were the same to their bifactor counterparts (2a and 2b, respectively).

Table S1

Standardized Parameter Estimates (with Standard Errors in Parentheses) of the Six-Factor CFA (Model 1a) and ESEM models (Model 1b)

	CFA		ESEM						
	Factor (λ)	δ	AS (λ)	RS (λ)	CS (λ)	AF (λ)	RF (λ)	CF (λ)	δ
Autonomy satisfaction (A-S)									
Item 1	**.559(.036)****	.312	**.461(.078)****	-.024(.067)	.173(.078)*	-.200(.063)**	.014(.096)	.178(.084)*	.345
Item 7	**.759(.028)****	.577	**.884(.109)****	-.053(.045)	-.045(.069)	.126(.057)*	-.036(.061)	-.007(.057)	.642
Item 13	**.772(.023)****	.596	**.798(.079)****	.065(.045)	-.010(.070)	.086(.051)	.105(.054)	-.097(.053)	.635
Item 19	**.594(.031)****	.353	**.414(.073)****	.050(.089)	.134(.126)	-.284(.070)**	-.025(.113)	.156(.136)	.410
Relatedness satisfaction (R-S)									
Item 3	**.631(.030)****	.398	.091(.061)	**.481(.071)****	-.132(.058)*	-.011(.060)	-.150(.087)	-.084(.067)	.410
Item 9	**.789(.025)****	.622	-.043(.059)	**.852(.075)****	.058(.053)	-.042(.045)	.075(.080)	-.006(.065)	.661
Item 15	**.829(.029)****	.688	.016(.050)	**.855(.079)****	.044(.048)	.079(.040)*	.016(.078)	-.022(.057)	.728
Item 21	**.658(.034)****	.433	.133(.062)*	**.398(.085)****	.107(.071)	-.065(.058)	-.266(.094)**	.195(.079)*	.461
Competence satisfaction (C-S)									
Item 5	**.752(.024)****	.565	.038(.091)	.052(.062)	**.699(.151)****	.042(.059)	.032(.104)	-.128(.143)	.636
Item 11	**.732(.027)****	.536	.177(.055)**	.077(.055)	**.521(.070)****	.063(.045)	.031(.072)	-.128(.064)*	.528
Item 17	**.710(.027)****	.505	.332(.058)**	-.016(.063)	**.408(.081)****	-.020(.055)	-.104(.076)	-.007(.071)	.517
Item 23	**.752(.027)****	.566	.063(.054)	.058(.047)	**.580(.067)****	-.008(.044)	.036(.057)	-.188(.057)**	.570
Autonomy frustration (A-Fr)									
Item 2	**.266(.043)****	.071	-.026(.080)	-.048(.070)	.101(.080)	**.297(.068)****	-.062(.092)	.054(.080)	.089
Item 8	**.717(.027)****	.513	-.156(.071)*	-.008(.053)	.034(.054)	**.630(.081)****	.032(.072)	.045(.067)	.554
Item 14	**.688(.033)****	.473	-.191(.078)*	.052(.071)	.045(.081)	**.461(.080)****	-.024(.098)	.243(.079)**	.443
Item 20	**.675(.029)****	.456	-.109(.056)	-.048(.066)	-.013(.059)	**.552(.066)****	.077(.083)	.040(.077)	.483
Relatedness frustration (R-Fr)									
Item 4	**.649(.033)****	.421	-.067(.069)	.082(.079)	.010(.069)	-.020(.053)	**.645(.135)****	.098(.116)	.454
Item 10	**.725(.028)****	.526	-.024(.064)	-.154(.096)	.077(.070)	.012(.053)	**.551(.140)****	.111(.098)	.511
Item 16	**.763(.028)****	.583	.035(.067)	-.026(.076)	-.029(.052)	.010(.056)	**.771(.108)****	.017(.067)	.630
Item 22	**.684(.028)****	.467	-.001(.061)	-.204(.067)**	.029(.070)	.056(.048)	**.469(.094)****	.065(.084)	.452
Competence frustration (C-Fr)									
Item 6	**.685(.029)****	.469	.126(.075)	.024(.074)	-.365(.088)**	.053(.059)	.155(.096)	**.407(.102)****	.497
Item 12	**.787(.019)****	.619	-.014(.048)	-.044(.053)	-.027(.102)	.071(.068)	.029(.110)	**.732(.145)****	.662
Item 18	**.726(.026)****	.528	-.040(.067)	.092(.066)	-.170(.103)	.041(.066)	.154(.095)	**.508(.106)****	.522
Item 24	**.780(.021)****	.608	.008(.055)	-.081(.052)	-.024(.111)	.169(.061)**	.074(.120)	**.629(.152)****	.623

Note. CFA: Confirmatory factor analysis; ESEM: Exploratory structural equation modeling; S: Need satisfaction; Fr: Need frustration; A: Need for autonomy; C: Need for competence; R: Need for relatedness; λ: Factor loading; δ: Item uniqueness; Target factor loadings are in bold; *$p < .05$; **$p < .01$.

Table S2

Latent Factor Correlations (and Standard Error in Parentheses) from the Six-Factor CFA (1a, below the diagonal) and ESEM (1b, above the diagonal) Models

	A-S	R-S	C-S	A-Fr	R-Fr	C-Fr
Autonomy satisfaction (A-S)	—	.461(.052)	.602(.054)	-.469(.076)	-.459(.070)	-.550(.063)
Relatedness satisfaction (R-S)	.522(.040)	—	.254(.062)	-.257(.052)	-.647(.044)	-.264(.062)
Competence satisfaction (C-S)	.779(.030)	.437(.044)	—	-.241(.069)	-.295(.056)	-.581(.097)
Autonomy frustration (A-Fr)	-.680(.043)	-.401(.049)	-.497(.045)	—	.458(.050)	.329(.095)
Relatedness frustration (R-Fr)	-.492(.043)	-.743(.040)	-.462(.047)	.614(.035)	—	.513(.141)
Competence frustration (C-Fr)	-.632(.038)	-.419(.042)	-.802(.035)	.657(.034)	.682(.032)	—

Note. CFA: Confirmatory factor analysis; ESEM: Exploratory structural equation modeling; All correlations are statistically significant ($p \leq .01$).

Table S3

Standardized Parameter Estimates (with Standard Errors in Parentheses) of the Bifactor-CFA Model (Model 2a) Including One G-Factor and Six G-Factors

	G-factor (λ)	S-factors	δ
Autonomy satisfaction (A-S)			
Item 1	**.463(.041)****	**.245(.061)****	.274
Item 7	**.608(.029)****	**.579(.073)****	.704
Item 13	**.628(.028)****	**.443(.056)****	.591
Item 19	**.554(.034)****	**.160(.050)****	.332
Relatedness satisfaction (R-S)			
Item 3	**.432(.041)****	**.434(.040)****	.375
Item 9	**.447(.036)****	**.679(.035)****	.661
Item 15	**.472(.034)****	**.708(.044)****	.724
Item 21	**.497(.037)****	**.406(.044)****	.411
Competence satisfaction (C-S)			
Item 5	**.570(.039)****	**.553(.049)****	.632
Item 11	**.587(.035)****	**.435(.048)****	.534
Item 17	**.661(.033)****	**.244(.050)****	.497
Item 23	**.603(.038)****	**.458(.051)****	.573
Autonomy frustration (A-Fr)			
Item 2	**-.132(.041)****	**.297(.054)****	.106
Item 8	**-.524(.031)****	**.536(.053)****	.562
Item 14	**-.528(.031)****	**.413(.052)****	.450
Item 20	**-.538(.033)****	**.383(.047)****	.437
Relatedness frustration (R-Fr)			
Item 4	**-.513(.035)****	**.418(.052)****	.438
Item 10	**-.522(.038)****	**.491(.050)****	.513
Item 16	**-.552(.037)****	**.554(.052)****	.613
Item 22	**-.508(.039)****	**.425(.046)****	.439
Competence frustration (C-Fr)			
Item 6	**-.573(.038)****	**.314(.054)****	.428
Item 12	**-.651(.032)****	**.508(.048)****	.682
Item 18	**-.616(.035)****	**.352(.057)****	.504
Item 24	**-.683(.030)****	**.391(.050)****	.619

Note. CFA: Confirmatory factor analysis; A: Need for autonomy; C: Need for competence; R: Need for relatedness; S: satisfaction; Fr: Frustration; λ: Factor loading; δ: Item uniqueness; Target factor loadings are in bold; *$p < .05$; **$p < .01$.

Table S4

Standardized Parameter Estimates (with Standard Errors in Parentheses) of the Two bifactor-CFA Model (Model 3a) Including Two G-Factors and Six S-Factors

	Satisfaction G-factor (λ)	Frustration G-factor (λ)	S-factors	δ
Autonomy satisfaction (A-S)				
Item 1	**.493(.044)****		**.180(.076)***	.725
Item 7	**.646(.030)****		**.564(.126)****	.265
Item 13	**.670(.029)****		**.368(.086)****	.416
Item 19	**.580(.035)****		**.093(.058)**	.655
Relatedness satisfaction (R-S)				
Item 3	**.404(.044)****		**.455(.041)****	.630
Item 9	**.433(.037)****		**.689(.035)****	.337
Item 15	**.464(.035)****		**.712(.044)****	.278
Item 21	**.487(.038)****		**.416(.044)****	.589
Competence satisfaction (C-S)				
Item 5	**.595(.041)****		**.538(.057)****	.357
Item 11	**.622(.036)****		**.384(.053)****	.466
Item 17	**.703(.032)****		**.168(.060)****	.477
Item 23	**.623(.040)****		**.424(.061)****	.432
Autonomy frustration (A-Fr)				
Item 2		**.140(.041)****	**.292(.056)****	.895
Item 8		**.530(.033)****	**.532(.058)****	.436
Item 14		**.547(.031)****	**.391(.052)****	.548
Item 20		**.547(.034)****	**.371(.049)****	.564
Relatedness frustration (R-Fr)				
Item 4		**.535(.034)****	**.392(.052)****	.560
Item 10		**.533(.036)****	**.480(.050)****	.486
Item 16		**.566(.035)****	**.540(.053)****	.388
Item 22		**.514(.038)****	**.417(.048)****	.562
Competence frustration (C-Fr)				
Item 6		**.597(.040)****	**.265(.068)****	.573
Item 12		**.682(.032)****	**.475(.059)****	.309
Item 18		**.645(.037)****	**.293(.072)****	.498
Item 24		**.721(.028)****	**.319(.057)****	.378

Note. CFA: Confirmatory factor analysis; A: Need for autonomy; C: Need for competence; R: Need for relatedness; S: Satisfaction; Fr: Frustration; λ: Factor loading; δ: Item uniqueness; Target factor loadings are in bold; *$p < .05$; **$p < .01$.

Table S5

Standardized Parameter Estimates (with Standard Errors in Parentheses) of the Two bifactor-ESEM Model (Model 3b) Including Two G-Factors and Six S-Factors

	Sat-G (λ)	Fr-G (λ)	A-S (λ)	R-S (λ)	C-S (λ)	A-Fr (λ)	R-Fr (λ)	C-Fr (λ)	δ
Autonomy satisfaction (A-S)									
Item 1	**.333(.084)****		**.082(.267)**	.078(.120)	.242(.086)**	-.386(.074)**	-.067(.098)	-.075(.085)	.659
Item 7	**.590(.100)****		**.063(.420)**	.086(.251)	.182(.126)	-.278(.101)**	-.147(.203)	-.313(.159)*	.410
Item 13	**.681(.156)****		**-.039(.413)**	.099(.282)	.205(.129)	-.282(.126)*	-.139(.223)	-.303(.181)	.292
Item 19	**.361(.457)**		**.769(.600)**	.138(.179)	.160(.165)	-.266(.193)	-.105(.059)	-.135(.151)	.134
Relatedness satisfaction (R-S)									
Item 3	**.144(.175)**		.066(.123)	**.508(.090)****	-.011(.050)	-.120(.058)*	-.271(.113)*	-.183(.071)*	.595
Item 9	**.200(.287)**		.041(.077)	**.713(.099)****	.125(.076)	-.068(.063)	-.213(.087)*	-.042(.083)	.382
Item 15	**.231(.339)**		.004(.104)	**.832(.087)****	.094(.099)	-.032(.028)	-.144(.071)*	-.138(.038)**	.204
Item 21	**.273(.127)***		.128(.130)	**.449(.092)****	.192(.080)*	-.090(.096)	-.494(.140)**	.108(.137)	.407
Competence satisfaction (C-S)									
Item 5	**.234(.120)**		-.025(.138)	.102(.048)*	**.693(.087)****	-.108(.052)*	-.015(.074)	-.313(.085)**	.345
Item 11	**.301(.161)**		.140(.210)	.126(.098)	**.529(.069)****	-.060(.059)	-.031(.073)	-.358(.049)**	.461
Item 17	**.341(.127)****		.178(.300)	.122(.102)	**.439(.069)****	-.183(.083)*	-.128(.083)	-.324(.074)**	.489
Item 23	**.248(.109)***		.021(.131)	.081(.053)	**.634(.080)****	-.095(.065)	-.114(.045)*	-.295(.086)**	.420
Autonomy frustration (A-Fr)									
Item 2		**-.123(.176)**	-.063(.070)	-.053(.042)	.027(.053)	**.255(.093)****	.046(.064)	.012(.088)	.910
Item 8		**-.234(.339)**	-.173(.194)	-.122(.054)*	-.129(.056)*	**.617(.132)****	.204(.098)*	.117(.147)	.447
Item 14		**-.278(.343)**	-.043(.188)	-.040(.055)	-.182(.046)**	**.549(.155)****	.167(.090)	.221(.157)	.507
Item 20		**-.250(.273)**	-.245(.188)	-.137(.053)*	-.168(.055)**	**.467(.146)****	.291(.074)**	.079(.152)	.522
Relatedness frustration (R-Fr)									
Item 4		**.080(.291)**	-.080(.106)	-.237(.080)**	-.087(.056)	.210(.091)*	**.430(.154)****	.399(.078)**	.536
Item 10		**.060(.258)**	-.021(.097)	-.416(.081)**	-.034(.055)	.242(.089)**	**.413(.166)***	.368(.059)**	.457
Item 16		**.081(.282)**	-.082(.059)	-.344(.099)**	-.116(.054)*	.180(.066)**	**.601(.154)****	.293(.113)**	.375
Item 22		**-.022(.228)**	-.022(.078)	-.376(.064)**	-.100(.065)	.186(.069)**	**.483(.118)****	.202(.135)	.538
Competence frustration (C-Fr)									
Item 6		**-.123(.205)**	.017(.168)	-.086(.073)	-.475(.062)**	.143(.066)*	.195(.138)	**.440(.120)****	.500
Item 12		**-.357(.245)**	-.061(.151)	-.102(.047)*	-.327(.059)**	.106(.135)	.263(.083)**	**.560(.163)****	.357
Item 18		**-.224(.228)**	-.100(.203)	-.044(.049)	-.351(.060)**	.108(.082)	.218(.087)*	**.543(.129)****	.461
Item 24		**-.451(.220)***	-.083(.146)	-.122(.047)*	-.320(.085)**	.104(.212)	.399(.055)**	**.438(.240)**	.311

Note. Sat-G: Global (G-Factor) representing need satisfaction; Dis-G: Global (G-Factor) representing need dissatisfaction; S-Factors: Specific factors from the bifactor model; S: Need satisfaction; Fr: Need frustration; A: Need for autonomy; C: Need for competence; R: Need for relatedness; λ: Factor loading; δ: Item uniqueness; Target factor loadings are in bold.; *$p < .05$; **$p < .01$;