

TRANSLATION AND VALIDATION OF THE ROMANIAN VERSION OF THE ITC-SENSE OF PRESENCE INVENTORY (ITC-SOPI) FOR ASSESSING PRESENCE IN VIRTUAL REALITY

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Abstract

Presence is a multidimensional construct for VR psychological interventions, but no standardized Romanian measure existed. This study translated and culturally adapted the ITC–Sense of Presence Inventory (ITC-SOPI) and tested its psychometric properties on a sample of 241 Romanian-speaking participants, after a VR experience. Confirmatory factor analysis supported the intended structure with four factors. ML estimation indicated a modest fit (CFI = .762, TLI = .749, RMSEA = .070, SRMR = .080), while an ordinal sensitivity analysis WLSMV showed an improved fit (CFI = .906, TLI = .900, RMSEA = .058, SRMR = .097). Subscales showed acceptable-to-excellent internal consistency ($\alpha=.765-.893$). Presence-related subscales correlated positively with IPQ dimensions ($r=.33-.64$). Negative Effects subscale correlated strongly with simulator sickness (SSQ; $r=.48-.71$) and was the main predictor of total SSQ ($\beta=.711$). Overall, the Romanian ITC-SOPI appears reliable and valid for VR research.

Keywords: presence, virtual reality, ITC-SOPI, Romanian adaptation, validation.

In recent years, the accelerated development of virtual reality (VR) technologies has made it possible to create increasingly complex and multisensory digital environments (Melo *et al.*, 2022), which facilitate users' real-time interaction while at the same time providing them with a sense of control over their own actions (Saran, 2025). VR applications are used in a wide range of domains, from mental health (Dellazizzo *et al.*, 2020) to professional training (Steen *et al.*, 2024), education (Kamińska *et al.*, 2019), and entertainment (Lai *et al.*, 2019). The evaluation of these applications does not target only the degree of symptom reduction or the increase in skill level, but also users' subjective experience, which has been emphasized as an important outcome dimension in VR-based interventions (Weber *et al.*, 2021).

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One of the most important concepts for understanding how people experience VR is presence (sense of presence). In the existing literature, multiple definitions have been proposed. For example, Kisker *et al.* (2021) define presence as the subjective feeling of existing inside a virtual world, with awareness of real surroundings and hardware gradually fading away. Regardless of the diversity of definitions that have emerged over time, most authors converge on the view that presence should be understood as a multidimensional construct that calls for cross-disciplinary perspectives and user-focused assessments of subjective psychological experience (Baños *et al.*, 2008; Williams *et al.*, 2025). Theories of presence are often grouped into descriptive and structural models (Diemer *et al.*, 2015). Descriptive models, such as that of Schubert *et al.* (2001), refer to the components of presence experienced in virtual reality, such as spatial presence, involvement, and realness. At the same time, structural models, such as that of Wirth *et al.* (2007), propose that spatial presence can be described as the outcome of a two-step process in which users first construct a mental model of the mediated environment – a stage influenced by attention allocation and visual spatial imagery – and then, in a second stage, involvement and suspension of disbelief, together with this model, give rise to the subjective feeling of being located in the virtual space. Therefore, in line with this distinction, descriptive models focus on the phenomenological components of the presence experience, whereas structural models focus on the underlying cognitive and perceptual processes in the user’s mind that generate this experience of presence (Diemer *et al.*, 2015).

Empirical findings on the role of presence as a mechanism of change in VR-based interventions are mixed. Pavic *et al.*’s (2023) results demonstrate that, when eliciting positive emotions, spatial and social presence mediate the relationship between immersion and subjective arousal. Other studies have shown that there is a relationship between presence and emotions, suggesting that both highly anxious and highly relaxing virtual environments are associated with increased presence, and that presence significantly predicts a range of emotional outcomes, particularly in anxious environments such as virtual park scenarios (Riva *et al.*, 2007). In contrast to these findings, some studies indicate that presence does not consistently predict clinical improvement, with cognitive variables such as self-efficacy and changes in dysfunctional beliefs emerging as stronger predictors of symptom reduction (Price & Anderson, 2007; Côté & Bouchard, 2009).

Given the central role of presence in modulating users’ emotional and subjective responses in VR (Riva *et al.*, 2007; Diemer *et al.*, 2015), valid and reliable instruments for measuring presence are essential. Although physiological and behavioral indices of presence have also been explored in the literature (Cummings & Bailenson, 2016), empirical studies most commonly assess presence

using self-report questionnaires (Halbig & Latoschik, 2021). Among the numerous instruments developed to assess presence, the Witmer and Singer Presence Questionnaire (PQ; Witmer & Singer, 1998), the Slater–Usoh–Steed questionnaire (SUS; Slater *et al.*, 1994; Usoh *et al.*, 2000), the IGroup Presence Questionnaire (IPQ; Schubert, Friedmann, & Regenbrecht, 2001), the ITC–Sense of Presence Inventory (ITC-SOPI; Lessiter, Freeman, Keogh, & Davidoff, 2001), the Multimodal Presence Scale (MPS; Makransky, Jensen, & Aaby, 2017), and the Temple Presence Inventory (TPI; Lombard, Ditton, & Weinstein, 2009) stand out as some of the most frequently used and recommended measures in contemporary VR research (Hein *et al.*, 2018; Bareišytė *et al.*, 2024; Kukshinov *et al.*, 2025).

Among all these instruments, the ITC–Sense of Presence Inventory (Lessiter *et al.*, 2001) is the most relevant for the purposes of the present study. It was designed to assess presence across different media contexts and to facilitate the comparability of results between different laboratories (Lessiter *et al.*, 2001). The inventory developed by Lessiter *et al.* (2001) includes a total of 44 items. These are organized into four distinct dimensions: Engagement, Negative Effects, Ecological Validity/Naturalness, and the Sense of Physical Space. Sense of Physical Space reflects the feeling of being spatially located in the mediated environment and being able to act within it; Engagement captures interest and psychological involvement with the content; Ecological Validity/Naturalness refers to the perceived realism and naturalness of the environment and events; whereas Negative Effects includes symptoms such as dizziness, nausea, or discomfort that may accompany media exposure (Lessiter *et al.*, 2001). The ITC-SOPI has also been translated and validated for other language populations. For example, Vasconcelos-Raposo *et al.* (2019) adapted the ITC-SOPI for Portuguese-speaking participants, confirming the four-factor structure and reporting acceptable internal consistency for all subscales. They concluded that the instrument is suitable for assessing presence in VR research with Portuguese samples (Vasconcelos-Raposo *et al.*, 2019).

To our knowledge, no standardized and psychometrically validated presence scale is currently available in Romanian. Existing VR studies conducted with Romanian-speaking samples either rely on instruments developed in other languages or use ad hoc translations that have not undergone a formal process of cultural adaptation and validation. In this context, we chose the ITC-SOPI as the basis for developing a Romanian measure of presence that can be applied across different media configurations, so that it can be used in a wide range of study designs (e.g., experimental laboratory studies, clinical interventions, educational applications). The aim of the present study is therefore to translate and culturally adapt the ITC-SOPI for the Romanian population and to examine its factorial structure, reliability, and construct validity in a sample of Romanian VR users. In the current study, the scale was initially adapted for use in virtual reality contexts, and we intend to extend its application to other media environments in future research.

METHODS

PARTICIPANTS

A total of 241 Romanian-speaking participants took part in the study and completed all measures included in the present analyses. Participants were recruited from the Faculty of Psychology and Educational Sciences in Cluj-Napoca. The sample included 223 women (92.53%) and 18 men (7.47%). All participants had been exposed to a virtual reality (VR) scenario before completing the questionnaires. Regarding prior experience with VR, 39.49% of the participants reported that they had previously used VR in an experimental context. In terms of VR-related knowledge, participants rated themselves on a four-point scale as follows: none (48.55%), basic (46.89%), intermediate (3.73%), and expert (0.83%). Unfortunately, participants' age was not collected in the present study.

MEASURES

ITC–Sense of Presence Inventory (ITC-SOPI)

The participants' sense of presence was measured using the ITC-SOPI (Lessiter *et al.*, 2001). The inventory is a cross-media instrument, in which the items (44; 5-point Likert scale) are grouped into four subscales: Sense of Physical Space, Engagement, Ecological Validity/Naturalness, and Negative Effects. It is divided into Part A (6 items) and Part B (38 items). Following the authors' recommendation, we removed item B6, as it was not included in the scoring of any subscale and was specific to the television context (Lessiter *et al.*, 2001). Thus, the final version of the ITC-SOPI adapted for the Romanian population within the present study contains 43 items.

Regarding the back-translation procedure used to adapt the scale for the Romanian population, established multi-step guidelines were followed (Sousa & Rojjanasrirat, 2011; Zhao *et al.*, 2024). First, two bilingual psychologists, Romanian native speakers, independently translated the inventory items (forward translations) from English into Romanian. In line with recommendations to prioritize conceptual equivalence over literal equivalence, the two translations were then compared item by item and reconciled into a single preliminary version through discussion and consensus. Next, this preliminary Romanian version underwent a blind back-translation into English conducted by a third bilingual translator. This translator was not involved in the forward translation process and was kept "blind" to both the original instrument and the study objectives (Sousa & Rojjanasrirat, 2011). The back-translated version was thereafter compared with the original English ITC-SOPI by all three translators acting as an expert committee. Discrepancies in meaning, nuance, and wording were discussed until consensus

was reached, and minor adjustments were made to the Romanian phrasing to improve conceptual and semantic equivalence.

Igroup Presence Questionnaire (IPQ)

Another questionnaire used to measure the sense of presence and to use it in the study analyses is the IPQ (Schubert *et al.*, 2001). It includes 14 items rated on a 7-point Likert-type scale, having 3 subscales (Spatial Presence, Involvement, Experienced Realism) and one General Presence item, being one of the most established presence questionnaires (Tran *et al.*, 2024).

Simulator Sickness Questionnaire

The SSQ (Kennedy *et al.*, 1993) was administered to quantify cybersickness following VR exposure. Participants rated 16 symptoms on a 4-point scale, and responses were combined to obtain Nausea, Oculomotor Disturbance, and Disorientation scores, as well as an overall SSQ total score (Kennedy *et al.*, 1993). The SSQ is widely used in the VR literature to assess simulator sickness (Bimberg *et al.*, 2020).

PROCEDURE

Google Forms was the platform used to recruit participants. In the first stage, participants signed up to take part in the study by indicating the day on which they wished to participate. Subsequently, in the second stage, those who registered received a second Google Forms link in which they selected the time slot at which they wanted to attend the experimental session in the laboratory. In the third stage, after completing informed consent and meeting the eligibility criteria, participants completed a short familiarization session with the virtual reality application, Nature Treks VR (Greener Games, 2019), conducted in the research laboratory. The exclusion criteria included minors, residents of foreign countries, non-Romanian speakers; a history of mental disorders, photophobia; and an epilepsy diagnosis or the presence/experience of epileptic seizures.

After participants familiarized themselves with the virtual reality application, they engaged in the experimental task. This task consisted of exploring a virtual reality environment called White Winter (Björling *et al.*, 2022), in which participants could observe various changes in the landscape and interact with characters within the application. During this task, Meta Quest 2 virtual reality headsets were used (Meta Platforms, Inc., 2020). After completing the experimental task, participants filled out the set of instruments selected for the statistical analyses. Only one session took place, and the total duration of the entire procedure was approximately 30 minutes.

ETHICAL CONSIDERATIONS

Ethical approval was granted by the Ethics Committee of the Faculty of Psychology and Educational Sciences, Babeş- Bolyai University. All participants provided written informed consent prior to participation. The ethical approval number is No. 16.704/13.10.2025.

DATA ANALYSIS

To validate the four-factor structure of the ITC-SOPI Inventory – comprising Engagement, Sense of Physical Space, Ecological Validity, and Negative Effects – we conducted a Confirmatory Factor Analysis (CFA). The four-factor model was specified a priori based on the original ITC-SOPI structure. First, we used maximum likelihood (ML) estimation as the primary CFA estimator because the ITC-SOPI items use a 5-point response format that is commonly treated as approximately continuous in SEM, and ML facilitates comparability with prior validation studies. Item distributions were examined via skewness and kurtosis to assess univariate departures from normality and to inform the interpretation of ML-based model fit. To assess the model's quality, we reported the SRMR and RMSEA (with a 90% confidence interval), alongside the chi-square test. Furthermore, the comparative indices TLI and CFI were calculated, following the standard SEM guidelines proposed by Brown (2015) and Bentler and Bonett (1980). Second, as a sensitivity analysis, we re-estimated the CFA treating the items as ordinal indicators using the WLSMV estimator with robust standard errors. The aim was to assess whether conclusions regarding the factor structure were robust to the estimation method. Third, in an exploratory post-hoc step within the CFA, we sought to improve model parsimony by removing items with standardized factor loadings below .40, even though loadings as low as .30 are often considered acceptable in initial adaptations (Brown, 2015). Cronbach's alpha coefficient was used to calculate internal consistency regarding the ITC-SOPI scores (Cronbach, 1951). Convergent validity was evaluated through Pearson correlations between the ITC-SOPI subscales and the IPQ subscales, as well as between the Negative Effects subscale and the SSQ scores (Campbell & Fiske, 1959). Furthermore, we employed a multiple linear regression model, defining the four inventory factors as predictors and the total SSQ score as the primary dependent variable. All these analyses were conducted in order to examine the extent to which experiences related to presence and negative effects explain the variance of simulator sickness (Cohen, Cohen, West, & Aiken, 2003). All analyses were based on complete cases ($N = 241$). The comprehensive statistical workflow, spanning from the initial CFA to the final regression models, was carried out using the JASP (Version 0.18; JASP Team, 2023).

RESULTS

CONFIRMATORY FACTOR ANALYSIS

CFA was used to test the original four-factor structure of the ITC-SOPI. Prior to CFA, item distributions were inspected for univariate normality (skewness and kurtosis). Several items showed pronounced skewness ($|\text{skewness}| > 2$), including Item_6_A (skewness = -3.806) and Item_26_B (skewness = 3.719). Kurtosis was elevated for a small number of items, with three items exceeding $|\text{kurtosis}| > 10$ (Item_5_A = 10.55 ; Item_6_A = 15.97 ; Item_26_B = 14.94). These departures were considered when interpreting ML-based fit indices. The initial model, which included all items, yielded a statistically significant chi-square value, $\chi^2(854) = 1858.23$, $p < .001$, as expected given the relatively large number of items and parameters (Bentler & Bonett, 1980). Overall model fit was modest, with CFI = $.762$ and TLI = $.749$. The RMSEA was $.070$, with a 90% CI $[.066, .074]$, and the SRMR was $.080$. Standardized factor loadings for the initial (full) CFA model are reported in Table 1.

Table 1

Standardized factor loadings for the Romanian ITC-SOPI: initial (full) four-factor CFA model (ML)

Factor	Indicator	Std. estimate	Std. Error	p
Sense of Physical Space	Item_4_B	0.568	0.048	< .001
	Item_7_B	0.591	0.051	< .001
	Item_9_B	0.604	0.053	< .001
	Item_12_B	0.597	0.052	< .001
	Item_13_B	0.457	0.059	< .001
	Item_18_B	0.765	0.037	< .001
	Item_19_B	0.507	0.067	< .001
	Item_22_B	0.381	0.047	< .001
	Item_23_B	0.569	0.047	< .001
	Item_24_B	0.427	0.066	< .001
	Item_25_B	0.594	0.055	< .001
	Item_28_B	0.618	0.050	< .001
	Item_29_B	0.356	0.055	< .001
	Item_31_B	0.478	0.064	< .001
	Item_33_B	0.462	0.055	< .001
	Item_34_B	0.680	0.046	< .001
	Item_35_B	0.545	0.050	< .001
	Item_36_B	0.739	0.034	< .001
	Item_38_B	0.737	0.048	< .001

Table 1 (continued)

Factor	Indicator	Std. estimate	Std. Error	p
Engagement	Item_1_A	0.413	0.067	< .001
	Item_3_A	0.411	0.060	< .001
	Item_4_A	0.677	0.055	< .001
	Item_5_A	0.390	0.094	< .001
	Item_6_A	0.591	0.071	< .001
	Item_1_B	0.606	0.067	< .001
	Item_2_B	0.669	0.048	< .001
	Item_3_B	0.385	0.066	< .001
	Item_8_B	0.740	0.046	< .001
	Item_16_B	0.544	0.054	< .001
	Item_17_B	0.449	0.075	< .001
	Item_30_B	0.396	0.058	< .001
	Item_32_B	0.667	0.053	< .001
Ecological validity	Item_5_B	0.751	0.044	< .001
	Item_11_B	0.785	0.044	< .001
	Item_15_B	0.806	0.030	< .001
	Item_20_B	0.409	0.066	< .001
	Item_27_B	0.537	0.062	< .001
Negative Effects	Item_2_A	0.422	0.060	< .001
	Item_10_B	0.779	0.039	< .001
	Item_14_B	0.769	0.043	< .001
	Item_21_B	0.740	0.051	< .001
	Item_26_B	0.515	0.067	< .001
	Item_37_B	0.769	0.043	< .001

Note. λ = standardized factor loading; SE = standard error; N = 241. Items labeled “_A” and “_B” correspond to Parts A and B of the inventory. The CFA model includes 43 items; item B6 was excluded following the original authors’ scoring recommendations.

As a confirmatory sensitivity analysis of the same a priori four-factor model, the four-factor model was re-estimated treating the 5-point Likert items as ordinal using the WLSMV estimator with robust standard errors. This ordinal solution indicated improved global fit: χ^2 (854) = 1536.54, $p < .001$; CFI = .906; TLI = .900; RMSEA = .058, 90% CI [.053, .062]; SRMR = .097. Overall, the pattern supported the intended four-factor structure.

EXPLORATORY POST-HOC REFINEMENT (ITEM TRIMMING)

As an exploratory post-hoc refinement, several items displayed relatively weak standardized loadings (*i.e.*, $< .40$) on their intended factors. Therefore, we specified an additional, more parsimonious four-factor solution in which these

low-loading items were excluded. This trimming was treated as an exploratory refinement to reduce model complexity, acknowledging that in early adaptations factor loadings around .30 may still be considered acceptable (Brown, 2015). The revised model yielded slightly better fit indices, $\chi^2(660) = 1485.24$, $p < .001$, CFI = .787, TLI = .773, RMSEA = .072 (90% CI [.067, .077]), and SRMR = .077. In the trimmed model all retained indicators loaded at .40 or higher on their intended factors. However, the improvement in global fit was marginal and did not alter the substantive interpretation of the four-factor structure. Therefore, we retained the full 43-item version to preserve content validity and comparability with the original instrument. Although the overall fit remained below commonly cited “good-fit” criteria (*e.g.*, CFI/TLI $\geq .95$; Hu & Bentler, 1999), overall, both models were broadly consistent with the original four-factor ITC-SOPI structure, although global fit was modest.

INTERNAL CONSISTENCY

Internal consistency of the Romanian ITC-SOPI subscales was examined using Cronbach’s alpha with 95% confidence intervals. The Sense of Physical Space subscale showed excellent reliability ($\alpha = .893$, 95% CI [.87, .917]). Engagement also demonstrated good internal consistency ($\alpha = .805$, 95% CI [.77, .841]). The Ecological Validity/Naturalness subscale showed acceptable to good reliability ($\alpha = .765$, 95% CI [.713, .817]), and the Negative Effects subscale likewise displayed good internal consistency ($\alpha = .819$, 95% CI [.787, .852]). The internal consistency for all subscales shows good results. Reliability analyses revealed good internal consistency across all four subscales of the inventory.

CONVERGENT VALIDITY

Convergent validity was evaluated by correlating the ITC-SOPI subscales with the dimensions of the Igroup Presence Questionnaire (IPQ) (Table 2).

The three subscales (Sense of Physical Space, Engagement, and Ecological Validity/Naturalness) of the ITC-SOPI correlated positively with the presence measured by the IPQ dimensions (Spatial Presence, Involvement, Experienced Realism) ($r = .33-.64$, $p < .001$). The highest association was observed between Sense of Physical Space and Spatial Presence ($r = .64$, $p < .001$) and between Engagement and General Presence ($r = .54$, $p < .001$). In contrast, the Negative Effects subscale showed small and largely non-significant associations with the IPQ dimensions ($r = -.18$ to $-.03$). This suggests that this subscale is partially distinct from the presence measured in the other scales, as expected (Lessiter *et al.*, 2001). At the same time, convergent validity with simulator sickness (SSQ) was examined by correlating the Negative Effects subscale from the ITC-SOPI with the SSQ subscales and the SSQ total score (Table 3).

Table 2

Pearson correlations between ITC-SOPI subscales and IPQ dimensions (convergent validity)

ITC-SOPI subscale		IPQ dimension	Pearson's r	p
Sense of Physical Space (ITC-SOPI)	–	General Presence (IPQ)	0.593	< .001
Sense of Physical Space (ITC-SOPI)	–	Spatial Presence (IPQ)	0.641	< .001
Sense of Physical Space (ITC-SOPI)	–	Involvement (IPQ)	0.436	< .001
Sense of Physical Space (ITC-SOPI)	–	Experienced Realism (IPQ)	0.448	< .001
Engagement (ITC-SOPI)	–	General Presence (IPQ)	0.543	< .001
Engagement (ITC-SOPI)	–	Spatial Presence (IPQ)	0.509	< .001
Engagement (ITC-SOPI)	–	Involvement (IPQ)	0.466	< .001
Engagement (ITC-SOPI)	–	Experienced Realism (IPQ)	0.332	< .001
Ecological Validity/Naturalness (ITC-SOPI)	–	General Presence (IPQ)	0.496	< .001
Ecological Validity/Naturalness (ITC-SOPI)	–	Spatial Presence (IPQ)	0.517	< .001
Ecological Validity/Naturalness (ITC-SOPI)	–	Involvement (IPQ)	0.394	< .001
Ecological Validity/Naturalness (ITC-SOPI)	–	Experienced Realism (IPQ)	0.540	< .001
Negative Effects (ITC-SOPI)	–	General Presence (IPQ)	-0.179	.005
Negative Effects (ITC-SOPI)	–	Spatial Presence (IPQ)	-0.095	.142
Negative Effects (ITC-SOPI)	–	Involvement (IPQ)	-0.032	.624
Negative Effects (ITC-SOPI)	–	Experienced Realism (IPQ)	-0.057	.375

Note. Pearson correlations are reported (two-tailed). N = 241. ITC-SOPI = ITC–Sense of Presence Inventory; IPQ = Igroup Presence Questionnaire.

Table 3

Pearson correlations between ITC-SOPI Negative Effects and SSQ scores

ITC-SOPI subscale		SSQ subscale	Pearson's r	p
Negative Effects (ITC-SOPI)	–	Nausea (SSQ)	0.484	< .001
Negative Effects (ITC-SOPI)	–	Oculomotor (SSQ)	0.708	< .001
Negative Effects (ITC-SOPI)	–	Disorientation (SSQ)	0.625	< .001
Negative Effects (ITC-SOPI)	–	Total (SSQ)	0.689	< .001

Note. Pearson correlations are reported (two-tailed). N = 241. ITC-SOPI = ITC–Sense of Presence Inventory; SSQ = Simulator Sickness Questionnaire

As we can observe, the Negative Effects subscale correlated positively with all SSQ dimensions (*e.g.*, Disorientation, $r = .63$, $p < .001$) and the SSQ Total score ($r = .69$, $p < .001$). Overall, this pattern is consistent with the intended conceptualization of the Negative Effects subscale as an indicator of adverse reactions/discomfort (Lessiter *et al.*, 2001) and with its convergence with simulator sickness, as measured by the SSQ.

MULTIPLE LINEAR REGRESSION PREDICTING TOTAL SSQ SCORES FROM ITC-SOPI SUBSCALES

A multiple linear regression analysis was conducted with the Total SSQ score as the dependent variable and the four ITC-SOPI subscales as simultaneous predictors. The overall model was significant, $F(4, 236) = 59.01$, $p < .001$, and explained 50.0% of the variance in simulator sickness, $R^2 = .50$, adjusted $R^2 = .492$. Standardized regression coefficients indicated that Negative Effects was the strongest predictor of Total SSQ ($B = 26.727$, $SE = 1.766$, $\beta = .711$, $t = 15.137$, $p < .001$), whereas the other subscales showed mixed associations with simulator sickness when controlling for the remaining predictors (Engagement: $B = 10.311$, $\beta = .188$, $p = .004$; Ecological Validity/Naturalness: $B = -4.898$, $\beta = -.146$, $p = .037$; Sense of Physical Space: $B = -2.840$, $\beta = -.064$, $p = .415$). In the multiple regression model, Negative Effects emerged as the dominant predictor of Total SSQ, while the remaining ITC-SOPI subscales contributed weakly or not at all after controlling for the other predictors.

DISCUSSION

The present study aimed to translate, culturally adapt, and psychometrically evaluate the Romanian version of the ITC–Sense of Presence Inventory (ITC-SOPI) for its use in studies involving virtual reality applications. A comprehensive analytical strategy was employed, including Confirmatory Factor Analysis (CFA), reliability analyses, convergent validity correlations, and multiple regression. Overall, the results provide solid preliminary evidence that the Romanian-language ITC-SOPI yields reliable subscale scores and supports the intended four-factor conceptualization in a Romanian VR sample.

Regarding structural validity and model evaluation, the CFA results were, broadly, in line with the original four-factor structure proposed by Lessiter *et al.* (2001), comprising Sense of Physical Space, Engagement, Ecological Validity/Naturalness, and Negative Effects. As is common in the case of complex, multidimensional instruments with many indicators and parameters, the overall model fit was modest in the initial model ($CFI = .76$, $TLI = .75$). Although the CFA was initially estimated using ML (treating 5-point items as approximately continuous), the ordinal WLSMV sensitivity analysis provided converging evidence for the four-factor structure. Future studies are encouraged to prioritize ordinal estimators (*e.g.*, WLSMV) when validating the Romanian ITC-SOPI in broader Romanian samples.

A more parsimonious CFA model, conducted by excluding items with standardized loadings $< .40$, produced only marginal changes in global fit, indicating that item reduction did not significantly alter the underlying structure (CFI = .787, TLI = .773).

Even though the ML-estimated CFA models (both the initial full-item model and the trimmed ML model) do not meet the most stringent conventional fit thresholds (*e.g.*, Hu & Bentler, 1999), Marsh *et al.* (2004) argue that such “golden rules” are often overly restrictive when applied to real-world psychological data and complex, multidimensional instruments. According to their critique, rigid cutoffs can lead to the unfair rejection of theoretically sound models, especially in item-level analyses where inherent complexity naturally leads to lower fit indices such as the CFI and TLI. It is worth noting that while the comparison-based indices (CFI/TLI) were modest, the absolute fit indices in our study (RMSEA = .070; SRMR = .080) remained within acceptable ranges (Brown, 2015), providing additional support for the model's viability.

Given that the more parsimonious model did not provide a substantial improvement in fit, it was concluded that the modest indices reflect the inherent complexity of the construct rather than specific psychometric failures of the items. Consequently, we decided to retain the original 43-item version of the inventory to preserve its full theoretical breadth and content validity, since the reduction did not significantly change the underlying structural performance.

The reliability analyses further support this decision, as the internal consistency for all subscales showed good to excellent results. The high Cronbach's alpha values (ranging from .765 to .893) indicate that the Romanian version of the ITC-SOPI is a highly dependable instrument for measuring the different dimensions of the VR experience.

Beyond the structural evaluation, the convergent validity results of the inventory provide solid evidence for the psychometric robustness of the Romanian version of the ITC-SOPI. The positive correlations between the Romanian ITC-SOPI inventory and the IPQ dimensions confirm that the instrument accurately captures the core constructs of the presence experience. The particularly high association between Sense of Physical Space and Spatial Presence (IPQ) aligns with the conceptual framework proposed by Lessiter *et al.* (2001), confirming that the Romanian version effectively captures the spatial dimension of presence as intended by the original authors.

Another important result of this study concerns the relationship between the Negative Effects subscale and simulator sickness. Negative Effects showed a strong and specific positive correlation with all dimensions of the Simulator Sickness Questionnaire (SSQ), especially with the SSQ Total score ($r = .69$). In addition, the fact that this subscale showed non-significant or weak associations with the IPQ dimensions further supports its discriminant validity and conceptual distinctiveness, as adverse reactions represent a separate dimension of the VR experience from presence itself.

The predictive power of the instrument was further demonstrated through the multiple linear regression analysis. The model explained 50% of the variance in total simulator sickness, a substantial effect for psychological research. The emergence of Negative Effects as the dominant predictor ($\beta = .711$) validates the role of this subscale as a primary indicator of user discomfort, suggesting that simulator sickness is primarily associated with Negative Effects rather than with the other presence-related subscales when considered simultaneously.

Regarding practical implications, a validated Romanian version of the ITC-SOPI provides a standardized presence measure that supports the cross-laboratory comparability highlighted for the original instrument. In Romania, this can facilitate systematic comparisons of presence and negative effects across VR studies and VR setups (Lessiter *et al.*, 2001). In applied VR development, presence is commonly measured – most often with validated questionnaires – to document user experience and interaction in both research and industry (Schwind *et al.*, 2019). Because a subjective sense of “being there” is one component contributing to realistic responding in immersive virtual environments (Slater, 2009) and presence has been described as a consensual metric for evaluating virtual-environment effectiveness (Vasconcelos-Raposo *et al.*, 2021), routine presence assessment can inform evaluation and iterative design decisions for VR applications where immersion is a key goal.

Taken together, the pattern of results – modest ML-based global fit, improved fit under ordinal WLSMV estimation, and strong reliability and criterion-related validity – provides initial evidence supporting the use of the Romanian ITC-SOPI in Romanian VR research.

LIMITS AND FUTURE DIRECTIONS

The first limitation of this study is the fact that the data were collected at a single measurement point, after a single exposure to VR, which prevented the evaluation of test–retest reliability. We recommend that future studies examine stability across several repeated sessions. The second limitation is the lack of formal testing of the instrument in a pilot study before the main data collection in order to evaluate face validity and comprehensibility (Sousa & Rojjanasrirat, 2011). This stage could help identify potentially ambiguous items. Third, convergent validity was assessed using the IPQ, and not an additional Romanian-language presence instrument. Although a local measure has been mentioned in Romanian contexts (Opriș, 2012), it is not currently available as a fully peer-reviewed, standardized, and publicly documented instrument, which limited local comparability across instruments. It is recommended to examine convergence with Romanian presence measurement instruments, if and when they become validated and accessible. The fourth limitation is the predominantly female sample, which may limit generalizability to other demographic groups. Replication on more heterogeneous samples may strengthen external validity. Unfortunately, participants’ age was not

collected, which prevented us from describing the age distribution of the sample and from examining potential age-related differences in presence or cybersickness. Accordingly, the present findings should be considered an initial validation of the Romanian ITC-SOPI. Future studies should recruit samples with a more even gender distribution, collect age data, and test measurement invariance across gender and age to evaluate whether the scale operates equivalently across demographic groups.

CONCLUSIONS

In conclusion, although the global fit indices reflect the inherent complexity of modeling a multidimensional instrument with 43 items, the overall psychometric profile of the Romanian-language ITC-SOPI is highly favorable. The combination of high internal consistency, strong convergent validity with the IPQ, and robust prediction of simulator sickness justifies the use of the full 43-item version. Overall, the present study provides initial validation evidence that the Romanian ITC-SOPI yields reliable scores and shows construct validity in a Romanian VR sample, supporting its use in Romanian VR research while future work should confirm invariance across gender and age.

REFERENCES

1. Baños, R. M., Botella, C., Rubió, I., Quero, S., García-Palacios, A., & Alcañiz, M. (2008). Presence and emotions in virtual environments: The influence of stereoscopy. *CyberPsychology & Behavior*, 11(1), 1–8. <https://doi.org/10.1089/cpb.2007.9936>
2. Bareișytė, L., Slatman, S., Austin, J., Rosema, M., van Sintemaartensdijk, I., Watson, S., & Bode, C. (2024). Questionnaires for evaluating virtual reality: A systematic scoping review. *Computers in Human Behavior Reports*, 16, Article 100505. <https://doi.org/10.1016/j.chbr.2024.100505>
3. Bentler, P. M., & Bonett, D. G. (1980). Significance tests and goodness of fit in the analysis of covariance structures. *Psychological Bulletin*, 88(3), 588–606. <https://doi.org/10.1037/0033-2909.88.3.588>
4. Bimberg, P., Weissker, T., & Kulik, A. (2020, March). *On the usage of the Simulator Sickness Questionnaire for virtual reality research*. In Proceedings of the 2020 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW). IEEE.
5. Björling, E. A., Sonney, J., Rodríguez, S., Carr, N., Zade, H., & Moon, S. H. (2022). Exploring the effect of a nature-based virtual reality environment on stress in adolescents. *Frontiers in Virtual Reality*, 3, 831026. <https://doi.org/10.3389/frvir.2022.831026>
6. Brown, T. A. (2015). *Confirmatory factor analysis for applied research* (2nd ed.). Guilford Press.
7. Campbell, D. T., & Fiske, D. W. (1959). Convergent and discriminant validation by the multitrait-multimethod matrix. *Psychological Bulletin*, 56(2), 81–105.
8. Cohen, J., Cohen, P., West, S. G., & Aiken, L. S. (2003). *Applied multiple regression/correlation analysis for the behavioral sciences* (3rd ed.). Lawrence Erlbaum Associates.
9. Côté, S., & Bouchard, S. (2009). Cognitive mechanisms underlying virtual reality exposure. *CyberPsychology & Behavior*, 12(2), 121–129. <https://doi.org/10.1089/cpb.2008.0008>
10. Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika*, 16(3), 297–334. <https://doi.org/10.1007/BF02310555>

11. Cummings, J. J., & Bailenson, J. N. (2016). How immersive is enough? A meta-analysis of the effect of immersive technology on user presence. *Media Psychology*, 19(2), 272–309. <https://doi.org/10.1080/15213269.2015.1015740>
12. Dellazizzo, L., Potvin, S., Luigi, M., & Dumais, A. (2020). Evidence on virtual reality-based therapies for psychiatric disorders: Meta-review of meta-analyses. *Journal of Medical Internet Research*, 22(8), e20889. <https://doi.org/10.2196/20889>
13. Diemer, J., Alpers, G. W., Peperkorn, H. M., Shibani, Y., & Mühlberger, A. (2015). The impact of perception and presence on emotional reactions: A review of research in virtual reality. *Frontiers in Psychology*, 6, 26. <https://doi.org/10.3389/fpsyg.2015.00026>
14. Greener Games. (2019). *Nature Treks VR* [Virtual reality application].
15. Halbig, A., & Latoschik, M. E. (2021). A systematic review of physiological measurements, factors, methods, and applications in virtual reality. *Frontiers in Virtual Reality*, 2, 694567. <https://doi.org/10.3389/frvir.2021.694567>
16. Hein, D., Mai, C., & Hußmann, H. (2018). *The usage of presence measurements in research: A review*. In Proceedings of the 10th International Conference on Virtual Worlds and Games for Serious Applications (VS-Games 2018).
17. Hu, L.-T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal*, 6(1), 1–55. <https://doi.org/10.1080/10705519909540118>
18. JASP Team. (2023). JASP (Version 0.18) [Computer software]. <https://jasp-stats.org/>
19. Kamińska, D., Sapiński, T., Wiak, S., Tikk, T., Haamer, R. E., Avots, E., Helmi, A., Ozcinar, C., & Anbarjafari, G. (2019). Virtual reality and its applications in education: Survey. *Information*, 10(10), 318. <https://doi.org/10.3390/info10100318>
20. Kennedy, R. S., Lane, N. E., Berbaum, K. S., & Lilienthal, M. G. (1993). Simulator Sickness Questionnaire: An enhanced method for quantifying simulator sickness. *The International Journal of Aviation Psychology*, 3(3), 203–220. https://doi.org/10.1207/s15327108ijap0303_3
21. Kisker, J., Gruber, T., & Schöne, B. (2021). Behavioral realism and lifelike psychophysiological responses in virtual reality by the example of a height exposure. *Psychological Research*, 85(1), 68–81. <https://doi.org/10.1007/s00426-019-01244-9>
22. Kukshinov, E., Tu, J., Szita, K., Senthil Nathan, K., & Nacke, L. E. (2025). Widespread yet unreliable: A systematic analysis of the use of presence questionnaires. Interacting with Computers. Advance online publication. <https://doi.org/10.1093/iwc/iwae064>
23. Lai, X., Lei, X., Chen, X., & Rau, P.-L. P. (2019). Can virtual reality satisfy entertainment needs of the elderly? The application of a VR headset in elderly care. In P.-L. P. Rau (Ed.), *Cross-cultural design: Culture and society* (Lecture Notes in Computer Science, Vol. 11577). Springer. https://doi.org/10.1007/978-3-030-22580-3_13
24. Lessiter, J., Freeman, J., Keogh, E., & Davidoff, J. (2001). *A cross-media presence questionnaire: The ITC-Sense of Presence Inventory*. Presence: Teleoperators and Virtual Environments, 10(3), 282–297. <https://doi.org/10.1162/105474601300343612>
25. Lombard, M., Ditton, T. B., & Weinstein, L. (2009). *Measuring presence: The Temple Presence Inventory (TPI)*. In Proceedings of the 12th Annual International Workshop on Presence (pp. 1–15).
26. Makransky, G., Jensen, L. L., & Aaby, A. (2017). Development and validation of the Multimodal Presence Scale for virtual reality environments: A confirmatory factor analysis and item response theory approach. *Computers in Human Behavior*, 72, 276–285. <https://doi.org/10.1016/j.chb.2017.02.066>
27. Marsh, H. W., Hau, K.-T., & Wen, Z. (2004). In search of golden rules: Comment on hypothesis-testing approaches to setting cutoff values for fit indexes and dangers in overgeneralizing Hu and Bentler's (1999) findings. *Structural Equation Modeling: A Multidisciplinary Journal*, 11(3), 320–341. https://doi.org/10.1207/s15328007sem1103_2
28. Melo, M., Gonçalves, G., Monteiro, P., Coelho, H., Vasconcelos-Raposo, J., & Bessa, M. (2022). Do multisensory stimuli benefit the virtual reality experience? A systematic review. *IEEE Transactions on Visualization and Computer Graphics*, 28(2), 1428–1442. <https://doi.org/10.1109/TVCG.2020.3010088>

29. Meta Platforms, Inc. (2020). Meta Quest 2 [Virtual reality headset].
30. Opreș, D. I. (2012). *Multilevel analyses of the mechanism of virtual reality intervention in emotional disorders* (Ph.D. thesis summary). Babeș-Bolyai University, Cluj-Napoca, Romania.
31. Pavić, K., Chaby, L., Gricourt, T., & Vergilino-Perez, D. (2023). Feeling virtually present makes me happier: The influence of immersion, sense of presence, and video contents on positive emotion induction. *Cyberpsychology, Behavior, and Social Networking*, 26(4), 238–245. <https://doi.org/10.1089/cyber.2022.0245>
32. Price, M., & Anderson, P. (2007). The role of presence in virtual reality exposure therapy. *Journal of Anxiety Disorders*, 21(5), 742–751. <https://doi.org/10.1016/j.janxdis.2006.11.002>
33. Riva, G., Mantovani, F., Capideville, C. S., Preziosa, A., Morganti, F., Villani, D., Gaggioli, A., Botella, C., & Alcañiz, M. (2007). Affective interactions using virtual reality: The link between presence and emotions. *CyberPsychology & Behavior*, 10(1), 45–56. <https://doi.org/10.1089/cpb.2006.9993>
34. Saran, M. (2025). Comparing hand-based and controller-based interactions in virtual reality learning: Effects on presence and interaction performance. *PeerJ Computer Science*, 11, e3168. <https://doi.org/10.7717/peerj-cs.3168>
35. Schubert, T. W., Friedmann, F., & Regenbrecht, H. (2001). The experience of presence: Factor analytic insights. *Presence: Teleoperators and Virtual Environments*, 10(3), 266–281. <https://doi.org/10.1162/105474601300343603>
36. Schwind, V., Knierim, P., Haas, N., & Henze, N. (2019). *Using presence questionnaires in virtual reality*. In Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems (CHI '19) (Paper 360, pp. 1–12). Association for Computing Machinery. <https://doi.org/10.1145/3290605.3300590>
37. Slater, M. (2009). Place illusion and plausibility can lead to realistic behaviour in immersive virtual environments. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 364(1535), 3549–3557. <https://doi.org/10.1098/rstb.2009.0138>
38. Slater, M., Usoh, M., & Steed, A. (1994). Depth of presence in virtual environments. *Presence: Teleoperators and Virtual Environments*, 3(2), 130–144. <https://doi.org/10.1162/pres.1994.3.2.130>
39. Sousa, V. D., & Rojjanasirirat, W. (2011). Translation, adaptation and validation of instruments or scales for use in cross-cultural health care research: A clear and user-friendly guideline. *Journal of Evaluation in Clinical Practice*, 17(2), 268–274. <https://doi.org/10.1111/j.1365-2753.2010.01434.x>
40. Steen, C. W., Söderström, K., & Stensrud, B. (2024). The effectiveness of virtual reality training on knowledge, skills and attitudes of health care professionals and students in assessing and treating mental health disorders: A systematic review. *BMC Medical Education*, 24, 541. <https://doi.org/10.1186/s12909-024-05423-0>
41. Tran, T. Q., Langlotz, T., Young, J., Schubert, T. W., & Regenbrecht, H. (2024). Classifying presence scores: Insights and analysis from two decades of the Igroup Presence Questionnaire (IPQ). *ACM Transactions on Computer-Human Interaction*, 31(5), Article 61, 1–26. <https://doi.org/10.1145/3689046>
42. Usoh, M., Catena, E., Arman, S., & Slater, M. (2000). Using presence questionnaires in reality. *Presence: Teleoperators and Virtual Environments*, 9(5), 497–503. <https://doi.org/10.1162/105474600566989>
43. Vasconcelos-Raposo, J., Melo, M., Teixeira, C., Cabral, L., & Bessa, M. (2019). Adaptation and validation of the ITC–Sense of Presence Inventory for the Portuguese language. *International Journal of Human-Computer Studies*, 125, 1–6. <https://doi.org/10.1016/j.ijhcs.2018.12.005>
44. Vasconcelos-Raposo, J., Melo, M., Barbosa, L., Teixeira, C., Cabral, L., & Bessa, M. (2021). Assessing presence in virtual environments: Adaptation of the psychometric properties of the Presence Questionnaire to the Portuguese populations. *Behaviour & Information Technology*, 40(13), 1417–1427. <https://doi.org/10.1080/0144929X.2020.1754911>

45. Weber, S., Weibel, D., & Mast, F. W. (2021). How to get there when you are there already? Defining presence in virtual reality and the importance of perceived realism. *Frontiers in Psychology*, 12, 628298. <https://doi.org/10.3389/fpsyg.2021.628298>
46. Williams, P., Kelly, M. A., Rowett, D., & Gwilt, I. (2025). Charting the landscape of presence in virtual reality research: A bibliometric review. *Frontiers in Virtual Reality*, 6, 1691240. <https://doi.org/10.3389/frvir.2025.1691240>
47. Wirth, W., Hartmann, T., Böcking, S., Vorderer, P., Klimmt, C., Schramm, H., Saari, T., Laarni, J., Ravaja, N., Gouveia, F. R., Biocca, F., & Sacau, A. (2007). A process model of the formation of spatial presence experiences. *Media Psychology*, 9(3), 493–525. <https://doi.org/10.1080/15213260701283079>
48. Witmer, B. G., & Singer, M. J. (1998). Measuring presence in virtual environments: A presence questionnaire. *Presence: Teleoperators and Virtual Environments*, 7(3), 225–240. <https://doi.org/10.1162/105474698565686>
49. Zhao, Y., Summers, R., Gathara, D., & English, M. (2024). Conducting cross-cultural, multi-lingual or multi-country scale development and validation in health care research: A 10-step framework based on a scoping review. *Journal of Global Health*, 14, 04151. <https://doi.org/10.7189/jogh.14.04151>

