Measurement Invariance and Latent Profile Analysis of the Test Anxiety Inventory

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Abstract: Researchers have recognized the need for updates of test anxiety scales for more measurement accuracy. However, studies that investigated the measurement invariance of the Test Anxiety Inventory (TAI), and identified the latent profiles remain scare not withstanding its wide usage in Nigeria. This might have an impact on how generalizability and reliance on outcomes from such an instrument are handled. We investigated the measurement invariance of TAI and the latent profiles among Nigerian adolescents. Gender constituted our focus in the measurement invariance given its significance in test anxiety research. Adolescent students (n=539) formed the sample of our study. We employed the confirmatory factor analysis (CFA) and the latent profile analysis (LPA) to measure the invariance and identify the class profiles. We found evidence of a measurement invariance across gender in both competing models given that we obtained strict measurement invariance. We also identified a four-class profile model for both male and female students: low (17.50%; 19.00%), moderate (17.50%; 34.40%), high (36.80 %; 32.80%), and very high (12.60%; 13.80%) test anxiety profiles respectively. We concluded that while the composed factors are equivalently scaled across gender that test anxious students were not monolithic given the identified profiles.

Keywords: *Adolescent, latent profile analysis, measurement invariance, test.*

Introduction

Test anxiety has demonstrated significant negative effects on students' academic success (Alemu & Feyssa, 2020; Mohamadia et al., 2014; Rehman et al., 2021; Selvi, 2021), life satisfaction and self-actualization (Mohamadia et al., 2014; Tahoon, 2021). Researchers (Tsegay et al., 2019) have investigated its prevalence among students to help document the rates and possible policy-making use. Its incidence in most countries ranges between 25 to 40% (Liu et al., 2021; Tsegay et al., 2019). The high rates are presumably predicted by some factors including low academic performance (Alamri & Nazir, 2022), the nature of tests (Azimi, 2016), the examiners' attributes (Wadi et al., 2022), parental pressure, and socio-demographics such as gender (Malespina & Singh, 2022; Suhas & Sathiyaseelan, 2020). These research showed that a variety of factors interact to make students anxious before tests. However, evidence shows that such factors as high self-efficacy, high self-esteem, social support and adequate examination preparation (Bayani, 2016; Maier et al., 2021; Salar et al., 2016) are protective factors against test anxiety. As examination pressure increases, there is also increasing evidence of examination stress resulting in test anxiety that has been considered detrimental to students (Putwain, 2008; Soares, 2019).

The development of test anxiety scales is one area of test anxiety research that has drawn much interest. Even though there are many reliable test anxiety scales, over the years, various models have been used to create scales that may measure test anxiety in students, which has given rise to debates on the dimensionality of test anxiety (Putwain et al., 2021). Indeed, understanding the accurate picture of test anxiety among students depends greatly on the validity and

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appropriateness of the scale deployed as Zeidner and Matthews (2003, p.972) have earlier noted that "attention to possible biases and careful statistical analysis of test anxiety scales is essential". Researchers have, more recently, also refined available test anxiety instruments (Thomas et al., 2018) to validate their internal construct structures and provide guidelines for their clinical usage. One of the earliest test anxiety scales was developed by Spielberger (1980). It has been frequently used in Nigeria to assess the prevalence of test anxiety among Nigerian students as well as the relationships between test anxiety and other important psychosocial variables (Anyamele et al., 2016; Galle et al., 2020; Nwokolo et al., 2017; Nwosu et al., 2016, 2017; Okoli & Nnoli, 2008). Additionally, several of these research have shown how test anxiety levels vary between male and female students.

To the best of our knowledge, TAI is frequently utilized in Nigeria; nevertheless, investigations demonstrating the construct validity of TAI using confirmatory factor analysis are still rare. Evidence showed that the only validation of the Spielberger test anxiety inventory among Nigerian students was conducted by Omoluabi (1993) establishing its concurrent, discriminate, and convergent validity. Aside from the fact that it was restricted to an exploratory data analysis, given the time the study was done, the population that made up the respondents may have different characteristics from the current population. Although the Spielberger Test Anxiety Inventory (TAI) is said to be a dimensional scale, the majority of studies have consistently employed it as a unidimensional construct, necessitating further research. Using multidimensional test anxiety scales as unidimensional scales against their internal conceptual structures can distort the psychometric properties of the scales among the Nigerian sample (Metibemu & Ojetude, 2017). The internal conceptual structure of TAI is yet to be confirmed among Nigerian students, even though it remains the most popular test anxiety scale among Nigerian researchers and practitioners.

Additionally, there appears to be a significant information gap in determining the psychometric properties of TAI in the Nigerian setting due to the inadequate number of studies validating TAI, and determining whether it is invariant among male and female students. Selvi (2021) has noted that it is incorrect for researchers to explain the differentiation of values obtained with scales between groups by only linking the characteristics of the individuals. He argued that differences may be caused by the measurement instrument rather than the individual. For example, it is possible for the measurement scale to mean different things for male and female students. Hence, it becomes pertinent that we ascertain if this instrument is invariant across gender. Given this, we examined the invariance of the scale among male and female students especially as gender is considered important in the test anxiety studies where female students consistently had higher scores than male students (Lowe, 2014).

More so, the test anxiety profiles of students using this scale have not been established among Nigerian students using more recent person-centered analytical approaches such as the latent profile analysis (LPA). Hence, we set out to confirm the instrument on Nigerian students using multi-group measurement invariance, as well as identifying test anxiety profiles of the students.

Thus, our first aim is to determine the measurement invariance of TAI using CFA. Chapell et al. (2005) have noted that literature is replete with evidence that many theoretical models of test anxiety have been developed including the drive model, cognitive-attentional models, skill deficit models, the self-regulation models, the self-worth model and the transactional model. This implies that it may be difficult for one model to fully explain test anxiety leading to several perspectives on how to approach test anxiety. Putwain et al. (2021) have noted that in test anxiety scale development, researchers have only agreed on the fact that it is multidimensional. TAI, which has been recognized as one of the most popular scales among researchers and practitioners (Chapell et al., 2005), is regarded as a dimensional test anxiety scale (Kubíková et al., 2019) involving the worry (TAI-W), the emotional (TAI-E), and the total (TAI-T) subscales. It was developed as a 20-item self-report measure of test anxiety among high school and university students (Spielberger, 1980). This scale has been revalidated in other countries such as the Czech Republic (Kubíková et al., 2019), Pakistan (Ali & Mohsin, 2013), and Greece (Papantoniou et al., 2011). These studies presented TAI as a dimensional scale. However, there is gross inadequacy in investigating its measurement invariance, especially within the Nigerian setting where it is widely used. More so, results could be inaccurate if the scale is not invariant across the groups (Selvi, 2021). We, therefore, hypothesized that TAI would be invariant among male and female students.

Second, we also aim to establish the test anxiety profiles of students using the LPA. This, we believe, will help to advance the guide for Nigerian practitioners who widely adopt this scale for identification and conducting of intervention programs. This is based on the fact that researchers argue that many tools accompanied by norms/cut score guides need to be updated (Putwain et al., 2021). Recent advances in test anxiety scale development incorporate person-centered approaches including LPA, with the capacity to reveal the heterogeneity in self-reported test anxiety using different test anxiety profiles (Lowe, 2021) and thereafter provide standards for identification/inclusion in research or clinical practices. Though, to our knowledge, there have not been research studies that have identified students' test anxiety profiles using TAI, we hypothesized that test anxious students would be heterogeneous. A similar study (Lowe, 2021) has established heterogeneous test anxious subgroups categorized as low, medium, and high test anxiety using the Test Anxiety Measure for Adolescents (TAMA) designed for the US secondary school students.

Methodology

Research Design

We employed a cross-sectional research paradigm. This was because the cross-sectional study paradigm (Fraenkel et al., 2011; Stockemer, 2019) aimed to investigate the behavioral traits that were common among our population by taking a cross-section of the population at a specific moment with the intention to generalize the findings (Creswell, 2009).

Sample and Data Collection

We randomly sampled our participants from ten state-funded secondary schools in Awka and Onitsha Education Zones of Anambra State. We sampled 60 secondary school students in Senior Secondary Class 2 (SS2) from the ten schools totaling 600 students. However, only 89.83% (48.4% = male; 51.6% = female; *M* age = 14.72, *SD* = 1.02) of the students completed the questionnaire. For the data collection process, we first discussed the essence of the research with the school authorities and obtained their permission to conduct the study. We explained to our participants that their participation in the research was voluntary and that they were permitted to withdraw from the study at any time. We ensured confidentiality by not providing spaces for students' names and registration numbers.

Instrument

Test anxiety scale. We employed the Test Anxiety Inventory (TAI) developed by Spielberger (1980). This scale consists of 20 items. It is a short self-report that consists of 20 items that measure students' test anxiety. It is measured on a four-point Likert scale of 1 for "almost never" to 4 for "almost always". In the scoring of the scale, item 1 is reverse scored and higher scores show higher test anxiety. Sample of the items include: "While taking examination, I feel relaxed and confident", "I do have an upset feeling while taking examination", "During examination, I feel very worried". This scale has been widely used in many countries including Nigeria. TAI, as used in several countries, has demonstrated internal consistency for the dimensions ranging from .66 to .94 (Ali & Mohsin, 2013; Kubíková et al., 2019; Papantoniou et al., 2011). Among Nigerian sample, Omoluabi (1993) reported internal consistency values for worry, α = .73 and emotionality, α = .79. The Cronbach's alpha test in our current study showed reliability indices of: Worry Factor = .85; Emotionality factor = .84 and the Total TAI = .93.

Analyzing of Data

We adopted the structural equation model (SEM) framework using confirmatory factor analysis (CFA). The CFA was conducted using the JASP software version 0.16.3.0. We employed the four main steps for testing measurement invariance (MI) which are configural, metric (weak factorial), scalar (strong factorial) and strict (residual or invariant uniqueness) invariance (Putnick & Bornstein, 2016). We followed current practice that stipulates the use of multiple fit statistics to establish the measurement invariance: chi-square ($\chi2$), Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA), and Standardized Root Mean-square Residual (SRMR). We considered the integration of alternative fit indexes appropriate given that the absolute fit statistic in terms of $\chi2$ is usually sensitive to sample size. We adopted the nested model comparisons which involve computing the difference between fit statistics for the two models (e.g., $\Delta\chi2$, ΔCFI) (Putnick & Bornstein, 2016). Our cut off points were based on the review on the MI conventions by Putnick and Bornstein (2016) in which change in CFI of -.02 and RMSEA of .03 were most appropriate for tests of metric invariance with large group sizes, but the traditional criteria of -.01 for ΔCFI and .01 for ΔRMSEA were appropriate for scalar invariance tests.

After the CFA and the measurement invariance were established, we adopted a latent profile analysis (LPA), a person-centered approach to establish the degree and incidence of test anxiety among our sample. We considered this as the best approach to analyze our data, given that as person-centered approach, LPA underscores the heterogeneity of a population against the variable-centered approach that assumes homogeneity of the population (Li et al., 2022). LPA was conducted by employing the Jamovi software version 2.3.12, and performed within the snowRMM module. We followed previous literature on the fit indices to adopt. These indices include the lowest values of the Bayesian Information Criterion (BIC) and the Akaike Information Criteria (AIC), entropy values closer to 1, and the Bootstrap Likelihood Ratio Test (BLRT) *p*-values smaller than 0.05 (Bauer, 2021; Li et al., 2022). More so, any class should contain at least a distribution of 25 participants or more (Gonzálvez et al., 2021), and the interpretability of the models (Bauer, 2021) should be taken into consideration in the analysis.

Findings / Results

Psychometric Properties of TAI

Table 1. Item-Level Analysis of TAI in the Male and Female Groups

Gender		Mean	SD	Skewness	Kurtosis	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted	Cronbach's Alpha Value (N items = 20)
Male	TAS1	3.0463	.83398	-.653	-.053	.018	.932	0.926
	TAS2	2.5953	.92262	-.223	-.767	.424	.925	
	TAS3	2.6245	1.00658	-.274	-.990	.595	.922	
	TAS4	2.3654	1.01777	.148	-1.088	.611	.922	
	TAS5	2.6988	.94932	-.269	-.825	.489	.924	
	TAS6	2.6216	1.05456	-.234	-1.143	.602	.922	
	TAS7	2.5637	.97189	-.104	-.961	.702	.920	
	TAS8	2.3962	.97892	.207	-.944	.700	.920	
	TAS9	2.9119	1.02464	-.579	-.801	.542	.923	
	TAS10	2.4346	.98225	.024	-1.013	.726	.919	
	TAS11	2.5747	1.01108	-.127	-1.067	.668	.921	
	TAS12	2.1544	1.00738	.396	-.962	.659	.921	
	TAS13	2.4672	.98530	-.018	-1.019	.631	.921	
	TAS14	2.6484	.96276	-.282	-.851	.505	.924	
	TAS15	2.2124	.99479	.325	-.962	.661	.921	
	TAS16	2.6420	.99817	-.159	-1.030	.537	.923	
	TAS17	2.2335	1.02315	.357	-.996	.673	.920	
	TAS18	2.4363	1.00329	.083	-1.057	.662	.921	
	TAS19	2.3502	.96112	.153	-.928	.731	.919	
	TAS20	2.4615	1.03718	.009	-1.078	.699	.920	
Female	TAS1	3.0219	.75075	-.559	.257	-.212	.930	0.921
	TAS2	2.5073	.91884	-.064	-.814	.474	.919	
	TAS3	2.5985	1.00882	-.272	-1.006	.507	.919	
	TAS4	2.3877	1.01178	.118	-1.079	.572	.917	
	TAS5	2.6968	.97529	-.399	-.799	.588	.917	
	TAS6	2.6643	1.02111	-.297	-1.015	.699	.915	
	TAS7	2.5109	1.02153	-.040	-1.113	.633	.916	
	TAS8	2.4224	.99561	.072	-1.041	.693	.915	
	TAS9	3.0217	1.00881	-.686	-.679	.465	.920	
	TAS10	2.4672	.98748	-.058	-1.031	.700	.915	
	TAS11	2.6763	1.06616	-.242	-1.176	.685	.915	
	TAS12	2.0288	.99778	.601	-.741	.676	.915	
	TAS13	2.4239	1.08444	.025	-1.290	.598	.917	
	TAS14	2.6087	.99039	-.192	-.985	.504	.919	
	TAS15	2.2509	1.07677	.334	-1.157	.638	.916	
	TAS16	2.7004	1.02528	-.307	-1.023	.532	.918	
	TAS17	2.3152	1.05757	.234	-1.162	.644	.916	
	TAS18	2.3043	1.01343	.163	-1.101	.661	.915	
	TAS19	2.3551	1.00761	.058	-1.117	.709	.914	
	TAS20	2.5000	1.07398	.009	-1.251	.716	.914	

Table 1 revealed that each item in both male and female groups has skewness and kurtosis values within the acceptable range of ± 2 and ± 7, indicating good normality (Finney & DiStefano, 2006). Except for item 1, whose corrected item-total correlation was less than the minimum value of.30, all items in the two groups had corrected item-total correlation values greater than. 40 (Cristobal et al., 2007). We therefore, deleted item 1 from further analysis. We also checked for significant outliers, and the results revealed no significant outliers. The Cronbach's alpha reliability for the Spielberg test anxiety inventory (TAI) was .93 for the male sample and .92 for the female sample.

Confirmatory Factor Analysis of TAI

First, we determined the model fits of the scale on the general sample before examining the model fit for male and female groups. Given that TAI has been used as both a one-dimensional and a multidimensional scale, we determined the competing models among the general sample. There was an adequate fit for the 19-item one-dimensional model: χ^2 = 506.147, *df* = 152; χ^2/df = 3.33; CFI = 0.991, TLI = 0.989, RMSEA = 0.070, and SRMR = 0.057. Factor loadings ranged from 0.494 to 0.805. Also, the two dimensional model of Worry (8-items) and Emotionality (8-items) had adequate fit indices: χ^2 = 358.481, *df* = 103; χ^2/df = 3.48; CFI = 0.990, TLI = 0.988, RMSEA = 0.071, and SRMR = 0.057. Its factor loadings ranged from 0.507 to 0.792. The dimensional model that included the TAI-Total was unfit. We therefore proceeded with the 19-item non-dimensional and the 16-item dimensional models in our measurement invariance analysis by first establishing the CFA for male and female students as presented in Table 2.

Table 2. CFA Results of the Models for Male and Female

Model	χ^2	df	χ^2/df	RMSEA	SRMR	TLI	CFI
Male							
Model 1- (one-dimensional-19 items)	343.940	152	2.26	0.075	0.067	0.989	0.990
Model 2- Two Factor (Worry: 7 items; Emotionality: 8 items)	196.828	89	2.21	0.072	0.064	0.990	0.988
Female							
Model 1 (one-dimensional-19 items)	316.554	135	2.35	0.077	0.069	0.988	0.989
Model 2- Two Factor (Worry: 7 items; Emotionality: 8 items)	196.689	89	2.21	0.069	0.064	0.990	0.989

In Table 2, we presented the fit indices of our CFA. We decided to run a number of CFAs for both male and female students. First, we ran a one-dimensional CFA with the 19 items having deleted item 1 because it was problematic. The model had adequate fit indices given that the CFI and TLI were greater than 0.95; RMSEA and SRMR were less than 0.08 (Hooper et al., 2008) for both male and female students. Furthermore, we ran a two-dimensional model CFA of the Spielberger TAI for the two groups since researchers have pointed out its dimensionality. The modification indices showed that item 17 cross loaded highly for male students and when it was deleted for both groups, the models showed a better fit. We continued further analysis with the 19-item one-dimensional model and the 15-item two-factor model.

Table 3. The Measurement Invariance of Non-Dimensionality/Dimensionality Factor Loadings and Item Intercepts

Model	χ^2	df	χ^2/df	$\Delta\chi^2$/df	CFI	ΔCFI	TLI	ΔTLI	RMSEA	ΔRMSEA	SRMR	ΔSRMR	Decision
Non-dimensionality (19 items)													
Model 1: Configural invariance	661.496	304	2.17	-	.991	_	.990	-	0.070	-	0.066	-	-
Model 2: Metric invariance	739.185	332	2.23	-0.06	.989	0.002	.989	0.001	0.081	-0.011	0.070	-0.0004	Accept
Model 3: Scalar invariance	702.782	359	1.96	0.27	.991	-0.002	.992	-0.003	0.063	0.018	0.066	0.004	Accept
Model 4: Strict Invariance	702.782	359	1.96	0.00	.991	0.000	.992	0.000	0.063	0.000	0.066	0.000	Accept
Dimensionality (Worry: 7 items; Emotionality: 8 items)													
Model 1: Configural invariance	379.306	178	2.13	-	.991	_	.981	-	0.068	-	0.064	-	
Model 2: Metric invariance	436.603	191	2.29	-0.16	.989	0.002	.987	-0.006	0.073	-0.005	0.069	-0.005	Accept
Model 3: Scalar invariance	415.743	219	1.90	0.39	.991	-0.002	.991	-0.004	0.061	0.012	0.064	0.005	Accept
Model 4: Strict Invariance	415.743	219	1.90	0.00	.991	0.000	.991	0.000	0.061	0.000	0.064	0.000	Accept

Table 3 revealed the measurement invariance of the models among the two groups. Both models (i.e., the 19-item one-dimension model and the 15-item two-dimension model) showed that the scale is invariant among the groups. The results showed that the configural models for the 19-item one-dimension model and the 15-item two-dimension model fit the data well: χ^2 = 661.496; *df* = 304; χ^2/df = 2.17; RMSEA = .070; SRMR = .066; CFI = .991; TLI = .990; χ^2 = 436.603; *df* = 191; χ^2/df = 2.29; RMSEA = .073; SRMR = .069; CFI = .991; TLI = .981 respectively. Hence, we used the results of the configural models as the baseline values to compare subsequent specified restricted models. Subsequently, the measurement invariance was fit going by the models tested (metric, scalar, and strict models) since changes in CFI,

RMSEA and SRMR are within the acceptable range of -.02 for ΔCFI and .03 for Δ SRMR which are most appropriate for tests of metric invariance with large group sizes. Also, the measurement invariance values were within the traditional criteria of -.01 for ΔCFI and .01 for ΔRMSEA which are most appropriate for scalar and strict invariance tests. This shows that both factor loadings and intercepts were invariant across gender when the 19-item one-dimension model and the 15-item two-dimension model are employed.

Latent Profile Analysis (LPA) for Male and Female Students

We adopted the current method (LPA) of generating cut scores for clinical guidance against the conventional variable approach. We intended to identify the test anxiety profiles of our students in order to ascertain how the students are grouped in the profiles to facilitate clinical practice. The fit indices of the LPA models are presented in Table 4, whereas the class distribution frequencies of the model are presented in Table 5.

Table 4. Fit Indexes of the LPA Models Using the 19-Item One-Dimensional CFA Model

Gender	Model	classes	AIC	BIC	Entropy	Prob_min	Prob_max	n_min	n_max	BLRT_p
Male	1	2	11172.93	11371.83	0.91	0.97	0.98	0.46	0.54	0.01
	2	3	10747.12	11014.61	0.93	0.95	0.98	0.17	0.58	0.01
	3	4	10570.92	10907.00	0.92	0.94	0.98	0.14	0.37	0.01
	4	5	10491.71	10896.37	0.92	0.87	0.99	0.12	0.29	0.01
Female	1	2	12516.23	12721.17	0.94	0.97	0.99	0.49	0.51	0.01
	2	3	12197.79	12473.39	0.92	0.96	0.98	0.21	0.40	0.01
	3	4	12016.03	12362.30	0.91	0.95	0.95	0.14	0.34	0.01
	4	5	11959.51	12376.45	0.89	0.89	0.97	0.14	0.34	0.01

Table 4 showed that there is a continuous decrease from model two through model 4 for male and female students though there was a b it increase in BIC values in model 4 for female students. Though model 4 could be said to have the least AIC and BIC, we accepted model 3 with four classes for both male and female students. Our judgment was based on the fact that an inspection of the class specific means revealed that model 4 has theoretical interpretability difficulty. Researchers have noted that no solution is worth retaining without good interpretability no matter how fitted the model (Bauer, 2021). The profiles are presented in Figures 1 and 2.
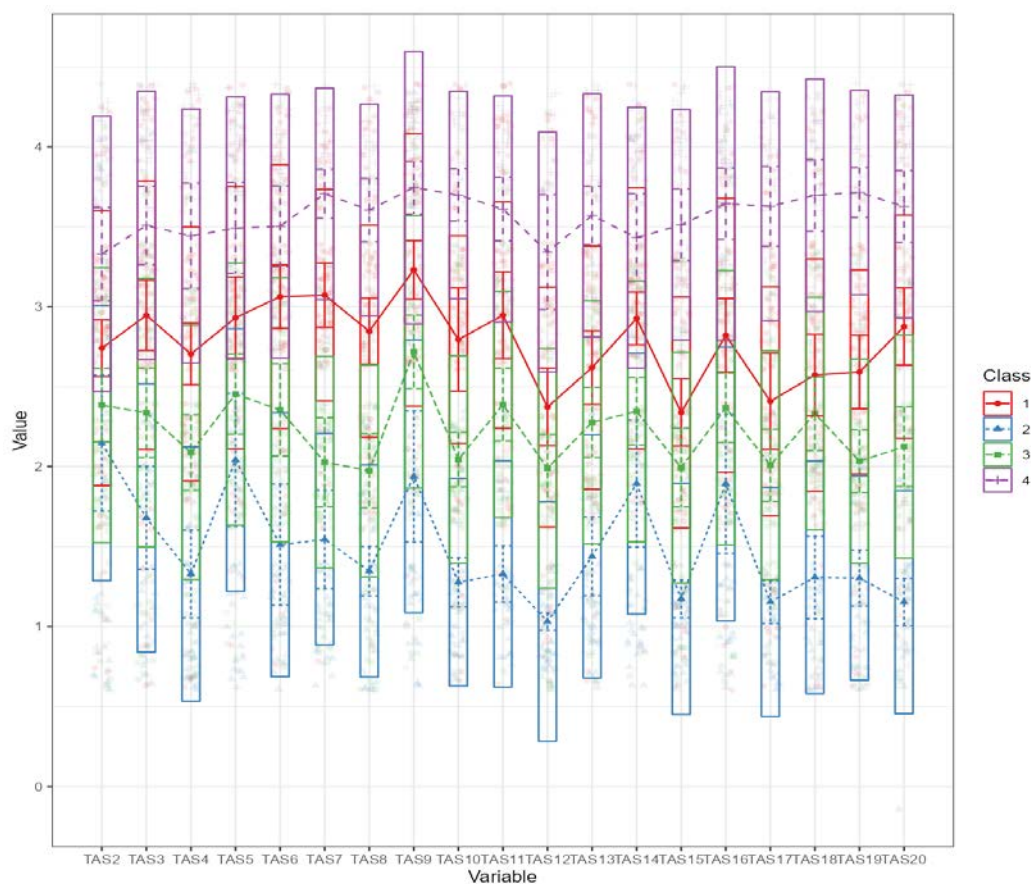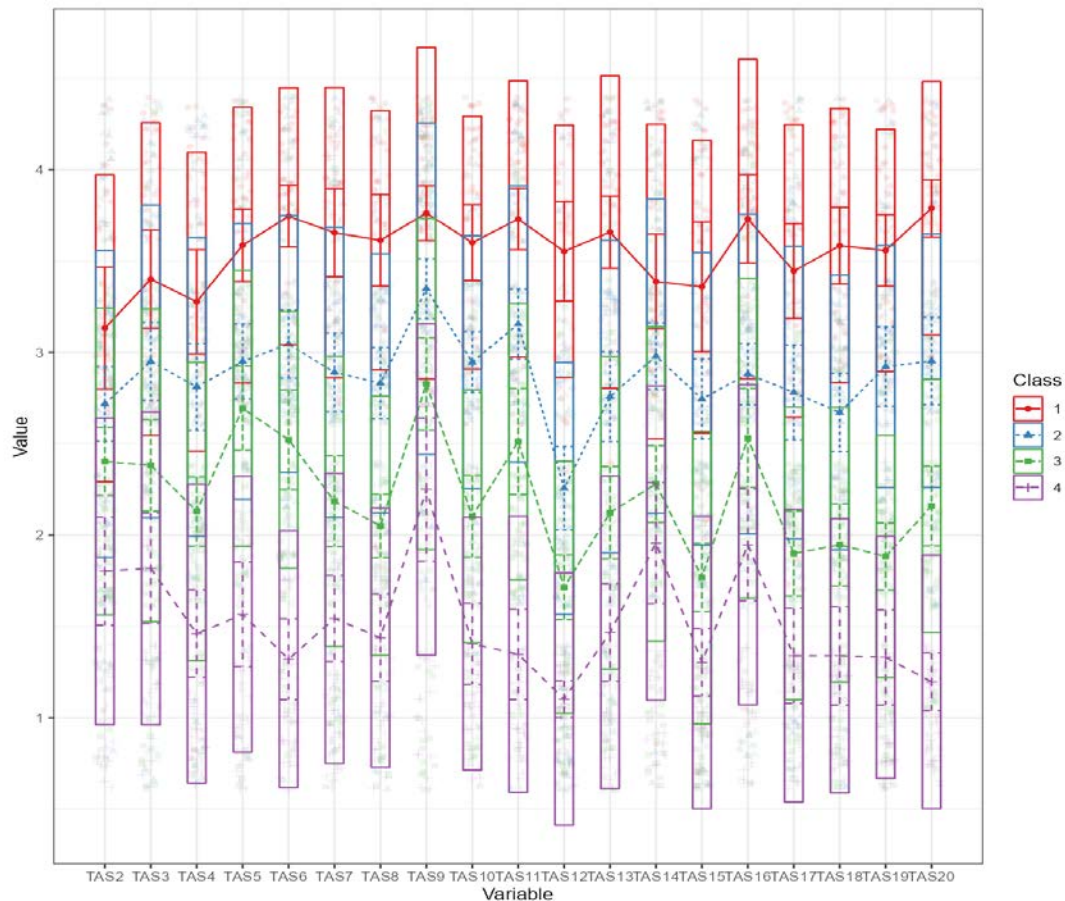

Figure 1. Male Profile Graph

Figure 2. Female Profile Graph

Table 5. Class Distribution Frequencies of the Four-Class Model for Male and Female Students

Variables	Profile one (High Test Anxious Students)			Profile two (Low Test Anxious Students)			Profile three (Moderate Test Anxious Students)			Profile four (Very High Test Anxious Students)		
	M	**SD**	**%**	**M**	**SD**	**%**	**M**	**SD**	**%**	**M**	**SD**	**%**
Male	52.99	3.72	36.80	28.40	5.06	17.50	42.17	3.32	17.50	68.09	4.78	12.60
	Profile one (Very High Test Anxious Students)			Profile two (High Test Anxious Students)			Profile three (Moderate Test Anxious Students)			Profile four (Low Test Anxious Students)		
	M	**SD**	**%**	**M**	**SD**	**%**	**M**	**SD**	**%**	**M**	**SD**	**%**
Female	67.86	4.12	13.80	54.78	3.56	32.80	42.07	4.00	34.40	28.79	4.86	19.00

Table 5 reveals the class distribution of the models for male and female students. For male students, Profile One captures students with high test anxiety ($M = 52.99 \pm 3.72$) comprising 36.80 % of the male students; profile 2 captures students with low test anxiety ($M = 28.40 \pm 5.06$) comprising 17.50 % of the male students; Profile Three consists of students with moderate test anxiety ($M = 42.17 \pm 3.32$) with 17.50 % of the male students whereas profile four are students with very high level of test anxiety ($M = 68.09 \pm 4.78$) comprising 12.60 % of the male students. For female students, Profile One consists of students with very high test anxiety ($M = 67.86 \pm 4.12$) and has 13.80 % of the female students; Profile Two is students with high test anxiety ($M = 54.78 \pm 3.56$) and consists of 32.80 % of the female students; Profile Three comprises students with moderate test anxiety ($M = 42.07 \pm 4.00$) and has 34.40 % of the female students whereas profile 4 consists of students with low test anxiety ($M = 28.79 \pm 4.86$) and is made up of 19.00 % of the female students. Though male students with very high test anxiety scores had a higher average score than their female counterparts, female students had a higher percentage of students in this profile.

Discussion

We aimed to establish the measurement invariance of the 20-item TAI by Spielberger (1980), and identify its profiles among adolescent students. The significance of our study rests on the fact that, notwithstanding the popularity of TAI among Nigerian researchers and practitioners, no study, to our knowledge, has either confirmed the factors among Nigerian students, or identified its profiles using LPA. Test anxiety scales have been used widely in comparative studies without testing for measurement invariance across groups which could lead to erroneous conclusions (Selvi, 2021). It becomes pertinent that measurement invariance of TAI is investigated within the Nigerian context.

Concerning the total sample size, our findings revealed that the 19-item one-dimension TAI model and the 16-item dimension (Worry and Emotionality) model had adequate fits among the students. This is contrary to similar studies that revalidated TAI in a context different from the original context (Kubíková et al., 2019; Papantoniou et al., 2011) that confirmed that the 20-item model and the 16-item dimensional model of TAI had adequate fit indices. Our present study could identify 19-item non-dimensional model and 16-item bi-dimensional models among the total sample. It has been noted earlier that studies that have employed CFA on TAI have reported inconsistent results (Zeidner & Matthews, 2003). However, our current models had adequate fit indices, and could be used among our population. The difference between our current result and the aforementioned prior studies may lie in the fact that they employed a translated version of TAI. In our study we did not translate the scale into a native Nigerian language given the prominent place of the English language in the Nigerian school system. More so, the poor performance of item 1 which was deleted given its corrected item-total correlation that was lower than the minimum value of .30 before the CFA could affirm the growing discussion in the body of literature that reverse-coded items in test anxiety scales may be measuring distinct construct such as test confidence (Thomas et al., 2018). There is a need for theories underpinning these to be re-evaluated.

Regarding the measurement invariance of TAI, we first examined competitive models among female and male students. We were able to identify a 19-item non-dimensional and a 15-item dimensional version of TAI given that item 17 in the worry sub-cluster cross-loaded significantly. This item was deleted for both groups. Our study demonstrated that the 19-item non-dimensional and the 15-item dimensional versions identified in our study had good psychometric properties and were invariant across male and female students. This implies that the scale can be used either in its non-dimensional or the dimensional version (Worry and Emotionality). Our findings revealed that the model provided configural invariance across gender indicating that the formal structure of the scale is the same. This provided the basis for further analysis. We obtained scalar, metric and strict measurement invariance in the models showing the comparable variance of the factor loadings, intercepts and residual variances across gender. By implication, the composed factors are equivalently scaled across gender, and differences might have arisen due to individuals' characteristics across gender and not necessarily the instrument itself. By inference, both male and female students interpret the scale similarly.

We proceeded to determine the test anxiety profiles of students using LPA. We identified a four-class model for both male and female students namely: low test-anxious, moderate test-anxious, high test-anxious and very high test-anxious students. Our results indicated that four groupings of individuals with similar patterns of text anxiety scores existed among male and female students. For both male and female students, the average scores exceed 52 and 67 for high and very high test anxiety, respectively. For male students, 17.50% have low and moderate test anxiety, respectively; 36.80 % have high test anxiety, whereas 12.60% have very high test anxiety. For female students, 19.00% have low test anxiety, 34.40% have moderate test anxiety, 32.80% have high test anxiety, and 13.80% have very high test anxiety. Considering the class distribution percentages from moderate to very high test anxiety scores, our findings revealed that female students may be more test anxious than their male counterparts, which is consistent with the current literature (Lowe, 2021). LPA has been conducted on test anxiety scales such as FRIEDBEN Test Anxiety Scale (Thomas et al., 2018; von der Embse et al., 2014), Mental Health Test (MHT) (Wen et al., 2020); Test Anxiety Measure for Adolescents (TAMA) (Lowe, 2021) to our knowledge, no research has used LPA for TAI. Prior studies have identified three-class profile models contrary to our four-class model. Most of the researchers termed their models as low, medium and high. We categorized our four-profile model as low, moderate, high, and very high test-anxious subgroups. This confirms that test-anxious students are not monolithic in composition, which should be considered during intervention programs.

Conclusion

Our findings revealed a 19-item non-dimensional model and a 15-item two-dimensional model, which were invariant across gender. We concluded that the composed factors are equivalently scaled across gender; and that differences in scores may have arisen due to individuals' characteristics across gender and not necessarily the instrument itself. Our LPA identified a four-class profile model leading to the conclusion that test anxious students are not monolithic. Female students were more test-anxious than their male counterparts, indicating they may be more perturbed about their examinations.

Recommendations

These findings are significant and have both theoretical and practical implications. First, we have added to the body of literature that the models are invariant across gender, and could be used among Nigerian adolescent students in both the non-dimensional and dimensional versions. It has also added to the body of literature the need to have an in-depth analysis of reverse coded items in TAI given that item one contributed poorly to the internal structure of the scale (Thomas et al., 2018). Regarding the LPA, researchers may use the profiles identified to ascertain students who need help and make informed decisions in mounting their intervention programs. It provided insight into groups that may be more vulnerable. The very high test anxious students scored highly across the dimensions (Worry and Emotionality) of TAI. These students may need extra support from teachers, parents, counselors, and psychologists. This will also enable researchers to mount focused intervention programs.

Limitations

Though our study makes a significant contribution to existing body of knowledge, there are some limitations worth mentioning here. First, our measurement invariance was limited to gender groups only. There are other variables like age, socioeconomic status that have been considered important in test anxiety research that could be used to establish the measurement invariance of TAI among our respondents. There is, therefore, the need for future studies to incorporate these variables. Second, another limitation is the difficulty to compare our findings with other findings with regards to LPA results, because LPA studies on TAI are scarce. Third, though our general sample size is large enough for CFA, our LPA may be limited by the sample size especially as it is conducted differently for male and female adolescent students.

Ethics Statements

The studies involving human participants were reviewed and approved by the Nnamdi Azikiwe University. The participants provided their written informed consent to participate in this study.

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Authorship Contribution Statement

Nwosu, Wahl, and Nwikpo: Conceptualization, design, analysis, writing. Ede and Hickman: Editing/reviewing, supervision.

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