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French Study of the Multidimensional Test Anxiety Scale (MTAS) in Relation to Performance, Age and Gender

Test Anxiety: What is it and Why is it Important?

In the highly performance-driven environment of modern societies, evaluative situations often induce negative achievement-related emotions. Test anxiety (TA) is a negative emotion, defined as a situation-specific form of trait anxiety; the tendency to appraise performance-evaluative situations as threatening and react with elevated state anxiety (Spielberger & Vagg, 1995). The negative impact of TA on academic performance has been shown in meta-analyses (e.g., Hembree,1988; von der Embse et al, 2018). In addition, test anxiety has been shown to be damaging to wellbeing, and physical and mental health (e.g., Putwain, Stockinger et al., 2021).

French context of Test Anxiety.

The French education system is known to highly value school achievements (Rey & Feyfant, 2014). Performance on school assessments and standardized tests are the main criteria for that determine students' access to upper secondary education (Farges et al, 2016). It is therefore not surprising that 65% of French secondary school students report "worry about getting poor grades at school" and score 62% on "fear of failure" indexes, which negatively impacts their academic self-perception as well as their future aspirations (OECD, 2017, 2019). These figures imply high TA. In the absence of validated psychometric tools for TA measuring in French, however, the prevalence of TA in French secondary school students is unknown.

Gender and Age Differences in Test Anxiety

There is long-standing evidence that female students report higher test anxiety scores (e.g., Hembree, 1988; Ringeisen et al., 2016) as well as anxiety more generally (e.g., Ohannessian et al., 2017). Despite the fact that female students report higher test anxiety they often show higher academic achievement than their male counterparts (e.g., Voyer, & Voyer,

2014). Age differences and developmental trends in test anxiety have not been widely studied. Wigfield and Eccles (1989) proposed test anxiety to develop during elementary and secondary school as students become progressively exposed to academic pressures. This reasoning was partly shown in Hembree's (1988) meta-analysis with test anxiety peaking at the age of 14 and showing a decline for the remainder of secondary school. In a more contemporary study (Putwain, von der Embse, et al., 2021) test anxiety increased from the ages of 11 to 18 years and were strongest from the ages of 15 to 18 years when students were preparing for and sitting high-stakes examinations.

Measurement Invariance

Group comparisons (e.g., for gender and age) for psychological attributes, like test anxiety, are often not directly measured but inferred from observed responses on scales. Critically, this means that scores from instruments reflect the same constructs and possess the same meaning for individuals belonging to different groups (AERA, APA, NCME, 2014). In order to be confident, that differences between the scores of groups are accurate and unbiased, it is necessary for measurement instruments to demonstrate measurement equivalence (or non-invariance) for the different groups they are measured in relation to. In practical terms, the equivalence of factor structure, factor-item loadings, and item intercepts needs to be demonstrated for gender and age if one wishes to examine mean differences between them. Sadly, with some rare exceptions (e.g., von der Embse et al., 2021) invariance in test anxiety scores for socio-demographic factors are lacking. Furthermore, it cannot be assumed that the invariance demonstrated in one education system and setting can be generalized to another.

Aims of the Current Study

The object of this study was twofold. First, to establish the psychometric properties of a French language version of the MTAS along with concurrent (trait anxiety and fear of assessment) and predictive validity (math exam scores). Mathematics exam scores were chosen

as these are used in French school system to assess the risk of dropping out of school, which is strongly related to anxiety (Bowers & Sprott, 2012; Quiroga et al., 2013). Second, to establish measurement invariance of MTAS scores for gender and age. Despite studies showing higher test anxiety scores in older and female participants, there is limited evidence for the measurement equivalence of test anxiety instruments for different gender and age groups.

Method

Participants

Five-hundred and twenty secondary school students participated in the study (224 girls and 266 boys; 10 students did not indicate their sex). The sample covered all four secondary years (Year 7 to Year 10) of two public schools in Strasbourg and Saint Etienne (Year 7: N = 82, Year 8: N= 114, Year 9: N = 100, Year 10: N = 56). One school was situated in a rural, and the other in an urban, location. Ages of participants varied from 11 to 16 years of age (M = 13.28, SD = 1.36).

Measures

Test anxiety was measured using the MTAS (see Table S5). Trait anxiety was measured using the six-item version of the State-Trait Anxiety Inventory (STAI: Marteau & Bekker, 1992; Gauthier & Bouchard ,1993) with 4-point scale (1 = *Not at all* to 4 = *Strongly agree*). We measured fear of assessment with a question "I am afraid of being graded." with 7-point scale (1 = *Not at all* to 7 = *Strongly agree*). Academic performance was taken from students' score on a mathematics exam taken in the final trimester of the school year, as it is typical for French schools to assess learning at the end of a year with a single exam.

Analytic Strategy

McDonald's ω was used to assess internal consistency of the MTAS and Exploratory Structural Equation Modeling (ESEM) to assessed factor structure. By allowing all items to correlate freely with all factors, the ESEM can provide a better model fit and representation of

a complex factor structure than a Confirmatory Factor Analysis and reduce the likelihood of biased parameter estimates (e.g., Marsh & al., 2013). Model fit was assessed with the following indicators and their recommended cut-off values (Hu & Bentler, 1999): RMSEA ≈.08, SRMR ≈.08, CFI ≈.95, and TLI ≈.95. Concurrent and predictive validity was examined through relations with trait anxiety and test performance. To test measurement invariance for age and gender we tested configural, metric (equality of item-factor loadings), scalar (invariance of item intercepts), and strict (invariance of residual variances), invariance models. Descriptive statistics were performed with R 4.0.4 (package Psych 2.09) and Jamovi 1.2.27. Confirmatory analyses and structural equation modeling were performed with M*plus* version 8.5 (Muthén & Muthén, 2017). Missing data for the factorial analyses were < 5% of the sample and handled using FIML. Participants without STAI, fear of assessment, or math exam scores were deleted from subsequent analyses.

Results

Exploratory Structural Equation Modeling

ESEM was conducted in order to validate the factor structure of the MTAS. Table S1 shows the factor loadings, descriptive statistics, and internal consistency for the 16 MTAS items. Worry items loaded on Factor 1, cognitive interference items on Factor 2, tension items on Factor 3, and physiological items on factor 4. One tension item (T3) cross-loaded to factor 4 ($\lambda = .37$). All other items showed small cross-loadings to non-target factors (λs <.3). This pattern of factor loadings confirms the four-factor structure of the MTAS, with the exception of item T3. However, we decided to keep this item in order to remain as close as possible to the original version. Internal consistency of all factors was high (ωs ≥ .76). Notably, the internal consistency of Factor 3 ($\omega = .81$) did not appear to be adversely affected by the cross-loaded item (T3).

Concurrent and Predictive Validity

Table 1 shows the correlations between the MTAS factors, the STAI, fear of assessment, and test performance. Moderate to strong intercorrelations were shown between the four MTAS factors and between the MTAS and the STAI and fear of assessment. Negative correlations were shown between test scores and three MTAS factors (with the exception of physiological indicators) and STAI.

Invariance Testing for Gender and Age

Invariance of MTAS scores for gender and age was established by testing models with increasing successive constraints: configurational, metric, and scalar. Since the χ^2 can be sensitive to the sample size (Chen, 2007), invariance thresholds were ΔCFI $\leq$ .01, ΔRMSEA $\leq$ .015, and ΔSRMR $\leq$ .03, for metric invariance and ΔCFI $\leq$.01, ΔRMSEA $\leq$ .015 and ΔSRMR $\leq$ .01 for scalar invariance. The comparison indicators between the indices in Table S2 showed that ΔCFI, ΔRMSEA and ΔSRMR are well below the recommended threshold in the comparisons between the models. On the basis of these different elements, it is possible to say that the measure is gender and age invariant. Scalar invariance was shown for gender and age and so we proceeded to examine differences in latent means for gender and age (see Tables S3 and S4). Statistically significant gender differences (ps <.05) were shown for all four MTAS factors with girls reporting higher test anxiety. In relation to age, cognitive interference was higher for older (p = .01) students. The remaining MTAS factors were stable over age (ps >.05).

Discussion

The aim of this study was to translate and to examine the psychometric qualities of French version of the MTAS as well as to test for measurement invariance for gender and age. Together with the good internal consistency of the four factors, and the expected positive relations with trait anxiety and fear of assessment, and negative relations with examination performance, the French language version of the MTAS has demonstrated sufficient psychometric qualities to

be used in future research and practice with confidence. Moreover, the study also contributed in the demonstration of the relative cultural universality of test anxiety in the French context, which is consistent with the previous literature (Frenzel et al., 2007; Pekrun & Goetz,?).

It is widely reported in a prior study (e.g., Hembree, 1988; Ringeisen et al., 2016) that girls report higher test anxiety. With notable exceptions (e.g., von der Embse et al., 2021), few studies have demonstrated that measurement properties of TA instruments are comparable for boys and girls. Findings of the present study add to the nascent body of work showing that gender differences in TA are underpinned by an equivalent latent structure. Studies investigating age differences in TA are rare (e.g., Putwain, von der Embse, et al., 2021) and none, to our knowledge, have demonstrated measurement invariance for age. Accordingly, findings of the present make a novel contribution to the literature by showing the MTAS to demonstrate measurement invariance for age. Wigfield and Eccles' (1989) assumption that TA would be higher in older students was partly supported. Previous studies, focusing on changes in students' emotion depending on their school year, reported the increase with age in negative emotional experience during secondary school years with its peak at adolescence (Martin-Krumm et al, 2017).

Higher TA scores in older participants were only demonstrated for cognitive interference. This may reflect the increasing cognitive demands of examinations for students in the latter stages of secondary education. The increase in cognitive interference with age can be problematic for academic performance as it is negatively correlated with exam scores. Older students take competitive exams on which their future depends. Educational programs to help students better manage this type of anxiety should therefore be advised, especially for important exams that are the most anxiety-provoking.

The MTAS can help to face the urgent concern to assess test anxiety in French students. It can further enable to study the interaction between self-concepts, well-being, performance

and TA in order to better understand how to reduce TA and to enhance performance and to increase motivation in students. It is notable that the decline in well-being, motivation, and school interest, in French students from 5th to 12th grade (Fenouillet et al., 2017), is the same period that TA is also increasing.

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Table 1

Correlations and Descriptive Statistics for the MTAS, STAI, Fear of Assessment and Test Scores

	W	CI	PI	T	*N*	*M*	*SD*	ω
Worry (W)					505	3.30	1.00	0.78
Cognitive Interference (CI)	.44***				505	2.74	1.01	0.80
Physiological Indicators (PI)	.40***	.33***			505	2.11	10.3	0.81
Tension (T)	.52***	.33***	.66***		505	2.97	1.10	0.84
STAI	.43***	.36***	.46***	.50***	469	2.23	0.67	0.77
Test Performance	-.18**	-.37***	-.04	-.17**	267	11.70	5.25	—
Fear of assessment	.44***	.32***	.41***	.42**	494	3.68	2.05	—

Note. * $p < .05$. ** $p < .01$. *** $p < .001$.

French Study of the Multidimensional Test Anxiety Scale (MTAS) in relation to performance, age and gender.

- Supporting Information -

This document contains materials designed to supplement the main text. The materials include the following:

- Table S1: Result of Exploratory Structural Equation Modeling, Omega and Descriptive Statistics
- Table S2: Tests of Measurement Invariance for Gender and Age
- Table S3: Descriptive statistics and Latent Means for Gender
- Table S4: Descriptive statistics and Latent Means for Age
- Table S5: MTAS items in French
- Measurement of TA
- Detail of measures
- Descriptive Statistics
- Psychometric Information
- Limitations of the study
- Conclusion
- Additional references

Table S1
Result of Exploratory Structural Equation Modeling, Omega and Descriptive Statistics

Items	Factors				Descriptive Statistics		
	1	2	3	4	*M*	*SD*	R^2
W1	**0.33**	0.25	0.09	0.21	2.80	1.29	.48
W2	**0.69**	0.00	0.08	0.03	2.91	1.27	.51
W3	**0.74**	0.08	0.06	0.03	2.67	1.28	.55
W4	**0.97**	0.12	0.04	0.04	2.81	1.40	.78
CI1	0.07	**0.82**	0.03	0.03	2.00	1.37	.62
CI2	0.02	**0.88**	0.03	0.00	2.61	1.40	.78
CI3	0.02	**0.66**	0.08	0.03	2.20	1.36	.52
CI4	0.13	**0.50**	0.03	0.06	1.90	1.23	.32
T1	0.00	0.01	**0.99**	0.13	3.36	1.36	.62
T2	0.03	0.05	**0.51**	0.28	3.16	1.32	.57
T3	0.08	0.04	**0.34**	0.37	2.64	1.34	.66
T4	0.03	0.04	**0.94**	0.10	2.90	1.37	.71
PI1	0.09	0.05	0.02	**0.71**	3.17	1.23	.81
PI2	0.02	0.00	0.03	**0.77**	3.49	1.35	.54
PI3	0.08	-0.02	0.23	**0.60**	3.30	1.28	.47
PI4	0.01	0.06	0.08	**0.75**	3.54	1.31	.77
ω	0.76	0.78	0.81	0.84			

Note. W= Worry; CI = Cognitive Interference; T = Tension; PI = Physiological indicators. Loadings on target factors emboldened.The ESEM showed a good fit to the data: $\chi^2(62) = 139.370$, $p < .001$, RMSEA = .050 [90% CIs .039 – .061], SRMR=.020, CFI=.988, and TLI=.978.

Table S2
Tests of Measurement Invariance for Gender and Age

	χ2 (df)	CFI	TLI	RMSEA	SRMR	ΔCFI	ΔTLI	ΔRMSEA	ΔSRMR
Gender									
Configural	457.485 (196)	0.916	0.897	0.074	0.064				
Metric	477.483 (208)	0.913	0.900	0.073	0.069	0.003	-0.003	0.001	-0.005
Scalar	486.950 (220)	0.914	0.906	0.071	0.067	0.001	-0.006	0.002	0.002
Strict	497.443(232)	0.915	0.912	0.068	0.066	-0.001	-0.006	0.003	0.001
Age									
Configural	450.549 (196)	0.921	0.904	0.073	0.061				
Metric	469.529 (208)	0.919	0.907	0.072	0.064	0.002	-0.003	0.001	-0.003
Scalar	495.685 (220)	0.915	0.907	0.072	0.066	0.004	0.000	0.000	-0.002
Strict	533.054 (232)	0.907	0.904	0.073	0.070	0.008	0.003	0.001	0.004

Note. Metric invariance was indicated by ΔCFI ≤ .01, ΔRMSEA ≤ .015 and ΔSRMR ≤ .03, and scalar invariance by ΔCFI ≤.01, ΔRMSEA ≤ .015 and ΔSRMR ≤ .01 (Chen, 2007; Cheung & Rensvold, 2002).

Table S3
Descriptive statistics and Latent Means for Gender

Factor	**Group**	***N***	***M***	***SD***	**Lat. *M***	***S.E.***	***p***
Worry	Female	237	3.57	0.94	0.38	0.08	<.001
	Male	259	3.06	1.00	0		
Cognitive Interference	Female	237	2.87	1.02	0.29	0.09	0.02
	Male	259	2.62	0.99	0		
Physiological Indicators	Female	237	2.35	1.14	0.49	0.10	<.001
	Male	259	1.89	0.87	0		
Tension	Female	237	3.21	1.08	0.41	0.10	<.001
	Male	259	2.77	1.08	0		

Table S4
Descriptive statistics and Latent Means for Age

Factor	**Group**	***N***	***M***	***SD***	**Lat. *M***	***S.E.***	***p***
Worry	11-13	268	3.35	1.05	0.12	0.10	0.23
	14-16	227	3.26	0.94	0		
Cognitive Interference	11-13	268	2.61	1.01	-0.28	0.10	0.01
	14-16	227	2.90	1.00	0		
Physiological Indicators	11-13	268	2.12	1.05	0.07	0.10	0.48
	14-16	227	2.09	1.02	0		
Tension	11-13	268	2.89	1.13	-0.15	0.10	0.15
	14-16	227	3.08	1.06	0		

Table S5
MTAS items in French

1. Avant une évaluation je me sens inquiet parce que je pense que je vais échouer (W1)
2. Avant une évaluation j'oublie ce que j'ai appris auparavant (CI1)
3. Même quand je suis préparé pour une évaluation je me sens anxieux de passer les épreuves (T1)
4. Mes mains tremblent avant le début d'un test/examen (PI1)
5. J'ai peur de donner une mauvaise réponse pendant une évaluation(W2)
6. Pendant une évaluation j'oublie ce que j'ai appris auparavant. (CI2)
7. Je me sens tendu avant de passer les épreuves (T2)
8. Mon cœur s'accélère pendant une évaluation (PI2)
9. Après des évaluations, je suis inquiet d'avoir échoué (W3)
10. Durant une évaluation, j'oublie ce que je connais vraiment (CI3)
11. Juste avant une évaluation je me sens paniqué (T3)
12. Pendant une évaluation j'ai l'estomac noué (PI3)
13. Après avoir passé une évaluation, je m'inquiète d'avoir mis des mauvaises réponses (W4)
14. Pendant une évaluation j'ai du mal à me concentrer (CI4)
15. Avant une évaluation je me sens anxieux (T4)
16. Mes mains tremblent lorsque je passe des évaluations (PI4)

W = Worry, CI = Cognitive Interference, T = Tension, and PI = Physiological Indicators.

Measurement of TA

Commonly used scales for measuring test anxiety have included the Worry-Emotionality Questionnaire (Liebert & Morris, 1967), the Test Anxiety Inventory (Spielberger, 1980), Revised Test Anxiety Scale (Benson et al., 1992), the Friedben Test Anxiety Scale (Friedman and Bendas-Jacob, 1997), and the Cognitive Test Anxiety Scale (Cassady & Johnson, 2002). These measures reveal a lack of a lack of consensus over the definition and dimensionality of test anxiety, and sometimes reply on anachronistic language and theory (Putwain, von der Embse, et al., 2021; von der Embse et al., 2021). The Multidimensional Test Anxiety Scale. (MTAS) was developed to address these concerns and showed strong internal consistency, factorial validity, test-retest reliability, and predictive validity (Putwain, von der Embse, et al., 2021; von der Embse et al., 2021). The MTAS is a 16-item scale corresponding to a four-correlated-factors model with two cognitive and two affective-physiological aspects of test anxiety. Previous studies of the MTAS have showed good psychometric properties:

strong internal consistency (ωs = .85 to .91), factorial validity (items loading on target factors λs = .46 to .92), and predictive validity where higher TA is related to elevated mental health risk (*r*s = .13 to .46), and lower examination performance (*r*s = .01 to .41), and well-being (*r*s = −.03 to −.33) (Putwain et al., 2021). Other studies using MTAS have also confirmed its good psychometric properties (von der Embrse et al, 2021) in terms of internal consistency (McDonald's ωs ≥ .83). Morever, MTAS scores were related to scores on an existing measure of test anxiety, Test Anxiety Inventory (TAI), Spielberger, (1980) in previous study (Putwain et al., 2021).

Detail of measures

MTAS items were translated into French following the transcultural validation procedure (Vallerand, 1989) and back translated to English to check the meaning of items remained accurate (Brislin, 1986). Participants responded to items on a 5-point scale (1 = *Not at all* to 5 = *Strongly agree*). Academic performance was taken from students' score on a mathematics exam taken in the final trimester of the school year. Self-reported gender and age were also collected. The project was explained to the direction and teaching stuff within the schools and was carried out in consultation with the principals and teachers involved. All participants filled out a consent form in which they were advised of the anonymity and confidentiality of the data for this study. Parental consent was also requested for all participants

Descriptive Statistics

Data distribution did not deviate significantly from normality; with skewness and kurtosis < ±1.5 (Kim, 2013). Table 1 showed McDonald's ωs > .75, indicating a good internal consistency for the MTAS dimensions and STAI scale.

Psychometric Information

The results of factor analysis showed that, even if item T3 did not initially load with the target factor, the remaining indicators confirmed a good structural quality of the MTAS scale.

In addition to structural validity, the concurrent and predictive validity were shown for trait anxiety and fear of assessment. The exam performance was found to significantly correlate negatively with dimensions 3 and 4 of the scale.

The results of this study in terms of performance are therefore in accordance with the original study (Putwain, von der Embse, et al., 2020) stating the strongest negative correlation between test anxiety and performance on cognitive interference component of test anxiety and the weakest for physiological indicators. This study confirms the relevance of considering the different components of test anxiety in relation to achievement.

Consistent with earlier studies of an English language version of the MTAS (Putwain et al., 2021; von der Embse et al., 2021), ESEM supported a four-factor structure.

Limitations of the study

However, the scope of this study is limited by the sample size. It would be necessary to replicate it with a larger sample. Furthermore, it uses a limited number of variables, and it would be necessary to better understand the links between evaluation anxiety and different forms of motivation but also de-motivation. Finally, trait anxiety has a relatively limited intra-person variance, so it would be important to study its variation over time.

Conclusion

The present study has demonstrated the French language MTAS to be suitable for use by researchers and practitioners and that comparisons for gender and age can be made with confidence that the scores represent the same constructs for different genders and ages. Follow-up studies are required to establish measurement invariance for other socio-demographic characteristics including gender and economic disadvantage in both English and French language versions of the MTAS. Nonetheless, the present study overcomes a significant obstruction for researchers and practitioners of French speaking populations, namely the

absence of a contemporary measure of TA that has been shown to measure valid and reliable data.

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