UNVEILING THE LATENT HIERARCHY OF PERSONALITY: A HIGHER-ORDER GRADED RESPONSE MODEL APPROACH TO THE INDONESIAN BIG FIVE INVENTORY-2

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Abstract: Personality traits influence how well university students adjust academically, how motivated they are to learn, and their overall well-being. To assess these traits in Indonesia, a valid and culturally sensitive instrument is required. This study evaluated the Indonesian Big Five Inventory-2 (BFI-2-BI) using the Higher-Order Graded Response Model (HO-GRM) with data from 710 undergraduate students. The HO-GRM successfully captured the hierarchical structure of personality at the domain and facet levels, outperforming a unidimensional model. The items performed well, the facets reflected meaningful cultural patterns, and the parameters showed strong measurement precision. The findings support the use of the BFI-2-BI as a reliable and culturally appropriate tool for assessing personality in higher education, with implications for research and counseling. The study also demonstrates the theoretical value of the HO-GRM in clarifying the latent hierarchy of personality.

Keywords: Big five inventory-2, personality assessment, higher-order graded response model, hierarchical structure, and cross-cultural validity.

INTRODUCTION:

Empirical findings across various fields underscore the critical role of personality in understanding human behavior, particularly in educational contexts (Liang et al., 2024; Lukman et al., 2021). University students encounter various academic, social, and emotional challenges that require psychological adaptation. The influence of personality on students' navigation of challenges, engagement with peers, and pursuit of academic objectives has been a subject of considerable research (Campos et al., 2024; Jusri & Lechner, 2025). A substantial body of research has consistently demonstrated the pivotal role of personality in academic adjustment during the nascent stages of university life (Erzen & Ozabaci, 2023; Jusri & Lechner, 2025), academic achievement (Shchebetenko et al., 2023), and the duration required to complete university studies (Brunton & Sugden, 2025; Wilson et al., 2022). Research indicates that, beyond factors such as adaptation, academic success, and study duration, personality also contributes fundamentally to other psychological attributes within the university environment, including academic motivation (Apostolov & Geldenhuys, 2022; Fuertes et al., 2020). As indicated in the review of literature, several factors have been identified as contributing to academic performance, including learning strategies (Albar et al., 2022), academic dishonesty (Hendy & Biderman, 2019), religiosity (Abdel-Khalek et al., 2023), academic self-efficacy (Wang et al., 2023), academic confidence (Sander & de la Fuente, 2020), and learning satisfaction (Rodrigues et al., 2024). These empirical findings highlight the urgency of personality research. However, the development of culturally appropriate assessment tools capable of comprehensively and accurately capturing personality traits is equally important (Kawashima et al., 2024; Vorvolakos et al., 2021). Recent theoretical work has also reexamined how cultural factors shape the expression and structure of personality traits (Allik et al., 2023; Benjamin & Guan, 2020; McCrae, 2021), suggesting that cross-cultural equivalence (construct, metric, scalar) must be explicitly tested in new translations and adaptations (Kong et al., 2022; McLarnon & Romero, 2020).

The Big Five personality model, based on trait theory, is firmly established in psychological assessment due to its utility in distinguishing general and specific personality traits (Bainbridge et al., 2022; Du et al., 2021). The model's hierarchical organization reflects the multilevel nature of personality, ranging from broad dispositional tendencies to more specific facet-level expressions (Castro et al., 2020; Danner et al., 2021; Nielsen & Kajonius, 2024; Williams & Carlson, 2024). This perspective provides a coherent theoretical link between personality structure and measurement models, underscoring the psychometric importance of assessing both domains and facets to capture individual differences.

Based on this theoretical foundation, the Big Five Inventory-2 (BFI-2) was designed as a standardized inventory that operationalizes these hierarchical principles. It has been applied across diverse cultural contexts (Siraji et al., 2025; Smederevac et al., 2024). The BFI-2 was constructed through rigorous psychometric procedures integrating advancements in personality theory and measurement methodology (Burro et al., 2025; Soto & John, 2017a, 2017b; Калугин et al., 2021). The BFI-2 is structured into a hierarchical arrangement of five broad domains, with each domain encompassing three nested facets that assess more specific traits. Furthermore, the instrument was designed to minimize acquiescence response bias (Soto & John, 2017b).

These design features aimed to enhance the accuracy of personality predictions and strengthen the utility of the BFI-2 as a measure of the Big Five dimensions (Denissen et al., 2020; Halama et al., 2020; Soto & John, 2017a, 2017b). Recent meta-analyses confirm that the BFI-2 is highly reliable across cultures and that analyses at the facet level reveal significant structural variation in how facets contribute to domains in different populations (Husain et al., 2025).

This hierarchical structure has significant implications for test development, psychometric analysis, and the validity of score interpretations (Akaeze et al., 2023; Loevinger, 1957; Reise & Revicki, 2015; Shaw & Flake, 2023). Recent scholarship emphasizes that ignoring hierarchical structures can obscure the interplay between general domains and specific facets, potentially leading to biased estimates of construct validity (Ringwald et al., 2023; Trizano-Hermosilla et al., 2021). Modeling these nested levels explicitly not only mitigates such risks but also allows researchers to gain a more nuanced understanding of how personality traits function across different cultural and educational contexts. Building on this need for precise modeling, the Higher-Order Item Response Model (HO-IRM) provides a robust framework for simultaneously estimating multiple latent traits (De la Torre & Song, 2009; Joo et al., 2023; Watkins et al., 2023). In this model, each item targets a specific facet-level trait while domain scores capture broader personality domains, enabling concurrent estimation of both levels with high precision.

The HO-IRM is a general framework for estimating multiple latent traits, while the HO-GRM is a specific implementation optimized for graded response data that allows for the simultaneous estimation of domain- and facet-level personality traits with high precision. Within the IRT framework, the HO-GRM facilitates concurrent estimation of general and specific personality traits with high precision, thereby enhancing both the structural understanding and measurement accuracy of personality (Fu et al., 2020; Zhang & Wang, 2021). Beyond statistical precision, the HO-GRM also strengthens theoretical claims about the hierarchical nature of personality, bridging psychometric modeling with contemporary personality theory. This integration highlights the model's capacity to advance both methodological rigor and theoretical understanding of personality, offering insights that extend beyond purely numerical evaluation (Boudreaux & Ozer, 2015; Huang & Wang, 2014; Huang et al., 2013; Wang, 2014). Applying the HO-GRM to the Indonesian version of the Big Five Inventory-2 (BFI-2-BI) allows for a culturally grounded evaluation of personality traits, capturing both domain-level and facet-level characteristics. By modeling these nested levels explicitly, this study provides a nuanced understanding of how the BFI-2-BI functions in Indonesia's higher education context, addressing gaps left by previous validations that primarily used Classical Test Theory (CTT) and did not account for hierarchical structure.

The BFI-2 has been widely translated. Global studies have confirmed the psychometric robustness of BFI-2 across various languages (Denissen et al., 2020; Føllesdal & Soto, 2022; Halama et al., 2020; Hausding & Horstmann, 2023; Hrebicova et al., 2020; Pires et al., 2023; Rammstedt et al., 2024; Shchebetenko et al., 2020; Smederevac et al., 2024; Toledo-Fernández et al., 2022; Vedel et al., 2021; Zhang et al., 2022). However, the majority of internal structure validations have relied on CTT, with only a few studies applying IRT approaches (Burro et al., 2025; Yoshino et al., 2022) and even fewer accounting for the inventory's inherent hierarchical structure, thereby limiting the depth of measurement validity. In the Indonesian context, previous psychometric evaluations of the BFI-2 have not yet employed IRT, and existing findings do not reflect measurement quality at the facet level (Ahya & Siaputra, 2022), which is critical for a nuanced and culturally grounded understanding of personality. Despite its advantages, the HO-GRM has yet to be applied to validate the BFI-2 in Indonesia.

This study aims to evaluate the psychometric properties of the Indonesian version of BFI-2 using the HO-GRM framework. This approach was chosen for its ability to comprehensively capture the hierarchical structure of personality traits beyond traditional measurement models. The study addresses the urgent need to develop personality inventories that are psychometrically robust and culturally relevant for the Indonesian population. University students were selected as the target population for strategic reasons. The HO-GRM framework was chosen after careful consideration. First, HO-GRM enables multilevel analyses that distinguish the contributions of specific facets to broader domains. Second, the HO-GRM provides a stronger framework for evaluating construct validity within Indonesia's cultural context. These findings are expected to provide the empirical foundation for culturally sensitive personality assessment tools, especially in higher education settings.

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METHOD

This study employed a quantitative approach and surveyed 710 undergraduate students from various Indonesian universities. Of those students, 508 (71.55%) were female and 202 (28.45%) were male. All participants were between 18 and 24 years old (mean = 19.10, standard deviation = 0.98). The instrument used was the Indonesian version of the Big Five Inventory-2 (BFI-2-BI), which comprises 60 items—four for each facet—that are rated on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). After receiving ethical clearance from the institutional ethics committee, the researchers collected data online via email and social media platforms. Ethical approval was granted by the Jawatankuasa Etika Penyelidikan Manusia, Universiti Sains Malaysia (JEPeM-USM; Protocol Code: USM/JEPeM/22010071). All participant responses were anonymized and treated confidentially to ensure data privacy. The sample size of 710 is considered adequate for higher-order applications of the graded response model, as supported by prior empirical and simulation studies (de la Torre & Hong, 2010; Depaoli et al., 2018; Kehinde et al., 2022; Valdivia & Dai, 2024). The psychometric evaluation of the BFI-2-BI was performed using the HO-GRM within the IRT framework. Analyses were conducted using the MIRT package in R.

RESULTS AND DISCUSSION

Model and Item Fit

We compared the HO-GRM with a unidimensional graded response model (UniGRM) to assess the fit between the model and the data. Multiple indices were used to evaluate the fit of the models: Root Mean Square Error of Approximation based on the $M2$ statistic ($RMSEA_{M2}$; Maydeu-Olivares & Joe, 2014); Akaike Information Criterion (AIC; Akaike, 1974); Bayesian Information Criterion (BIC; Schwarz, 1978); and differences in log likelihood ($-LL$) values, as assessed by the likelihood ratio test (LRT). A model was considered a better fit if it showed lower AIC and BIC values and significant improvement in $-LL$ (Bader & Moshagen, 2025; Johansson et al., 2024). According to the criteria proposed by Maydeu-Olivares and Joe (Maydeu-Olivares & Joe, 2014; Sathyanarayana S & Mohanasundaram, 2024; Savalei et al., 2024), a model shows an adequate fit when $RMSEA_{M2}$ is less than .089, a close fit when $RMSEA_{M2}$ is less than .050, and an excellent fit when $RMSEA_{M2}$ is less than .0125.

The results indicated that the HO-GRM exhibited superior fit compared to the UniGRM. The HO-GRM demonstrated substantially lower AIC and BIC values despite increased model complexity, suggesting a more parsimonious and accurate data representation. $RMSEA_{M2}$ values for four of the five domains Extraversion (.044), Agreeableness (.080), Negative Emotionality (.042), and Open-Mindedness (.081)—fell within the "adequate to close" fit range. Although Conscientiousness had a slightly higher $RMSEA_{M2}$ value (.091), it still represented an improvement over the UniGRM (.099). The LRT between the HO-GRM and UniGRM was statistically significant ($p < .050$), providing empirical evidence that the HO-GRM more adequately captured the underlying data structure. Fit indices are summarized in Table 1.

TABLE 1 Results of the Goodness of Fit Test of BFI-2-BI's Domains

Domains	Models	$M2$	$RMSEA_{M2}$	AIC	BIC	LL	LRT	Fit Model
Extraversion	UniGRM	79.10**	.069	21671.04	21944.95	-10775.52		HO-GRM is more informative
	HO-GRM	36.35**	.044	21502.18	21789.79	-10688.09	174.86**	
Agreeableness	UniGRM	134.11**	.095	20893.99	21167.91	-10387.00		HO-GRM is more informative
	HO-GRM	84.52**	.080	20754.78	21042.40	-10314.39	145.21**	
Conscientiousness	UniGRM	143.29**	.099	20491.87	20765.79	-10185.93		HO-GRM is more informative
	HO-GRM	105.01**	.091	20339.93	20627.54	-10106.96	157.95**	
Negative-Emotionality	UniGRM	89.10**	.074	22407.86	22681.78	-11143.93		HO-GRM is more informative
	HO-GRM	34.25**	.042	22264.56	22552.17	-11069.28	149.30**	
Open-Mindedness	UniGRM	79.35**	.069	20943.44	21217.36	-10411.72		HO-GRM is more informative
	HO-GRM	86.02**	.081	20427.03	20714.64	-10150.51	522.41**	

Note: ** $p < .001$. AIC = Akaike Information Criterion, BIC = Bayesian Information Criterion, $-LL$ = -Log Likelihood, LRT = Likelihood Ratio Test. $RMSEA_{M2}$ = Root Mean Square Error of Approximation $M2$.

These findings empirically support the theoretical assumption of a hierarchical personality structure within the Big Five framework. The HO-GRM confirms that individual items load onto specific facets, which represent broader personality domains. This configuration reflects the facet-within-domain nesting explicitly adopted in the development of the BFI-2 (Soto & John, 2017b). It is also consistent with Cattell's original theoretical perspective, in which facets (specific traits) are considered distinct manifestations of higher-order traits (common traits) (Babcock & Wilson, 2020; Cattell & Mead, 2008; Cattell, 1943; Musek, 2024; Nielsen & Kajonius, 2024; Williams & Carlson, 2024). Previous studies have consistently reported evidence for this hierarchical structure (Costa & McCrae, 1995; DeYoung et al., 2007; Hofstee et al., 1992; Mottus et al., 2017; Saucier & Ostendorf, 1999; as cited in Soto & Jackson, 2020). These results not only demonstrate the robustness of the BFI-2-BI measurement model but also reinforce the broader applicability of hierarchical trait modeling in personality assessment. It also aligns with the measurement model Soto & John (Soto & John, 2017b) adopted in developing the BFI-2, which was explicitly designed to reflect this facet-level nesting within overarching domains. Thus, the results substantiate both the empirical validity of the measurement model and the multidimensional, hierarchical nature of personality.

The evaluation of item fit revealed that all BFI-2-BI items exhibited *RMSEA S-X²* values below .05, thereby meeting the established cutoff for an acceptable fit (Bean, 2021; Zein & Akhtar, 2025). These results suggest that the HO-GRM adequately represents participant response patterns and that the hierarchical design of the BFI-2-BI effectively captures the construct structure. The *S-X²* and *RMSEAS-X²* values are documented in Table 2.

These findings carry substantial implications for the validity and reliability of the measurement (Paek, 2022; Petrillo et al., 2024). Initially, all items exhibited a consistent behavior with the assumptions of the hierarchical model. The hierarchical model posits that item responses are influenced by a specific trait (facet) that is nested under a broader trait (domain). Secondly, the items' satisfactory fit strengthens the instrument's internal validity, thereby suggesting that the responses to the items conform to the proposed model's expectations.

Facet-Level Parameter Estimates

The subsequent analysis of facet-to-domain parameter estimates within the BFI-2-BI structure revealed that facet contributions did not always align with the theoretical hierarchy initially proposed in developing the BFI-2. These findings are critical for enhancing our understanding of how personality structures manifest within the Indonesian cultural context, particularly among emerging adults such as university students. In line with recent cross-cultural research, these results indicate that the hierarchical structure of the BFI-2 shows a considerable degree of invariance across translations and cultural contexts (Rammstedt et al., 2024). For extraversion, the strongest contributor was energy level with a beta coefficient ($\beta = .94$), followed by assertiveness ($\beta = .82$) and sociability ($\beta = .81$). Contrary to the predominant literature on the subject, which emphasizes Sociability as the primary facet of Extraversion (Goldberg, 1999; Soto & John, 2017b), this study found that energy level dominated. This pattern suggests that among Indonesian university students, Extraversion is predominantly manifested through enthusiasm and active engagement, rather than through social boldness or interpersonal openness. This tendency may be attributable to the demands of academic life, which prioritize cognitive and physical engagement over social interaction (Akaeze et al., 2023; Marenco-Escuderos et al., 2023; Soares et al., 2021).

Within the construct of Agreeableness, Trust emerged as the most salient facet, with a beta coefficient ($\beta = .87$). This was followed by Respectfulness ($\beta = .83$) and Compassion ($\beta = .80$). Although Compassion is theoretically emphasized as the affective core of Agreeableness (Goldberg, 1999; Hofstee et al., 1992; Soto & John, 2017b), the findings of this research indicate that Trust in others is more central for Indonesian youth. The centrality of trust in this context is likely indicative of Indonesia's collectivist cultural values, in which interpersonal trust and social harmony are foundational The prominence of Respectfulness in this context underscores the cultural emphasis on politeness, deference, and social etiquette (Nashori et al., 2020; Pratama et al., 2024; Suryahadi et al., 2024).

The Conscientiousness domain demonstrated a notably stable psychometric structure, with Productiveness ($\beta = .92$), Responsibility ($\beta = .92$), and Organization ($\beta = .89$) all contributing nearly equally. This consistency mirrors the findings of international studies that have highlighted Conscientiousness as a domain with a strong, cohesive internal structure (Føllesdal & Soto, 2022; Yoshino et al., 2022; Zhang et al., 2022). In the Indonesian context, this stability signifies that Conscientiousness is expressed in both universal and culturally reinforced manners. Among Indonesian students, conscientious behavior is characterized by personal responsibility, structured planning, and productive effort—traits that are emphasized from early education through university that align with the universal facets of Conscientiousness.

For Negative Emotionality, Depression ($\beta = .96$) and Anxiety ($\beta = .95$) emerged as the predominant facets. Concurrently, Emotional Volatility exhibited a diminished contribution ($\beta = .76$). Although Anxiety is con-

ceptually considered the core facet of this domain, the Indonesian sample emphasized depressive symptoms—such as hopelessness and emotional fatigue—as more central. The prevalence of depressive symptoms in this population may be associated with academic stress, future uncertainty, and the transitional challenges characteristic of emerging adulthood (Cui et al., 2024; Dalmış et al., 2025; Henriques et al., 2024; Mwita et al., 2025; Newcomb-Anjo et al., 2017; Ramadianto et al., 2022). The lower weight of Emotional Volatility may reflect cultural norms that discourage overt emotional expression in favor of maintaining social harmony (Bebko et al., 2019; Istiqlal et al., 2022; Suryaningrum, 2021; Virdiyanti, 2025; Wei et al., 2013), as substantiated by recent research from Indonesia that emphasizes how cultural values influence emotional control.

Finally, the subject's Open-Mindedness manifested a distinctive pattern of contributions. Intellectual Curiosity ($\beta = .82$) and Creative Imagination ($\beta = .82$) exhibited a strong predictive capacity for the domain. Conversely, Aesthetic Sensitivity exhibited a considerably less substantial contribution, with a beta value of .56. In contrast to other domains, Open-Mindedness was not designed with a single dominant facet due to ongoing debate about whether it reflects intellect, imagination, or aesthetics (DeYoung, 2015; Soto & John, 2017b). In the context of Indonesian higher education, the pronounced contributions of curiosity and imagination likely reflect the significance of intellectual exploration and creativity in academic life (Ma et al., 2025). Conversely, aesthetic interests may be regarded as less pivotal to students' daily functioning (Qiao & Jiang, 2023a, 2023b), suggesting that, in this population, openness is more closely tied to academic and creative engagement than to aesthetic appreciation.

These results suggest that facet-level contributions to each domain are not entirely invariant across contexts and are likely shaped by cultural and developmental factors. Utilizing a student sample to represent emerging adulthood, this study provides critical insights into the potential variability of internal domain structures of the BFI-2-BI. These findings underscore the importance of contextually grounded interpretations in cross-cultural personality assessment and the need to empirically evaluate local facet contributions before concluding personality profiles.

Item Parameter Estimates

Item discrimination was interpreted based on the criteria proposed by Baker and Kim (2004, 2017). According to Baker and Kim (Baker & Kim, 2004, 2017; Siraji & Haque, 2022; Zein & Akhtar, 2025; Zorowitz et al., 2023), values of $0.01 \leq a \leq 0.34$ are classified as very low; values of $0.35 \leq a \leq 0.64$ are classified as low; values of $0.65 \leq a \leq 1.34$ are classified as moderate; values of $1.35 \leq a \leq 1.69$ are classified as high; values of $a > 1.70$ are classified as very high; and values of $a = +\infty$ (infinity) are classified as perfect. Most item parameter estimates revealed high to very high discrimination values, indicating strong capability in distinguishing individuals based on levels of the underlying trait. This pattern was especially pronounced in the Conscientiousness and Negative Emotionality domains, where several items exhibited extremely high discrimination ($a > 2.30$), reinforcing the instrument's sensitivity in measuring these constructs. Nonetheless, a few items showed moderate discrimination, and one item (item 22R under Respectfulness; $a = 0.63$) was identified as having low discrimination. Although still within an acceptable range, items with moderate to low-performance warrant further examination in future validation studies (Belay et al., 2022; Ebel & Frisbie, 1991; Xie & Cobb, 2020).

The threshold parameters ($b1$–$b4$) showed that the BFI-2-BI accurately captures a broad spectrum of trait levels. The thresholds ranged from –6.66 to 4.80 across all items, indicating the instrument's capacity to detect extremely low and high personality traits. This distribution improves measurement precision across the latent continuum (Samejima, 1969; Terluin et al., 2023; Zein & Akhtar, 2025). However, extremely skewed thresholds may raise concerns about item targeting. For instance, Item 35 (Open-Mindedness) with $b1 = -6.66$ and item 24R (Negative Emotionality) with $b4 = 4.80$ are likely only informative for individuals at the extreme ends of the trait spectrum. While these items contribute to extended trait coverage, their practical utility in general populations should be further evaluated, including the potential for measurement bias (Dåderman et al., 2025). Complete parameter estimates, including β coefficients, discrimination, and thresholds, are presented in Table 2.

TABLE 2 BFI-2-BI's Items and Facets Parameter

Domains/Facet/ Items	β	Item Fit		Item Parameters				
		S-X^2	$RMSEA_{S-X^2}$	a	$b1$	$b2$	$b3$	$b4$
Extraversion								
Sociability	.81							
1		59.21	.01	1.63	-3.47	-1.97	-0.07	1.29
16R		86.29	.02	1.60	-1.58	-0.44	1.11	2.31
31R		77.65	.02	1.51	-1.55	-0.19	1.34	2.71

Domains/Facet/ Items	β	Item Fit		Item Parameters				
		$S\text{-}X^2$	$RMSEA_{S\text{-}X^2}$	a	b1	b2	b3	b4
46		79.46	.02	1.70	-2.73	-1.22	0.51	1.95
Assertiveness	.82							
6		79.48	.02	1.10	-4.50	-2.20	0.24	2.13
21		74.19	.01	1.59	-2.69	-1.25	0.61	2.03
36R		91.23	.02	0.72	-4.83	-2.21	0.72	3.67
51R		91.90	.01	0.95	-3.11	-1.31	0.86	2.67
Energy Level	.94							
11R		64.71	.00	1.33	-3.02	-1.63	0.03	1.70
26R		98.35	.02	1.44	-2.02	-0.69	0.68	2.27
41		49.34	.01	2.40	-3.09	-1.82	-0.13	0.87
56		47.98	.00	1.53	-4.07	-2.58	-0.44	1.16
Agreeableness								
Compassion	.80							
2		57.41	.02	2.06	-3.37	-2.12	-0.83	0.53
17R		51.01	.01	2.00	-3.44	-2.15	-0.92	0.44
32		43.95	.01	2.07	-3.53	-2.46	-0.71	0.95
47R		57.35	.02	2.11	-3.17	-2.32	-1.08	0.21
Respectfulness	.83							
7		76.64	.02	1.56	-3.57	-2.37	-0.92	0.23
22R		77.03	.02	0.63	-6.23	-4.21	-2.08	0.37
37R		96.38	.02	0.80	-4.02	-1.80	-0.02	1.96
52		91.97	.03	1.36	-2.72	-1.25	0.58	1.77
Trust	.87							
12R		65.49	.01	0.99	-4.04	-2.79	-1.14	0.58
27		76.87	.02	1.04	-5.10	-3.35	-1.41	0.53
42R		95.77	.02	0.76	-2.86	-0.94	1.21	3.38
57		57.88	.00	1.04	-4.71	-2.89	-0.28	1.57
Conscientiousness								
Organization	.89							
3R		59.13	.02	2.72	-2.33	-1.07	0.00	1.18
18		57.37	.01	2.09	-3.15	-1.44	0.02	1.30
33		86.05	.03	1.78	-3.44	-2.19	-0.85	0.50
48R		79.00	.02	1.32	-3.66	-2.22	-1.07	0.34
Productiveness	.92							
8R		50.43	.00	1.76	-2.69	-1.33	0.33	1.55
23R		80.47	.02	1.93	-2.18	-0.57	0.74	1.80
38		72.91	.02	2.30	-2.39	-1.07	0.25	1.46
53		56.94	.02	2.40	-2.72	-1.54	-0.29	1.05

(Table 2 continues)
(Table 2 (continued)

Domains/Facet/ Items	β	Item Fit		Item Parameters				
		$S\text{-}X^2$	$RMSEA_{S\text{-}X^2}$	a	b1	b2	b3	b4
Responsibility	.92							
13		90.24	.02	1.38	-3.03	-1.90	-0.36	1.87
28R		125.93	.03	1.13	-1.78	0.29	1.67	2.49
43		76.10	.02	1.47	-3.15	-2.41	-0.44	1.39
58R		77.69	.01	1.19	-3.22	-1.25	0.31	2.07
Negative-Emotionality								
Anxiety	.95							
4R		88.00	.02	1.49	-1.73	-0.47	1.00	2.79

Domains/Facet/ Items	β	Item Fit		Item Parameters				
		$S\text{-}X^2$	$RMSEA_{S\text{-}X^2}$	a	$b1$	$b2$	$b3$	$b4$
19		68.28	.00	1.80	-2.41	-1.43	-0.20	1.16
34		58.35	.00	1.76	-3.07	-2.01	-0.70	0.55
49R		90.98	.01	1.37	-2.39	-1.34	0.12	1.52
Depression	.96							
9R		63.24	.00	1.95	-1.62	-.61	0.42	1.63
24R		123.34	.03	0.90	-1.90	0.00	2.44	4.80
39		83.23	.02	1.68	-2.43	-1.34	-0.26	0.95
54		64.05	.01	2.96	-1.44	-0.64	0.23	1.22
Emotional Volatility	.76							
14		109.34	.02	1.02	-3.67	-2.05	-0.42	1.17
29R		61.44	.00	1.40	-1.93	-0.63	1.10	2.85
44R		76.08	.01	1.31	-1.59	0.06	1.98	3.91
59		84.39	.01	1.27	-2.34	-0.85	0.67	2.28
Open-Mindedness								
Aesthetic Sensitivity	.56							
5R		82.76	.02	1.14	-3.54	-2.11	-0.37	1.35
20		92.79	.03	1.35	-3.80	-2.38	-0.61	1.00
35		50.51	.02	1.03	-6.66	-5.39	-2.30	-0.02
50R		53.72	.01	1.22	-5.08	-3.73	-1.79	0.23
Intellectual Curiosity	.82							
10		59.29	.02	1.19	-5.17	-3.65	-1.48	0.49
25R		77.56	.01	0.89	-2.79	-0.92	1.28	3.10
40		63.97	.02	1.17	-5.87	-3.48	-1.24	0.61
55R		94.52	.03	1.02	-3.63	-2.15	0.54	2.20
Creative Imagination	.82							
15		47.03	.01	2.14	-3.27	-1.71	0.18	1.60
30R		71.29	.02	1.56	-2.72	-1.45	0.29	1.84
45R		104.85	.03	0.74	-4.65	-2.99	-1.07	1.38
60		64.08	.02	1.84	-3.47	-1.72	0.44	1.65

Note: β = facet factor loading; a = item discrimination; b = threshold parameters; $S\text{-}X^2$ = standardized chi-square item-fit statistic; $RMSEA_{S\text{-}X^2}$ = root mean square error of approximation associated with the item-fit statistic.

These findings provide substantial evidence of the structural validity and psychometric soundness of the BFI-2-BI. The observed variability in facet contributions underscores the necessity of employing culturally responsive approaches that balance preserving theoretical construct integrity with local expressions of personality. The present study lends support to the implementation of the BFI-2-BI within the Indonesian context, thereby contributing to a more comprehensive understanding of cross-cultural personality assessment dynamics.

Information Function and Standard Error
The information function is pivotal in evaluating the measurement precision of psychological instruments across the latent trait continuum (Feuerstahler, 2022; Franchignoni et al., 2023; Keetharuth et al., 2021; Şahin Kursad, 2023). In this study, information was analyzed at three levels—item (Item Information Function, *IIF*), facet (Facet Information Function, *FIF*), and domain (Scale Information Function, *SIF*)—to assess the precision of the BFI-2-BI in capturing the five major personality domains. Results indicated that the instrument provides adequate and consistent information across various theta (θ) levels, with differing distributions across domains and facets. The findings of the study demonstrated that the instrument yielded sufficient and reliable data across various theta levels, exhibiting distinct distributions across domains and facets.
At the item level, maximum *IIF* values ranged as follows: Extraversion (0.63–3.87), Agreeableness (0.30–2.99), Conscientiousness (0.95–4.30), Negative Emotionality (0.76–2.57), and Open-Mindedness (0.42–2.53). These variations are indicative of differences in measurement sensitivity, with Conscientiousness demonstrating the highest overall precision. To our knowledge, previous validation studies of the BFI-2 have used CTT approaches predominantly and have not reported item-level information functions (Lignier et al., 2023; Danner et al., 2019; Denissen et al., 2020; Føllesdal & Soto, 2022; Gallardo-Pujol et al., 2022; Halama

et al., 2020; Hausding & Horstmann, 2023; Hrebicova et al., 2020; Pires et al., 2023; Rammstedt et al., 2024; Shchebetenko et al., 2020; Smederevac et al., 2024; Toledo-Fernández et al., 2022; Vedel et al., 2021; Yoshino et al., 2022; Zhang et al., 2022). This study builds on that literature by incorporating an IRT framework. This allows for a more precise evaluation of measurement accuracy across the latent continuum. These results affirm that the BFI-2-BI meets psychometric standards for measuring a broad range of personality traits.

Facet- and domain-level analyses yielded further insights into measurement coverage and peak information. The Conscientiousness scale demonstrated the highest peak values for both *FIF* and *SIF* (*FIF* = 4.32–10.52; *SIF* = 24.52; *SE* < 0.50), indicating exceptional precision across a broad range of θ, particularly from –0.50 to +1.00. The facets that contributed the most information were Productiveness (*FIF* = 10.52; *SE* = 0.31 at θ = +1.00) and Organization (*FIF* = 9.98 at θ = 0.00; *SE* = 0.32). These results confirm their central role as indicators of Conscientiousness.

In contrast, Agreeableness and Open-Mindedness exhibited optimal precision at lower trait levels (Agreeableness: *SIF* = 16.70; *SE* = 0.24 at θ = –2.50; Open-Mindedness: *SIF* = 13.10; *SE* = 0.28 at θ = –2.00). The observed peak measurement precision at the lower ends of these traits continually suggests that the BFI-2-BI is particularly effective in identifying individuals with lower tendencies in these traits—possibly reflecting sociocultural factors shaping the expression of personality in Indonesian populations. Compassion (*FIF* = 10.60; *SE* = 0.31 at θ = –2.50) and Creative Imagination (*FIF* = 6.46; *SE* = 0.39 at θ = 0.50) were the most informative facets within their respective domains.

The study found that Extraversion and Negative Emotionality exhibited balanced information profiles across the mid to high (Extraversion) and low (Negative Emotionality) θ ranges. Extraversion demonstrated optimal precision from θ = 0.00 to +1.00, driven by Energy Level (*FIF* = 7.48; *SE* = 0.37) and Sociability (*FIF* = 6.57; *SE* = 0.39 at θ = +1.00). Negative Emotionality was most precise between θ = –1.50 and –0.50, supported by strong information from Anxiety (*FIF* = 6.99; *SE* = 0.38) and Depression (*FIF* = 10.61; *SE* = 0.31). These patterns confirm the utility of these domains depending on the distribution of traits in the target population

The conversion of information function values into reliability coefficients revealed that facet-level reliabilities ranged from .72 to .91. In contrast, domain-level reliability values were notably higher (.93 to .96). These coefficients exceed the conventional threshold of .70, indicating strong internal consistency across the instrument (D'Avila et al., 2021; Nunnally & Bernstein, 1994; Siraji & Haque, 2022). Furthermore, the reliability values of the BFI-2-BI at the facet and domain levels are comparable to those reported for the original BFI-2, as well as for its adaptations in other languages. This suggests that the Indonesian version of the BFI-2 achieves a similar level of measurement consistency across cultural contexts (Rammstedt et al., 2024; Soto & John, 2017b).

In summary, the BFI-2-BI demonstrated adaptive measurement precision for evaluating traits across multiple latent levels. The construct of Conscientiousness was identified as the most precise and comprehensive, followed by Negative Emotionality. Extraversion was most effective for high-trait individuals, whereas Agreeableness and Open-Mindedness excelled in detecting low-trait profiles. The distribution of information functions reinforces the theoretical validity of domain structures and highlights the BFI-2-BI's applicability for IRT-based psychological assessment. Figure 1 presents the domain-level information functions, and Appendix A reports the summary of FIF, SIF, and SE values, along with reliability coefficients.
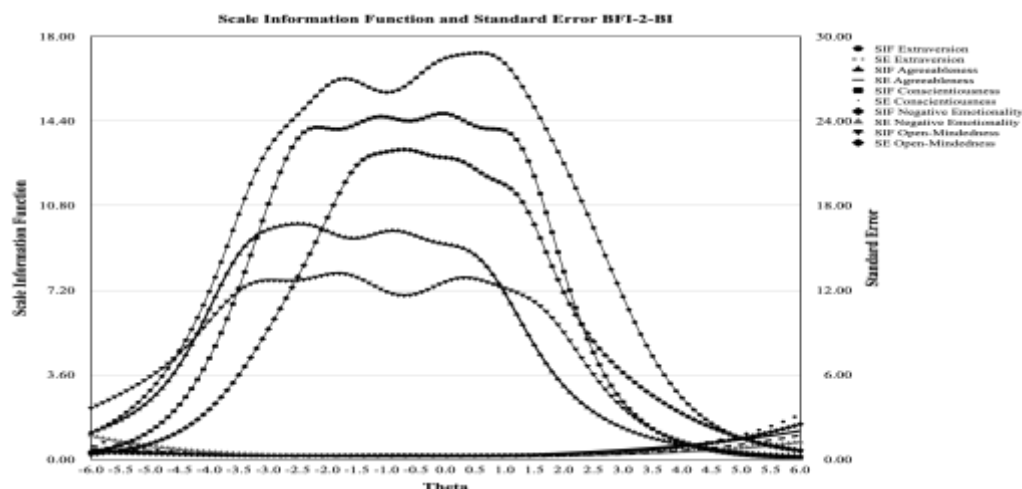

FIGURE 1 Scale Information Function and Standard Error

CONCLUSION

This study established the structural validity of the BFI-2-BI using the HO-GRM. The HO-GRM proved psychometrically robust, confirming that items coherently map onto facets and domains in line with the Big Five's hierarchical framework. This study addresses the prior lack of facet-level, IRT-based validation of the BFI-2 in Indonesia, providing new evidence on its hierarchical structure and cultural relevance. At the same time, the differential salience of specific facets—such as Energy Level in Extraversion and Trust in Agreeableness—highlighted how cultural and developmental contexts shape the manifestation of personality traits among Indonesian university students. These findings affirm the BFI-2-BI as a psychometrically sound and culturally sensitive measure of personality in higher education settings.

Beyond establishing validity, this study underscores the utility of the BFI-2-BI for psychological assessment and personality research in academic contexts. The instrument offers practical value for applications such as student counseling, academic guidance, and personality-based educational research. Future research should extend validation across demographic groups, non-student populations, and cultural settings to ensure measurement invariance and broaden the generalizability of the BFI-2-BI in cross-cultural contexts.

LIMITATIONS AND SUGGESTIONS

The present study has limitations due to its reliance on a homogeneous sample of Indonesian undergraduates aged 18–24. This restricts the generalizability of the findings beyond student populations. Additionally, the analyses focused solely on validity evidence based on the internal structure of the HO-GRM. This leaves other key sources of validity evidence, such as predictive, convergent, and discriminant validity, unaddressed. Future research should validate the BFI-2-BI among broader demographic groups, systematically test measurement invariance across Indonesia's diverse ethnic subcultures and genders, and incorporate additional sources of validity evidence to reinforce its status as a psychometrically robust and culturally sensitive measure of personality.

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APPENDIX A

Information Function, Standard Error, and Reliability

Facet/ Domain	Parameter	-3.00	-2.50	-2.00	-1.50	-1.00	-0.50	0.00	0.50	1.00	1.50
Sociability	FIF	3.92	4.84	5.67	6.20	6.32	6.35	6.44	6.53	**6.57**	6.39
	SE	0.51	0.45	0.42	0.40	0.40	0.40	0.39	0.39	**0.39**	0.40
	Reliability	.80	.83	.85	.86	.86	.86	.87	.87	**.87**	.86
Assertiveness	FIF	2.94	3.22	3.30	3.30	3.21	3.10	3.16	3.31	**3.36**	3.31
	SE	0.58	0.56	0.55	0.55	0.56	0.57	0.56	0.55	**0.55**	0.55
	Reliability	.75	.76	.77	.77	.76	.76	.76	.77	**.77**	.77
Energy Level	FIF	6.38	6.61	6.94	6.59	6.09	6.79	**7.48**	7.45	6.92	5.29
	SE	0.40	0.39	0.38	0.39	0.41	0.38	**0.37**	0.37	0.38	0.43
	Reliability	.86	.87	.87	.87	.86	.87	**.88**	.88	.87	.84
Extraversi	SIF	13.23	14.67	15.91	16.08	15.62	16.24	17.08	**17.29**	16.85	14.99
	SE	0.27	0.26	0.25	0.25	0.25	0.25	0.24	**0.24**	0.24	0.26
	Reliability	.93	.94	.94	.94	.94	.94	.94	**.95**	.94	.94
Compassion	FIF	10.41	**10.60**	10.07	9.57	10.04	9.74	9.27	8.82	6.71	3.78
	SE	0.31	**0.31**	0.32	0.32	0.32	0.32	0.33	0.34	0.39	0.51
	Reliability	.91	**.91**	.91	.91	.91	.91	.90	.90	.87	.79
Respectfulness	FIF	3.37	3.56	3.60	3.60	**3.61**	3.58	3.49	3.27	2.85	2.37
	SE	0.54	0.53	0.53	0.53	**0.53**	0.53	0.54	0.55	0.59	0.65
	Reliability	.77	.78	.78	.78	**.78**	.78	.78	.77	.74	.70
Trust	FIF	**2.54**	**2.54**	2.52	2.52	2.53	2.53	2.50	2.40	2.22	1.95
	SE	**0.63**	**0.63**	0.63	0.63	0.63	0.63	0.63	0.65	0.67	0.72

Facet/ Domain	Parameter	-3.00	-2.50	-2.00	-1.50	-1.00	-0.50	0.00	0.50	1.00	1.50
	Reliability	**.72**	**.72**	.72	.72	.72	.72	.71	.71	.69	.66
Agreeablenes s	SIF	16.31	**16.70**	16.19	15.69	16.18	15.84	15.26	14.48	11.79	8.11
	SE	0.25	**0.24**	0.25	0.25	0.25	0.25	0.26	0.26	0.29	0.35
	Reliability	.94	**.94**	.94	.94	.94	.94	.94	.94	.92	.89
Organizatio n	FIF	7.26	8.92	9.16	9.40	9.94	9.63	**9.98**	9.12	8.67	6.69
	SE	0.37	0.33	0.33	0.33	0.32	0.32	**0.32**	0.33	0.34	0.39
	Reliability	.88	.90	.90	.90	.91	.91	**.91**	.90	.90	.87
Productiven ess	FIF	6.98	9.61	10.04	10.15	10.08	10.10	10.28	10.36	**10.52**	9.31
	SE	0.38	0.32	0.32	0.31	0.32	0.31	0.31	0.31	**0.31**	0.33
	Reliability	.87	.91	.91	.91	.91	.91	.91	.91	**.91**	.90
Responsibili ty	FIF	3.88	4.23	4.28	4.24	4.27	**4.32**	4.26	4.15	4.14	4.07
	SE	0.51	0.49	0.48	0.49	0.48	**0.48**	0.48	0.49	0.49	0.50
	Reliability	.80	.81	.81	.81	.81	**.81**	.81	.81	.81	.80
Conscientio usness	SIF	18.12	22.76	23.47	23.79	24.28	24.05	**24.52**	23.63	23.32	2.07
	SE	0.23	0.21	0.21	0.21	0.20	0.20	**0.20**	0.21	0.21	0.22
	Reliability	.95	.96	.96	.96	.96	.96	**.96**	.96	.96	.95
Anxiety	FIF	4.61	5.96	6.76	**6.99**	**6.99**	6.95	6.81	6.54	5.98	4.89
	SE	0.47	0.41	0.38	**0.38**	**0.38**	0.38	0.38	0.39	0.41	0.45
	Reliability	.82	.86	.87	**.87**	**.87**	.87	.87	.87	.86	.83
Depression	FIF	2.17	3.79	6.57	9.71	10.53	**10.61**	10.36	9.90	9.44	7.83
	SE	0.68	0.51	0.39	0.32	0.31	**0.31**	0.31	0.32	0.33	0.36
	Reliability	.68	.79	.87	.91	.91	**.91**	.91	.91	.90	.89

(APPENDIX A continues)

APPENDIX A (continued)

Facet/ Domain	Parameter	-3.00	-2.50	-2.00	-1.50	-1.00	-0.50	0.00	0.50	1.00	1.50
Emotional Volatility	FIF	2.46	3.21	3.82	4.17	**4.29**	**4.29**	4.22	4.15	4.06	3.94
	SE	0.64	0.56	0.51	0.49	**0.48**	**0.48**	0.49	0.49	0.50	0.50
	Reliability	.71	.76	.79	.81	**.81**	**.81**	.81	.81	.80	.80
Negative- Emotionalit y	SIF	9.24	12.96	17.15	2.87	21.81	**21.85**	21.40	2.59	19.48	16.66
	SE	0.33	0.28	0.24	0.22	0.21	**0.21**	0.22	0.22	0.23	0.25
	Reliability	.90	.93	.94	.95	.96	**.96**	.96	.95	.95	.94
Aesthetic Sensitivity	FIF	3.66	**3.72**	3.71	3.66	3.64	3.63	3.55	3.33	2.94	2.37
	SE	0.52	**0.52**	0.52	0.52	0.52	0.53	0.53	0.55	0.58	0.65
	Reliability	.79	**.79**	.79	.79	.78	.78	.78	.77	.75	.70
Intellectual Curiosity	FIF	**3.13**	3.10	3.08	3.06	3.02	3.00	3.03	3.00	2.81	2.47
	SE	**0.57**	0.57	0.57	0.57	0.58	0.58	0.57	0.58	0.60	0.64
	Reliability	**.76**	.76	.75	.75	.75	.75	.75	.75	.74	.71
Creative Imagination	FIF	5.90	5.86	6.31	6.18	5.22	5.10	6.02	**6.46**	6.38	6.34
	SE	0.41	0.41	0.40	0.40	0.44	0.44	0.41	**0.39**	0.40	0.40
	Reliability	.86	.85	.86	.86	.84	.84	.86	**.87**	.86	.86
Open- Mindedness	SIF	12.68	12.68	**13.10**	12.90	11.88	11.73	12.59	12.79	12.13	11.18
	SE	0.28	0.28	**0.28**	0.28	0.29	0.29	0.28	0.28	0.29	0.30
	Reliability	.93	.93	**.93**	.93	.92	.92	.93	.93	.92	.92