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Psychometric network analysis of the Multidimensional Assessment of Interoceptive Awareness, version 2 (MAIA-2) in Peruvian adults

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Abstract

Interoception is a complex, multidimensional construct that refers to the nervous system's processing of internal bodily signals. Currently, there are no comprehensive measurement tools available to capture the full complexity of interoception. The Multidimensional Assessment of Interoceptive Awareness, Version 2 (MAIA-2), is a widely accepted and utilized interoceptive questionnaire that measures the multiple dimensions of conscious interoception through self-report. The aim of this study was to demonstrate the validity of a new Spanish translation of the MAIA-2 in Peruvian adults and to examine the dimensionality of the MAIA-2. A total of 414 Peruvian participants residing in Lima (Peru) were included; 85% were young adults between 18 and 27 years. The fit of the structural equation model (SEM) was assessed using confirmatory factor analysis (CFA). The dimensionality of the MAIA-2 was assessed using bootstrap exploratory bootstrap graph analysis (bootEGA). The results of the CFA suggest an oblique model (8 factors, 34 items) with modifications (items 11, 12, and 15 deleted). The bootEGA analyses indicate that a five-dimensional model is more parsimonious. These findings suggest that the MAIA-2 may have fewer dimensions than the original eight-dimensional theoretical model. The Peruvian Spanish version of the MAIA-2 proves to be a valid and reliable tool for assessing interoception in Peruvian adults, though slight variations in the dimensional structure were observed compared to the original model. This provides a solid basis for future research and clinical applications in Spanish-speaking contexts.

Keywords Interoception, Interoceptive awareness, Network analysis, Psychometric properties, MAIA-2

Introduction

Interoception is a complex, multidimensional construct that refers to the nervous system's processing of internal bodily stimuli, encompassing a range of physiological signals [1–3]. In recent years, several multidimensional theoretical models of interoception have been proposed, including those with three [2], four [4], six [5], and eight components [6]. A comprehensive multidimensional theoretical framework of interoception was recently developed based on the aforementioned three-, six-, and eight-component models [2,

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5–7]. This framework presents the following eight dimensions in ascending levels of interoceptive processing: *Neural Representation, Strength of Afferent Signals, Preconscious Impact of Afferent Signals, Interoceptive Accuracy, Self-Report and Interoceptive Beliefs, Interoceptive Insight, Interoceptive Attention, and Attribution of Interoceptive Sensations* [2].

The scientific study of interoception began more than a century ago [8], but research over the last two decades has revealed its importance for both physical and psychological health [6, 9]. Currently, efforts are being made to improve the understanding of various aspects of interoception at the neurophysiological [10–12], theoretical [1, 2, 4–7, 13–16], interventional [15, 17–19], and measurement levels [18, 20–22]. Additionally, recent studies highlight that interoceptive awareness is not solely determined by biological mechanisms but is also influenced by cultural, social, and environmental factors [16, 23]. These factors shape how individuals perceive, interpret, and respond to bodily sensations, underscoring the importance of considering contextual variables when assessing interoception in diverse populations.

The term "self-report and interoceptive beliefs" refers to assessments of individuals' beliefs about their interoceptive sensations and experiences, which may be either consciously accessible or not [2]. This term had also been referred to as "sensitivity" or "subjective measures" of interoception [2], with "interoceptive awareness" [6, 18], *frequently used as a synonym for "body awareness"* [13, 18, 20], as reflected in measures such as the Body Awareness Questionnaire. Interoceptive awareness has been defined as the multiple dimensions of conscious interoception that can be captured by self-report [18], but it has also referred to the relationship between "subjective measures" (e.g., Body Perception Questionnaire) and "objective measures" (e.g., heartbeat detection task) of interoception. Self-report questionnaires for interoception assess overarching beliefs that are thought to reflect more stable trait-like aspects of interoceptive awareness [2]. In clinical settings, these measures provide insights into the phenomenological experience of interoception and can complement behavioral or brain-based measures in predicting certain health outcomes [2, 17, 18]. Interoception assessed by questionnaires *("self-report and interoceptive beliefs")* typically shows positive changes associated with mindfulness-based interventions and other mind-body therapies in both clinical and non-clinical samples [14, 15, 24, 25]. These interventions include, for example, hatha yoga, meditation, Tai Chi, mindfulness, contemplative training (such as silent retreats and meditation), mindful awareness in body-oriented therapy, and mindfulness-based cognitive therapy (MBCT) [1, 14, 15, 17, 24].

The most frequently cited interoception questionnaires as measures of *"interoceptive sensitivity"* or *"self-report scales"* include the Body Perception Questionnaire (BPQ) [26], Body Awareness Questionnaire (BAQ) [27], Private Body Consciousness Sub-Scale (PBCS) of the Body Consciousness Questionnaire (BCQ) [28], Self-Awareness Questionnaire (SAQ) [29], and the Multidimensional Assessment of Interoceptive Awareness (MAIA) [14]. A systematic review, which informed the development of the MAIA, included twelve *"body awareness"* questionnaires, including those mentioned above, with the exception of the SAQ and MAIA [13, 20]. The BPQ contains items from other constructs, including exteroception (hearing) and attention [21]. The BAQ is intended to "measure beliefs about one's sensitivity to normal, non-emotive bodily processes"[13]. The PBCS is intended to measure the *"disposition to focus on internal body sensations," "awareness of interoceptive feedback,"* and *"sensitivity to changes in bodily states"* [13]. The SAQ was also designed to measure commonly felt body sensations, referred to as *"interoceptive awareness"* [29]. However, it contains two items that appear to be related to automatic imitation *("when somebody coughs, I feel like coughing too")* and tiredness (*"I feel breathless without engaging in any type of exertion or effort"*). Interoception questionnaires have been developed in various contexts as efforts continue to improve the understanding and conceptualization of self-reported interoception. This is reflected in recent studies indicating that interoception questionnaires assess different constructs, suggesting that their use should be differentiated based on specific assessment needs [3, 22, 30].

The MAIA is an interoception questionnaire created to measure the multiple dimensions of conscious interoception that can be captured by self-report [18]. This instrument is designed to distinguish between adaptive attentional modes, characterized by mindfulness, and less adaptive modes, which may be associated with preoccupation or distraction regarding bodily sensations [13, 20]. However, it is important to clarify that the MAIA is not designed to directly assess clinically 'maladaptive' aspects of interoception, such as somatosensory amplification or symptom hyperawareness. Instead, it focuses on assessing adaptability in the management of bodily sensations. Additionally, the MAIA is useful for evaluating the effectiveness of mind-body therapies in both clinical and experimental research contexts [20]. The MAIA theoretical model presents eight dimensions, which, in sequential order, involve ascending levels of conscious interoception. These dimensions are as follows: Noticing, Not-Distracting, Not-Worrying, Attention Regulation, Emotional Awareness, Self-Regulation, Body Listening, and Trusting [18, 20]. Items in the *"Not-Distracting"* and

"Not-Worrying" dimensions capture information about the maladaptive, anxiety-characterized attention mode of interoception, specifically regarding distraction and preoccupation with physical symptoms (e.g., *"I ignore physical tension or discomfort until they become more severe"* [Not-Distracting] and "I start to worry that something is wrong if I feel any discomfort" [Not-Worrying]) [14]. The items in the *"Attention Regulation," "Self-Regulation," "Body Listening,"* and *"Trusting"* dimensions capture information on the adaptive attentional mode of interoception, which is characterized by mindfulness [14].

Strengths of the MAIA include its multidimensionality, ability to differentiate between attentional modes of interoception, and sensitivity to treatment-associated changes [14]. In general, the weaknesses of the MAIA include low internal consistency in the "Noticing," "Not-Distracting," and "Not-Worrying" dimensions, [31] as well as a variable factor structure—ranging from eight, seven, six, to three factors—with modifications across various sociocultural contexts [32]. The MAIA-2 was developed after the addition of five new items to the Not-Distracting and Not-Worrying dimensions to improve their internal consistency [18]. Subsequently, several validation studies of the MAIA-2 have confirmed its original factor structure [33–36]. Measurement invariance between males and females was demonstrated across all dimensions except for "Not-Worrying" and "Attention Regulation" [36].

However, some validation studies of the MAIA-2 have reported psychometric deficiencies similar to those found in the MAIA [25, 37–39]. Specifically, low factor loadings have been reported for two items (5 and 6 [Not-Distracting]) [34]; along with low internal consistency in the "Noticing," [18, 33], "*Not-Worrying*" [18, 25], and "*Trusting*" [39], as well as difficulties in replicating the original factor structure, particularly with the proposed seven- [25, 37] and six-factor models [38, 39]. Due to these psychometric shortcomings of the MAIA-2, a 24-item short version of the MAIA-2 was recently developed, which confirmed the eight-factor structure and demonstrated measurement invariance between groups based on gender and sport participation [31].

Traditionally, statistical procedures to assess the dimensionality of a questionnaire have relied on factor analysis, such as exploratory factor analysis (EFA) [40]. In recent years, a new field of psychometrics called network psychometrics has emerged, proposing novel approaches to assess the dimensionality of constructs in multivariate data [40, 41]. These approaches include exploratory graph analysis (EGA) and bootstrap exploratory graph analysis (bootEGA) [41]. BootEGA is considered a novel and robust method in network psychometrics for estimating the stability of dimensions and items in multivariate data [41].

In our study, we emphasize that the BootEGA method, based on graph theory, offers an intuitive graphical visualization of the data structure and requires fewer statistical assumptions than traditional factorial methods. These features facilitate a more flexible and straightforward interpretation of the data, which is especially useful for identifying clusters of closely related items [42]. Although EGA may require specific technical skills and involve less conventional interpretation, its combination with bootstrap techniques in BootEGA provides additional statistical robustness, allowing for estimates of the stability of the detected clusters. This capability is particularly important in studies where the stability of the data structure is crucial [41]. In the current study, the application of BootEGA is justified by the nature of the data and the specific objectives of the research, providing a statistically sound and appropriate methodology for our analysis. To our knowledge, researchers have primarily used factor analysis to assess the dimensionality of the MAIA and MAIA-2, except for one study that applied EGA to analyze convergence among several interoceptive questionnaires [22].

The MAIA has been translated into approximately 30 languages, making it widely accepted for assessing interoception [18, 43]. Despite the existence of Chilean [44] and European Spanish translations [34], significant cultural and linguistic differences across Spanish-speaking countries justify the need for a new version tailored to Peruvian adults. Cultural factors, such as beliefs about the body and health practices specific to Peru, may influence interoceptive awareness and, consequently, affect the psychometric performance of the MAIA-2. For example, variations in educational levels, regional dialects, and conceptual understanding of interoceptive sensations can impact the accuracy and validity of assessments. In Peru, there has been growing interest in mindfulness practices, including yoga, meditation, and other mind-body therapies aimed at improving well-being [13]. While mindfulness questionnaires have been adapted locally, interoception questionnaires, such as the MAIA-2, have not yet undergone cultural adaptation [13]. Though versions of the MAIA have been adapted into Chilean Spanish and translated into European Spanish, a successful adaptation requires ensuring linguistic, cultural, conceptual, and metric equivalence to the original. This process involves considering the specific linguistic, cultural, and psychological characteristics of the target population. For example, the validation of the MAIA in a Colombian sample led to a modified seven-factor structure, highlighting the importance of ensuring that items

are comprehensible to participants, particularly university students [45, 46].

To ensure that the content holds similar meaning for all populations, evidence of content validity and response processes is essential [46, 47]. This can be obtained through methods such as expert judgments and cognitive interviews [25, 44]. It has been hypothesized that the linguistic and sociocultural characteristics of Peruvians (e.g., education level) could influence the comprehension of the MAIA-2. The present study aimed to demonstrate the validity of a new Spanish translation of the MAIA-2 in Peruvian adults and to examine its dimensionality. Furthermore, it is worth noting that other psychological questionnaires also have Peruvian adaptations, underscoring the importance of culturally relevant adaptations in psychometric assessments.

Based on previous studies indicating variability in the factor structure of the MAIA-2 across different cultural contexts, we hypothesize that the dimensionality of the newly translated MAIA-2 in Peruvian adults may differ from the original eight-factor model, potentially presenting fewer or modified factors due to cultural influences. Specifically, we anticipate that cultural beliefs and practices in Peru, such as traditional healing methods and local understandings of body awareness, may affect interoceptive awareness in unique ways compared to other Spanish-speaking countries. While the MAIA-2 has demonstrated strong psychometric properties in various studies, we also expect that certain dimensions, such as "Not-Worrying" and "Noticing," which have shown low reliability in other contexts, may present similar challenges in the Peruvian population.

Materials and Methods

Participants

A total of 491 individuals participated in the study, with 128 completing the survey online and 363 participating in person. Participants for the online survey were recruited through social media platforms, where the survey link was shared widely. Individuals were able to access and complete the survey from any location in Peru using their personal electronic devices, such as mobile phones or computers. For the in-person sample, participants were recruited from two educational institutions in Lima: a university and a military school. Surveys were administered in group settings by two trained psychology professionals who provided detailed verbal instructions and responded to any questions that arose during the completion of the questionnaires.

We excluded a total of 77 participants for the following reasons: 31 participants did not reside in the department/province of Lima, 14 participants had Venezuelan nationality, 12 were under 18 years of age, 8 did not provide essential sociodemographic data such as weight and sex, 7 did not accept the informed consent, and 5 submitted incomplete questionnaires with at least five missing data points. Cases with fewer than five missing data points (1–4 missing values) were included in the analysis, and the cross-tabulated mean was calculated for the missing data to ensure the robustness of the results.

Instruments

Sociodemographic data registration form

A questionnaire was developed to collect information on the following sociodemographic data: sex, age, weight, height, nationality, department/province of current residence, and educational level.

Multidimensional Assessment of Interoceptive Awareness, Version 2 (MAIA-2)

The MAIA is an interoception questionnaire designed to measure the multiple dimensions of conscious interoception that can be captured through self-report [2, 20]. The MAIA-2 has a structure of eight dimensions and 37 items that in sequential order involve ascending levels of interoceptive consciente: *Noticing* (4 items), Non-*Distracting* (6 reverse items), *Not worrying* (5 items, of which 3 are inverse), *Attention regulation* (7 items), *Emotional awareness* (5 items), *Self-regulation* (4 items), *Body listening* (3 items), and *Trusting* (3 items) [18]. The measurement scale is ordinal with six Likert-type response options (never = 0 to always = 5) [44, 48]. The eight factors presented the following internal consistency values: $\alpha = .64\text{-}.83$ (Mehling et al., 2018); ordinal $\alpha = .78\text{-}.95$ [35]; $\omega = .82\text{-}.93$ [36]. In this research, a version of the MAIA-2 translated into Spanish was used in the Peruvian context (see Supplementary material 1). In addition, the coding was modified, and the frequency options of the response format were completed (never = 1; almost never = 2; sometimes = 3; frequently = 4; almost always = 5, and always = 6), thus the instruction for calculating the inverse items also changed (7 - x). Since the direct items are scored on a scale of 1 to 6, the inverse items should be scored using the following subtraction: 7 - x. For example, if the response to inverse item 5 ("I ignore physical tension or discomfort until they become more severe") is "always" (6), the score (7 − 6) would result in 1.

Procedure

A Peruvian translator specialized in psychology, but unfamiliar with the construct, prepared the initial draft of the Spanish translation of the MAIA-2. The lead author (LV-R) then met with a bilingual native Spanish speaker, who was not familiar with the construct but was well-acquainted with U.S. culture, to read, analyze, and compare the initial draft of the translation with the original

MAIA-2 and the Chilean version of the MAIA [44]. The translator performed the certified direct English-to-Spanish translation of the MAIA-2. The final version of the MAIA-2, translated and adapted to Peruvian Spanish, resulted from an iterative process involving revisions and modifications based on (1) the direct translation, (2) extensive discussions between LV-R and a bilingual native Spanish speaker, (3) expert judgments, (4) cognitive interviews, and (5) several discussions between LV-R and one of the other authors (AS-B).

Expert Judgments

The purpose of the expert judgments was to obtain evidence on the pertinence, relevance, and clarity of the items in relation to the dimensions and construct of the MAIA-2. The theoretical analysis conducted by AS-B and LV-R identified that the MAIA-2 is epistemologically based on the humanistic theoretical approach to psychology. Gestalt therapy, which also includes body work in the "here and now," is rooted in this approach. The psychologists had knowledge of various theoretical approaches and were trained in psychological assessment within a specific sociocultural context. Approximately 20 specialists were contacted by email, WhatsApp, and in person. Six Peruvian psychologists agreed to participate as judges (3 men, 3 women; place of residence: Lima = 5, Oxapampa Province = 1; specialty: Gestalt therapy completed or in progress = 3, clinical psychology = 2, research = 1). The judges considered the linguistic, sociocultural, and psychological characteristics of the target population (Peruvian adults) and used a Likert scale (Strongly disagree = 1; Disagree = 2; Agree = 3; Strongly agree = 4) to rate their opinion on relevance ("the item measures the dimension and the construct"), importance ("the item is important and not redundant with another item"), and clarity ("the item is understandable and not confusing"). The judges provided their opinions in writing through a document prepared specifically for this purpose. Four judges responded using the digital format, while the other two used the paper format. The judges were given the freedom to respond at their convenience and to submit the document within a reasonable period of time (e.g., one week). Quantitative analysis was performed using an online calculator to obtain Aiken's V coefficient (V).

Cognitive interviews

To address the feedback provided by the expert judges, a series of cognitive interviews was conducted to identify and resolve any additional issues with the MAIA-2 items. Eleven adults residing in Peru were contacted via WhatsApp to participate in this process, and ten of them (7 women, 3 men) voluntarily agreed to participate. Participants ranged in age from 25 to 64 years and had different levels of education, including higher and secondary education.

The cognitive interviews were designed to gather evidence about problematic elements in the items (e.g., words, expressions, response format) that could lead to misunderstandings or difficulties for the target population. Interviewees were asked to complete the MAIA-2 and then engaged in retrospective probing, where standardized questions were posed to understand how they interpreted specific items and why certain questions may have been confusing. For example, the term *"tensión física"* in item 5 was interpreted by some as *"emotional stress"*, leading to the revision of the item to *"malestar físico"* to clarify its meaning.

After these modifications were made, the revised items were re-administered to a subset of participants to ensure the changes were clear and appropriate. These cognitive interviews helped validate the cultural and linguistic relevance of the MAIA-2 items for the Peruvian population. Both qualitative and quantitative analyses were performed on the interview data, using Aiken's V coefficient (V) to assess the clarity and relevance of the modified items.

Sample size calculation

An a priori sample size calculator for structural equation models was used with the following parameters and values: anticipated effect size (.3), desired power level (.95), number of latent variables (8), number of observed variables (37), and probability level (.05) [49]. The minimum recommended sample size was 256 participants. Sample participants were recruited both virtually and in person. The decision to combine survey modalities (virtual and face-to-face) was made due to the time frame established for recruitment. Virtually, participants completed the survey using a personal electronic device (e.g., cell phone) from anywhere in the country. The survey was designed in Google Forms and disseminated through social networks. In the face-to-face setting, participants completed the survey in a group using pencil and paper in the classrooms of a university and a military school located in Lima, Peru. The survey was administered by two psychology professionals, who provided oral instructions and addressed any questions that arose. Peruvian adults aged 18 to 69 years, with a minimum educational level of completed secondary school, and residing in Lima, Peru, were considered for inclusion. Participants who did not meet these criteria were excluded. The necessary permissions were obtained for administering the paper surveys in both educational institutions.

Ethical aspects

The virtual and paper survey contained informed consent and questionnaires. Informed consent consisted of explaining the duration and procedure of the survey; purpose of the research; right to refuse participation or discontinue participation after it has begun; absence of consequences for refusal or withdrawal of participation; absence of benefits due to participation; guarantee of confidentiality and anonymity, as well as the contact of the lead author. Anonymity, privacy, and confidentiality were guaranteed in the use of the information collected throughout the research process. The Ethical Principles of Psychologists and the Code of Conduct were respected [50, 51].

Data analysis

Descriptive statistical analysis of the sociodemographic data (frequencies, percentages, and arithmetic mean) was performed. The minimum value established for V was ≥.70 [52]. The fit of the structural equation model (SEM) was assessed through confirmatory factor analysis (CFA), in which the recommended weighted least squares means and variance adjusted (WLSMV) estimation method was employed for ordinal data in violation of the normality assumption [53]. The following parameters and cutoff points considered acceptable were used: chi-square over degrees of freedom (χ^2/df = 2–5) [54, 55], comparative fit index (CFI ≥ .90), Tucker-Lewis index (TLI ≥ .90), standardized root mean square residual (SRMR < .08), root mean square error of approximation (RMSEA < .08), and factor loadings (λ ≥ .40) [56]. The internal consistency method of reliability was estimated using the ordinal (ordinal α) and omega (ω) alpha coefficient with acceptable factor values ≥ .70 [53]; values ≈ .90 can be considered "excellent"; ≈ .80 "very good", and ≈ .70 "adequate" [57]. The mean variance extracted (AVE) was analyzed with acceptable factor values ≥ .50 [58].

The dimensionality of the MAIA-2 was assessed using bootstrap exploratory bootstrap graph analysis (bootEGA), which is considered a novel and robust approach in network psychometrics for estimating the stability of dimensions and items in multivariate data [41]. The parametric procedure was used to generate data on all starting replicate samples (500), the graphical operator network estimation method graph absolute minimum selection and shrinkage (GLASSO) to estimate the graphical Gaussian model (GGM), as well as the Walktrap community detection algorithm [59].

Descriptive statistics were calculated for the MAIA-2 dimensions (median, standard deviation, confidence interval, and quantile), which provides a general understanding of the stability of the dimensions [59]. Structural consistency, defined as the degree to which the items of a dimension show interrelations and homogeneity within the multidimensional structure of the questionnaire, was used to evaluate the stability of the dimensions, which is observed in the coherent grouping of communities in a psychological network [41]. Thus, structural consistency is an alternative measure to the reliability coefficients (e.g., α, ω) of the internal consistency method commonly used in factor analysis [41, 59]. We considered items with acceptable stability (≥ .75) and significant average network loadings for a small effect size (≥ .15) [59].

Measurement invariance between groups according to sex was assessed using multigroup confirmatory factor analysis (MFCA). Values of ΔCFI and ΔRMSEA (≤ .010) [60] were considered [60] to accept measurement invariance in the three constraining stages (scalar, metric, and residual) [61].

Jamovi (version 2.3) [62] was used to perform the descriptive statistical analysis of the sociodemographic data, and RStudio (version 4.3.0.) [63], the packages *"psych"* [64], *"lavann"* [65], *"semPlot"* [66], *"semTools"* [67], *"EGAnet"* ([68], and *"qgraph"* ([69] to perform the rest of the analyses.

Results

A total of 414 Peruvian participants with residence in Lima were included, 85% were young adults aged 18–27 years (252 females = 61%; 162 males = 39%; age range = 18–64; M_{age} = 23.4; educational level [incomplete university = 71%; complete university = 19%; complete high school = 10%]; M_{weight} = 65 kg; M_{height} 1.63 m; M_{BMI} = 24.4 [normal]) (see Table 1).

Table 1 Sociodemographic data of participants

Characteristics		f	%	*M*
Sex	Male	162	39	
	Female	252	61	
Age	18–27	351	85	
	28–37	42	10	
	38–47	8	2	
	48–57	7	2	
	58–64	6	1	
Level of education	High school completed	43	10	
	University incomplete	294	71	
	University complete	77	19	
Weight (kg)				65
Height (m)				1.63
BMI				24.4

Nota. *f* frequencies, *BMI* body mass index, *kg* kilograms, *m* meters, *M* arithmetic mean, *M* arithmetic mean

Expert judgments

Six Peruvian psychologists participated as judges, three men and three women, five residing in Lima and one in the department of Pasco, Peru. Most of the items (35/37) obtained acceptable values at the lower limit of the confidence interval corresponding to Aiken's V coefficient (95% CI [.67-.82]) in the three aspects of the content evaluated (relevance, pertinence, and clarity). The first two items obtained values < .65 at the lower limit (95% CI [.61]), specifically in the following aspects of the content: clarity (item 1) and relevance (item 2).

Cognitive interviews

Respondents opined on the MAIA-2 items and response format based on the completion of several types of retrospective cognitive probes (paraphrasing, comprehension/interpretation, confidence judgment, and general) [70]. The results of the qualitative analysis were congruent with those of the quantitative analysis. Between 70 % ad 100 % o the respondents achieved a positive result in the probe, thus most of the items (18/24) obtained acceptable values in the Aiken V coefficient (.70 − 1). The remaining items (5, 6, 19, 20, 22, 34, 35) obtained values < .70. The following problematic items were identified: (a) the initial negation in item 5 caused confusion, so "I do not realize it" was changed to "I ignore"; (b) several items were interpreted to include an emotional aspect, so the word "physical" was added to specify that discomfort or pain referred to the physical level (sensations), ensuring consistency with the description of the dimensions and the construct; (c) the word "posture" in item 18 was also interpreted as related to "job position" or "point of view," so it was necessary to complement it with the word "bodily"; (d) the expression "become aware" in item 19 generated confusion, so it was changed to "pay attention"; (e) the wording of several items (20, 22, 25, 28, 35, 36) caused confusion, so they were rephrased. For example, item 35 ("I feel comfortable in my body") was interpreted in relation to self-esteem, and item 36 ("I feel my body is a safe place") was confusing due to a lack of context.

Factor analysis

The first oblique model corresponding to the original factor structure of the MAIA-2 was analyzed; it presented fit indices with acceptable values: $\chi^2/df = 2.967$; CFI = .930; TLI = .923; SRMR = .066; RMSEA = .069 (90% CI [.065-.073]). However, it presented factor loadings with values lower than the minimum accepted (.039-.069) in the inverse items of *Not-Worrying* (11, 12, 15). These items were removed, and a second model was analyzed. The second oblique model showed acceptable values of fit indices: $\chi^2/df = 3.133$; CFI = .935; TLI = .927; SRMR = .057; RMSEA = .072 (90% CI [.068-.076]). This model presented slightly better values than the first one in CFI, TLI, and SRMR, and therefore it was considered the model with the best fit (see Table 2).

The first model presented factor loadings with the following values: .748-.846 on items 1–4 (*Noticing*); .753-.843 on items 5–10 (*Non-Distracting*); .039-.722 on items 11–15 (*Not worrying*); .628-. 869 on items 16–22 (*Attention regulation*); .725-.853 on items 23–27 (*Emotional awareness*); .772-.864 on items 28–31 (*Self-regulation*); .827-.864 on items 32–34 (*Body listening*), and .850-.892 on items 35–37 (*Trusting*). All these values were statistically significant (p < .001], except items 11, 12, 15 (p = .285-.558) which obtained factor loadings with values inferior to the minimum accepted [.039-.069] (Fig. 1).

The second model (without items 11, 12, 15) presented factor loadings with acceptable values: .749-.846 on items 1–4 (*Noticing*); .753-.843 on items 5–10 (*Non-Distracting*); .678-.741 on items 13, 14 (*Not worrying*); .628-.869 on items 16–22 (*Attention regulation*); .725-.853 on items 23–27 (*Emotional awareness*); .772-.864 on items 28–31 (*Self-regulation*); .827-.864 on items 32–34 (*Body listening*) and .850-.892 (*Trusting*). All these values were statistically significant (p < .001) (Fig. 1).

Dimensionality of MAIA-2 using bootstrap exploratory graphical analysis (bootEGA)

The first psychological network model was represented by seven dimensions, the red nodes grouped the items of *Self-regulation* ("au" 28–31), *Body listening* ("ec" 32–34), and *Trusting* ("co" 35–37) which resulted in the first dimension called Body connection. The light blue nodes grouped the *Non-Distracting* ("nd" 5–10 [inverse]) items and resulted in the second dimension. The green nodes grouped the *Emotional awareness* items ("ce" 23–27) and resulted in the third dimension.

Table 2 Fit indices of oblique models of confirmatory factor analysis (CFA)

Model	χ^2	df	χ^2/df	CFI	TLI	SRMR	RMSEA	CI 90% RMSEA	
								Lower	Superior
M1: 8 factors, 37 items	1783.325	601	2.967	0.930	0.923	0.066	0.069	0.065	0.073
M2: 8 factors, 34 items	1563.207	499	3.133	0.935	0.927	0.057	0.072	0.068	0.076

Note. χ^2 chi-square, *df* degrees of freedom, *CFI* comparative fit index, *TLI* Tucker-Lewis index, *SRMR* Standardized root mean square residual, *RMSEA* Root mean square error of approximation, *CI* Confidence interval

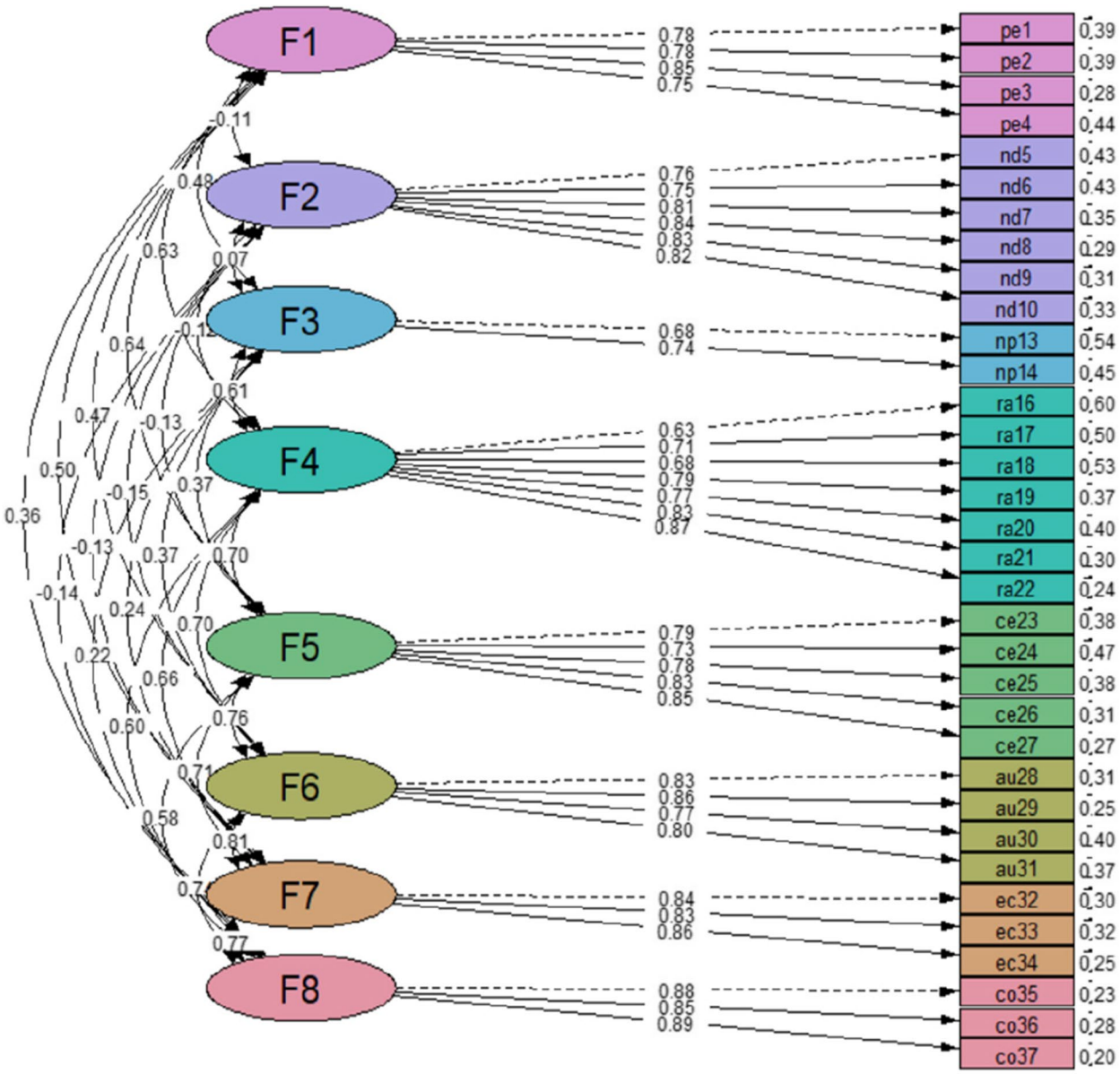

Fig. 1 Oblique 8-factor model of MAIA-2. Note. Second model (M2) of 34 items. CO: *(Trusting/Confianza)*, EC: *(Body listening/Escucha corporal)*, AU: *(Self-regulation/Autorregulación)*, CE: *(Emotional awareness/Conciencia emocional)*, RA: *(Attention regulation/Regulación de la atención)*, NP: *(Not worrying/No preocuparse, ND: (Non-Distracting/No distraerse), PE: (Noticing/Percepción)*

The orange nodes were grouped three items of *Attention regulation* ("ra" 16–18) and two items of *Not worrying* ("np" 13, 14), resulting in the fourth dimension. The yellow-colored nodes grouped the three inverse items of *Not worrying* ("np" 11, 12, 15) and resulted in the fifth dimension. The purple nodes grouped the *Trusting* items ("co" 1–4) and resulted in the sixth dimension. Finally, the dark blue nodes were grouped four items of *Attention regulation* ("ra" 19–22), resulting in the seventh dimension (see Fig. 2A).

The visual and semantic analysis of the *Self-regulation*, *Body listening*, *Trusting*, and *Attention regulation* dimensions, together with the analysis of item stability, suggested the need to evaluate a second model. After eliminating the *Not worrying* items ("np" 11–15), which in the first model represented the fifth dimension with yellow nodes (inverse items 11, 12, 15) and part of the fourth dimension with orange nodes (direct items 13, 14), the second model considered more parsimonious was obtained.

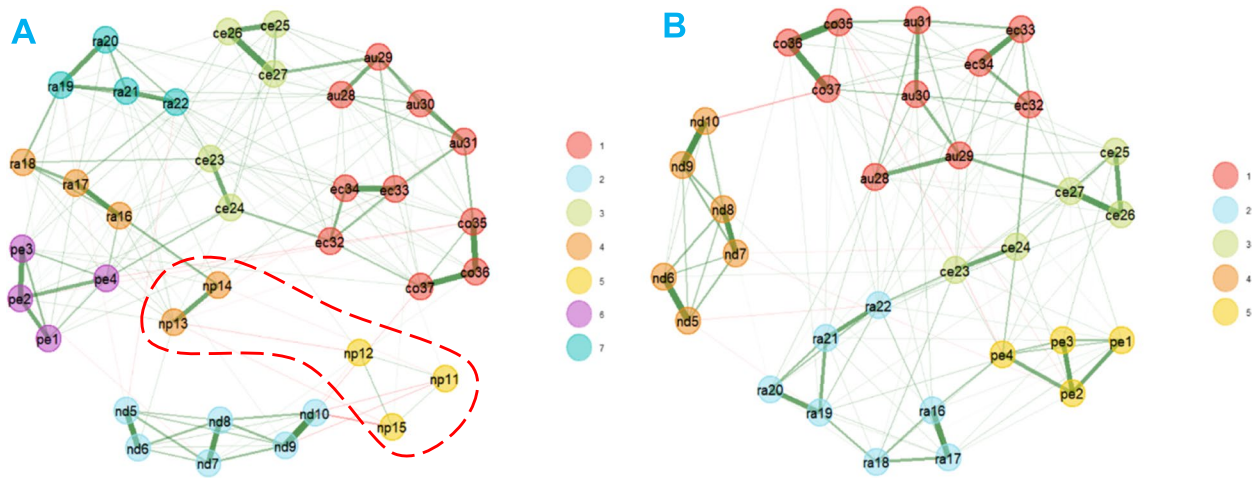

Fig. 2 Dimensionality of MAIA-2 assessed by bootstrap exploratory bootstrap graph analysis (bootEGA). Note: Comparison between model A *(7 dimensions, 37 items)* and model B *(5 dimensions, 32 items)*. CO: *(Trusting/Confianza)*, EC: *(Body listening/Escucha corporal)*, AU: *(Self-regulation/Autorregulación)*, CE: *(Emotional awareness/Conciencia emocional)*, RA: *(Attention regulation/Regulación de la atención)*, NP: *(Not worrying/No preocuparse*, ND: *(Non-Distracting/No distraerse)*, PE: *(Noticing/Percepción)*

This model was represented by five dimensions, the red nodes grouped the items of *Self-regulation* ("au" 28–31), *Body listening* ("ec" 32–34), and *Trusting* ("co" 35–37) which resulted in the first dimension called Body connection. The light blue nodes grouped the *Attention Regulation* items ("ra" 16–22) and resulted in the second dimension. The green nodes grouped the *Emotional Awareness* items ("ce" 23–27) and resulted in the third dimension. The orange nodes grouped the *Not distracting* ("nd" 5–10 [inverse]) items, which resulted in the fourth dimension. Finally, the yellow nodes grouped the Trusting items ("pe" 1–4), which resulted in the fifth dimension (see Fig. 2B).

The first model (model A: 7 dimensions, 37 items) presented a median of 6 dimensions; standard deviation of 1; confidence interval (95% CI [4–8]) and quantile (4–8). The second model (model B: 5 dimensions, 34 items) presented a median of 5 dimensions; standard deviation of 1; confidence interval (95% CI [3–7]) and quantile (5–8). These results suggest that MAIA-2 has fewer dimensions than the original 8-dimensional theoretical model (see Table 3).

In the first model (model A), the items of the dimensions presented values indicating stability (0.77–1.00), however, the items of the sixth dimension (*Noticing*) represented by the purple nodes ("pe" 1–4) presented instability (0.52). In the second model (model b), the items of all dimensions were stable (0.76–1.00). The second model showed stability (see Fig. 3).

In the first model (model A), items "ra19", "ra21" and "au29" presented significant network loadings in two dimensions ("ra19" and "ra21" in the fourth and sixth dimensions, and "au29" in the first and third dimensions), i.e., these items presented cross loadings in the mentioned dimensions. In the second model (model B) with the "*Not worrying*" items ("np" 11–15) removed, the significant average network loadings resulted consistent according to the grouping of the items in the dimensions, although the item "au29" continued to present cross-loadings, this time, in the first and fourth dimensions, indicating that this item is multidimensional (see Table 4).

Table 3 Descriptive statistics of MAIA-2 dimensions in all baseline replicate samples

	n.Boots	median.dim	SD.dim	CI.dim	Lower.CI	Upper.CI	Lower. Quantile	Upper. Quantile
Model A	500	6	1	2	4	8	4	8
Model B	500	5	1	2	3	7	5	8

Note. *n.Boots* number of starting replicate samples, *median.dim* median, *SD.dim* standard deviation, *CI = 95%* confidence interval, *Lower* lower limit, *Upper* upper limit, Model A: 7 dimensions, 37 items; Model B: 5 dimensions, 32 items.

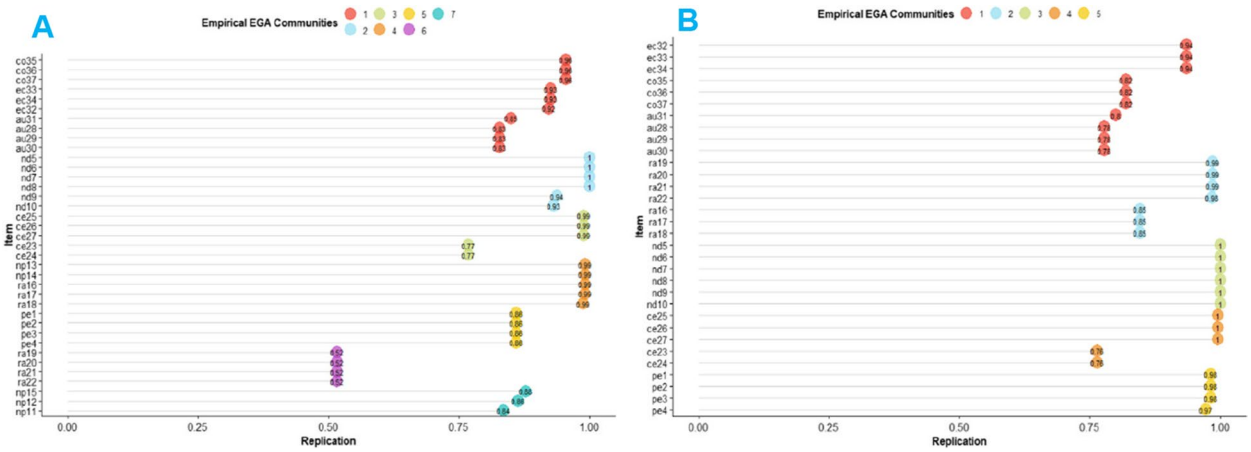

Fig. 3 Stability of MAIA-2 items. Note: Comparison between model A (7 dimensions, 37 items) and model B (5 dimensions, 32 items)

Measurement invariance

Measurement invariance between groups according to sex was accepted by observing values of ΔCFI and ΔRMSEA ≤ .010 in the three restrictive stages; thus, interoceptive awareness was an equivalent construct for males and females in this research (see Table 5).

Reliability using the internal consistency method

The factors of the second model of the AFC (eight factors, 34 items) presented good values of ordinal alpha (ordinal α = .863-.905) and omega (ω = .847-.887) reliability coefficients, except for the third factor (*Not worrying*) (αordinal = .669; ω = .639), in which the inverse items (11, 12, 15) were eliminated and it was left with only the two direct items (13, 14). Likewise, they showed acceptable values of the average variance extracted (AVE = .505-.762) (see Table 6).

Discussion

The *Multidimensional Assessment of Interoceptive Awareness, Version 2 (MAIA-2)* is an interoception questionnaire designed to measure the multiple dimensions of conscious interoception that can be captured through self-report [2, 18]. The present study aimed to demonstrate the validity of a new Spanish translation of the MAIA-2 in Peruvian adults and to examine its dimensionality using *bootEGA*. Evidence is presented that supports the validity, reliability, and fairness of the MAIA-2 in Peruvian adults.

A new translation of the MAIA-2 into Peruvian Spanish was produced. The strategies and methods employed—direct translation, multiple reviews and discussions, expert judgments, and cognitive interviews—provided valuable insights at each stage of the translation process. In this version of the MAIA-2, the coding was modified, and the frequency options of the response format were completed (never = 1; almost never = 2; sometimes = 3; frequently = 4; almost always = 5; always = 6). Consequently, the instruction for calculating the inverse items was also adjusted (7 - x). This response format was understandable to the respondents in this study. In most previous MAIA-2 studies, the direct and reverse translation method was used [25, 31, 33–36, 38]. A previous MAIA-2 study involved an expert committee to assess "language validity" (Turkish), but no results were reported [37]. Some previous MAIA and MAIA-2 studies used the cognitive interviewing method and reported the most relevant findings [25, 44]. The previous MAIA-2 study reported comprehension problems with two items (12 and 35) [44].

The cognitive interviews conducted in this study helped identify several problematic elements in the MAIA-2. For example, the negation in item 5 caused confusion and was revised from 'I don't realize' to 'I ignore.' Additionally, to clarify that the items referred to physical sensations rather than emotional states, the word 'physical' was added to several items. Similarly, ambiguous terms like 'posture' in item 18 and 'become aware' in item 19 were clarified as 'bodily posture' and 'pay attention,' respectively. Several other items (20, 22, 25, 28, 35, 36) were rephrased for better clarity.

On the other hand, it is worth mentioning that the differences between the Chilean version of the MAIA, the Spanish version of the MAIA-2, and the Peruvian version of the MAIA-2 are detailed below [34, 44]: The two previous versions retained the original response format (Likert scale from 0 = never to 5 = always) [34]. The Spanish version of the MAIA-2 is not publicly available, so it cannot be included in this comparison [34]. The Chilean version of the MAIA includes the feminine gender in adjectives,

Table 4 Average network loadings of MAIA-2 items across all baseline replicate samples

Model A	1	2	3	4	5	6	7	Model B	1	2	3	4	5
pe1	0.024	−0.001	0.028	0.059	**0.281**	0.021	0.000	pe1	0.025	0.044	−0.001	0.018	**0.282**
pe2	−0.009	−0.008	0.051	0.045	**0.443**	0.004	−0.006	pe2	−0.008	0.011	−0.007	0.037	**0.458**
pe3	0.021	−0.002	0.047	0.060	**0.329**	0.044	0.004	pe3	0.020	0.054	−0.002	0.039	**0.327**
pe4	−0.016	0.000	0.106	0.093	**0.235**	0.013	−0.008	pe4	−0.022	0.060	0.002	0.104	**0.239**
nd5	0.001	**0.321**	0.000	−0.008	−0.001	−0.018	−0.008	nd5	0.003	−0.020	**0.329**	0.001	0.000
nd6	0.000	**0.342**	0.004	0.019	0.002	0.002	−0.008	nd6	0.000	0.008	**0.347**	0.006	0.004
nd7	0.005	**0.360**	0.003	0.003	−0.010	0.005	−0.007	nd7	0.005	0.007	**0.382**	0.005	−0.009
nd8	0.000	**0.398**	−0.001	0.002	0.000	−0.001	−0.019	nd8	0.000	0.002	**0.410**	−0.001	0.000
nd9	0.000	**0.352**	−0.004	0.004	−0.001	−0.002	−0.055	nd9	0.001	0.005	**0.400**	−0.006	0.000
nd10	−0.032	**0.274**	−0.003	0.001	−0.005	−0.001	−0.146	nd10	−0.034	−0.001	**0.305**	−0.003	−0.005
np11	0.007	−0.054	0.002	−0.010	0.000	0.002	0.118	np11	-	-	-	-	-
np12	0.005	−0.009	0.005	−0.005	0.000	0.013	**0.155**	np12	-	-	-	-	-
np13	−0.010	0.017	0.011	**0.206**	0.056	0.025	−0.087	np13	-	-	-	-	-
np14	0.019	0.003	0.007	**0.220**	0.015	0.017	−0.018	np14	-	-	-	-	-
np15	0.007	−0.037	0.002	−0.009	−0.005	0.003	**0.169**	np15	-	-	-	-	-
ra16	0.019	0.011	0.009	**0.298**	0.057	0.009	−0.014	ra16	0.024	**0.186**	0.019	0.007	0.076
ra17	0.007	−0.003	0.005	**0.292**	0.057	0.098	0.002	ra17	0.006	**0.279**	−0.002	0.002	0.068
ra18	0.017	−0.001	0.038	**0.205**	0.031	0.101	−0.002	ra18	0.016	**0.199**	0.003	0.039	0.045
ra19	0.018	−0.005	0.015	**0.182**	0.035	**0.325**	0.008	ra19	0.016	**0.327**	−0.005	0.012	0.040
ra20	0.033	0.005	0.020	0.145	0.003	**0.294**	0.004	ra20	0.031	**0.274**	0.007	0.017	0.006
ra21	0.037	0.000	0.031	**0.163**	0.017	**0.338**	0.002	ra21	0.035	**0.303**	−0.001	0.030	0.018
ra22	0.069	−0.010	0.089	0.131	0.019	**0.267**	0.022	ra22	0.067	**0.251**	−0.014	0.086	0.019
ce23	0.052	0.005	**0.159**	0.068	0.050	0.097	0.001	ce23	0.050	0.104	0.008	**0.160**	0.054
ce24	0.050	−0.010	**0.170**	0.028	0.099	0.052	−0.003	ce24	0.051	0.037	−0.013	**0.175**	0.096
Model A	1	2	3	4	5	6	7	Model B	1	2	3	4	5
ce25	0.055	−0.002	**0.277**	0.007	0.044	0.012	0.012	ce25	0.054	0.006	−0.002	**0.280**	0.045
ce26	0.026	0.001	**0.336**	0.021	0.026	0.050	0.006	ce26	0.023	0.043	0.002	**0.349**	0.024
ce27	0.085	0.002	**0.310**	0.007	0.028	0.012	−0.002	ce27	0.086	0.009	0.003	**0.315**	0.029
au28	**0.183**	−0.001	0.042	0.053	0.003	0.093	0.015	au28	**0.180**	0.091	−0.001	0.033	0.003
au29	**0.203**	−0.001	**0.162**	0.011	0.009	0.005	0.002	au29	**0.200**	0.009	−0.001	**0.158**	0.008
au30	**0.187**	−0.004	0.065	0.046	0.010	0.012	0.016	au30	**0.185**	0.028	−0.005	0.056	0.012
au31	**0.256**	−0.002	0.032	0.012	−0.008	0.011	0.000	au31	**0.252**	0.013	−0.002	0.020	−0.012
ec32	**0.182**	0.000	0.110	0.012	0.007	0.033	0.005	ec32	**0.184**	0.025	0.001	0.105	0.006
ec33	**0.259**	0.002	0.028	−0.001	0.025	0.002	0.002	ec33	**0.270**	0.000	0.002	0.017	0.024
ec34	**0.257**	−0.003	0.034	0.020	0.007	0.054	0.006	ec34	**0.260**	0.045	−0.004	0.028	0.008
co35	**0.282**	0.000	0.030	0.011	−0.028	0.017	0.010	co35	**0.262**	0.017	0.000	0.025	−0.033
co36	**0.290**	0.007	0.004	0.010	0.002	0.020	0.010	co36	**0.255**	0.017	0.008	0.004	0.002
co37	**0.254**	−0.030	0.022	0.013	0.018	0.029	0.009	co37	**0.239**	0.024	−0.034	0.019	0.019

Note. Model A: 7 dimensions, 37 items; Model B: 5 dimensions, 32 items. Mean network loadings significant for small effect size: ≥0.15 (bold values). *CO* (Trusting/Confianza), *EC* (Body listening/Escucha corporal), *AU* (Self-regulation/Autorregulación), *CE* (Emotional awareness/Conciencia emocional), *RA* (Attention regulation/Regulación de la atención), *NP* (Not worrying/No preocuparse, *ND* (Non-Distracting/No distraerse), *PE* (Noticing/Percepción)

Table 5 Measurement invariance between groups according to sex

Invariance	χ^2	df	χ^2/df	*p*	CFI	RMSEA	ΔCFI	ΔRMSEA
Configural	2231.500	908	2.458	-	0.838	0.084	-	-
Scalar	2281.300	935	2.440	0.005	0.835	0.083	0.003	0.001
Metric	2346.100	962	2.439	0.000	0.830	0.083	0.005	0.000
Residual	2414.400	994	2.429	0.000	0.826	0.083	0.004	0.000

Note. Model 2 of the network analysis: 5 dimensions, 32 items. χ^2 chi-square, *df* degrees of freedom, *p p*-value, *CFI* comparative fit index, *RMSEA* root mean square error of approximation, *ΔCFI* difference of CFI, *ΔRMSEA* difference of RMSEA

Table 6 Reliability estimated using the internal consistency method

	F1	F2	F3	F4	F5	F6	F7	F8
$^{ordinal}\alpha$	0.863	0.905	0.669	0.896	0.881	0.887	0.878	0.898
ω	0.847	0.869	0.639	0.887	0.880	0.869	0.857	0.883
AVE	0.624	0.643	0.505	0.578	0.636	0.666	0.710	0.762

Note. AFC Model 2: 8 factors, 34 items. *AVE* average variance extracted

for example, *"tenso(a)."* The items that show the most significant differences between the Chilean version of the MAIA and the Peruvian version of the MAIA-2 (common to both versions, with MAIA-2 numbering) are as follows: 3, 5, 6, 12, 17, 19, 20, 21, 22, 25, 26, 28, 29, 31, 32, 33, 34, 35, and 36.

Four previous studies [33–36] presented a factor structure conforming to the original eight-factor, 37-item structure of the MAIA-2 [18]. However, other studies presented alternative factor structures, such as 6 factors with 26 items [38]; 7 factors with 34 items [37]; 7 factors with 31 items [25], and 8 factors with 24 items [31]. In our study, items 11, 12, and 15 from the "Not Worrying" dimension were removed due to psychometric issues, similar to the approach taken by Tosun et al. [37], who also excluded these inverse items. This decision was based on their low internal consistency and difficulties in item comprehension, which have been noted in other studies as well. While the removal of these items raises concerns about whether the full scope of interoceptive avoidance is being measured, we ensured that the remaining items in the dimension captured the core aspects of the construct. As seen in the study by Da Costa et al. [38], where all items from this dimension were removed, the exclusion of problematic items can enhance the psychometric properties of the scale without significantly compromising its validity. In our analysis, the revised structure maintained acceptable fit indices, suggesting that the overall measurement of interoception was preserved, even with the removal of these items.

Two psychological network models were tested. Although the two estimated models show the multidimensionality of the MAIA-2, the number of dimensions does not correspond to the original theoretical model of the questionnaire [18]. Nevertheless, the five-dimensional model proved to be more stable and provided better fit indices compared to the eight-factor model. Specifically, the five-factor solution showed improved statistical robustness, with lower RMSEA and SRMR values, which are indicative of a better model fit. Theoretical considerations also support the selection of the five-factor model over the eight-factor structure. The five-dimensional model offers a more integrated and practical conceptualization of interoception that is particularly relevant for the Peruvian context, where cultural factors such as somatic awareness and health beliefs might differ from those considered in the development of the original model. For instance, the merging of related dimensions such as *"Self-regulation"* and *"Body listening"* into a broader *"Body Connection"* dimension allows for a more holistic representation of how bodily sensations are experienced by Peruvian adults. This adjustment not only reflects the cultural specificity of the population but also provides a simpler, more interpretable framework for assessing interoceptive awareness. In contrast, the original eight-factor model may introduce unnecessary complexity and item redundancy when applied in the Peruvian setting. Although the eight-factor model was theoretically grounded, its granularity might not align with the way interoceptive processes are interpreted across different cultural contexts, leading to less reliable factor loadings. As a result, the five-factor model is favored in both statistical and practical terms, offering a more suitable structure for measuring interoception within the Peruvian population.

The second model was represented by five dimensions, the red nodes grouped the first dimension called Body Connection, which was formed by the original dimensions *Self-regulation* ("au" 28–31), *Body listening* ("ec" 32–34), and *Trusting* ("co" 35–37). Node au31 *"When I am caught up in thoughts, I can calm my mind by focusing on my body/breathing "* was related to node ec33 *"When I am upset, I take time to explore how my body feels"* and node co35*"I am at home in my body"*, which may mean that relaxation through conscious attention to the body or breathing, facilitates the recognition of bodily sensations associated with the emotion, as well as the generation of a state of inner tranquility. Although Body Connection (*Self-regulation*, *Body listening*, *Trusting*) does not fully represent the Mind-body integration dimension (*Emotional awareness*, *Self-regulation*, *Body listening*) corresponding to the initial MAIA conceptual framework, it was consistent with the conceptual framework of the construct as it is represented by the last three dimensions of MAIA-2, which follow a sequential order of ascending levels of interoceptive awareness.

Likewise, node nd10 *"When I feel unpleasant body sensations, I occupy myself with something else so I don't*

have to feel them" was negatively related to node co37 *"I trust my body sensations"*, which may mean that ignoring bodily sensations perceived as unpleasant generates distrust of those sensations. Node ce27 *"I notice how my body changes when I feel happy / joyful"* was related to node au29 *"When I become aware of my body, I feel a sense of calm"*, which may mean that conscious attention to bodily sensations such as those generated by joy, generates a state of tranquility. Node ce24 *"When something is wrong in my life, I can feel it in my body"* was related to node ec32 *"I listen for information from my body about my emotional state"*, possibly because attention to bodily sensations associated with the emotional state may be more present in difficult life experiences. In turn, node ce24 *"When I bring awareness to my body, I feel a sense of calm"* was related to node pe4, *"I notice changes in my breathing, such as whether it slows down or speeds up"*, which may be because the identification of subtle bodily sensations (e.g., breathing) enables the recognition of more complex bodily sensations (e.g., muscle tension). Node ra22 *"I am able to consciously focus on my body as a whole"* was related to node ce23 *"I notice how my body changes when I am angry"*, this may be due to the fact that conscious attention to bodily sensations allows us to perceive the bodily change associated with the emotion. Node pe4 "*I notice changes in my breathing, such as whether it slows down or speeds up"* was related to node ra16 *"I can pay attention to my breath without being distracted by things happening around me*", which may suggest that attention to changes in breathing facilitates sustained attention to the breathing process.

Network analysis is prioritized over factor analysis for several reasons: the stable psychological network model demonstrated theoretical consistency with the construct; CFA models from several previous studies did not reflect the original eight-factor, 37-item structure of the MAIA-2; in addition, the bootEGA represents a robust approach in network psychometrics for assessing dimensionality, which provided significant empirical evidence for the psychometric investigation of MAIA-2.

The results of the analysis of measurement invariance between groups by sex are consistent with those of a previous study [31]. In another study, men scored significantly higher than women on the *"Not-Worrying"* and *"Attention Regulation"* dimensions [71]. Similar to two previous studies, the third factor ("Not-Worrying") did not show adequate values in internal consistency measures (ordinal α, ω) [1, 51].

The results of this study should be interpreted considering cultural factors that may have influenced the perception and self-report of interoception in the Peruvian population. As in the study by Freedman et al. [72], which identified cultural differences in body awareness between Americans and Japanese, it is likely that cultural differences between the Peruvian population and other cultures could have impacted the MAIA-2 findings. In Peru, the influence of traditional health practices, spiritual beliefs, and cultural gender norms may have affected how participants experience and report their bodily sensations. These cultural differences underscore the importance of contextualizing the MAIA-2 results within the specific cultural framework of the studied population and suggest the need for future research to explore these cultural variations in greater depth.

Limitations

This study has several limitations that should be considered when interpreting the results. First, the translation process of the MAIA-2 into Peruvian Spanish did not include multiple translations or the use of a back-translation method, which could have affected the linguistic and cultural equivalence of the instrument. Furthermore, a second phase of cognitive interviews with a different group of participants was not conducted after item modification, which limited the ability to validate the adaptations made.

Another limitation is related to the exclusion of Venezuelan citizens, although this exclusion was to maintain cultural homogeneity and ensure that the data reflected the experiences of Peruvian adults. However, it may limit the generalizability of the results, especially in a context where migration is an important demographic factor. The decision to exclude Venezuelan participants was based on potential cultural and health-related behavioral differences.

Moreover, the sampling was non-probabilistic and limited to young adults in Lima, which restricts the geographic and demographic representativeness of the sample, thereby affecting the ability to generalize the results to the Peruvian population as a whole. Finally, although novel analysis techniques like bootEGA, which are promising for assessing the dimensionality of complex constructs, were used, these techniques are less conventional and may require further validation within the scientific community to ensure their reliability and applicability in future studies.

Practical and clinical implications

This study could trigger relevant impacts both in the field of research and clinical intervention regarding interoceptive awareness in the Peruvian adult population. Elucidation of the dimensions of interoceptive awareness and validation of the MAIA-2 instrument could facilitate further exploration and understanding of this construct in specific contexts in Peru. Furthermore, the findings obtained could be vital for the adaptation or

development of clinical interventions aimed at improving interoceptive awareness and, possibly, the quality of life of individuals. The potential applications of these interventions could be broad, ranging from the management of chronic conditions to support in the treatment of mental disorders. In the clinical context, improved understanding of interoceptive awareness and the availability of a validated instrument could enable health care professionals to incorporate interoceptive awareness-based intervention strategies into their practices, which could result in more holistic and patient-centered therapeutic approaches. Currently, there are no objective tools that can comprehensively assess the various facets of interoception [6, 18], which is why the MAIA-2 is presented as the most suitable measure for this purpose [14, 18]. The MAIA-2 is an internationally widely used self-assessment questionnaire, and has multiple advantages such as its multidimensionality, ability to discern attentional modes of interoceptive awareness, and sensitivity to detect treatment-associated changes [14].

Future directions

For future research, it would be important to test the revised MAIA-2 in different populations and contexts to validate the stability and generalizability of the findings. Specifically, replication studies in other Spanish-speaking regions, such as Central America and the Caribbean, would be valuable, as cultural, social, and economic differences may influence how individuals perceive interoceptive sensations. Additionally, longitudinal studies could provide insights into how mindfulness practices or body-oriented interventions affect interoception over time. It would also be relevant to explore the validity of the MAIA-2 in clinical populations, such as those with psychosomatic disorders, to assess its utility as a diagnostic tool in clinical settings. Finally, continuous evaluation of the dimensional structure of the MAIA-2 using advanced psychometric approaches like network analysis is recommended to further refine the understanding of the interoception construct.

Conclusion

This study addressed the dimensionality assessment of the MAIA-2 using the bootEGA method, enabling a rigorous exploration of its components. The results obtained provide initial evidence of the instrument's validity and reliability in a sample of Peruvian adults, supporting its potential usefulness and accuracy in measuring the proposed constructs. However, it is important to interpret these findings with caution, as this is only a first step in the validation of the MAIA-2 in this specific context. Although the analysis suggests that the MAIA-2 is a suitable instrument for use in this demographic group, further research is required to confirm its applicability and efficacy in various contexts within Peru. These results underscore the potential of the MAIA-2 as a valuable tool for future research on interoception in the Peruvian context. However, it is recommended that its validity and reliability continue to be explored in different populations.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s40359-025-02480-y.

Supplementary Material 1.

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Authors' contributions

LV-R and AS-B designed and developed the study protocol, organized the survey, oversaw data collection, and wrote the first draft of the manuscript. AS-B, NDCG-D, and JS assisted with data analysis, interpretation of results, and revision of the manuscript. LV-R, SPC-C, and AS-B contributed to drafting and reviewing several versions of the manuscript. All authors reviewed and approved the final version of the manuscript.

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Data availability

The data sets generated to support the findings of this study are not publicly available, but can be requested from the corresponding author.

Declarations

Ethics approval and consent to participate

Ethical guidelines and standards of conduct in psychological research were respected, and the corresponding tools and procedures were properly followed. Additionally, the research protocol was reviewed and approved by the Research Ethics Committee of the Universidad César Vallejo (Lima, Peru). In addition, informed consent was obtained from the participants. The study was conducted in accordance with the ethical standards and amendments included in the Declaration of Helsinki.

Consent for publication

Not Applicable.

Competing interests

The authors declare no competing interests.

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