

Psychometric validation and cross-cultural invariance of the Arabic Neuroception of Psychological Safety Scale (NPSS) among women in higher education

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ARTICLE INFO

Keywords:

Psychological safety
Neuroception of Psychological Safety Scale (NPSS)
Arabic validation
Measurement invariance
Psychometrics
Polyvagal Theory
Women in higher education

ABSTRACT

Psychological safety supports engagement, trust, and persistence in higher education, yet validated Arabic instruments to assess it among women in North Africa and the Middle East are limited. The Neuroception of Psychological Safety Scale (NPSS), grounded in Polyvagal Theory, which proposes that the autonomic nervous system continuously evaluates cues of safety and threat through a process known as neuroception, has not been extensively evaluated in Arab higher-education contexts. This gap is particularly relevant given that Arab women in universities may navigate sociocultural expectations, gender norms, and institutional dynamics that shape perceptions of safety. The present study assessed the psychometric properties of the Arabic-adapted NPSS among women in Algerian and Egyptian universities, and examined its measurement invariance across countries. A multi-institution cross-sectional survey was conducted with 1,302 women enrolled in higher education. Participants completed the Arabic-translated NPSS. Confirmatory factor analysis (CFA) using WLSMV (Weighted Least Squares Mean and Variance adjusted) estimation tested the theorized three-factor structure (Social Engagement, Compassion, Body Sensations). Internal consistency (Cronbach's α , McDonald's ω), convergent validity (average variance extracted [AVE]), discriminant validity (HTMT [heterotrait-monotrait] ratios), and measurement invariance (configural, metric, scalar, and strict invariance using multigroup CFA) were also evaluated. The three-factor model showed excellent fit (CFI \approx 0.98, TLI \approx 0.97, RMSEA \approx 0.044, and SRMR \approx 0.063). Standardized loadings were weak to moderate (0.39–0.79), and factor correlations were moderate (0.44–0.69). Internal consistency was high across subscales (α/ω : 0.82–0.90). Convergent validity was acceptable (AVE 0.40–0.53), and HTMT values (0.64–0.66) supported discriminant validity. Multigroup CFA indicated full configural, metric, scalar, and strict invariance across Algerian and Egyptian samples. The findings demonstrate that the Arabic NPSS has a stable factor structure, strong reliability, and cross-country invariance among women in higher education in Algeria and Egypt. The validated scale enables meaningful comparisons and supports institutional monitoring and targeted interventions to enhance psychological safety.

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<https://doi.org/10.1016/j.ijans.2026.101056>

Received 5 December 2025; Received in revised form 25 March 2026; Accepted 25 March 2026

Available online 26 March 2026

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1. Introduction

Psychological safety refers to an environment where individuals feel comfortable expressing themselves, taking risks, and proposing ideas without fear of negative consequences (Edmondson & Lei, 2014; Jamal et al., 2023). First conceptualized in the 1960s (Schein & Bennis, 1965), the construct gained significant empirical traction following Edmondson's (1999) seminal work on team learning, and has since expanded across four research themes—task accomplishment, learning behaviors, improved work experience, and leadership—with renewed importance during complex global events such as the COVID-19 pandemic (Edmondson & Bransby, 2023; Edmondson et al., 2016; Smith et al., 2023).

Psychological safety is a multidimensional construct affecting outcomes at individual, team, and organizational levels, shaped by both individual and contextual factors (Wanless, 2016). In educational settings, it strengthens trust, communication, and belonging, making it critical for student well-being and learning outcomes (Baeva & Bordovskaia, 2015). These effects are particularly salient for groups whose participation is constrained by social or structural factors—a reality that disproportionately affects women.

1.1. Psychological safety and women

Research has consistently shown gender differences in psychological safety. This vulnerability is documented across diverse educational and professional contexts. For instance, female nursing students report lower academic safety than their male peers, alongside higher cognitive load in simulation-based learning (Roh et al., 2022), while for Ukrainian refugee women, psychological safety has been reported to be a prerequisite for social adaptation and entrepreneurial engagement (Gadomska-Lila & Ścibior-Butrym, 2025). Moreover, the antecedents of safety appear to differ by gender. For example, women's psychological safety in virtual teams is more dependent on social presence than on task awareness (Lim, 2022), and its expression varies by context, such as in team versus individual sports settings (Blynova et al., 2022). These disparities intensify within higher education institutions, where structural and cultural constraints—such as glass-ceiling dynamics, unequal academic labor allocation, and male-patterned human resource systems—restrict women's voice, visibility, and advancement (David, 2015; Meza-Mejia et al., 2023). Therefore, strengthening women's psychological safety requires institution-level frameworks that embed equity into curricula, management processes, and support structures, alongside transparent promotion criteria, mentoring investment, and clear accountability for equity outcomes (Fia et al., 2023; Meza-Mejia et al., 2023; Verdugo-Castro et al., 2022).

1.2. Psychological safety in Arab and North African academic contexts

Despite women's substantial representation in Arab higher education, their psychological safety remains largely unexamined. In Algeria, women account for nearly 60% of university enrolments, yet this educational dominance has not translated into proportionate professional advancement (Zahia, 2018). In Egypt, university-expansion reforms from the 1960s to the 1970s increased female labor-force participation by approximately 13%, but structural ceilings persist (Elsayed & Shirshikova, 2023). Across Arab academia, policy audits show limited equity provisions and underdeveloped family-care supports, reproducing vertical segregation despite large cohorts of qualified women (Karam & Afioni, 2014).

Research on psychological safety in Arabic-speaking contexts is sparse, with the majority of studies focusing on adjacent constructs such as psychological empowerment and psychosocial support rather than Edmondson-style psychological safety (Inter-agency Network for Education in Emergencies, 2018; Moubarak et al., 2022). A scoping review in Saudi Arabian healthcare confirmed that psychological safety is

under-researched locally and called for Arabic-adapted measures (Ali et al., 2025). The few available studies—a survey of working women in Riyadh (Al-Farraj, 2024) and a bilingual university study in Egypt (Hendawy et al., 2024)—are sector-specific and limited in scope, underscoring the need for validated, culturally appropriate instruments.

1.3. Polyvagal theory as a theoretical foundation for psychological safety

The present study is grounded in polyvagal theory (Porges, 2007, 2009), which offers a neurobiological account of psychological safety through the lens of the autonomic nervous system. The theory proposes that the vagus nerve operates via two pathways: the ventral vagal complex, which supports social engagement and cooperation, and the dorsal vagal system, which triggers defensive immobilization responses (Hanazawa, 2022; Porges, 2009). Crucially, feeling safe is framed as a biological necessity—regulated through a process termed neuroception—that is prerequisite to social engagement, learning, and optimal functioning (Porges, 2015, 2022). When environments are perceived as threatening, collaboration and performance are compromised (Grassmann, 2024; Mair, 2019). Grounded in this framework, the Neuroception of Psychological Safety Scale NPSS (Morton et al., 2024) was developed to operationalize these neurobiological processes. Although the NPSS demonstrates robust psychometric properties in Western contexts (Cogan et al., 2024, 2025; Spinoni et al., 2024), its applicability in Arabic-speaking, North African academic environments has not been established.

1.4. Literature gap and present study

Psychological safety has become increasingly recognized as a critical factor in education and professional development (Edmondson & Bransby, 2023; Edmondson & Lei, 2014). However, no empirical studies have yet examined how women experience psychological safety in Algerian or Egyptian higher education. This research gap is further accentuated by the absence of validated Arabic-language instruments capable of capturing neuroceptive dimensions of psychological safety. The present study addressed these contextual and methodological gaps by validating the NPSS for this under-researched population, providing a culturally sensitive instrument for assessing women's perceived safety in academic environments. Two research questions guided the study: (i) What are the psychometric properties—including factor structure, reliability, and validity—of the NPSS among women in higher-education settings in Algeria and Egypt?; and (ii) Is the NPSS measurement invariant across Algerian and Egyptian women in higher education? Validating the NPSS in this context represents a critical step toward identifying systemic barriers and informing policies and interventions that foster inclusive and equitable academic environments for women in the region.

2. Method

2.1. Study design and Setting

The present study used a cross-sectional design and was conducted in two North African countries: Algeria and Egypt. Both countries share a broadly similar Arab-Islamic cultural and socioeconomic context, and each has a well-established public higher education system that is widely accessible and serves a large student and academic staff population. Public universities in both settings are co-educational institutions, making them suitable sites for recruiting female students and staff as a study population.

2.2. Sample size

Multiple researchers recommend a minimum sample size of 200 for simple structure of confirmatory factor analysis (CFA) or structural

equation modeling (SEM), and at least 400 for complex structures (Hair et al., 2019; Kline, 2023). If, using Weighted Least Squares Mean and Variance adjusted (WLSMV) estimator to handle ordinal scale, a larger sample size (e.g., 1000 or above) is required (Nussbeck et al., 2006). Because the present study used WLSMV in CFA, the sample size of 1,302 participants was adequate and consistent with guidance from SEM and CFA literature (Nussbeck et al., 2006). Furthermore, the present study involved multi-group invariance testing across two independent national samples (Algeria, $n = 788$; Egypt, $n = 514$), which inherently requires sufficient power within each subgroup, making a larger overall sample methodologically necessary (Vandenberg & Lance, 2000). Although large sample size may cause potential inflation of Type I errors, model evaluation can be made based on alternative fit indices (please see *Statistical analysis* section for details) that are less sensitive to sample size than the χ^2 statistic (Hair et al., 2019, pp. 639–640; Kline, 2023, p. 110).

2.3. Study sample

A cross-sectional study surveyed 1302 females—students and staff—at public universities in Algeria ($n = 788$; 60.5%) and Egypt ($n = 514$; 39.5%). All participants were aged 18 years or older. No upper age limit was applied. However, because recruitment was confined to university students and staff, the sample was naturally bounded within a working/studying adult age range. The study recruited literate females (to ensure comprehension of study materials and consent) who were either enrolled in or employed by those institutions, resident locally, and willing to provide written informed consent.

The study recruited literate females (to ensure comprehension of study materials and consent) who were either enrolled in or employed by those institutions, resident locally, and willing to provide written informed consent. Exclusion criteria were limited to individuals unable to read or understand the study materials or to provide voluntary written informed consent, including due to cognitive impairment, coercion, or incapacity, in order to uphold ethical and methodological standards.

2.4. Sampling

Convenience sampling was employed as the sampling strategy. This approach was selected given the practical constraints of accessing university populations across two countries and the exploratory nature of the study objectives. Convenience sampling involved recruiting participants who were readily accessible and willing to take part in the study. Participants were recruited by approaching them on campus through direct face-to-face contact in common areas (such as libraries, cafeterias, and student lounges) and faculty offices, as well as by contacting them via institutional communication channels such as university email lists and faculty announcement boards. In the Algerian sites, research team members visited multiple faculties across the participating universities on scheduled days and invited eligible women present at the time to participate. In the Egyptian sites, a parallel procedure was followed, with the addition of online dissemination through institutional email lists to reach staff and students who could not be approached in person. Participation was entirely voluntary. No incentives were offered, and individuals were free to decline without consequence.

2.5. Measurement and translation procedure

Grounded in polyvagal theory, the Neuroception of Psychological Safety Scale (NPSS) (Morton et al., 2024) is a 29-item instrument distilled from an initial 107-item pool via exploratory factor analysis (EFA) and CFA. The scale assesses perceived psychological safety across three subscales (Social Engagement, Compassion, and Bodily Sensations), rating items (e.g., “I felt valued”) on a five-point Likert scale from 1 (*Strongly disagree*) to 5 (*Strongly agree*), with subscale and total scores

obtained by summing items (with higher scores indicating greater psychological safety). The NPSS has demonstrated robust psychometric properties across multiple samples and languages. Studies conducted in the United Kingdom (Cogan et al., 2024, 2025) and Italy (Spinoni et al., 2024; Poli & Miccoli, 2024) have consistently replicated the three-factor structure, supported measurement invariance across gender, and reported acceptable-to-excellent internal consistency, test–retest reliability, and convergent and discriminant validity. These findings support the suitability of the NPSS for cross-cultural research and its use in health and social care settings, including trauma-informed practice.

For the Arabic adaptation, the authors received permission from the developers and then conducted two independent forward translations by bilingual psychologists (reconciling discrepancies), had an expert panel ensure conceptual and cultural accuracy, performed blinded back-translations by native English speakers to check consistency, held cognitive debriefing sessions with target respondents to confirm clarity, and incorporated minor edits before final proofreading—resulting in the version administered in the present study.

2.6. Data collection

Data collection took place between May 2024 and December 2024. Surveys were distributed both on paper and electronically. Paper-based surveys were administered face-to-face. Here, they were handed directly to participants who completed them on the spot in the presence of a research team member, and were collected immediately upon completion. This direct administration procedure meant that all distributed paper surveys were completed and returned in full, with no surveys lost or left incomplete. Online surveys were designed to prevent submission of incomplete responses, ensuring that only fully completed forms were submitted. To address missing data, strict procedures were implemented. As noted, the online survey was designed to prevent submission of incomplete responses, and the paper surveys were carefully checked to ensure all items were completed. These measures ensured complete data for analysis. Therefore, all 1,302 responses were complete and included in the analysis. Participation was anonymous, and all data were handled confidentially.

2.7. Statistical analysis

To analyze the study data, JASP software (version 0.19.3), mimicking the lavaan package in R, was used. Descriptive statistics (frequencies, percentages, means, standard deviations [SDs]) were computed prior to psychometric testing of the Arabic version of NPSS. CFA tested the hypothesized three-factor structure (Social Engagement, Compassion, Bodily Sensations) and was estimated using robust diagonally weighted least squares (i.e., WLSMV). Model fit was evaluated using the comparative fit index (CFI), Tucker-Lewis index (TLI), root mean square error of approximation (RMSEA) (with 90% confidence interval [CI]), and standardized root mean square residual (SRMR), following conventional thresholds (CFI/TLI ≥ 0.90 –.95, RMSEA ≤ 0.08 , SRMR ≤ 0.08) (Hoyle, 1995).

Reliability and validity were assessed as follows: internal consistency via Cronbach’s α and McDonald’s ω (> 0.7 is adequate (Taber, 2018)); average variance extracted (AVE) from standardized CFA solutions (> 0.5 is adequate and > 0.4 is acceptable (Fornell & Larcker, 1981)); and discriminant validity via heterotrait-monotrait (HTMT) ratio, with values < 0.85 considered adequate (Roemer et al., 2021).

Measurement invariance across countries (Algeria vs. Egypt) was tested sequentially under WLSMV using four nested models: configural (identical factor structure), metric (equal loadings), scalar (equal loadings and item intercepts), and strict (equal loadings, item intercepts, and item residuals) invariance models. Invariance was evaluated using the WLSMV scaled difference test with accepted cutoffs ($\Delta CFI \leq 0.010$, $\Delta RMSEA \leq 0.015$, and $\Delta SRMR \leq 0.010$ for loadings and ≤ 0.005 for thresholds/means) (Chen, 2007).

2.8. Ethical considerations

Ethical approval to conduct the study was obtained prior to data collection. Institutional authorization was granted by Hassiba Benbouali University of Chlef, Algeria (Authorization No. 29/2024, dated 29 May 2024), and by the Scientific Association for Mental Health in Sharkia Governorate, Egypt. The study was conducted in full accordance with the ethical principles outlined in the Declaration of Helsinki. To protect participant autonomy, all participants were fully informed about the study's purpose, procedures, voluntary nature, and their right to withdraw at any time without penalty before providing consent. Written informed consent was obtained from all participants prior to data collection. To protect participant identity and confidentiality, all surveys were anonymous (i.e., no names, identification numbers, or any personally identifiable information were collected). Electronic data were stored on password-protected servers accessible only to the research team. Data were used exclusively for research purposes and reported only in aggregate form.

3. Results

3.1. Characteristics of participants

Table 1 shows the demographic characteristics of the participants. Over half of participants were from Algeria (n = 788; 60.5%). The sample was predominantly young adults aged between 18 and 23 years (n = 997; 76.6%), and most were single (n = 1,099; 84.4%). In terms of educational level, the largest proportion of participants were at the university bachelor's level (n = 913; 70.1%), followed by the master's level (n = 249; 19.1%). As for employment status, students constituted the largest group in the sample (n = 1,145; 87.9%). Moreover, approximately two-thirds of participants reported their financial situation as moderate (n = 821; 63.1%).

3.2. Item-level analysis and descriptive statistics

Table 2 presents descriptive statistics and standardized factor

Table 1
Demographic characteristics of participants (N = 1302).

Characteristic	Category	n	%
Country	Algeria	788	60.5
	Egypt	514	39.5
Age group (years)	18–23	997	76.6
	24–30	89	6.8
	31–40	113	8.7
	41–50	78	6.0
	51–60	25	1.9
Marital status	Single	1,099	84.4
	Married	178	13.7
	Divorced	20	1.5
	Widowed	5	0.4
Educational level	Bachelor's/Licence	913	70.1
	Master's	249	19.1
	Doctorate	140	10.8
Employment status	Student	1,145	87.9
	Professor	93	7.1
	Administrator	36	2.8
	Student and administrator	15	1.2
	Professor and administrator	13	1.0
Economic status	Moderate	821	63.1
	Good	388	29.8
	Low	56	4.3
	Excellent	37	2.8

loadings for the 29 NPSS items. Item means ranged from 3.10 (PS14) to 4.17 (PS19), with standard deviations between 0.86 and 1.15, reflecting moderate variability and absence of floor or ceiling effects. Skewness values were mostly negative (−0.29 to −1.31), indicating a tendency toward higher endorsements, while kurtosis ranged from −0.70 to 2.22, suggesting item responses are generally close to normal.

3.3. Confirmatory factor analysis and model fit

The hypothesized three-factor structure of the NPSS was supported by the CFA. The model fit contained a significant χ^2 test ($\chi^2 = 1308.489$; $df = 374$; $p < 0.001$) and a normed chi-square (χ^2/df) of 3.50. Despite the significant χ^2 value—common in large samples—all other fit indices indicated an adequate to good model fit. More specifically, CFI and TLI were 0.976 and 0.974, respectively, both exceeding the conventional threshold of 0.95, which points to excellent fit. The RMSEA was 0.044 and the SRMR was 0.063; both values fell well within accepted cutoffs (≤ 0.08), further supporting the appropriateness of the model. Collectively, these results confirmed that the three-factor solution provided a robust representation of the underlying scale factor structure and supported the multidimensional conceptualization of the NPSS.

3.4. Standardized item loadings for the NPSS

Fig. 1 shows the factor loading information for NPSS items in the CFA. It also shows three correlated latent factors: social engagement, compassion, and body sensation. Each observed item loaded directly onto its respective latent factor, with standardized loadings presented in the figure. The Social Engagement factor was assessed with 14 items (PS1–PS14), with factor loadings ranging from 0.389 to 0.706, indicating moderate to strong associations between items and the underlying construct. Compassion was assessed with seven items (PS15–PS21), with factor loadings ranging from 0.596 to 0.747, consistently demonstrating solid relationships. The Body Sensation factor was assessed with eight items (PS22–PS29), with factor loadings ranging from 0.638 to 0.787, reflecting good convergence on the latent factor. Inter-factor correlations are also shown: Social Engagement correlated strongly with Compassion (0.689) and moderately with Body Sensation (0.635), while Compassion and Body Sensation had a lower correlation (0.440), supporting the empirical distinctiveness of the three constructs.

3.5. Reliability and validity

After confirming adequate model fit for the NPSS, the scale's reliability and validity were evaluated across three domains. All three NPSS factors demonstrated strong reliability in the form of internal consistency: Social Engagement ($\alpha = 0.898$, $\omega = 0.902$), Compassion ($\alpha = 0.815$, $\omega = 0.860$), and Body Sensations ($\alpha = 0.898$, $\omega = 0.898$). All reported values exceeded the commonly accepted threshold of 0.70, indicating that the item sets for each factor were internally consistent and that reliability indices were acceptable. Convergent validity assessed using AVE was generally acceptable (0.401 for Social Engagement, 0.448 for Compassion, and 0.527 for Body Sensations), suggesting an adequate proportion of variance in items is explained by their respective factors. Discriminant validity was evaluated using the Heterotrait-Monotrait (HTMT) ratio. All HTMT values were below the 0.85 cutoff (maximum reported = 0.664), confirming that the NPSS factors were empirically distinct from each other (Table 3).

3.6. Measurement invariance of the NPSS across countries (Algeria vs. Egypt)

Measurement invariance of the NPSS was assessed across Algerian and Egyptian samples using a sequence of increasingly restrictive models: configural, metric, scalar, and strict invariance (Table 4). The initial configural invariance model demonstrated acceptable fit (CFI =

Table 2
Item descriptive statistics and standardized factor loadings.

Factor	Item No.	Item (full text)	Mean	SD	Skewness	Kurtosis
Social Engagement	Item 1	I felt valued	3.68	0.94	-0.90	0.79
	Item 2	I felt comfortable expressing myself	3.76	1.00	-0.96	0.65
	Item 3	I felt accepted by others	3.83	0.91	-0.99	1.19
	Item 4	I felt understood	3.47	1.04	-0.64	-0.16
	Item 5	I felt like others got me	3.33	1.06	-0.47	-0.44
	Item 6	I felt respected	3.96	0.86	-1.16	2.03
	Item 7	There was someone who made me feel safe	3.90	1.11	-1.04	0.44
	Item 8	There was someone that I could trust	3.82	1.15	-0.94	0.09
	Item 9	I felt comforted by others	3.47	1.05	-0.60	-0.18
	Item 10	I felt heard by others	3.59	1.00	-0.81	0.30
	Item 11	I felt like people would try their best to help me	3.18	1.13	-0.29	-0.70
	Item 12	I felt cared for	3.66	0.99	-0.77	0.34
	Item 13	I felt wanted	3.70	0.99	-0.84	0.50
	Item 14	I didn't feel judged by others	3.10	1.05	-0.29	-0.61
Compassion	Item 15	I felt able to empathise with other people	4.04	0.87	-1.25	2.22
	Item 16	I felt able to comfort another person if needed	4.11	0.87	-1.20	1.82
	Item 17	I felt compassion for others	4.07	0.88	-1.22	2.01
	Item 18	I wanted to help others relax	3.96	0.91	-1.02	1.19
	Item 19	I felt like I could comfort a loved one	4.17	0.89	-1.31	2.07
	Item 20	I felt so connected to others I wanted to help them	3.96	0.96	-1.13	1.38
	Item 21	I felt caring	3.69	0.98	-0.80	0.46
Body Sensations	Item 22	My heart rate felt steady	3.44	1.02	-0.64	-0.10
	Item 23	Breathing felt effortless	3.42	1.05	-0.62	-0.29
	Item 24	My voice felt normal	3.58	0.97	-0.79	0.24
	Item 25	My body felt relaxed	3.38	1.03	-0.61	-0.24
	Item 26	My stomach felt settled	3.27	1.10	-0.57	-0.54
	Item 27	My breathing was steady	3.44	1.04	-0.68	-0.17
	Item 28	I felt able to stay still	3.53	1.02	-0.79	0.17
	Item 29	My face felt relaxed	3.37	1.04	-0.60	-0.30

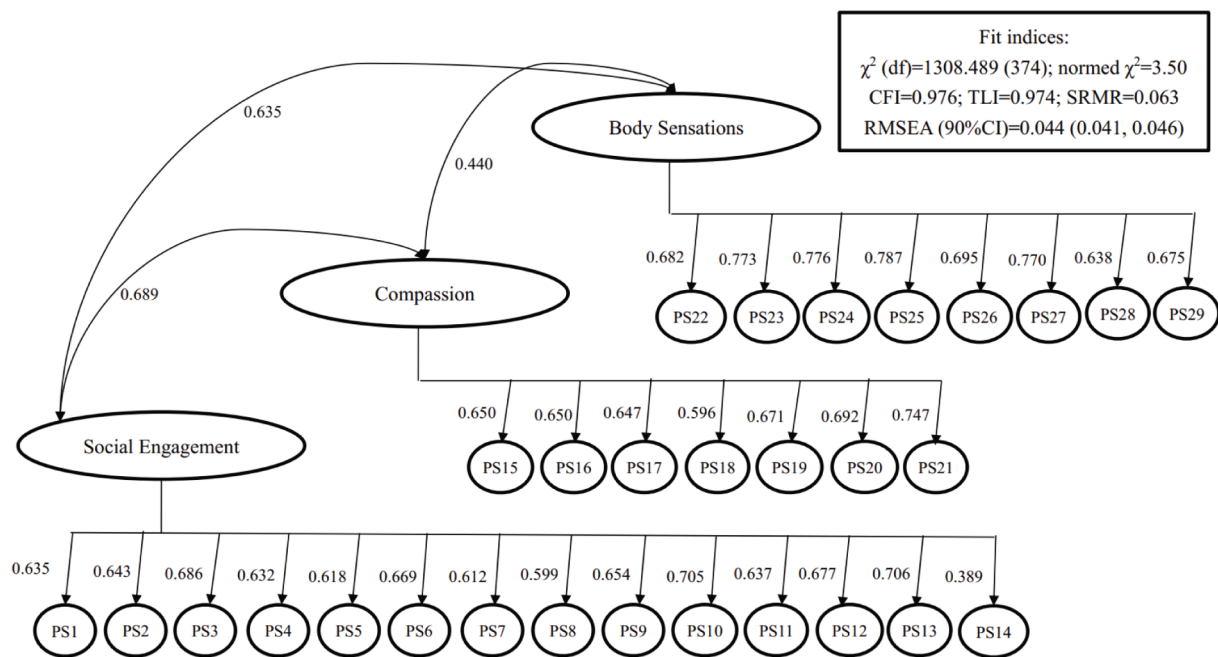


Fig. 1. Standardized confirmatory factor analysis model for the NPSS.

Table 3
Reliability and validity estimates for Neuroception of Psychological Safety Scale (NPSS) factors.

Construct	α	ω	AVE	Heterotrait-monotrait ratio		
				Social engagement	Compassion	Body Sensations
Social Engagement	0.898	0.902	0.401	1,000		
Compassion	0.815	0.860	0.448	0.664	1,000	
Body Sensations	0.898	0.898	0.527	0.646	0.421	1,000

AVE=average variance extracted.

0.980, RMSEA = 0.041, SRMR = 0.069, TLI = 0.978), indicating that the same three-factor structure was appropriate for both groups. Metric invariance, which tests for equality of factor loadings across groups, was also supported. The change in fit indices from the configural to the metric model was minimal ($\Delta CFI = -0.004$, $\Delta RMSEA = 0.003$, $\Delta SRMR = 0.003$), all well within recommended thresholds. This demonstrates that the relationships between items and their underlying factors were equivalent across Algeria and Egypt. Similarly, scalar invariance—which examines the equality of item intercepts—was established. Changes in fit indices remained negligible ($\Delta CFI = -0.001$, $\Delta RMSEA = 0.000$, $\Delta SRMR = -0.002$), confirming that mean comparisons between groups were meaningful. Finally, the strict invariance model, which further constrains residual variances to be equal across groups, also showed acceptable fit ($CFI = 0.973$, $RMSEA = 0.045$, $SRMR = 0.073$, $TLI = 0.973$), and that changes in indices were again minor ($\Delta CFI = 0.001$, $\Delta RMSEA = 0.001$, $\Delta SRMR = 0.003$). Overall, these results provide strong evidence for the stability and equivalence of the NPSS measurement structure across both Algerian and Egyptian participants, supporting the use of the scale for cross-cultural comparisons between these groups.

4. Discussion

The primary goal of the present study was to rigorously evaluate the psychometric properties of the Arabic version of NPSS among 1302 women in higher education settings across Algeria and Egypt. The results broadly supported the hypothesized three factor structure—Social Engagement, Compassion and Body Sensations—with robust fit indices ($CFI \approx 0.98$, $TLI \approx 0.97$, $RMSEA \approx 0.044$, $SRMR \approx 0.063$). Standardized factor loadings were moderate to strong, inter-factor correlations were moderate (0.44–0.69), and internal consistency coefficients exceeded conventional thresholds (α/ω : 0.82–0.90). Convergent validity was acceptable (AVE: 0.40–0.53), and discriminant validity (HTMT \approx 0.42–0.66) suggested distinct constructs. Multigroup CFA findings established configural, metric, scalar and strict invariance across Algerian and Egyptian samples, supporting the scale’s cross-cultural comparability.

Internal consistency across factors was high (α and $\omega > 0.81$), indicating that items within each factor reliably assessed their latent constructs (Taber, 2018). AVE values near or above 0.40 indicate moderate convergent validity—provided that composite reliability is ≥ 0.60 –0.70 and indicator loadings are adequate (Fornell & Larcker, 1981). Although the AVE for Social Engagement and Compassion fell slightly below the ideal 0.50 benchmark (Fornell & Larcker, 1981), their high reliability and theoretical coherence mitigate concerns. Body Sensations exceeded the AVE standard, affirming strong item convergence. HTMT ratios below 0.85 confirmed discriminant validity (Henseler et al., 2015), indicating that the three NPSS dimensions capture different aspects of psychological safety.

The confirmed three-factor solution aligned closely with the polyvagal informed theory underpinning the NPSS. Social Engagement captures the perception of interpersonal safety and trust—reflecting the ventral vagal state that facilitates social connection and co-regulation (Morton et al., 2024). Compassion captures feelings of warmth and acceptance toward others (Cogan et al., 2025). Polyvagal theorists posit that compassion reflects a calm vagal state projecting safety to oneself

and others (Porges, 2022). Body Sensations captures awareness of internal bodily cues (steady heartbeat, calm breathing) that indicate physiological safety (Morton et al., 2024). The moderate inter-factor correlations indicate that these domains are related aspects of neuroceptive safety yet retain empirical distinctiveness. Social Engagement and Compassion are closely associated, while the lower correlation between Compassion and Body Sensations underscores a meaningful distinction between social-emotional and interoceptive facets.

The psychometric properties of the NPSS, although statistically coherent, should not be read at face value. They need to be situated within the high-context, collectivist communication norms of Algeria and Egypt. In Hall’s (1976) terms, these societies prioritize group harmony and concerns for ‘face’, systematically incentivizing indirect signaling over explicit self-assertion. In such contexts, meaning flows through relational cues, which can naturally increase covariation between social-relational NPSS factors (Social Engagement and Compassion), while interoceptive Body Sensations remain more distinct.

Egyptian studies have consistently shown preferences for indirect refusals and mitigation strategies, reinforcing expectations of subdued self-presentation in evaluative self-reports (Morkus, 2014; Nelson et al., 2002). Culturally, both settings lean towards collectivist conditions—Egypt clusters low on individualism within the Arab region, and Algeria is characterized by high collectivism and uncertainty avoidance—that prioritize group loyalty and reputational equilibrium (The Culture Factor, 2023). In Algeria, humor frequently serves relational and tension-management functions within group networks, a pattern evident in public discourse and recent cultural history (Perego, 2023). Accordingly, strong model fit and cross-country invariance should be read alongside these norms. Moderate inter-factor correlations likely reflect shared high-context social-signaling logic, whereas the discriminant validity of body sensations aligns with the more private, individually felt nature of interoceptive cues. These findings echo prior validations among Western samples (Cogan et al., 2024, 2025; Morton et al., 2024; Poli & Miccoli, 2024; Spinoni et al., 2024), which likewise report a stable three factor structure and strong psychometric properties.

The present study’s findings are consistent with earlier NPSS validation studies. Morton et al. (2024) and Cogan et al. (2024) reported that the NPSS exhibited excellent internal consistency and a stable three factor structure among UK and health worker samples. Spinoni et al. (2024) replicated this structure among Italian adults and recommended modest modifications for optimal fit. Moreover, the present study extends this literature by confirming strict measurement invariance across two MENA (Middle East and North African) countries and focusing exclusively on women in higher education—an under-represented population in the psychological safety literature. The AVE values and inter-factor correlations observed were similar to those reported in Western samples, suggesting that the neuroceptive constructs underlying psychological safety are culturally robust while still sensitive to local nuances.

Cross-cultural measurement invariance demonstrated that factor loadings, intercepts, and residuals were stable across Algerian and Egyptian participants—critical for meaningful between-country comparisons. In practical terms, this means that women in both contexts interpreted the NPSS items in comparable ways. This similarity was not surprising given the two countries’ shared sociocultural and educational environments. Both Algeria and Egypt are Arab-majority societies, and

Table 4
Measurement invariance of the Neuroception of Psychological Safety Scale (NPSS) across countries (Algeria vs. Egypt).

Invariance	χ^2	df	p	TLI	CFI	RMSEA	SRMR	$\Delta\chi^2$	Δdf	p	ΔTLI	ΔCFI	$\Delta RMSEA$	$\Delta SRMR$
Configural	1566.205	748	<0.001	0.978	0.980	0.041	0.069	–	–	–	–	–	–	–
Metric	1738.315	774	<0.001	0.975	0.976	0.044	0.072	172.110	26	<0.001	–0.003	–0.004	0.003	0.003
Scalar	1801.490	800	<0.001	0.975	0.975	0.044	0.070	63.175	26	<0.001	0.000	–0.001	0.000	–0.002
Strict	1923.352	829	<0.001	0.973	0.973	0.045	0.073	121.862	29	<0.001	–0.002	0.001	0.001	0.003

TLI = Tucker-Lewis index; CFI = comparative fit index; RMSEA = root mean square error of approximation; SRMR = standardized root mean square residual.

have broadly comparable higher-education systems, labor market structures, and gender norms. Female students and working women alike navigate similar stressors—balancing traditional expectations with academic or professional ambitions—creating a common experiential frame through which NPSS items are understood.

5. Strengths, limitations, and future directions

A notable strength of the present study was the large, multi-institution sample spanning two countries, enabling rigorous multigroup CFA. The use of WLSMV estimation for ordinal data and comprehensive invariance testing enhanced methodological robustness (Rhemtulla et al., 2012; Sass et al., 2014). However, there are some limitations. The use of a convenience sampling method may have introduced sampling technique bias (i.e., selection bias) because participants were recruited based on accessibility rather than probability-based procedures. Therefore, the sample may not be fully representative of the wider population of Arab women in higher-education contexts. The cross-sectional design precluded assessment of test–retest reliability or predictive validity. The sample comprised solely women, most of whom were young students. Therefore, the results may not generalize to men, older adults or non-academic populations. Self-report measures not only contain methodological biases (e.g., social desirability, memory recall) but also capture conscious perceptions rather than implicit neuroception, and polyvagal theorists note that neuroception operates largely outside awareness. Some items showed lower loadings, and AVE values for two factors were marginal. Item refinement would likely improve convergent validity. Future research should evaluate the NPSS in mixed-gender and clinical populations, examine test–retest reliability and predictive validity, integrate physiological markers (e.g., heart rate variability) to triangulate implicit safety, and explore qualitative accounts of psychological safety across MENA contexts.

6. Implications and conclusion

The present study demonstrated that the Arabic-adapted NPSS is a psychometrically sound instrument for assessing psychological safety among women in Algerian and Egyptian higher-education contexts. By confirming the three-factor structure and establishing cross-country measurement invariance, researchers and practitioners are provided with a reliable psychometric instrument to evaluate how social engagement, compassion, and bodily sensations influence academic experiences. Because psychological safety is associated with trust, engagement, and resilience, systematically assessing it may inform interventions and policies to promote women's participation and leadership in MENA academia. In sum, the present validation study contributes to growing evidence that the NPSS captures key dimensions of psychological safety across cultural contexts, while highlighting the importance of situating psychometric results within individuals' socio-cultural landscapes.

Funding or sources of support

This research was supported by Al-Mujadilah Center for Women, Qatar.

CRediT authorship contribution statement

Aiche Sabah: Writing – original draft, Resources, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Musheer A. Aljaberi:** Writing – review & editing, Writing – original draft, Visualization, Validation, Resources, Methodology, Investigation, Formal analysis, Conceptualization. **Fawzia Belahdji:** Writing – original draft, Resources, Data curation. **Djamila Benamour:** Writing – original draft, Resources, Data curation. **Chung-Ying Lin:** Writing – review & editing, Writing – original draft, Visualization, Validation,

Methodology, Formal analysis, Conceptualization. **Susanne van Hooft:** Writing – review & editing, Writing – original draft, Visualization, Validation, Resources. **Rukman Awang Hamat:** Writing – review & editing, Writing – original draft, Visualization. **Mark D. Griffiths:** Writing – review & editing, Writing – original draft, Visualization, Validation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

None.

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