JOURNAL OF STATISTICS AND DATA SCIENCE EDUCATION
2026, VOL. 00, NO. 0, 1–13
https://doi.org/10.1080/26939169.2026.2646167

Statistics Anxiety: Validity, Measurement Invariance, and Educational Correlates in the Hungarian STARS

Janos Salamon[a], Jenny Terry[b], András Zsidó[c,d], Balazs Aczel[e], and Tamás Nagy[e]

[a]Department of Ergonomics and Psychology, Budapest University of Technology and Economics, Budapest, Hungary; [b]School of Psychology, University of Sussex, Brighton, United Kingdom; [c]Institute of Psychology, University of Pécs, Pécs, Hungary; [d]Szentágothai Research Centre, University of Pécs, Pécs, Hungary; [e]Institute of Psychology, ELTE Eötvös Loránd University, Budapest, Hungary

ABSTRACT
Statistics anxiety is a specific form of anxiety that arises when individuals encounter statistical concepts. It has been shown to affect educational outcomes and hinder academic performance. This study investigated the construct validity, measurement invariance, and discriminant validity of the Hungarian version of the Statistics Anxiety Rating Scale (STARS). Furthermore, we examined the relationship between statistics anxiety and performance in a statistics course and on the Cognitive Reflection Test that measures analytical thinking. The sample comprised 377 participants (85% female) with a mean age of 20.6 years, predominantly freshmen from Eötvös Loránd University and the University of Pécs. Our findings provide evidence for the reliability and validity of the Hungarian STARS, preserving its bifactor structure and subscales. All levels of measurement invariance were achieved, indicating that the Hungarian STARS reliably assesses statistics anxiety across universities and statistics course experience. Discriminant validity analysis revealed that statistics anxiety is distinct from other constructs. The global level of statistics anxiety had a weak negative correlation with performance and with analytical thinking. These results highlight the reliability and validity of the Hungarian STARS for measuring statistics anxiety in university settings. Supplementary materials for this article are available online.

ARTICLE HISTORY
Received January 2025
Accepted March 2026

KEYWORDS
Higher education; STARS; Statistics anxiety; Statistics education

1. Introduction

Learning and understanding data analysis and statistics have become inevitable in modern academia, serving as the backbone for research across various disciplines (Donoho 2017). These fields and related skills enable researchers to design studies and analyze datasets, providing empirical evidence for arguments. With the increasing availability of data and the growing emphasis on evidence-based decision-making, proficiency in statistics has become essential (Galeano and Peña 2019). Statistical knowledge is fundamental for interpreting scientific studies, identifying trends, and making predictions. Consequently, understanding and applying statistical principles is indispensable for students and professionals alike.

1.1. Statistics Anxiety

Many university students in the social sciences experience anxiety about learning statistics (Onwuegbuzie and Wilson 2003). Statistics anxiety is a psychological construct that refers to feelings of apprehension, fear, or unease when encountering statistical concepts, engaging in statistical analysis, or taking statistics courses (Chew and Dillon 2014). It differs from other forms of anxiety, such as math anxiety and generalized anxiety, in that it can occur even when mathematical deduction of statistical procedures is not part of a course, and it is not limited to those who tend to experience somatic symptoms of anxiety (Zeidner 1991; Trassi et al. 2022).

1.2. The Measurement of Statistics Anxiety

Measuring statistics anxiety is crucial because this anxiety can impede students' ability to learn and apply statistical concepts—essential skills across many academic and professional fields. High levels of anxiety can hinder comprehension, reduce performance, and diminish confidence, ultimately leading to negative attitudes toward statistics and data science (Onwuegbuzie and Wilson 2003; Trassi et al. 2022). By accurately assessing statistics anxiety, educators and researchers can identify students who are struggling and develop targeted interventions to alleviate this anxiety.

Understanding statistics anxiety is also important as the basic concepts of statistics have become fundamental knowledge in everyday life, often referred to as statistical literacy (Shields 2005). As more aspects of decision-making rely on data, the

CONTACT Janos Salamon salamon.jon@gmail.com Department of Ergonomics and Psychology, Budapest University of Technology and Economics, 2 Magyar tudósok körútja, H-1117 Budapest, Hungary.

Supplementary materials for this article are available online. Please go to www.tandfonline.com/ujse.

ability to interpret and use statistical information is increasingly essential (Wolff et al. 2016). This growing need for statistical literacy means that more people will require a solid foundation in statistics, starting from an early age (Bargagliotti et al. 2020). Consequently, the concept of statistics anxiety may become even more important as future children learn statistical concepts earlier (Afdal et al. 2019). By understanding and addressing statistics anxiety, educators can create more effective teaching strategies and supportive learning environments, ensuring that students build the confidence and competence needed to thrive in a data-centric world (Chew and Dillon 2014).

Several instruments have been developed to assess statistics anxiety. In their systematic review, Faraci and Malluzzo (2014) identified eight such scales, most of which rely on multidimensional self-report measures. Among these, the Statistics Anxiety Rating Scale (STARS; Cruise, Cash, and Bolton 1985) is by far the most frequently used. The Statistical Anxiety Scale (SAS; Vigil-Colet, Lorenzo-Seva, and Condon 2008), derived from the STARS and comprising the same three subscales, represents the only other well-validated measure focusing exclusively on statistics anxiety. More recently, context-specific instruments have been proposed for online learning environments (e.g., the Statistics Anxiety Scale in the Online or Hybrid setting, SASOH; Liu 2021), though their empirical validation is still limited.

1.3. The Statistics Anxiety Rating Scale (STARS)

The Statistics Anxiety Rating Scale (STARS; Cruise, Cash, and Bolton 1985) was developed to assess statistics-related anxiety and attitudes across six subscales: Interpretation Anxiety, Test and Class Anxiety, Fear of Asking for Help, Worth of Statistics, Computational Self-Concept, and Fear of Statistics Teachers. Recent studies have recommended distinguishing the first three as indicators of statistics anxiety and the latter three as attitudinal components toward statistics and instructors (Chew, Dillon, and Swinbourne 2018; Chew and Dillon 2014; e.g., DeVaney 2016; Macher et al. 2013). Consistent with this distinction, studies using the English version of the scale (Hanna, Shevlin, and Dempster 2008; DeVaney 2016) and the German version (Papousek et al. 2012) found that a confirmatory factor analysis (CFA) model including two correlated second-order factors representing Statistics Anxiety and Negative Attitudes toward Statistics provided the best and most parsimonious fit to the data.

Evidence provide support for the validity and reliability of the STARS. The subscales of the original English version have demonstrated acceptable internal consistencies (i.e., reliability, meaning the items consistently measure the same construct) across studies ($\alpha = 0.80$–.96). As evidence of construct validity (i.e., evidence that a scale actually measures the psychological construct it is intended to measure), Chew, Dillon, and Swinbourne (2018) found that the two higher-order factors of the English-language STARS, namely STARS Anxiety and STARS Negative Attitudes, exhibited theoretically consistent patterns of association with related constructs. STARS Anxiety correlated strongly with SAS Anxiety ($r = 0.89$) and moderately negatively with positive attitudes toward statistics ($r = -0.42$), whereas STARS Negative Attitudes correlated moderately with SAS Anxiety ($r = 0.57$) and strongly negatively with positive attitudes ($r = -0.79$). These findings further support the conceptual and empirical distinction between anxiety and attitudinal components within the internal structure of the English version of the STARS. Moreover, further evidence for convergent (i.e., the degree to which the scale relates to theoretically similar constructs) and criterion-related validity (i.e., the extent to which the scale predicts relevant external outcomes) was provided by Onwuegbuzie (2004), who found that higher STARS scores were significantly associated with academic procrastination driven by fear of failure and task aversiveness.

Additional support came from Papousek et al. (2012), who demonstrated predictive (i.e., evidence that the scale forecasts relevant outcomes) and discriminant validity (i.e., evidence that statistics anxiety is distinct from related forms of anxiety). They showed that STARS Anxiety and Attitudes predicted both subjective and physiological stress responses during exam situations even after controlling for general trait anxiety. Beyond physiological and subjective stress responses, researchers have also investigated whether statistics anxiety meaningfully predicts course outcomes, such as exam scores and final grades. However, evidence to date suggests that these associations are generally small and inconsistent. Studies using STARS and related measures have documented negative, near-zero, and occasionally even positive or non-linear relations between anxiety and academic achievement (see Trassi et al. 2022).

The STARS has been translated into several languages, including Greek (Lavidas, Manesis, and Gialamas 2021), Chinese (Liu and Onwuegbuzie 2011), German (Macher et al. 2015a), Arabic (Nasser 2004), and Hebrew (Steinberger 2020). Moreover, in a recent international study, additional translations were produced in Bahasa Indonesia, Dutch, Estonian, French, Italian, Polish, Portuguese, Romanian, Serbian, Slovak, Slovenian, Spanish, Turkish, and Ukrainian (Terry et al. 2023). As part of this multisite project, we also translated the STARS into Hungarian. The Hungarian translation and validation will make the scale available to Hungarian speakers. With tens of thousands of students learning statistics each year as part of their education, making the STARS available in Hungarian will help advance research and may facilitate understanding of statistics anxiety in this context.

1.4. Aims of the Study

Hungary has a well-established higher education system with approximately 293,000 students enrolled in tertiary institutions during the 2024/2025 academic year (KSH 2025). Our study focused on two leading Hungarian institutions in statistics education. Eötvös Loránd University (ELTE) offers statistical training in several social science disciplines, including psychology, sociology, and economics. The University of Pécs provides foundational statistics education in its undergraduate curricula in psychology and sociology. Beyond these two institutions, most larger Hungarian universities offer data science or statistics-related education to undergraduates. The field of data science has seen rapid growth in Hungarian higher education, with several universities now offering BSc and MSc programs. This educational landscape demonstrates Hungary's commitment to developing statistical literacy among its students, making the assessment of statistics anxiety particularly relevant in this context. The validation of a Hungarian instrument to assess statistics anxiety can provide an important tool for educators across these institutions to better understand and address statistics anxiety in their diverse statistics and data science programs.

The study aims to investigate the construct validity of the Hungarian version of the Statistics Anxiety Rating Scale (STARS; Cruise, Cash, and Bolton 1985). Moreover, we test the measurement invariance of the scale (i.e., whether the scale measures the construct in the same way across different groups) across previous learning experiences and different universities. Further, we investigate discriminant validity against multiple related concepts, such as math anxiety, test anxiety, cognitive and somatic anxiety, and fear of negative evaluation. Moreover, we investigate how statistics anxiety is related to performance in a statistics course and to analytical thinking.

2. Materials and Methods

2.1. Participants

This study was part of a multi-site project investigating the construct validity and psychometric properties of the STARS and other related scales across multiple languages (see Terry et al. 2023). The dataset partially overlaps with that of the original project, whose main aim was to examine whether mathematics and statistics anxieties represent distinct constructs (see preregistration: *https://osf.io/ercqs/files/5jrvz*). After completing data collection for that multilab study ($N = 206$), we collected additional data in the following semester ($N = 177$) to enable a more thorough adaptation and validation of the Hungarian version of the STARS. As our focus was not on comparing mathematics and statistics anxiety, we did not administer the full questionnaire used in the Terry et al. (2023) study. In this study, we concentrated on the Hungarian responses and gathered additional data to enable a more comprehensive analysis. We wanted to collect at least as much data as is recommended for conducting CFA, that is, at least 10 times the number of items (Bentler and Chou 1987). Moreover, as we planned to test measurement invariance, we aimed for subgroups with at least 100 participants (Cheung and Rensvold 2002).

Psychology students from the two largest Hungarian universities—Eötvös Loránd University (ELTE) and the University of Pécs (PTE) — were invited to take part in the study. Participation was incentivized through partial course credits or a lottery, where gift cards worth approximately 15€each were randomly distributed among participants at the conclusion of data collection.

Cases were excluded based on the pre-registered criteria of the original study. First, duplicate entries were removed; second, participants were asked at the end of the questionnaire if they had filled out the questionnaire truthfully. Those who responded "No" were excluded ($N = 2$), along with those who failed to respond to any of the six attention check questions ($N = 10$) that instructed participants to select a specific answer. Moreover, we also excluded those participants who had less than a 50% survey completion rate.

Table 1. Sample characteristics.

	All participants (N = 377)
Age	
Mean (SD)	20.6 (3.16)
Median [Min, Max]	20.0 [18.0, 42.0]
Missing	29 (7.7%)
Gender	
Female	296 (78.5%)
Male	55 (14.6%)
Other	2 (0.5%)
Missing	24 (6.4%)
University	
Eötvös Loránd University	248 (65.8%)
University of Pécs	129 (34.2%)
University year	
1st Year	261 (69.2%)
2nd Year	43 (11.4%)
3rd Year	50 (13.3%)
Other	3 (0.8%)
Missing	20 (5.3%)
Previous statistics course experience	
Experience with statistics	125 (33.2%)
No statistics experience	233 (61.8%)
Missing	19 (5.0%)
Cognitive Reflection Test performance (0–3)	
Mean (SD)	1.33 (0.747)
Median [Min, Max]	1.00 [0, 2.00]
Missing	12 (3.2%)
Grade at the end of the statistics course (1–5)	
Mean (SD)	4.26 (0.896)
Median [Min, Max]	4.00 [1.00, 5.00]
Missing	58 (15.4%)

A total of 377 participants were included in the study (55, 15% male) with a mean age of 20.6 years (SD = 3.2), most of them (69%) were freshmen at Eötvös Loránd University (66%) or the University of Pécs (34%). Most participants (62%) were taking their first statistics course at the time of the study, meaning they had not yet received formal instruction in statistics, while 33% had completed at least one statistics-related class previously. The average statistics grade at the end of the course was 4.3 (SD = 0.9) on a scale of 1–5. The average of correct answers for the three Cognitive Reflection Test questions was 1.3 (SD = 0.7) on a scale of 0–3. See Table 1 for details about participant characteristics.

2.2. Measurement and Procedure

Participants filled out the questionnaire online in Qualtrics. Statistics anxiety was measured using the Statistics Anxiety Rating Scale (STARS; Cruise, Cash, and Bolton 1985). The original STARS includes six subscales; however, only three measure statistics anxiety. The other three—Computational Self-Concept, Worth of Statistics, and Fear of Statistics Teachers—are considered measures of attitudes toward statistics (Hanna, Shevlin, and Dempster 2008; Papousek et al. 2012). Thus, we only included the three statistics anxiety subscales: Test and class anxiety (TCA; 8 items, $\alpha = 0.896$), Interpretation anxiety (IA, 11 items, $\alpha = 0.877$), and Fear of asking for help (FOA, 4 items, $\alpha = 0.892$). These STARS subscales demonstrated high internal consistency in the present sample. Each item describes a situation involving statistics in the relevant setting, and participants indicate how much anxiety they feel in those situations on a 5-

point Likert-type scale (1 = "no anxiety" to 5 = "very much anxiety"). See the scale items in Table 4.

We measured anxiety related to mathematics with the Revised Math Anxiety Rating Scale (R-MARS; Baloğlu nd Zelhart 2007). R-MARS has three subscales, measuring mathematics test anxiety ($\alpha = 0.920$), numerical task anxiety ($\alpha = 0.924$), and mathematics course anxiety ($\alpha = 0.851$), all of which showed very good internal consistency, and uses a 5-point Likert-type scale (1 = "no anxiety" to 5 = "very much anxiety"). Due to the study's focus, the R-MARS was not included in the second wave of data collection. As a result, only about half of the participants completed this scale (N = 170), which limited our ability to estimate latent factors.

We measured trait anxiety with the trait scale of the State-Trait Inventory for Cognitive and Somatic Anxiety (STICSA; Ree et al. 2008). The trait subscale is further broken down into cognitive ($\alpha = 0.872$) and somatic symptoms ($\alpha = 0.862$), both of which demonstrated good internal consistency. The answers are provided on a 5-point Likert-type scale (1 = "not at all" to 4 = "very much so").

We used the Revised Test Anxiety Scale (R-TAS; Benson and El-Zahhar 1994) to measure anxiety related to taking tests. The scale contains four subscales: worry ($\alpha = 0.835$), tension ($\alpha = 0.878$), test-irrelevant thinking ($\alpha = 0.752$), and bodily symptoms ($\alpha = 0.746$), all of which demonstrated acceptable to good internal consistency. The answers are provided on a 5-point Likert-type scale (1 = "almost never" to 4 = "almost always").

We included the Brief Fear of Negative Evaluation Scale-Straightforward (BFNES; Carleton et al. 2011) to assess the fear of negative evaluation. The answers are provided on a 5-point Likert-type scale (1 = "not at all characteristic of me" to 5 = "extremely characteristic of me"). The scale has good reliability ($\alpha = 0.950$).

We also used the revised Cognitive Reflection Test (CRT) to measure analytical thinking (Shenhav, Rand, and Greene 2012). The test consisted of three problems, each of which required a numerical response. For example, "A bat and a ball cost \$1.10 in total. The bat costs \$1.00 more than the ball. How much does the ball cost?" We calculated the number of correct answers (0–3) for each participant. We included the CRT to assess whether statistics anxiety is related to general analytic reasoning beyond domain-specific statistical skills. To assess statistics course experience, we asked participants, "Are you currently studying your first statistics course/module?" Course instructors also provided students' grades for the statistics courses they were taking at the semester's end. The grade ranges between 1 (fail) to 5 (excellent). Course grades were available for 319 participants.

2.3. Translation Process

The Hungarian version of the questionnaire was developed using a team-based approach outlined by Behr and Shishido (2016), as recommended in the international SMARVUS project (Terry et al. 2023). This framework emphasizes collaborative deliberation, conceptual rather than literal equivalence, and iterative consensus formation during cross-cultural instrument adaptation. In line with this approach, our translation operationalized these principles through structured team discussions and predefined evaluative considerations described below.

The translation was conducted by three authors with expertise in psychology and statistics education. Two translators independently produced initial versions of all scale items. The parallel translations were subsequently compared in group meetings, which served as a forum for discussing observed differences between the alternative renderings. The types of discrepancies discussed during the meetings were later summarized into thematic categories (lexical choice, syntactic structure, and conceptual scope) to describe the dominant patterns of variation encountered during the process.

All discrepancies were discussed in team meetings and evaluated using the three decision criteria summarized in Table 2. These criteria were used as guiding principles for decision-making. When neither initial translation fully satisfied the evaluative considerations, a third integrative formulation was generated that combined the strengths of the alternatives.

As illustrated in Table 2, translation differences most commonly reflected variations in lexical choices, syntactic organization, or conceptual framing. In several cases, a more literal rendering would have preserved surface correspondence with the English wording but would have reduced naturalness or shifted the perceived level of technicality. Accordingly, conceptual equivalence at the level of the psychological situation was prioritized over strict lexical fidelity. Clarity and naturalness in Hungarian academic language were also important considerations, particularly when literal translation risked producing awkward or overly technical phrasing. Preservation of psychometric intent functioned as an overarching guiding consideration; options were rejected if they risked systematically altering perceived difficulty, abstraction level, or the cognitive or emotional framing of the item.

Following consensus development of the preliminary Hungarian version, the instrument was pilot-tested with a small group of undergraduate students. Participants were asked to identify any items perceived as unclear, ambiguous, or unnatural. Feedback primarily concerned minor stylistic refinements rather than substantive misunderstandings. Based on this feedback, limited wording adjustments were implemented to improve fluency while preserving the previously established conceptual decisions. No item required structural or conceptual revision at this stage.

2.4. Data Processing and Statistical Analysis

We used R 4.3.3 for conducting data analysis (R Core Team 2024). We used the *lavaan* package for structural equation modeling (Rosseel 2012).

We conducted CFA with a robust maximum likelihood (MLR) estimator to investigate the factor structure of the scales. This estimator provides tests of model fit and standard errors that are robust to non-normality. In the first stage of the analysis, we assessed four alternative CFA solutions of the STARS (see Figure 1 for a visual overview of these models). The model sequence was selected to systematically test the scale's dimensionality in light of prior research, which has

Table 2. Examples of translation discrepancies and their resolution.

Type of discrepancy	Conceptual equivalence	Clarity & naturalness in Hungarian	Preservation of psychometric intent
Lexical choice 1: "Trying to understand the odds in a lottery" → "Felmérni a lottó gyõzelem esélyét" (literal translation: "Assessing the probability of winning the lottery")	The phrase "odds" could be translated more technically (e.g., "valószínûségi arányok"), but this would shift the meaning toward formal probability theory rather than everyday judgment. The chosen wording preserves the applied, lay interpretation of chance.	The more literal rendering sounded technical and less idiomatic. "Felmérni …esélyét" is common Hungarian usage and easily comprehensible to students.	Because the item measures anxiety in everyday statistical reasoning contexts, not formal derivation, conceptual equivalence outweighed literal fidelity. Naturalness supported this decision.
Lexical choice 2: "Confidence" (elsewhere in scale instructions) rendered as everyday assurance rather than statistical confidence	Hungarian allows a technical equivalent referring to statistical confidence (e.g., confidence interval context). The team selected wording reflecting psychological certainty.	The technical rendering risked confusion outside a statistical frame. The chosen term matched everyday academic discourse.	Avoiding technical inflation was prioritized to maintain the intended abstraction level and prevent altering item difficulty.
Syntactic structure 1 "Going over a final examination in statistics after it has been marked." → "Egy kijavított statisztika kurzus záróvizsgájának áttekintése."	The English clause contains a passive construction ("after it has been marked") that required restructuring in Hungarian. The final version integrates the completion of marking adjectivally ("kijavított") while preserving the post-evaluation review context.	A literal subordinate-clause translation would have resulted in a heavier, less idiomatic sentence. The chosen phrasing is syntactically concise and natural in Hungarian academic usage.	Preserving the temporal framing (reviewing the exam after grading) was essential to maintain the intended anxiety-eliciting scenario. Structural condensation was therefore allowed, provided the evaluative sequence remained unambiguous.
Syntactic structure 2: "Interpreting the meaning of a probability value once I have found it" → "Valószínûség értelmezése, miután az értéket már kiszámítottam." (Literal translation: "Interpreting a probability after calculating it")	English gerund constructions required nominalization in Hungarian. The team ensured that the cognitive act (interpretation after computation) remained sequentially intact.	Direct translation would have produced an overly long clause. The chosen phrasing is grammatically compact and idiomatic.	Maintaining the temporal sequencing ("after calculation") was essential to preserve the task framing; thus, structural simplification did not override conceptual sequencing.
Conceptual scope 1: "Arranging to have a body of data put into the computer" → "Felkészülni arra, hogy egy adag adatot viszek fel a számítógépbe." (Literal translation: "Preparing to input a set of data into the computer")	The English phrasing is institutionally neutral. Hungarian literal translation suggested delegating data entry. The final wording reflects active involvement, closer to student experience.	The literal equivalent was bureaucratic in tone. The chosen phrasing aligns with typical Hungarian student practices.	The team prioritized experiential realism to preserve the intended anxiety trigger (handling data), even if literal agency structure shifted slightly.
Conceptual scope 2: "Reading an advertisement for a car which includes figures on miles per gallon, depreciation, etc." → localized adaptation of units and explanatory phrasing	"Miles per gallon" has no direct everyday relevance in Hungary. The team retained the consumption concept but clarified it in metric framing.	Without adaptation, the unit reference would be unfamiliar and distracting. Clarification improved accessibility.	Cultural adaptation was prioritized to preserve functional equivalence (interpreting quantitative consumer information), even though literal correspondence was reduced.

yielded moderate to high correlations among STARS subscales and has proposed both unitary and multidimensional conceptualizations of statistics anxiety. Specifically, we estimated: a one-factor solution (Model M1), a first-order solution (Model M2), a second-order solution with 3 specific and one higher-order factor (Model M3), and a bifactor solution (i.e., a model that separates a general factor from multiple specific factors measured by the same items) including the 3 Specific (S) factors and a co-existing General (G) factor (Model M4). This sequence of models follows conventional practice in scale validation research (e.g., Morin, Arens, and Marsh 2016), where increasingly complex models are tested to determine whether the instrument represents a single general construct, multiple correlated dimensions, or a hierarchical or bifactor structure. These model forms are also consistent with the conceptualization proposed in the original development of the STARS (Cruise, Cash, and Bolton 1985), which posited both domain-specific and general sources of statistics anxiety. To compare the models, we adhered to the guidelines of Morin, Arens, and Marsh (2016). In addition to assessing goodness-of-fit, we closely examined the standardized parameter estimates, with a focus on the magnitude of the correlations between the factors.

Furthermore, measurement invariance was tested (Meredith 1993; Millsap 2011) across groups based on the two universities and participants' experience with statistics. The measurement invariance tests were conducted progressively, introducing equality constraints to various parameters, ranging from the least restrictive to the most restrictive models (Meredith 1993; Millsap 2011). The sequence of invariance tests was the following: (1) configural, (2) weak, (3) strong, (4) strict, (5) latent variance-covariance, and (6) latent mean invariance. See Appendix 1 in the online supplementary materials for further details.

Due to the oversensitivity of the chi-square ($\chi 2$) test of exact fit to sample size, the models' adequacy was evaluated using the following established sample size-independent goodness-of-fit indices (Hu and Bentler 1999; Marsh, Hau, and Grayson 2005):

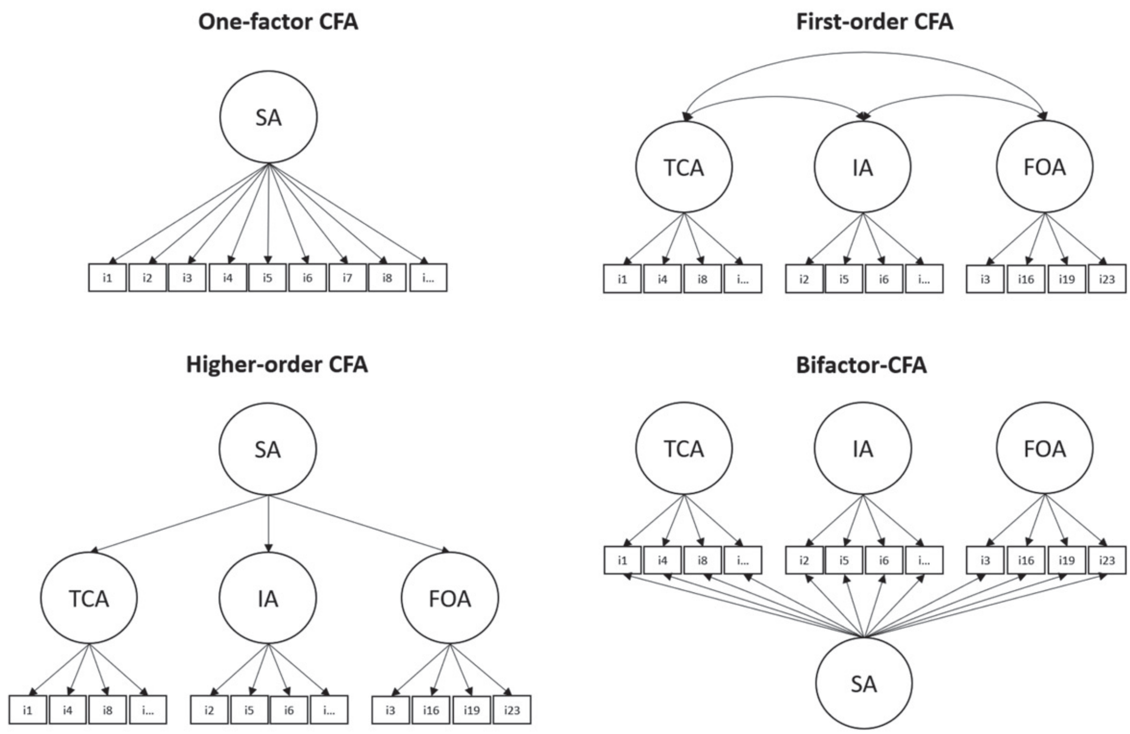

Figure 1. Schematic representation of the estimated model for the STARS.
Notes: i1-i23 = item 1–23; SA = Statistics Anxiety; TCA = Test and Class Anxiety; IA = Interpretation Anxiety; FOA = Fear of Asking For Help. Unidirectional arrows represent factor loadings, bidirectional arrows represent correlations. For visual clarity, only representative items are displayed in each model; all 23 items were included in the actual analyses.

the comparative fit index (CFI), the Tucker-Lewis Index (TLI), and the root mean square error of approximation (RMSEA). CFI and TLI were considered adequate or excellent if their values exceeded 0.90 and 0.95, respectively. On the other hand, RMSEA was deemed acceptable or excellent if it fell below 0.08 and 0.06, respectively. In measurement invariance tests, nested models were compared by examining changes (Δ) in goodness-of-fit indices. A decrease of more than 0.010 in CFI and TLI or an increase of at least 0.015 in RMSEA would indicate a lack of invariance across groups (Cheung and Rensvold 2002; Chen 2007). The validity evidence of the bifactor-CFA solution was assessed by calculating correlations between the factors, focusing on its test-criterion relationship. Reliability was assessed using McDonald's (1970) model-based composite reliability coefficient (ω). Consistent with recommendations for multidimensional and bifactor structures, we interpret ω values in relation to the proportion of variance attributed to the factor rather than relying on a universal cutoff (Perreira et al. 2018). In bifactor models, true score variance is distributed across both the general and specific factors, which makes traditional reliability thresholds such as 0.70 or 0.80, typically used for first-order unidimensional models, inappropriate (Perreira et al. 2018). Furthermore, Reise, Bonifay, and Haviland (2013) emphasize that correlated factors and second-order models are nested within bifactor structures and note that there are no established benchmarks for omega in such models. They tentatively suggest that values above approximately .50 may indicate that a factor explains at least as much variance as measurement error, with higher values being preferable (Reise, Bonifay, and Haviland 2013). Following these recommendations, ω values in the present study are interpreted in relation to the factor's theoretical role, its share of true score variance, and the broader measurement context rather than against any fixed threshold.

The data and analysis code for the present study are publicly available on the project's OSF page: *https://osf.io/ud973/*.

3. Results

3.1. Structural Analysis and Measurement Invariance

Table 3 (Part A) presents the goodness-of-fit statistics for the examined factor structures of STARS. The one-factor solution (M1) and the three-factor CFA model (M2) had a poor fit to the data. Moderate to high correlations among the three statistics anxiety factors suggested conceptual overlaps and a possible unmodeled general factor. To test this, we compared second-order and bifactor models, including a general statistics anxiety factor and three specific factors. The fit of the second-order model (M3) was identical to that of the first-order model. In contrast, the bifactor model (M4) had an excellent fit to the data, and it was superior to the first-order model.

Parameter estimates from the bifactor model (Model M4) are reported in Table 4. These results showed a well-defined and highly reliable statistics anxiety G-factor ($\lambda = 0.359$ to 0.768, $\omega = 0.944$, 95% CI [0.934, 0.952]). Over and above participants' global levels of statistics anxiety, the fear of asking for help S-factor retained meaningful unique variance with relatively high factor loadings ($\lambda = 0.441$ to 0.783) and a satisfactorily high level of scale score reliability ($\omega = 0.843$, 95% CI [0.806, 0.870]). In contrast, over and above their associations with the statistics anxiety G-factor, the majority of the items demonstrate

Table 3. CFA and Measurement Invariance of STARS.

	$\chi 2$(df)	CFI	TLI	RMSEA [95% CI]
A) Comparison of factor structures				
M1. One-factor CFA	1450.592* (230)	.701	.672	.119 [.114, .125]
M2. Three-factor CFA	612.642* (227)	.906	.895	.067 [.061, .074]
M3. Second-order CFA	612.642* (227)	.906	.895	.067 [.061, .074]
M4. Bifactor CFA	363.429* (207)	.962	.953	.045 [.038, .052]
B) Measurement Invariance Across Universities				
MU1. Configural invariance	576.556* (414)	.961	.952	.046 [.037, .054]
MU2. Weak invariance	641.497* (456)	.955	.950	.047 [.038, .055]
MU3. Strong invariance	675.717* (475)	.951	.948	.048 [.039, .055]
MU4. Strict invariance	707.624* (498)	.949	.948	.047 [.040, .055]
MU5. Latent variance-covariance invariance	713.517 (502)	.949	.948	.048 [.040, .055]
MU6. Latent means invariance	728.620* (506)	.946	.946	.049 [.041, .056]
C) Measurement Invariance Across Experience				
ME1. Configural invariance	579.019 (414)	.959	.95	.047 [.038, .056]
ME2. Weak invariance	639.883 (456)	.954	.949	.048 [.039, .056]
ME3. Strong invariance	701.364 (475)	.944	.940	.052 [.044, .060]
ME4. Strict invariance	726.309 (498)	.943	.942	.051 [.043, .058]
ME5. Latent variance-covariance invariance	736.714 (502)	.941	.941	.051 [.043, .059]
ME6. Latent means invariance	755.630 (506)	.938	.938	.053 [.045, .060]

Notes: The table shows fit statistics for the different conceptualizations of STARS (A), measurement invariance testing across universities (B), and statistics course experience (C). The best fit statistics were obtained for the bifactor model, and we found no evidence of measurement invariance. M = Model; MU = Models for Universities; ME = Models for Statistics Course Experience.
$^*p < 0.05$ for the goodness-of-fit tests.

a relatively low level of unique variance in relation to the test and class anxiety ($\lambda = 0.097$ to 0.629), and the interpretation anxiety ($\lambda = -0.069$ to 0.618) S-factors, which are mostly characterized by relatively low loadings. Despite the relatively low level of unique variance, the scale score reliabilities of both the test and class anxiety ($\omega = 0.699$, 95% CI [0.615, 0.754]) and the interpretation anxiety ($\omega = 0.554$, 95% CI [0.420, 0.643]) S-factors remained acceptable. Uniqueness values ranged from .10 to .84, suggesting that while some items were largely explained by the latent factors, others retained a considerable amount of item-specific variance.

The current findings indicate that the test and class anxiety and interpretation anxiety items predominantly captured participants' overall statistics anxiety levels rather than the pure test and class anxiety and interpretation anxiety linked to their a priori-defined S-factors beyond the influence of the G-factor. In interpreting bifactor results, it is crucial to recognize that S-factors may be less defined due to items' dual association with both G-factors and S-factors, unlike in first-order models. Moreover, employing full latent variables rather than manifest scale scores mitigates measurement error, thereby increasing the reliability of the factors.

Measurement invariance was tested across the two universities (Part B in Table 3) to verify the validity of the final bifactor-CFA model and to ensure these group-based comparisons are meaningful. The configural model with no equality constraints provided an excellent model fit based on CFI, TLI, and RMSEA (0.961, 0.952, and 0.046, respectively), suggesting that the factor structure is reasonably similar at both universities. Next, we imposed equality constraints on the factor loadings, leading to some, but not meaningful model fit deteriorations (ΔCFI $= -0.008$, ΔTLI $= -0.002$, ΔRMSEA $=$ 0.001). These results showed support for the weak invariance of the bifactor-CFA measurement model. The gradual inclusion of the equality constraints on the additional parameters (i.e., intercepts, uniquenesses, latent variances and covariances, and latent means) showed that CFI, TLI, and RMSEA indicated a good fit at all levels of invariance. CFI and TLI never decreased by more than 0.010, with the largest change being -0.006 in the case of weak invariance. RMSEA never increased more than .015, with the largest difference being +0.001. Similar results were obtained when the bifactor CFA was contrasted along groups based on participants' experience with statistics (Part C in Table 3). These results consistently support the latent mean invariance and replicability of the bifactor CFA solution across universities and levels of statistics experience.

3.2. Validity Evidence Based on Test-Criterion Relationship

Correlations between latent factors were calculated to assess the validity evidence of the bifactor CFA solution based on its test-criterion relationship. For details about CFA of the other scales, see Appendix 2, Table S1 and Table S2 in the online supplementary materials. The measurement models of the correlates were estimated to determine their adequate validity evidence and reliability.

Beyond the Spearman bivariate correlations among the measured factors (STARS, STICSA, R-TAS, BFNE-S, RMARS subfactors), grades, and Cognitive Reflection Test scores, Table 5 also shows the correlations among their corresponding latent factors. Global levels of statistics anxiety positively correlated with somatic symptoms ($r = 0.437$, $p < 0.001$) and cognitive symptoms ($r = 0.455$, $p < 0.001$), as well as with worry ($r = 0.427$, $p < 0.001$), tension ($r = 0.477$, $p < 0.001$), test-irrelevant thinking ($r = 0.257$, $p < 0.001$), and bodily symptoms ($r = 0.432$, $p < 0.001$), and also with the fear of negative evaluation ($r = 0.395$, $p < 0.001$). Global levels of statistics anxiety showed a weak but significant negative relationship with grades ($r = -0.142$, $p = 0.011$) and with Cognitive Reflection Test scores ($r = -0.208$, $p < 0.001$). Over and above the statistics anxiety G-factor, some of the statistics anxiety S-factors also showed additional relations with the correlates, supporting their added value. More specifically, there was a moderately

Table 4. Standardized parameter estimates from the bifactor-CFA solution for the Hungarian version of STARS (Model M4).

Item	Original, English Version (Cruise, Cash, and Bolton 1985)	Hungarian Version	STA (λ)	TNC (λ)	IA (λ)	FOA (λ)	δ
Test and class anxiety							
Item 1	Studying for an examination in a statistics course.	Egy statisztika kurzus vizsgájára tanulni.	.731**	.329**			.357
Item 4	Doing the coursework for a statistics course.	A statisztika kurzus feladatainak elvégzése.	.768**	.135*			.392
Item 8	Doing an examination in a statistics course.	Vizsgázás egy statisztika kurzuson.	.615**	.618**			.240
Item 10	Walking into the room to take a statistics test.	Besétálni egy szobába, ahol statisztikából vizsgázom.	.546**	.629**			.306
Item 13	Finding that another student in class got a different answer than I did to a statistical problem.	Rájönni arra, hogy egy hallgatótársam eltérõ válaszra jutott egy statisztikai probléma során, mint én.	.615**	.181**			.589
Item 15	Waking up in the morning on the day of a statistics test.	Egy statisztika vizsga napjára ébredni.	.624**	.585**			.268
Item 21	Enrolling in a statistics course.	Regisztrálni egy statisztika kurzusra.	.608**	.097			.620
Item 22	Going over a final examination in statistics after it has been marked.	Egy statisztika kurzus kijavított záróvizsgájának áttekintése.	.565**	.255*			.616
Interpretation anxiety							
Item 2	Interpreting the meaning of a table in a journal article.	Táblázat értelmezése egy tudományos cikkben.	.601**		.530**		.358
Item 5	Making an objective decision based on empirical data.	Empirikus adatok alapján objektív döntést hozni.	.677**		.181*		.508
Item 6	Reading a journal article that includes some statistical analyses.	Olyan folyóirat-cikk elolvasása, amely tartalmaz néhány statisztikai elemzést.	.609**		.493**		.385
Item 7	Trying to decide which analysis is appropriate for my research project.	Annak az eldöntése, hogy milyen elemzés megfelelõ a kutatási projektemhez.	.681**		.094		.527
Item 9	Reading an advertisement for a car which includes figures on miles per gallon, depreciation, etc.	Egy autó hirdetését elolvasni, amely egy ábrát tartalmaz az autó kilométerenkénti üzemanyag-fogyasztásáról, értékcsökkenésről stb.	.377**		.292**		.773
Item 11	Interpreting the meaning of a probability value once I have found it.	Valószínûség érték értelmezése, miután azt kiszámítottam.	.691**		.208**		.479
Item 12	Arranging to have a body of data put into the computer.	Felkészülni arra, hogy egy halom adatot viszek be a számítógépbe.	.584**		.155*		.635
Item 14	Determining whether to reject or retain the null hypothesis.	Annak meghatározása, hogy elvetjük-e vagy fenntartjuk-e a nullhipotézist.	.644**		−0.069		.580
Item 17	Trying to understand the odds in a lottery.	Felmérni a lottó győzelem esélyét.	.359**		.172*		.841
Item 18	Watching a student search through a load of computer output from his/her research.	Megfigyelni ahogy egy diák a saját kutatásához egy halom számítógépes eredményt néz át.	.533**		.178*		.684
Item 20	Trying to understand the statistical analyses described in the abstract of a journal article.	Megpróbálni megérteni egy folyóirat cikk absztraktjában leírt statisztikai elemzéseket.	.566**		.618**		.299
Fear of asking for help							
Item 3	Going to ask my statistics teacher for individual help with material I am having difficulty understanding.	A statisztika tanáromtól egyéni segítséget kérni olyan anyaggal kapcsolatban, amit nem értek.	.498**			.761**	.173
Item 16	Asking one of my teachers for help in understanding statistical output.	Egy tanáromtól segítséget kérni statisztikai eredmények értelmezéséhez.	.538**			.783**	.097
Item 19	Asking someone in the computer lab for help in understanding statistical output.	Statisztikai eredmények értelmezéséhez segítséget kérni valakitől egy egyetemi számítógép teremben.	.513**			.529**	.457
Item 23	Asking a fellow student for help in understanding statistical output.	Egy eredmény értelmezéséhez segítséget kérni egy másik tanulótól.	.491**			.441**	.564
ω			.944**	.699**	.554**	.843**	

Notes: STA: Statistics Anxiety G-factor; TNC: Test and class anxiety S-factor; IA: Interpretation anxiety S-factor; FOA: Fear of asking for help S-factor; λ: Factor loading; δ: Item uniqueness; ω: model-based omega composite reliability.
$^{*}p < 0.05$; $^{**}p < 0.01$.

positive correlation between the test and class anxiety S-factor and tension ($r = 0.480$, $p < 0.001$), a weak positive correlation between the test and class anxiety S-factor and worry ($r = 0.193$, $p = 0.002$), and the bodily symptoms ($r = 0.249$, $p < 0.001$). Furthermore, over and above the statistics anxiety G-factor, the fear of asking for help S-factor also showed a weak positive correlation with somatic symptoms ($r = 0.145$, $p = 0.007$) and cognitive symptoms ($r = 0.147$, $p = 0.006$), with bodily symptoms (r $= 0.162$, $p = 0.005$) and with the fear of negative evaluation ($r = 0.124$, $p = 0.019$). In contrast, over and above the statistics anxiety G-factor the interpretation anxiety S-factor did not show any additional relations with the correlates (all *p*s > 0.08).

4. Discussion

The study evaluated the construct and discriminant validity of the Hungarian adaptation of the Statistics Anxiety Rating Scale (STARS). Our finding that a bifactor model with a strong general statistics anxiety factor and three specific factors (Test and Class Anxiety, Interpretation Anxiety, Fear of Asking for Help) provided the best fit is broadly consistent with prior research using the original English STARS and its translations. Studies using the full six-subscale version typically report high intercorrelations among the subscales, and support the multidimensional, higher-order representations that separate a general statistics anxiety factor from an attitude factor (Chew, Dillon, and Swinbourne 2018; DeVaney 2016; e.g., Papousek et al.

Table 5. Spearman bivariate correlations between the latent factors (below diagonal) and between the measured factors (above diagonal).

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. STARS G-factor																
2. Test and class anxiety S-factor	.00		.71**	.53**	.39**	.40**	.40**	.56**	.20**	.42**	.35**	.75**	.43**	.65**	−0.14*	−0.17**
3. Interpretation anxiety S-factor	.00	.00		.47**	.35**	.37**	.36**	.37**	.22**	.33**	.31**	.59**	.54**	.59**	−0.07	−0.21**
4. Fear of asking for help S-factor	.00	.00	.00		.36**	.39**	.28**	.36**	.16**	.34**	.34**	.43**	.26**	.49**	−0.01	−0.08
5. STICSA Somatic symptoms	.44**	.10	.05	.15**		.69**	.45**	.49**	.39**	.67**	.47**	.34**	.36**	.35**	.04	−0.03
6. STICSA Cognitive symptoms	.46**	.07	.03	.15**	.77**		.54**	.52**	.46**	.52**	.64**	.32**	.34**	.29**	.08	.02
7. R-TAS Worry	.43**	.19**	.05	.06	.55**	.62**		.58**	.46**	.52**	.48**	.35**	.23**	.22**	−0.01	−0.13*
8. R-TAS Tension	.48**	.48**	−0.01	.08	.55**	.58**	.67**		.25**	.67**	.47**	.52**	.26**	.17*	.10	−0.20**
9. R-TAS Irrelevant	.26**	.01	.04	.03	.46**	.53**	.62**	.28**		.28**	.26**	.17*	.29**	.21**	−0.04	−0.06
10. R-TAS Bodily symptoms	.43**	.25**	.04	.16**	.85**	.63**	.68**	.79**	.37**		.44**	.43**	.26**	.30**	.03	−0.14**
11. Fear of negative evaluation	.40**	.08	−0.06	.12*	.52**	.72**	.53**	.50**	.31**	.50**		.23**	.15	.13	.08	−0.04
12. RMARS Mathematics test anxiety													.51**	.67**	−0.11	−0.29**
13. RMARS Numerical task anxiety														.48**	−0.02	−0.24**
14. RMARS Mathematics course anxiety															−0.17*	−0.16*
15. Grade	−0.14*	−0.03	.12	.11	.04	.09	−0.02	.09	.02	.05	.08					.03
16. Cognitive Reflection Test	−0.21**	−0.05	−0.06	.06	−0.03	.01	−0.15**	−0.22**	−0.02	−0.15*	−0.03				.04	

Notes: RMARS was not included in the second wave of data collection (see Measurement section), resulting in a smaller sample ($N = 170$) that was insufficient for estimating latent values. Consequently, latent correlations involving RMARS are not reported. Course grades were available for 319 participants, and for all other variables, the sample size was 377.
$^{*}p < 0.05$; $^{**}p < 0.01$.

2012). Our results extend this work by showing that even when only the three "anxiety" subscales are used, a bifactor structure still captures the data better than one- or three-factor solutions, suggesting that the common variance across these dimensions can be meaningfully summarized as a general statistics anxiety construct in the Hungarian context as well. Taken together with evidence from the German, Hebrew, and Greek adaptations that also report multidimensional yet highly correlated STARS factors (Lavidas, Manesis, and Gialamas 2021; Liu and Onwuegbuzie 2011; Nasser 2004; e.g., Papousek et al. 2012; Steinberger 2020), our findings suggest that the underlying structure of statistics anxiety is largely comparable across languages and cultural settings, supporting the cross-cultural robustness of the STARS framework.

As a further support of this equivalence, the standardized factor loadings obtained for the Hungarian version generally fall within or slightly below the ranges reported in studies using the original English-language versions of the STARS (e.g., Cruise, Cash, and Bolton 1985: 0.48–0.86; Hanna, Shevlin, and Dempster 2008: 0.42–0.94; Papousek et al. 2012: 0.49–0.89; DeVaney 2016: 0.55–0.86). The relatively lower loadings observed for the Test and Class Anxiety and Interpretation Anxiety subfactors are likely due to methodological rather than translation-related differences: as the bifactor model used here partitions shared variance between the general and specific factors, resulting in smaller S-factor loadings compared to traditional higher-order or first-order models. This pattern supports the conclusion that the Hungarian version measures the same underlying constructs as the original and that the adaptation preserves the factorial meaning of the STARS items.

The internal consistency coefficients for the Hungarian STARS subscales ($\alpha = 0.88$–0.90) closely mirror those obtained in other adaptations: German $\alpha = 0.86$–0.88 (Papousek et al. 2012), Hebrew $\alpha = 0.76$–0.91 (Steinberger 2020), Arabic $\alpha = 0.69$–0.88 (Nasser 2004), Chinese $\alpha = 0.72$–0.86 (Liu and Onwuegbuzie 2011), and Greek $\alpha = 0.90$–0.93 (Lavidas, Manesis, and Gialamas 2021). This convergence suggests that the Hungarian version retains the reliability of the original instrument and performs comparably to other established translations.

Few published studies have systematically examined full measurement invariance for the STARS across educational contexts. The invariance of the Hungarian version across universities and previous statistics experience suggests that the scale operates equivalently for students at different institutions and at different points in their statistics learning. This complements recent large-scale, cross-national work on the SMARVUS dataset, which focused primarily on cross-language comparisons (Terry et al. 2023), by demonstrating that even within a single country, the STARS can be used for meaningful group comparisons of latent means. Future research could build on this by testing invariance across additional groups that have been shown to differ in statistics anxiety, such as gender and academic field (e.g., Baloğlu, Deniz, and Kesici 2011; González et al. 2016; Ralston 2020), using the Hungarian STARS to examine whether these patterns generalize to the Hungarian higher education context.

The discriminant validity analysis of the Hungarian STARS revealed that while the general factor of statistics anxiety and its specific subscales were related to similar constructs, they remained well distinguishable. Notably, statistics anxiety was related to general cognitive and somatic anxiety, different aspects of test anxiety, and fear of negative evaluation, yet remained distinct from each of these constructs. This pattern closely mirrors findings from previous STARS research, which shows that although statistics anxiety correlates with broader dispositions such as worry, intolerance of uncertainty, and procrastination, it does not reduce to any of these constructs alone (e.g., Onwuegbuzie 2004; Williams 2013).

In addition, the relatively stronger association of the Fear of Asking for Help factor with fear of negative evaluation, beyond the general statistics anxiety factor, is consistent with work emphasizing the social evaluative and self-presentational components of statistics anxiety, including concerns about appearing incompetent (e.g., Onwuegbuzie 2004; Malik 2015). Fear of negative evaluation reflects a cognitive–emotional orientation toward anticipating criticism or unfavorable judgment. This tendency aligns conceptually with maladaptive cognitive emotion-regulation strategies such as rumination or catastrophizing (Garnefski, Kraaij, and Spinhoven 2001), as well as with performance-avoidance academic goals that center on avoiding poor performance or negative appraisal (Elliot and Church 1997). Both domains have been linked to higher statistics anxiety in previous work (e.g., Lalande et al. 2019; McIntee et al. 2022). Consistent with these findings, fear of negative evaluation showed a positive association with statistics anxiety in our data.

Nevertheless, recent work has questioned whether statistics and mathematics anxieties are genuinely distinct constructs or reflections of the same underlying academic anxiety (Terry et al. 20206). In our study, the two scales showed high correlations, consistent with this emerging view. In their recent study, Terry et al. (20206) directly examined whether statistics anxiety is meaningfully distinct from mathematical anxiety. They found evidence of jangle fallacy—meaning, that the two constructs are conceptually the same. This suggests that administering both scales within the same study is unnecessary. However, both instruments are equally valid, and the STARS may be more appropriate in contexts where students are learning statistics rather than other areas of mathematics.

We found that the statistics anxiety general factor had a weak but significant negative correlation with grades and with critical thinking. The weak negative correlation we observed between global statistics anxiety and course grades is similar in magnitude to those typically reported in the literature. As summarized by Terry et al. (20206) and consistent with the scoping review by Macher et al. (2015b), studies using STARS and related measures have found small and sometimes inconsistent associations between statistics anxiety and achievement, ranging from negative to near-zero, and in some cases even showing small positive or curvilinear relationships (e.g., Macher et al. 2013; Sesé et al. 2015; Paechter et al. 2017; Zimmerman and Austin 2018). Our results contribute to this mixed pattern by showing that in a Hungarian sample with a restricted and skewed grade distribution, statistics anxiety still shows a statistically reliable, albeit modest, negative association with performance. Furthermore, the small negative association between statistics anxiety and performance on the Cognitive Reflection Test suggests that higher anxiety may be linked to a lower tendency to engage in analytic reasoning beyond domain-specific skills. This finding is in line with Mahak et al. (2025), who reported a similarly small negative association between statistics anxiety and deliberative thinking responses on an analytic reasoning task. The Hungarian STARS, therefore, also appears sensitive not only to domain-specific performance outcomes but also to individual differences in analytic thinking.

The validated structure and discriminant properties of the Hungarian adaptation of STARS have important practical implications for educational settings. The ability of the scale and its subscales to reliably identify specific types of statistics anxiety means that educators and psychologists can more accurately pinpoint the areas in which students struggle. This targeted identification is crucial for developing tailored interventions and support strategies (Chew and Dillon 2014). For instance, students identified with high levels of Test and Class Anxiety might benefit from exam preparation workshops and test-taking strategies. In contrast, those with high Interpretation Anxiety could be provided with additional resources and practice opportunities to enhance their data interpretation skills. Similarly, students who exhibit a pronounced Fear of Asking for Help could be encouraged to participate in peer tutoring programs or given more opportunities to engage in one-on-one consultations with instructors (Chew and Dillon 2014).

Overall, the present findings converge with a substantial body of research on the STARS and related instruments. The Hungarian version reproduces the core structural, reliability, and correlational patterns reported in original and translated versions of the scale, while adding novel evidence on bifactor structure, comprehensive measurement invariance across educational contexts, and relations to analytical thinking. In this sense, our study does not merely adapt an existing instrument but situates the Hungarian STARS within a broader, international research tradition on statistics anxiety, thereby providing a solid foundation for future comparative and intervention studies in Hungarian higher education.

4.1. Limitations

Despite its strengths, this study has limitations. Participation was voluntary, which may have introduced self-selection bias; for instance, students with greater interest or confidence in statistics might have been more likely to participate. However, this concern may be mitigated by the fact that the statistics anxiety scores in our dataset were approximately symmetric and showed no extreme skew or restricted range. This suggests that the sample did not disproportionately consist of unusually confident or low-anxiety students, which reduces, though does not entirely eliminate, the likelihood of substantial self-selection bias. The sample included only psychology students, potentially limiting generalizability to other disciplines. Moreover, our sample overrepresented freshmen and women; therefore, some findings may not generalize to other demographic groups. However, the gender distribution of our sample is broadly consistent with typical patterns in psychology programs, where women tend to be overrepresented, including in the current Hungarian context. Future studies should aim for more balanced samples across gender and university year, include a wider range of academic fields and institutions, and thereby enable tests of measurement invariance and confirm the applicability of the Hungarian STARS across diverse demographic and academic contexts. Another limitation is that only approximately half of the sample ($N = 170$) completed the Math Anxiety Scale, limiting comparability with statistics anxiety. However, other studies have extensively covered the relationship between math and statistics anxiety, mitigating this limitation (Zeidner 1991; Paechter et al. 2017).

4.2. Conclusion

The present study confirms the reliability and validity of the Hungarian adaptation of the STARS, maintaining its bifactor structure with subscales consistent with the original version. The discriminant validity analyses further reinforce that while statistics anxiety is related to more general forms of anxiety such as cognitive anxiety, somatic anxiety, and fear of negative evaluation, it nonetheless remains a distinct construct. These findings underscore the utility of the Hungarian STARS in both research and practical applications, providing a robust tool for identifying and addressing statistics anxiety among students.

Future research should continue to explore the use of the STARS in diverse educational contexts and investigate the efficacy of targeted interventions designed based on the insights provided by this scale.

Authors Contributions

The authors made the following contributions, based upon the Contributor Roles Taxonomy (CRediT): Janos Salamon: Formal analysis, Investigation, Visualization, Writing—original draft, and Writing—review & editing; Jenny Terry: Investigation, and Writing—review & editing; András Zsidó: Investigation, Resources, Validation, Writing—original draft, and Writing—review & editing; Balazs Aczel: Resources, Validation, and Writing—review & editing; Tamás Nagy: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing—original draft, and Writing—review & editing. All authors approved the final version of the article.

AI Statement

The authors used ChatGPT (OpenAI, GPT-4.1, 2025 version) for language editing and grammatical improvement only. All substantive scientific content is the sole responsibility of the authors.

Ethics Statement

Informed consent was obtained from all participants included in the study. All procedures in studies involving human participants were performed in accordance with the ethical standards of the Research Ethics Committee of the Faculty of Education and Psychology at Eötvös Loránd University (ELTE), which granted ethical approval for the study (reference number: ELTE-PPK-KEB-2021/292). Participation by the involved universities was based on their agreement to take part in the research under this approved protocol.

Disclosure Statement

The authors have no conflicts of interest to declare.

Funding

Janos Salamon was supported by project no. EKÖP-24-4-II, which has been implemented with the support provided by the Ministry of Culture and Innovation of Hungary from the National Research, Development and Innovation Fund, financed under the University Research Scholarship Programme funding scheme; Tamás Nagy was supported by Excellence Fund of ELTE Eötvös Loránd University, János Bolyai Research Scholarship of the Hungarian Academy of Sciences; András Zsidó was supported by Research Fund of the National Research, Development and Innovation Office (OTKA PD 137588 and OTKA FK 146604), and the János Bolyai Research Scholarship provided by the Hungarian Academy of Sciences.

Data Availability Statement

All data and code to reproduce the analysis can be found on the Open Science Framework (*https://osf.io/ud973/*).

ORCID

Janos Salamon http://orcid.org/0000-0002-4005-7090
Balazs Aczel http://orcid.org/0000-0001-9364-4988

References

Afdal, A., Alizamar, A., Ilyas, A., Zikra, Z., Taufik, T., Erlamsyah, E., Sukmawati, I., Ifdil, I., Ardi, Z., Marjohan, M., Netrawati, N., Zahri, T. N., Putriani, L., Fikri, M., Munawir, M., Syahputra, Y., Astuti, A. D., Trizeta, L., Erwinda, L., Pramudiastuti, N. K., Favorita, E. E., Achyar, N., Susanti, L., and Asmarni, A. (2019), "Contribution of Statistical Anxiety to Student Learning Outcomes: Study in Universitas Negeri Padang," *Journal of Physics: Conference Series*, 1157, 042126. DOI: 10.1088/1742-6596/1157/4/042126.

Baloğlu, M., Deniz, M. E., and Kesici, Ş. (2011), "A Descriptive Study of Individual and Cross-Cultural Differences in Statistics Anxiety," *Learning and Individual Differences*, 21, 387–391. DOI: 10.1016/j.lindif.2011.03.003.

Baloğlu, M., and Zelhart, P. F. (2007), "Psychometric Properties of the Revised Mathematics Anxiety Rating Scale," *The Psychological Record*, 57, 593–611. DOI: 10.1007/BF03395597.

Bargagliotti, A., Franklin, C., Arnold, P., Gould, R., Johnson, S., Perez, L., and Spangler, D. A. (2020), *Pre-K-12 Guidelines for Assessment and Instruction in Statistics Education II (GAISE II): A Framework for Statistics and Data Science Education*, Alexandria, VA: American Statistical Association.

Behr, D., and Shishido, K. (2016), "The Translation of Measurement Instruments for Cross-Cultural Surveys," in *The SAGE Handbook of Survey Methodology*, Los Angeles, CA: Sage Publications, 269–287. DOI: 10.4135/9781473957893.n19.

Benson, J., and El-Zahhar, N. (1994), "Further Refinement and Validation of the Revised Test Anxiety Scale," *Structural Equation Modeling: A Multidisciplinary Journal*, 1, 203–221. DOI: 10.1080/10705519409539975.

Bentler, P. M., and Chou, C.-P. (1987), "Practical Issues in Structural Modeling," *Sociological Methods & Research*, 16, 78–117. DOI: 10.1177/0049124187016001004.

Carleton, R. N., Collimore, K. C., McCabe, R. E., and Antony, M. M. (2011), "Addressing Revisions to the Brief Fear of Negative Evaluation Scale: Measuring Fear of Negative Evaluation across Anxiety and Mood Disorders," *Journal of Anxiety Disorders*, 25, 822–828. DOI: 10.1016/j.janxdis.2011.04.002.

Chen, F. F. (2007), "Sensitivity of Goodness of Fit Indexes to Lack of Measurement Invariance," *Structural Equation Modeling: A Multidisciplinary Journal*, 14, 464–504. DOI: 10.1080/10705510701301834.

Cheung, G. W., and Rensvold, R. B. (2002), "Evaluating Goodness-of-Fit Indexes for Testing Measurement Invariance," *Structural Equation Modeling: A Multidisciplinary Journal*, 9, 233–255. DOI: 10.1207/S15328007SEM0902_5.

Chew, P. K. H., and Dillon, D. B. (2014), "Statistics Anxiety Update: Refining the Construct and Recommendations for a New Research Agenda," *Perspectives on Psychological Science: a Journal of the Association for Psychological Science*, 9, 196–208. DOI: 10.1177/1745691613518077.

Chew, P. K. H., Dillon, D. B., and Swinbourne, A. L. (2018), "An Examination of the Internal Consistency and Structure of the Statistical Anxiety Rating Scale (STARS)," *PLoS One*, 13, e0194195. DOI: 10.1371/journal.pone.0194195.

Cruise, R. J., Cash, R. W., and Bolton, D. L. (1985), "Development and Validation of an Instrument to Measure Statistical Anxiety," in *American Statistical Association 1985 Proceedings of the Section on Statistical Education*, 92—-97.

DeVaney, T. A. (2016), "Confirmatory Factor Analysis of the Statistical Anxiety Rating Scale with Online Graduate Students," *Psychological Reports*, 118, 565–586. DOI: 10.1177/0033294116644093.

Donoho, D. (2017), "50 Years of Data Science," *Journal of Computational and Graphical Statistics*, 26, 745–766. DOI: 10.1080/10618600.2017.1384734.

Elliot, A. J., and Church, M. A. (1997), "A Hierarchical Model of Approach and Avoidance Achievement Motivation," *Journal of Personality and Social Psychology*, 72, 218–232. DOI: 10.1037/0022-3514.72.1.218.

Faraci, P., and Malluzzo, G. A. (2024), "Psychometric Properties of Statistics Anxiety Measures: A Systematic Review," *Educational Psychology Review*, 36, 56. DOI: 10.1007/s10648-024-09897-8.

Galeano, P., and Peña, D. (2019), "Data Science, Big Data and Statistics," *TEST*, 28, 289–329. DOI: 10.1007/s11749-019-00651-9.

Garnefski, N., Kraaij, V., and Spinhoven, P. (2001), "Negative Life Events, Cognitive Emotion Regulation and Emotional Problems," *Personality and Individual Differences*, 30, 1311–1327. DOI: 10.1016/s0191-8869(00)00113-6.

González, A., Rodríguez, Y., Faílde, J. M., and Carrera, M. V. (2016), "Anxiety in the Statistics Class: Structural Relations with Self-Concept, Intrinsic Value, and Engagement in Two Samples of Undergraduates," *Learning and Individual Differences*, 45, 214–221. DOI: 10.1016/j.lindif.2015.12.019.

Hanna, D., Shevlin, M., and Dempster, M. (2008), "The Structure of the Statistics Anxiety Rating Scale: A Confirmatory Factor Analysis Using UK Psychology Students," *Personality and Individual Differences*, 45, 68–74. DOI: 10.1016/j.paid.2008.02.021.

Hu, L., and 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, 1–55. DOI: 10.1080/10705519909540118.

KSH (2025), "Felsőfokú alap- és mesterképzésben hallgatók képzési terület szerint [Students in higher education bachelor's and master's programs by field of study]," *hu*. Available at *https://www.ksh.hu/stadat_files/okt/hu/okt0022.html*.

Lalande, D., Cantinotti, M., Williot, A., Gagnon, J., and Cousineau, D. (2019), "Three Pathways from Achievement Goals to Academic Performance in an Undergraduate Statistics Course," *Statistics Education Research Journal*, 18, 94–105. DOI: 10.52041/serj.v18i1.152.

Lavidas, K., Manesis, D., and Gialamas, V. (2021), "Investigation of the Statistical Anxiety Rating Scale Psychometric Properties with a Sample of Greek Students," *International Journal of Educational Psychology*, 10, 116. DOI: 10.17583/ijep.2021.6032.

Liu, L. (2021), "Assessing Statistics Anxiety in an Online or Hybrid Setting: The Adaption and Development of a New Instrument Sasoh," *Statistics Education Research Journal*, 20, 2. DOI: 10.52041/serj.v20i1.96.

Liu, S., and Onwuegbuzie, A. J. (2011), "Examination of the Score Reliability and Validity of the Statistics Anxiety Rating Scale in a Chinese Population: Comparisons of Statistics Anxiety," *Journal of Educational Enquiry,* 11, 29–42.

Macher, D., Paechter, M., Papousek, I., Ruggeri, K., Freudenthaler, H. H., and Arendasy, M. (2013), "Statistics Anxiety, State Anxiety during an Examination, and Academic Achievement," *The British Journal of Educational Psychology*, 83, 535–549. DOI: 10.1111/j.2044-8279.2012.02081.x.

Macher, D., Paechter, M., Ruggeri, K., and Papousek, I. (2015a), "STARS-D—Statistics Anxiety Rating Scale—Deutsche Fassung," *ZPID (Leibniz Institute for Psychology)—Open Test Archive*. DOI: 10.23668/PSYCHARCHIVES.4514.

Macher, D., Papousek, I., Ruggeri, K., and Paechter, M. (2015b), "Statistics Anxiety and Performance: Blessings in Disguise," *Frontiers in Psychology*, 6, 1116. DOI: 10.3389/fpsyg.2015.01116.

Mahak, S., Malone, S., Elsherif, M., Hand, C. J., and Morsanyi, K. (2025), "Academic Anxiety and Cognitive Reflection in Neurodivergence Based on Evidence from a Large International Sample," *Scientific Reports*, 15, 37522. DOI: 10.1038/s41598-025-21504-6.

Malik, S. (2015), "Undergraduates' Statistics Anxiety: A Phenomenological Study," *The Qualitative Report*, 20, 120–133. DOI: 10.46743/2160-3715/2015.2101.

Marsh, H. W., Hau, K.-T., and Grayson, D. (2005), "Goodness of Fit in Structural Equation Models," in *Contemporary Psychometrics: A Festschrift for Roderick P. McDonald,* Hillsdale, NJ: Lawrence Erlbaum Associates, 275–340. *https://psycnet.apa.org/fulltext/2005-04585-000.pdf*.

McDonald, R. P. (1970), "The Theoretical Foundations of Principal Factor Analysis, Canonical Factor Analysis, and Alpha Factor Analysis," *British Journal of Mathematical and Statistical Psychology*, 23, 1–21. DOI: 10.1111/j.2044-8317.1970.tb00432.x.

McIntee, S.-E., Goulet-Pelletier, J.-C., Williot, A., Deck-Léger, E., Lalande, D., Cantinotti, M., and Cousineau, D. (2022), "(Mal)Adaptive Cognitions as Predictors of Statistics Anxiety," *Statistics Education Research Journal*, 21, 5. DOI: 10.52041/serj.v21i1.364.

Meredith, W. (1993), "Measurement Invariance, Factor Analysis and Factorial Invariance," *Psychometrika*, 58, 525–543. DOI: 10.1007/BF02294825.

Millsap, R. E. (2011), *Statistical Approaches to Measurement Invariance*, London, UK: Routledge.

Morin, A. J. S., Arens, A. K., and Marsh, H. W. (2016), "A Bifactor Exploratory Structural Equation Modeling Framework for the Identification of Distinct Sources of Construct-Relevant Psychometric Multidimensionality," *Structural Equation Modeling: A Multidisciplinary Journal*, 23, 116–139. DOI: 10.1080/10705511.2014.961800.

Nasser, F. M. (2004), "Structural Model of the Effects of Cognitive and Affective Factors on the Achievement of Arabic-Speaking Pre-Service Teachers in Introductory Statistics," *Journal of Statistics Education*, 12, 1–19. DOI: 10.1080/10691898.2004.11910717.

Onwuegbuzie, A. J. (2004), "Academic Procrastination and Statistics Anxiety," *Assessment & Evaluation in Higher Education*, 29, 3–19. DOI: 10.1080/0260293042000160384.

Onwuegbuzie, A. J., and Wilson, V. A. (2003), "Statistics Anxiety: Nature, Etiology, Antecedents, Effects, and Treatments–a Comprehensive Review of the Literature," *Teaching in Higher Education,* 8, 195–209. DOI: 10.1080/1356251032000052447.

Paechter, M., Macher, D., Martskvishvili, K., Wimmer, S., and Papousek, I. (2017), "Mathematics Anxiety and Statistics Anxiety. Shared but Also Unshared Components and Antagonistic Contributions to Performance in Statistics," *Frontiers in Psychology*, 8, 1196. DOI: 10.3389/fpsyg.2017.01196.

Papousek, I., Ruggeri, K., Macher, D., Paechter, M., Heene, M., Weiss, E. M., Schulter, G., and Freudenthaler, H. H. (2012), "Psychometric Evaluation and Experimental Validation of the Statistics Anxiety Rating Scale," *Journal of Personality Assessment*, 94, 82–91. DOI: 10.1080/00223891.2011.627959.

Perreira, T. A., Morin, A. J. S., Hebert, M., Gillet, N., Houle, S. A., and Berta, W. (2018), "The Short Form of the Workplace Affective Commitment Multidimensional Questionnaire (WACMQ-S): A Bifactor-ESEM Approach among Healthcare Professionals," *Journal of Vocational Behavior*, 106, 62–83. DOI: 10.1016/j.jvb.2017.12.004.

Ralston, K. (2020), "Sociologists Shouldn't Have to Study Statistics': Epistemology and Anxiety of Statistics in Sociology Students," *Sociological Research Online*, 25, 219–235. DOI: 10.1177/1360780419888927.

R Core Team (2024), R: The R Project for Statistical Computing. Available at: *https://www.r-project.org/*.

Ree, M. J., French, D., MacLeod, C., and Locke, V. (2008), "Distinguishing Cognitive and Somatic Dimensions of State and Trait Anxiety: Development and Validation of the State-Trait Inventory for Cognitive and Somatic Anxiety (STICSA)," *Behavioural and Cognitive Psychotherapy*, 36, 313–332. DOI: 10.1017/s1352465808004232.

Reise, S. P., Bonifay, W. E., and Haviland, M. G. (2013), "Scoring and Modeling Psychological Measures in the Presence of Multidimensionality," *Journal of Personality Assessment*, 95, 129–140. DOI: 10.1080/00223891.2012.725437.

Rosseel, Y. (2012), "Lavaan: An R Package for Structural Equation Modeling," *Journal of Statistical Software*, 48, 1–36. DOI: 10.18637/jss.v048.i02.

Sesé, A., Jiménez, R., Montaño, J. J., and Palmer, A. (2015), "Can Attitudes toward Statistics and Statistics Anxiety Explain Students' Performance? / Pueden Las Actitudes Hacia La Estadística Y La Ansiedad Estadística Explicar El Rendimiento de Los Estudiantes?," *Revista de Psicodidactica / Journal of Psychodidactics*, 20, 285–304. DOI: 10.1387/revpsicodidact.13080.

Shenhav, A., Rand, D. G., and Greene, J. D. (2012), "Divine Intuition: Cognitive Style Influences Belief in God," *Journal of Experimental Psychology. General*, 141, 423–428. DOI: 10.1037/a0025391.

Shields, M. (2005), "Information Literacy, Statistical Literacy, Data Literacy," *IASSIST Quarterly*, 28, 6–6. DOI: 10.29173/iq790.

Steinberger, P. (2020), "Assessing the Statistical Anxiety Rating Scale as Applied to Prospective Teachers in an Israeli Teacher-Training College," *Studies in Educational Evaluation*, 64, 100829. DOI: 10.1016/j.stueduc.2019.100829.

Terry, J., Ross, R. M., Counsell, A., Alter, U., Ellis, J. L., Beribisky, N., Zsido, A. N., Garrido-Vásquez, P., Santos, F. H., Hallett, D., et al. (2026), "The Fault in Our STARS: International Evidence That the Statistics Anxiety Rating Scale and the Revised Mathematics Anxiety Rating Scale Overlap," *PsyArXiv.* DOI: 10.31234/osf.io/gzucd_v1.

Terry, J., Ross, R. M., Nagy, T., Salgado, M., Garrido-Vásquez, P., Sarfo, J. O., Cooper, S., Buttner, A. C., Lima, T. J. S., Öztürk, Ý., Akay, N., Santos, F. H., Artemenko, C., Copping, L. T., Elsherif, M. M., Milovanoviæ, I., Cribbie, R. A., Drushlyak, M. G., Swainston, K., Shou, Y., Leongómez, J. D., Palena, N., Abidin, F. A., Reyes-Rodríguez, M. F., He, Y., Abraham, J., Vatakis, A., Jankowsky, K., Schmidt, S. N. L., Grimm, E., González, D., Schmid, P., Ferreira, R. A., Rozgonjuk, D., Özhan, N., O'Connor, P. A., Zsido, A. N., Stiglic, G., Rhodes, D., Rodríguez, C., Ropovik, I., Enea, V., Nurwanti, R., Estudillo, A. J., Beribisky, N., Himawan, K. K., Geven, L. M., van Hoogmoed, A. H., Bret, A., Chapman, J. E., Alter, U., Flack, Z. M., Hanna, D., Soltanlou, M., Banik, G., Adamkoviè, M., van der Ven, S. H. G., Mosbacher, J. A., Şen, H. H., Anderson, J. R., Batashvili, M., de Groot, K., Parker, M. O., Helmy, M., Ostroha, M. M., Gilligan-Lee, K. A., Egara, F. O., Barwood, M. J., Thomas, K., McMahon, G., Griffin, S. M., Nuerk, H.-C., Counsell, A., Lindemann, O., Van Rooy, D., Wege, T. E., Lewis, J. E., Aczel, B., Monaghan, C., Al-Hoorie, A. H., Huber, J. F., Yapan, S., Garrido Vásquez, M. E., Callea, A., Ergiyen, T., Clay, J. M., Mertens, G., Topçu, F., Tutlu, M. G., Täht, K., Mikkor, K., Caso, L., Karner, A., Storm, M. M. C., Daroczy, G., Zein, R. A., Greco, A., Buchanan, E. M., Schmid, K., Hunt, T. E., De Keersmaecker, J., Branney, P. E., Randell, J., Clark, O. J., Steltenpohl, C. N., Malu, B., Teke, B., Ramis, T., Agrigoroaei, S., Badcock, N. A., McAloney-Kocaman, K., Semenikhina, O. V., Graf, E. W., Lea, C., Ogba, K. T. U., Guppy, F. M., Warhurst, A. C., Lindsay, S., Al Khateeb, A., Scharnowski, F., de Kwaadsteniet, L., Francis, K. B., Lecompte, M., Webster, L. A. D., Morsanyi, K., Forwood, S. E., Walters, E. R., Tip, L. K., Wagge, J. R., Lai, H. Y., Crossland, D. S., Darda, K. M., Flack, T. R., Leviston, Z., Brolly, M., Hills, S. P., Collins, E., Roberts, A. J., Cheung, W.-Y., Leonard, S., Verschuere, B., Stanley, S. K., Xenidou-Dervou, I., Ghasemi, O., Liew, T., Ansari, D., Guilaran, J., Penny, S. G., Bahnmueller, J., Hand, C. J., Rahajeng, U. W., Peterburg, D., Takacs, Z. K., Platow, M. J., and Field, A. P. (2023), "Data from an International Multi-Centre Study of Statistics and Mathematics Anxieties and Related Variables in University Students (the SMARVUS Dataset)," *Journal of Open Psychology Data*, 11, 8. DOI: 10.5334/jopd.80.

Trassi, A. P., Leonard, S. J., Rodrigues, L. D., Rodas, J. A., and Santos, F. H. (2022), "Mediating Factors of Statistics Anxiety in University Students: A Systematic Review and Meta-Analysis," *Annals of the New York Academy of Sciences*, 1512, 76–97. DOI: 10.1111/nyas.14746.

Vigil-Colet, A., Lorenzo-Seva, U., and Condon, L. (2008), "Development and Validation of the Statistical Anxiety Scale," *Psicothema*, 20, 174–180. *https://www.ncbi.nlm.nih.gov/pubmed/18206081*.

Williams, A. S. (2013), "Worry, Intolerance of Uncertainty, and Statistics Anxiety," *Statistics Education Research Journal*, 12, 48–59. DOI: 10.52041/serj.v12i1.321.

Wolff, A., Gooch, D., Cavero Montaner, J. J., Rashid, U., and Kortuem, G. (2016), "Creating an Understanding of Data Literacy for a Data-Driven Society," *The Journal of Community Informatics*, 12, 9–26. DOI: 10.15353/joci.v12i3.3275.

Zeidner, M. (1991), "Statistics and Mathematics Anxiety in Social Science Students: Some Interesting Parallels," *The British Journal of Educational Psychology*, 61 (Pt 3), 319–328. DOI: 10.1111/j.2044-8279.1991.tb00989.x.

Zimmerman, W. A., and Austin, S. R. (2018), "Using Attitudes and Anxieties to Predict End-of-Course Outcomes in Online and Face-to-Face Introductory Statistics Courses," *Statistics Education Research Journal*, 17, 68–81. DOI: 10.52041/serj.v17i2.159.