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Psychometric analysis of two versions of the Big Five Inventory-15 in Chilean college students: internal structure, measurement invariance and association with subjective well-being

Análisis psicométrico de dos versiones del Big Five Inventory-15 en estudiantes universitarios chilenos: estructura interna, invarianza de medición y asociación con bienestar subjetivo

Análise psicométrica de duas versões do Big Five Inventory -15 em estudantes universitários chilenos: estrutura interna, invariância de medição e associação com bem-estar subjetivo

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Data availability: The dataset supporting the results of this study is not available.

Abstract: The purpose of this research was to analyze the internal structure of the Big Five Inventory-15 (BFI-15), measurement invariance and its association with subjective well-being, in Chilean college students. A sample of 1011 college students (female = 54.80%; M_{age} = 21.55 years; SD_{age} = 2.11 years) was used. Results showed the Peruvian version of BFI-15 (BFI-15p) has more consistent indicators regarding their internal structure (e.g., factor loadings) compared to the German (BFI-15a) version, an invariant structure between men and women, and a significant association with subjective well-being was found. Finally, the construct reliability and scores reliability reached adequate magnitudes. It is concluded that the BFI-15p has adequate psychometric properties for use in Chilean college students.
Keywords: personality; subjective well-being; validity; reliability

Resumen: El objetivo de esta investigación fue analizar la estructura interna de dos versiones del Big Five Inventory-15 (BFI-15), invarianza de medición y su relación con el bienestar subjetivo en estudiantes universitarios chilenos. Participaron 1011 estudiantes (mujeres = 54.80 %; M_{edad} = 21.55 años; DE_{edad} = 2.11 años). Los resultados indican que la versión peruana del BFI-15 (BFI-15p) tiene indicadores más consistentes con relación a su estructura interna (e.g., cargas factoriales) en comparación a la versión alemana (BFI-15a), así como una estructura invariante entre hombres y mujeres, y una asociación significativa con las dimensiones del bienestar subjetivo. Finalmente, la confiabilidad del constructo y de las puntuaciones alcanzó magnitudes adecuadas. Se concluye que el BFI-15p presenta propiedades psicométricas adecuadas para su uso en universitarios chilenos.
Palabras clave: personalidad; bienestar subjetivo; validez; confiabilidad

Resumo: O objetivo desta investigação foi analisar a estrutura interna de duas versões do Big Five Inventory-15 (BFI-15), invariância de medição e a sua relação com o bem-estar subjetivo em estudantes universitários chilenos. Participaram 1011 estudantes universitários (mulheres = 54.80%; M_{idade} = 21.55 anos; DP_{idade} = 2.11 anos). Os resultados indicam que a versão peruana do BFI-15 (BFI-15p) tem indicadores mais consistentes em relação à sua estrutura interna (por exemplo, cargas fatoriais) em comparação com a versão alemã (BFI-15a), bem como uma estrutura invariante entre homens e mulheres, e uma associação significativa com as dimensões do bem-estar subjetivo.

Por fim, a confiabilidade do construto e das pontuações atingiram magnitudes adequadas. Conclui-se que o BFI-15p apresenta propriedades psicométricas adequadas para uso em estudantes universitários chilenos.
Palavras-chave: personalidade; bem-estar subjetivo; validade; confiabilidade

The model of the Big Five factors

Personality is typically regarded as the set of characteristics that make an individual think, feel, and act in a unique way (McKnight et al., 2019), and, at its extreme, as a superordinate construct that encompasses various cognitive and non-cognitive elements (Dangi et al., 2020). Therefore, it refers to the individual's particularity and what distinguishes them from everyone else, as well as a set of stable and enduring psychological traits across time and situations, which allows for establishing a characteristic style of interaction with the physical and social context (Mõttus et al., 2017). According to Barbachán-Ruales et al. (2018), university students possess a multitude of traits intrinsic to their personality; however, this are revealed effectively when manifested in circumstances susceptible to being interpreted in the light of self-awareness. In this line, motivational agents are sought to drive them to study and face the challenges outlined in the educational sphere, granting them hope to achieve their aims and purposes.

Personality could be conceived as a system determined by traits and dynamic processes that intervene in the individual psychological process, and although there are some approaches that highlight these elements, the model of the Big Five factors (BFF) (McCrae & Costa, 1999, 2004) is one of the most important and is the most recognized taxonomy for assessing personality traits (Zhang et al., 2019). Over the last decades, the BF model has been acknowledged as a primordial representation of prominent and non-pathological personality traits, whose modification contributes to the emergence of personality disorders, such as antisocial, borderline, and narcissistic disorders (Angelini, 2023).

The BFF model indicates that individuals are characterized by a pattern of thoughts, feelings, and actions that can be grouped around five dimensions: neuroticism, extraversion, openness, agreeableness, and conscientiousness (McCrae & Costa, 2004). Its validity, universality, and longitudinal stability have been supported by empirical research (e.g., McAdams & Pals, 2006), as this model tends to be stronger in Western cultures than in non-Western ones, as well as with similar levels of education and income (Rammstedt et al., 2013). However, it is also known that it does not replicate in some contexts (e.g., Fetvadjiev & van der Vijver, 2015), as modifications made to various scales alter both the instrument and the interpretations of the items (e.g., Fetvadjiev & van der Vijver, 2015), which drives the creation of other theoretical personality models oriented towards specific idiosyncrasies (e.g., Gurven et al., 2013). This suggests that cultural and ethnic differences can influence how personality traits are expressed and perceived. Although the Big Five model provides a relevant framework for understanding human personality, it is important to recognize the need for complementary approaches in certain cultures and ethnicities.

The first dimension, neuroticism, is characterized by the tendency to experience negative affect (sadness, fear, anger, guilt, etc.), being associated with emotional stability and emotion management, which translates into vulnerability and anxiety (Zhang et al., 2024). Thus, it can predict a lower ability to cope with adverse events (Angelini, 2023; Zuo et al., 2024). The second dimension, extraversion, is associated with a sociable state characterized by assertiveness and confidence, meaning those who appreciate socializing with others and teamwork, who are emotionally positive (Bertoquini & Ribeiro, 2006), and are capable of individually impacting the interaction of the belonging group (Barry & Friedman, 1998). The third dimension called openness is related to imagination, curiosity, originality, diversified and non-traditional interests, proactive intellectual activity, and preference for tasks involving cognitive complexity (McCrae & Costa, 1997). The fourth dimension, agreeableness, is characterized by sympathy, flexibility, trust, tolerance, and concern for others, with a prosocial orientation and preference for the development of group activities (Costa & McCrae, 1992), which would facilitate the establishment of positive interpersonal relationships. The last dimension, conscientiousness, refers to organization, self-discipline, persistence, prudence, and planning ability (Kaftan & Freund, 2018) to achieve personal goals, as well as being associated with greater self-control and a lower level of aggressive externalization (McCrae & Costa, 1999).

As previously stated, personality assessment is relevant in the university setting for both research purposes and applied contexts, either due to its evolutionary relevance regarding differences

according to sex or age (e.g., Zhang et al., 2024; Zhao et al., 2024), or its association with relevant variables such as academic performance (conscientiousness; Vedel, 2014), academic motivation (neuroticism and conscientiousness; McGeown et al., 2014), procrastination (neuroticism and openness; Ocansey et al., 2020), motivational self-regulation (conscientiousness; Ljubin-Golub et al., 2019), academic dishonesty (conscientiousness and agreeableness; Giluk & Postlethwaite, 2015), academic self-efficacy (conscientiousness and openness; McIlloy et al., 2015), social support (extraversion; Barańczuk, 2019), academic burnout (neuroticism; Prada-Chapoñan et al., 2020; agreeableness and neuroticism; Araújo, 2024), or subjective well-being (Nunes et al., 2009).

Personality and Gender Differences

Evolutionary or sociocultural differences between men and women are evident in the manifestation of their behaviors in specific environments (Schmitt et al., 2017), making it relevant to have valid and reliable measures to expose these differences. For example, previous studies indicate that sex differences with respect to the Big Five personality traits are inconclusive, as while female university students show higher scores in all five personality traits (Bunker et al., 2021; Sander & Fuente, 2020), other studies show that women scored higher in extraversion, agreeableness, and neuroticism than men (Liu et al., 2024), and for other authors, men score higher in openness, extraversion, and conscientiousness (Abdel-Khalek, 2021). On the other hand, in other studies, women were found to score higher in extraversion, conscientiousness, and openness, while scoring similarly in agreeableness and neuroticism (Bunnett, 2020; Dominguez-Lara et al., 2019). However, sometimes groups are compared without providing evidence of measurement invariance (Pendergast et al., 2017), which could lead to questioning the legitimacy of the differences found as they could be attributed to aspects unrelated to the construct (bias).

Personality and subjective well-being

Subjective well-being (SWB) refers to a set of emotional and cognitive assessments made about various areas of life (Diener et al., 2009). On one hand, the cognitive dimension corresponds to life satisfaction (LS), which is the overall evaluation process of one's life (Emmons, 1986) that arises from the comparison between the individual's current and ideal life circumstances, considering important elements such as goals, values, or culture (Calleja & Masón, 2020). On the other hand, the emotional dimension is constituted by positive affect (PA) and negative affect (NA; Diener et al., 2002), which represent emotional elements (pleasure, happiness, distress, etc.). Thus, high SWB includes various positive emotional experiences, few negative emotional experiences (e.g., depression or anxiety), and LS understood as a whole. In this way, it is understood that different life trajectories, personality traits, brain architecture, as well as the environment and culture in which individuals find themselves, influence the individual and subjective perspective of well-being (Oguntayo et al., 2024; van Valkengoed et al., 2023).

In this line of thought, one of the most studied predictors of SWB is personality (Lucas, 2018), specifically from the Big Five model, providing two explanations about the association between these constructs. Firstly, there is talk of a temperamental model, which explains the direct relationships between underlying physiological systems and the affective experiences individuals have, and secondly, an instrumental model that understands well-being as an indirect outcome of the conditions individuals create based on their personality traits (Lucas, 2018; McCrae & Costa, 1991).

So, neuroticism and extraversion can be related to SWB through the mechanisms inherent in both models. For example, from the temperamental model, the level of SWB experienced by individuals with high neuroticism and extraversion can be partially justified by their basic affective levels and the intensity of the emotional responses that characterizes them (McCrae & Costa, 1991). Regarding the instrumental model, conscientiousness and openness are considered important traits, although not determinants for SWB (McCrae & Costa, 1991); however, the confidence of extraverts to face life, as well as the situational perception of threat and concern for potentially stressful events experienced by individuals with a high degree of neuroticism, help change the perception of the context and, consequently, affect SWB (Margolis & Lyubomirsky, 2018).

Regarding the relationship between personality and SWB, empirical evidence indicates that extraversion is directly related to positive affect (PA) and life satisfaction (LS); conscientiousness is directly associated with LS and PA, and both extraversion and conscientiousness are inversely related

to negative affect (NA). Neuroticism is linked to elevated levels of NA, as well as low levels of LS and PA (Anglim et al., 2020; Carmona-Halty & Rojas-Paz, 2014; Jensen et al., 2020; Kobylińska et al., 2022).

The Big Five Inventory and its Short Versions

As mentioned, the importance of personality for predicting individual behavior is clear, so it is relevant to assess it with instruments that have evidence of reliability and validity. Thus, while a variety of scales are used for this purpose, one of the most well-known and widely used freely accessible instruments is the Big Five Inventory (BFI; John et al., 1991), which has a standard Spanish version free of regionalisms, facilitating its understanding in different Spanish-speaking contexts (Benet-Martínez & John, 1998). It is not overly lengthy (44 items), is freely accessible (users do not need to purchase usage rights) and has psychometric studies in the Latin American context (Dominguez-Lara et al., 2018; Salgado et al., 2016) and recently in Chilean university students (Lara et al., 2021).

The BFI assesses the BFF dimensionally and has various short versions that provide a more comprehensive assessment of the model's dimensions. This is useful especially when evaluating more than one construct in the same study within the framework of explanatory designs and when maximizing respondent participation, or when time or space available to evaluate the construct is quite short. For example, there are 10-item version (Rammstedt & John, 2007) and 15-item version (Gerlitz & Schupp, 2005; Marcos et al., 2023; Zhang et al., 2019) with two and three items per dimension respectively, which show acceptable results in the Western European context (Courtois et al., 2020; Guido et al., 2015; Rammstedt, 2007), although their psychometric quality decreases when analyzed in different contexts (Dominguez-Lara & Merino-Soto, 2018a; Kim et al., 2010; Kunnel et al., 2019).

From this situation, an alternative 15-item version was generated (BFI-15p; Dominguez-Lara & Merino-Soto, 2018a) that presents favorable psychometric evidence at the level of internal structure in Peru and Mexico (Dominguez-Lara & Merino-Soto, 2018b; Dominguez-Lara et al., 2022). It is of interest to analyze its suitability in a Chilean sample considering the importance of personality in the academic field (Mammadov, 2022) because, as far as is known, there are no brief instruments that measure this construct, which could also contribute to conducting future transnational studies in the field of personality. Additionally, the analysis of measurement invariance according to sex was a recommendation from previous studies that, due to methodological issues, could not be executed (Dominguez-Lara & Merino-Soto, 2018b; Dominguez-Lara et al., 2022).

The present study

Validity evidence regarding internal structure is important as it allows us to conclude whether the item configuration is consistent with previous theory (Steyn & Ndofirepi, 2022). Therefore, the study analyzed whether the internal structure of the two versions of the BFI-15 (Peruvian and German) is compatible with the Big Five model in Chilean university students, considering the item distribution and magnitude of factorial loads.

Regarding the internal structure of the BFI-15, it is expected that the Peruvian model will receive greater support in the Chilean sample than the German model due to geographical proximity and shared cultural aspects (Hypothesis 1).

The literature indicates that the dimensions of the BFF model are theoretically and empirically linked (Dominguez-Lara et al., 2018; Jensen et al., 2020; Lara et al., 2021), so positive associations are expected between the extraversion, agreeableness, conscientiousness, and openness dimensions, and negative associations between these dimensions and neuroticism (Hypothesis 2). Regarding reliability, it is expected that the calculated coefficients (α and ω) will reach acceptable magnitudes (> .70; Hypothesis 3), and that the measure with greater structural support (BFI-15p or BFI-15a) presents evidence of measurement invariance between men and women (Hypothesis 4).

Finally, it is necessary to implement other procedures to provide more validity evidence, especially those involving constructs theoretically related to enrich the initial findings. In this regard, it is expected that the personality dimensions of the BFI-15 will be significantly associated with the dimensions of SWB: LS, PA, and NA. Specifically, the following direction of correlations: PA and LS will show a positive association with extraversion, agreeableness, conscientiousness, and openness, while the association of these dimensions with NA will be negative. On the other hand, neuroticism will show a positive association with NA and a negative association with PA and LS (Hypothesis 5).

Method

Design

This is an instrumental study (Ato et al., 2013) aimed at studying the psychometric properties of two versions of the BFI-15 (Peruvian and German), regarding internal structure, association with other variables, and reliability.

Participants

Using non-probabilistic convenience sampling, the present study included 1011 Chilean university students (54.80% female) aged between 18 and 30 years (M = 20.55; SD = 2.11). The students were enrolled in different higher education institutions affiliated with the Consortium of State Universities of Chile, studying in the first (23%), second (27%), third (30%), and fourth year (20%) and in various study programs: psychology (18%), social work (12%), engineering (25%), kinesiology (15%), nursing (19%), and physics (11%). The inclusion criteria for participation in the study were being of legal age and enrolled in an institution affiliated with the Consortium of State Universities of Chile.

Instruments

The Spanish version of the Big Five Inventory (BFI; Benet-Martínez & John, 1998) was used to assess personality. The BFI evaluates the BFF factors (extraversion, agreeableness, conscientiousness, neuroticism, and openness) using 44 items with five response options ranging from Strongly Disagree (1) to Strongly Agree (5). It is worth mentioning that the validated extensive version in Chile (Lara et al., 2021) was not used as a base because it lacks some items necessary to structure the Peruvian and German versions (items 11, 22, 26, 28, 38). Thus, the 15-item German (Gerlitz & Schupp, 2005) and Peruvian (Dominguez-Lara & Merino-Soto, 2018a) versions were structured based on the BFI items as shown in Table 1.

Table 1
Configuration of each dimension according to the model

	Model	
	Germany	Peru
Extraversion	1, 6(I), 43	1, 11, 43
Neuroticism	9(I), 26, 38	4, 15, 30
Conscientiousness	3, 25(I), 29	14, 21, 34
Agreeableness	22(I), 28, 37	7, 37, 41
Openness	5, 17, 20	17, 23, 39

Note. I: Inverted Items.

Furthermore, in addition to the BFI, the three dimensions of SWB (SWLS, PA, and NA) were evaluated. Specifically, the Spanish translation of the Satisfaction with Life Scale (SWLS; Diener et al., 1985) conducted by Atienza et al. (2000) was used. The SWLS assesses overall life satisfaction through five items with scores ranging from completely disagree (1) to completely agree (7). Adequate reliability and validity indicators have been found in the Chilean population (Vera-Villarroel et al., 2012).

Additionally, the Spanish translation of the Positive and Negative Affect Schedule (PANAS; Watson et al., 1988) developed by Robles and Paéz (2003) was used. PANAS includes 20 items (10 for positive affect and 10 for negative affect) with response options ranging from very little or none (1) to extremely (5). Adequate reliability and validity indicators have been found in the Chilean population (Dufey & Fernández, 2012).

Procedure

First, a linguistic analysis of the BFI was conducted to detect comprehension difficulties. Specifically, three expert judges determined whether the BFI items might not be understood by the target population (e.g., Chilean university students). During this stage, no items were objected to or modified. In the second stage, invitations to participate in the study were sent through the institutional channels of the Consortium of State Universities to various Heads of Departments. At this stage,

documentation regarding the study's objectives and needs was sent to the departments that agreed to collaborate. In the third stage, the procedure involved contacting students in their respective classrooms, formalizing their participation through written consent that included the study's objectives and general aspects, and finally administering the instrument individually, anonymously, and voluntarily, using a pencil-and-paper procedure. This procedure was conducted in accordance with the principles of the Declaration of Helsinki (World Medical Association, 1964).

Data Analysis

Regarding the preliminary descriptive analysis, skewness and kurtosis indices are considered acceptable if they are around 2 and 7, respectively (Finney & DiStefano, 2006). For the structural analysis, an analysis based on exploratory structural equation modeling (ESEM; Asparouhov & Muthén, 2009) was implemented using the WLSMV estimation method, based on polychoric matrices, for the two proposed structures (BFI-15a and BFI-15p). Oblique target rotation (ε = .05; Asparouhov & Muthén, 2009) was used, whereby the loading of the item on the primary factor was freely estimated, and secondary loadings were specified as close to zero (∼0).

The models were evaluated based on their fit indices as well as the magnitude of the factor loadings (measures of construct representativeness). In this regard, the CFI (> .90; Marsh et al., 2004), RMSEA (< .08; Browne & Cudeck, 1993), and WRMR (≤ 1.00; DiStefano et al., 2018) were assessed. Factor loadings close to .60 were expected considering the number of items per dimension (Dominguez-Lara, 2018). Furthermore, since ESEM provides information on factor loadings in secondary factors (cross-loadings), the factor simplicity index (FSI) was calculated to assess the relevance of these. A FSI greater than .70 (Fleming & Merino-Soto, 2005) would indicate that the item is influenced to a greater extent by a single factor. For this purpose, Mplus version 7 was used.

The construct reliability was estimated using the coefficient ω (> .70; Hunsley & Marsh, 2008). As a preliminary step to calculating the α coefficient, the assumption of tau-equivalence (Dunn et al., 2014) was analyzed, which refers to the statistical equality of factor loadings within each dimension. Thus, the variation of the $\chi 2$ statistic was considered, where a statistically significant difference between the congeneric and tau-equivalent models indicates that the assumption is not met. The DIFFTEST command in Mplus (Asparouhov & Muthén, 2006) was used for this procedure.

Regarding the reliability of the scores, given the sample size (> 300) and the number of items (< 6), Cronbach's α coefficients above .70 were considered acceptable (Ponterotto & Ruckdeschel, 2007). However, considering that the α coefficient is sensitive to the number of items and the fulfillment of tau-equivalence, the average inter-item correlation (rij > .20; Clark & Watson, 1995) was also implemented.

Subsequently, measurement invariance of the best short version between men and women was analyzed using a multigroup factorial analysis. This procedure involves a gradual restriction of equivalence in internal structure (configurable invariance), factor loadings (weak invariance), thresholds (strong invariance), and residuals (strict invariance) across groups (Pendergast et al., 2017). Thus, measurement invariance is supported based on the variation of fit indices CFI and RMSEA (ΔCFI > -.01, ΔRMSEA < .015; Chen, 2007).

Finally, the association between the dimensions of the BFI-15 and the dimensions of subjective well-being (life satisfaction, PA, and NA) was evaluated using Pearson's correlation coefficient. An effect size approach was employed, considering a correlation greater than .20 as significant: between .20 and .50, low association; between .50 and .80, moderate association; above .80, high association (Ferguson, 2009). It's worth mentioning that the association between the dimensions of the BFI-15 was assessed based on the magnitude of the interfactor correlation according to the parameters established above.

Results

Regarding the descriptive analysis, the skewness and kurtosis of all items were acceptable (Table 2). In terms of validity evidence based on internal structure, both the German model (CFI = .977; RMSEA [90%] = .053 [.044, .062]; WRMR = .630) and the Peruvian model (CFI = .995; RMSEA [90%] = .029 [.019, .040]; WRMR = .393) showed acceptable indicators.

Table 2. *Descriptive analysis of the items*

			Descriptive analysis			
Dimension	Item	Descriptor	*M*	*SD*	g1	g2
Extraversion	1	Talkative	3.69	1.09	-0.58	-0.36
	6	Reserved	2.83	1.28	0.17	-1.01
	11	Energetic	3.76	1.03	-0.64	-0.14
	16	Quiet	3.38	1.26	-0.28	-0.95
	27	Shy	3.23	1.23	-0.10	-1.02
	32	Enthusiastic	3.71	0.99	-0.48	-0.27
	40	Assertive	3.74	1.03	-0.63	-0.16
	43	Sociable	3.74	1.09	-0.57	-0.45
Neuroticism	4	Melancholic	2.27	1.22	0.60	-0.69
	9	Controlled	2.67	1.11	0.29	-0.62
	15	Tense	2.95	1.22	0.03	-0.99
	19	Stable	2.31	1.04	0.61	-0.11
	26	Worried	3.80	0.99	-0.53	-0.28
	30	Temperamental	2.62	1.25	0.23	-0.98
	35	Calm	2.24	1.01	0.66	-0.09
	38	Nervous	2.89	1.22	0.10	-0.96
Conscientiousness	3	Thorough	3.90	0.99	-0.62	-0.21
	8	Careless	2.62	1.10	0.35	-0.63
	14	Reliable	4.02	0.96	-0.93	0.50
	18	Disorganized	3.40	1.23	-0.34	-0.85
	21	Persistent	4.12	0.95	-0.96	0.40
	25	Lazy	3.74	1.22	-0.63	-0.63
	29	Efficient	4.00	0.86	-0.66	0.28
	34	Organized	3.50	1.03	-0.36	-0.45
	42	Distracted	2.72	1.19	0.19	-0.85
Agreeableness	2	Critical	2.47	0.97	0.44	-0.15
	7	Generous	4.07	0.83	-0.77	0.58
	13	Confrontational	3.41	1.16	-0.13	-0.99
	22	Rude	4.05	1.11	-1.01	0.08
	24	Confident	3.64	1.03	-0.55	-0.23
	28	Indulgent	3.31	1.22	-0.27	-0.90
	33	Distant	3.17	1.14	0.06	-0.80
	37	Kind	3.98	0.90	-0.67	-0.08
	41	Supportive	4.07	0.88	-0.77	0.15
Openness	5	Innovative	3.88	0.94	-0.57	-0.19
	10	Open	3.87	1.00	-0.69	-0.09
	12	Routine-oriented	3.64	1.17	-0.43	-0.77
	17	Art-sensitive	3.91	1.12	-0.82	-0.14
	20	Imaginative	4.10	0.93	-1.01	0.76
	23	Inventive	3.86	0.98	-0.65	0.00
	31	Clever	3.81	0.93	-0.56	0.05
	36	Thoughtful	3.98	0.91	-0.66	0.03
	39	Knowledgeable	3.55	1.19	-0.47	-0.65
	44	Rejects art	3.81	1.18	-0.64	-0.50

Notes. *M:* Mean; *SD*: Standard Deviation; g1: Skewness; g2: Kurtosis.

Regarding the magnitude of factor loadings, the Peruvian model (Table 4) and the German model (Table 3) both exhibit one and four loadings of low magnitude (< |.50|), respectively. Additionally, the Peruvian model displays the most straightforward factorial structure (only one complex item; Table 4), unlike the German model, which has six (40%) complex items (Table 3).

Thus, although the five-factor structure is favorably recovered in both cases, the Peruvian model emerges as the more parsimonious one with better factor loading parameters (Hypothesis 1 is supported).

On the other hand, concerning inter factorial correlations, the German model showed five non-significant correlations (< .20), whereas the Peruvian model only presented one. Therefore, the second hypothesis receives support for the Peruvian model.

Table 3
ESEM analysis and factorial simplicity of the BFI-15a.

	F1	F2	F3	F4	F5	FSI
Item 1	*.71*	-.04	.15	.09	.04	.92
Item 6 (I)	*.60*	-.03	-.27	-.10	-.10	.76
Item 43	*.72*	.12	.04	-.05	.07	.95
Item 22 (I)	-.06	*.57*	.25	-.13	-.20	.67
Item 28	-.01	*.33*	-.17	-.01	.17	.60
Item 37	.16	*.66*	.01	.14	.12	.85
Item 3	-.03	-.10	*.70*	.14	.12	.90
Item 25 (I)	-.02	.22	*.54*	-.20	-.19	.63
Item 29	.03	.15	*.55*	-.04	.19	.80
Item 9 (I)	.15	-.24	.00	*.25*	-.28	.32
Item 26	.09	.12	.24	*.38*	.12	.54
Item 38	-.14	.05	-.17	*.70*	-.08	.87
Item 5	.04	-.09	.14	-.10	*.71*	.91
Item 17	.07	.19	.04	.22	*.38*	.55
Item 20	.03	.05	-.03	-.09	*.85*	.98
F1	1					
F2	.21	1				
F3	.10	.50	1			
F4	.05	-.04	-.07	1		
F5	.32	.40	.30	.12	1	

Notes. (I): Inverted item; in italics: factor loadings on the theoretical factor; F1: Extraversion; F2: Agreeableness; F3: Conscientiousness; F4: Neuroticism; F5: Openness; FSI: Factorial simplicity index.

Table 4
ESEM analysis and factorial simplicity of the BFI-15p

	F1	F2	F3	F4	F5	FSI
Item 1	*.75*	-.04	.06	.16	-.04	.93
Item 11	*.37*	.07	.16	-.23	.12	.51
Item 43	*.86*	.08	-.13	-.03	-.02	.96
Item 7	-.04	*.78*	.08	.00	-.01	.98
Item 37	.10	*.63*	.03	-.03	.10	.94
Item 41	.11	*.72*	.02	-.05	.07	.95
Item 14	.00	.18	*.64*	.05	-.11	.87
Item 21	.01	-.07	*.84*	-.02	.10	.97
Item 34	-.01	.01	*.53*	.00	.00	1.00
Item 4	-.05	.03	-.06	*.72*	-.01	.98
Item 15	-.03	.10	.06	*.65*	-.02	.96
Item 30	.07	-.23	.02	*.61*	.09	.82
Item 17	-.03	.19	-.02	.15	*.67*	.86
Item 23	.13	-.07	.15	-.10	*.55*	.81
Item 39	-.06	-.02	-.08	.00	*.80*	.98
F1	1					
F2	.47	1				
F3	.35	.53	1			
F4	-.34	-.21	-.29	1		
F5	.46	.42	.45	-.10	1	

Notes. (I): Inverted item; in italics: factor loadings on the theoretical factor; F1: Extraversion; F2: Agreeableness; F3: Conscientiousness; F4: Neuroticism; F5: Openness; FSI: Factorial simplicity index.

Preliminary to the reliability analysis, tau-equivalence was examined, which did not receive support in the Peruvian version ($\Delta\chi^2 = 94.47$; $\Delta df = 10$; $p < .001$) nor in the German version ($\Delta\chi^2 = 138.89$; $\Delta df = 10$; $p < .001$). However, Cronbach's alpha coefficient is reported for descriptive purposes.

According to Table 5, the German version shows the lowest indicators of construct and score reliability. Specifically, regarding Cronbach's alpha coefficient, the BFI-15p reaches magnitudes close to the required minimum (≈ .70), although the average inter-item correlation was acceptable in all cases. The German version does not reach the established minimum in both cases.

Finally, the omega coefficient reaches acceptable magnitudes in all dimensions of the BFI-15p, and in the BFI-15a, it only exceeds .70 in two dimensions. Therefore, the Peruvian version presents better indicators of construct reliability and scores (Hypothesis 3).

Table 5
Reliability coefficients

	F1	F2	F3	F4	F5
Score reliability					
α_{german}	.63	.42	.58	.29	.67
$\alpha_{peruvian}$	.69	.78	.66	.65	.68
r_{german}	.37	.21	.33	.11	.42
$r_{peruvian}$	.43	.55	.39	.38	.42
Construct reliability					
ω_{german}	.72	.53	.63	.43	.70
$\omega_{peruvian}$	.72	.76	.72	.70	.72

Notes. F1: Extraversion; F2: Agreeableness; F3: Conscientiousness; F4: Neuroticism; F5: Openness; α: Cronbach's alpha coefficient; r: average inter-item correlation; ω: omega coefficient.

Measurement invariance by gender

For this stage, only the Peruvian version was considered, given its structural characteristics and reliability compared to the German version. According to the variation in fit indices (Table 6), there is evidence of measurement invariance between men and women (Hypothesis 4).

Regarding the evidence of validity based on the relationship with other variables, in general terms, the dimensions of neuroticism and responsibility show a significant relational pattern with the dimensions of subjective well-being as expected (Table 7). These results provide support for hypothesis 5.

Table 6
Measurement invariance by gender and age

	CFI	RMSEA	CI RMSEA	ΔCFI	ΔRMSEA
Baseline					
Men	.991	.041	.024, .056		
Women	.997	.024	.000, .040		
Measurement invariance					
Configural	.996	.023	.007, .033		
Weak	.994	.023	.011, .032	-.002	.000
Strong	.994	.023	.011, .032	.000	.000
Strict	.992	.025	.016, .033	-.002	.002

Notes. CFI: Comparative Fit Index; RMSEA: Root Mean Square Error of Approximation; CI: Confidence Interval; Δ: Change.

Table 7
Relationship between subjective well-being and personality

	LS	AP	AN
Extraversion	.37	.44	-.26
Neuroticism	-.27	-.39	.58
Conscientiousness	.29	.32	-.14
Agreeableness	.24	.34	-.17
Openness	.27	.25	-.11

Notes. LS: life satisfaction; PA: positive affect; NA: negative affect.

Discussion

The research described here aimed to gather evidence of validity based on the internal structure of two versions of the BFI-15 in Chilean university students, as well as their association with subjective well-being (SWB). Given the reported evidence, it is estimated that this objective has been achieved.

In terms of internal structure analysis, although the magnitude of fit indices is a reasonable indication of dimensionality, favorable magnitudes consistently appear in the context of ESEM analysis, but they do not guarantee a solid internal structure due to the presence of cross-loadings (e.g., Lara et al., 2021). Therefore, it is desirable to consider other elements associated with internal structure such as the magnitude of factor loadings and factorial simplicity. In addition to ensuring model validity, models with inconsistent or excessively complex factor loadings can indicate issues with data interpretation or with the instrument's own structure (Matos & Rodrigues, 2019).

In this regard, only one item from the Peruvian version of the BFI-15 (BFI-15p) shows a low loading and is factorially complex in the Chilean participant group, but in the German version (BFI-15a), more items with these characteristics were observed. These results align with the study conducted on Peruvian university students (Dominguez-Lara & Merino-Soto, 2018a), where the German proposal did not succeed because the items were not sufficiently associated to consolidate a dimension, impacting both the construct representativeness (factor loadings below expectations) and factorial simplicity (presence of factorial complex items). Likewise, the findings are similar to those obtained with Mexican university students, where the BFI-15p received favorable evidence regarding its internal structure in that group (Dominguez-Lara et al., 2022). It is worth noting that those items categorized as "complex" in the BFI-15a are the reverse-scored items, reaffirming the recommendation to minimize or refrain from their use due to the methodological issues they bring (see Suárez-Alvarez et al., 2018). This could be explained by cultural proximity (Rammstedt et al., 2013), as there are more similarities between Chile and Peru and Mexico, where the BFI-15p works well, than with Germany, where its version does have favorable evidence in neighboring countries (e.g., Courtois et al., 2020).

Regarding reliability, the performance of the BFI-15p stands out in terms of construct reliability (> .70). However, the reliability of the scores was decisive, as while the Peruvian version showed acceptable results (≈ .70), this was not the case for the German version (< .60). This situation becomes more complex when considering that neither of the models met tau-equivalence, implying that reliability is underestimated (Candrinho et al., 2023; Dunn et al., 2014), and given the values of the ω coefficient, the BFI-15p appears to be the most efficient. This significantly impacts decision-making, as it is known that the magnitude of score reliability (α coefficient) of a variable negatively affects subsequent statistical analyses (Merino-Soto, 2020). Additionally, the α coefficient depends on the number of items and compliance with tau-equivalence (Candrinho et al., 2023), so the average inter-item correlation was used as a complementary measure of score reliability (Gallego et al., 2024), but even in those circumstances, the BFI-15a performs poorly compared to the BFI-15p.

In this regard, only the BFI-15p shows better performance in terms of construct reliability and scores. This pattern was observed in other studies, where the score reliability of the German version was quite low (Dominguez-Lara & Merino-Soto, 2018a; Kim et al., 2010; Kunnel et al., 2019), while the BFI-15p showed coefficients of greater magnitude (Dominguez-Lara et al., 2022; Dominguez-Lara & Merino-Soto, 2018a, 2018b).

In view of these findings, it is necessary to note that the presence of low magnitudes of the coefficient α, even with acceptable fit indices, could be associated with both the brevity of the scale and the breadth of the construct being evaluated (Stanley & Edwards, 2016). In any case, it should be noted that these magnitudes are not useful for making decisions derived from the individual use of the instrument in a professional setting; they are only useful for research-related contexts.

Regarding invariance, favorable evidence was found in both men and women, allowing for fair comparisons. In this regard, it would be interesting to study these differences in the future, as it would be a pioneering study considering the use of brief versions.

The magnitude and direction of the associations between the dimensions of the BFI-15p and the dimensions of the SWB align with previous evidence (Anglim et al., 2020; Carmona-Halty & Rojas-Paz, 2014; Jensen et al., 2020; Kobylińska et al., 2022). This provides further evidence of validity insofar as a personality profile characterized by low neuroticism, high extraversion, high agreeableness, and high conscientiousness would facilitate the development of positive cognitive perspectives as well as more

stable and satisfying relationships (Serrano et al., 2020). Depending on the level of a particular personality trait, individuals will develop more positive (or negative) affects in response to different events they experience in their lives, which will directly impact their satisfaction, an important aspect in the university context.

Regarding the practical implications of the results, the BFI-15p presents a distinctive feature compared to other instruments for this purpose: its reduced number of items. Thus, its use reduces the possibility of random or unconscious responses that could affect the results. Additionally, the parsimony of the BFI-15p reduces the likelihood of survey refusal due to time constraints. This is especially relevant as researchers use various scales in studies, and the use of shortened scales like the BFI-15p can minimize these issues. This allows, for example, rapid application in various situations, such as psychological assessment in selection processes or institutional research to evaluate professionals. Furthermore, the importance of continuing the assessment of personality traits in the university context is emphasized. The specificity of this context requires special attention to the well-being, quality of life, and mental health of students, justified by the evidence observed in the various studies cited above on the relationship between these variables and personality traits. Additionally, it is useful to have a brief version of the BFI that presents adequate psychometric properties in other countries in the region, as this would facilitate cross-cultural research because it is known that, at least individually, the internal structure is satisfactorily replicated. Thus, in conjunction with the validation of the full version in Chile (Lara et al., 2021), there are more tools available for academics and researchers to continue enriching the knowledge about the construct in this part of the continent, given its relevance throughout a person's life (Mõttus & Rozgonjuk, 2021).

Concerning the study's strengths, it's important to highlight the large sample size (> 1000), which allowed for greater precision in the estimations. Similarly, the use of ESEM should be emphasized, as it is currently the best option for representing a complex model like the Big Five, rather than a confirmatory factor analysis (e.g., Chiorri et al., 2016). However, there were also limitations inherent in the method, such as biases associated with self-report scales, especially in this context, as well as the lack of representativeness of the data concerning the Chilean university population. Although the large sample size reduces sampling error, generalization should be approached with caution.

In conclusion, the BFI-15p is deemed as an instrument with adequate psychometric properties for use in Chilean university students: it exhibits a solid internal structure, appropriate reliability indicators, and coherent associations with dimensions of subjective well-being, a construct of paramount importance guiding public policies in European countries (Calleja & Masón, 2020).

Furthermore, for future replication studies, it is recommended to incorporate additional external variables to deepen the understanding of the validity of score interpretations of this measure. Additionally, other forms of response quality control could be employed to minimize biases in overestimation and underestimation of personality traits. However, given the large sample size and the procedures used in this research, the data suggest the suitability of the BFI-15p. Similarly, future studies could employ probabilistic sampling and conduct a comparative analysis by gender, as the theoretical argumentation, state-of-the-art analysis, and empirical evidence go beyond the objectives of this manuscript. Lastly, exploring the temporal stability of the dimensions and conducting an invariance analysis by country of origin would be beneficial due to the importance of personality in different contexts (Dash et al., 2019; Thielmann et al., 2020; Zell & Lesick, 2022).

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