Can Attitudes Toward Statistics
and Statistics Anxiety Explain Students' Performance?

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Abstract

The aim of this study was to investigate the relationships between math background, trait anxiety, test anxiety, statistics anxiety, attitudes toward statistics and statistics performance in a sample of 472 university students enrolled in statistics courses of Health Sciences majors. A Structural Equation Modeling (SEM) approach showed the attitudes as the stronger direct predictor of performance, and played a full mediating role on the relationship between statistics anxiety and performance. Contrary to hypothesized, the direct contribution of math background, trait anxiety, and test anxiety to performance was non-significant. A final model posited that performance was positively and directly affected by attitudes, and in turn attitudes were positively influenced by math background and negatively affected by anxiety. Math background also appeared as negative predictor of anxiety. Finally, test anxiety was a positively direct predictor of statistics anxiety.

Keywords: Attitudes, anxiety, statistics performance, test anxiety, structural equation modeling.

Resumen

El estudio investiga las relaciones entre bagaje matemático, ansiedad rasgo, ansiedad ante los exámenes, ansiedad ante la estadística, actitudes hacia la estadística, y rendimiento, en una muestra de 472 estudiantes de asignaturas estadísticas de Ciencias de la Salud mediante modelos de ecuaciones estructurales. Las actitudes son el principal predictor del rendimiento y mediadoras entre ansiedad y rendimiento. Las relaciones entre bagaje matemático, ansiedad rasgo, y ansiedad ante los exámenes, sobre el rendimiento no fueron significativas, contra hipótesis. El modelo final postula que el rendimiento está afectado directa y positivamente por las actitudes, y éstas son influidas positivamente por el bagaje matemático, y negativamente por la ansiedad. El bagaje matemático es predictor negativo de la ansiedad y la ansiedad ante los exámenes es un predictor directo positivo de la ansiedad ante la estadística.

Palabras clave: Actitudes, ansiedad, rendimiento en estadística, ansiedad ante los exámenes, modelos de ecuaciones estructurales.

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Introduction

Many university students report performance problems when they are enrolled in statistics courses, especially belonging to health and social sciences. Those courses and especially their exams produce a high degree of anxiety in students and an inadequate academic performance (Baloglu, 2003; Benson, 1989; Carmona, 2004; Carmona, Martínez, & Sánchez, 2005; Chiesi & Primi, 2010; Gal, Ginsburg, & Schau, 1997; Macher, Paechter, Papousek, & Ruggeri, 2012; Musch & Bröder, 1999; Onwuegbuzie & Seaman, 1995; Tremblay, Gardner, & Heipel, 2000). Some students could consider these subjects a burden because they are not self-confident about their statistics competences (Chiesi & Primi, 2010). In this way, the worse consequence of this lack of self-confidence is that "many students believe that a statistics course is a major threat to the attainment of a degree, and low performance has become a problem in many educational institutions worldwide" (Vigil-Colet, Lorenzo, & Condon, 2008, p. 175). For this reason, it is essential to obtain empirical evidences about the main variables that explain students' statistics performance. Editorial paper of the special issue of the Statistics Education Research Journal (SERJ) (focused on attitudes toward statistics) (Schau, Millar, & Petocz, 2012) highlighted the need to build on theory and knowledge about attitudes toward

statistics, and encouraged researchers to use complex quantitative modelling methods. In this paper, a Structural Equation Model (SEM) approach is implemented to test a model including potential predictors of statistics performance.

One of these potential predictors is Statistics anxiety, "an anxiety which occurs as a result of encountering statistics in any form and at any level, and which appears to involve a complex array of emotional reactions which have the propensity to debilitate learning" (Onwuegbuzie & Daley, 1999, p. 1089). Test anxiety can be defined as a situation specific trait characterized by the predisposition to react with elevated anxiety in a contexts related to performance (Hodapp, Glanzmann, & Laux, 1995; Keith, Hodapp, Schermelleh-Engel, & Moosbrugger, 2003). So, statistics anxiety could be considered a more specific construct than test anxiety, and a better predictor of statistics performance than test anxiety or other general anxiety measures because direct relationship among these measures and statistics performance is non-significant (Finney & Schraw, 2003; Furnham & Chamorro-Premuzic, 2004; Hair & Hampson, 2006; Vigil-Colet et al., 2008). In turn, test anxiety measures are more related to general performance than other general anxiety measures, such as trait anxiety (Rindermann & Neubauer, 2001; Vigil et al., 2008). Consequently, the use of specific

measures as direct predictors of statistics performance is suggested.

Other potential predictor is Attitudes toward statistics (Budé et al., 2007; Chiesi et al., 2010; Lalonde & Gardner, 1993; Nasser, 2004; Onwuegbuzie, 2003; Ramírez, Schau, & Emmioğlu, 2012; Sorge & Schau, 2002; Tempelaar, van Der Loeff, & Gijselaers, 2007; Tremblay et al., 2000; Wisenbaker, Scott, & Nasser, 2000). Lalonde and Gardner (1993) tested a SEM model including measures of mathematical aptitude, statistics anxiety and attitudes, motivation to learn statistics, and effort, in predicting statistics performance. Aptitude was a direct positive predictor of performance and negative of statistics anxiety, which in turn appeared as predictor of both motivation and performance. The path from statistics anxiety to performance was non-significant. Tremblay et al. (2000) replicated Lalonde and Gardner's model (1993), and contrary to expected, a significant and negative relationship from statistics anxiety to performance, and a negative path from attitudes to anxiety were obtained. Data from prior statistics outcomes and math background were also suggested to be included as potential performance's predictor (Cassady & Johnson, 2002; Elosúa, López-Jáuregui, Bully, & Mujika, 2012; Sorge & Schau, 2002). Tempelaar et al. (2007) obtained that statistics performance was affected by attitudes but not by statistical reasoning with a SEM approach. More recently, Hood, Creed, and Neumann (2012) replicated Sorge and Schau's model (2002) and found past performance as the stronger predictor of performance, together with only two dimensions of attitudes (effort and expectancies), and that improving statistics foundational skills should increase both attitudes and performance.

Another relevant work is the Anxiety-Expectation Mediation (AEM) model (Onwuegbuzie, 2003) where both statistics anxiety and achievement's expectation were expected to mediating the relationship between cognitive, personality, and person characteristics, and performance. Statistics anxiety and achievement played a central role, mediating the relationship between performance and research anxiety, study habits, course load, and the number of statistics courses taken. One year later, Nasser (2004) obtained a high positive effect of mathematical aptitude and a lower, but significant, positive effect of attitudes on performance with a SEM approach. Anxiety was also found to be directly and negatively linked to attitudes and the path between anxiety and performance was non-significant, consistently with Lalonde and Gardner (1993), but in contrast with Onwuegbuzie's (2003) and Tremblay's et al. (2000) studies.

Chiesi and Primi (2010) proposed a SEM model where math-

ematical background affects both mathematical knowledge and attitudes toward statistics. These two variables influenced statistics anxiety, which in turn was directly related to attitudes and performance. A direct effect from mathematical knowledge to performance was also included. Potential changes in attitudes during the course due to the interaction with the contents and the requirements of the discipline, and whether this change was mediated by initial mathematical competence were considered. Results showed that both post-test attitudes and mathematical knowledge were directly and positively related to performance, but anxiety only indirectly affected performance through attitudes.

In summary, literature review reveals major differences about (a) variables and measurement instruments included in the models; (b) the complex interrelationships among the predictors of statistics performance; and (c) the predictors' magnitude. In this regard, Slootmaeckers (2012) pointed out that there is a small but growing body of studies showing a relation between attitudes toward statistics and statistics performance, and that there are scarce studies including also statistics anxiety, and their antecedents, in a single model. This is the main reason that substantiates the appropriateness of this study.

The structural model

The model hypothesized (model A) that math background and statistics anxiety are direct predictors of attitudes toward statistics, with a positive and negative relationship respectively expected. In turn, math background is directly and negatively related to statistics anxiety. Also trait anxiety and test anxiety are considered positive direct predictors for statistics anxiety. Finally, math background, attitudes, statistics anxiety, test anxiety and trait anxiety are hypothesized as direct predictors of performance, with a positive effect in the two first cases, and negative with the three anxiety-related variables (see Figure 1).

The model posited that a higher level of both numerical ability and mathematics self-concept should increase a positive attitude toward statistics. Conversely, lower level of numerical background could make students feel overwhelmed by the content of statistics courses. In turn, lower levels of trait anxiety and test anxiety should decrease statistics anxiety, and this chain of effects also should increase a positive attitude. So, a better statistics performance for students with better attitudes toward statistics and lower statistics anxiety is expected. Sociodemographical variables such us gender, age, income, or residence
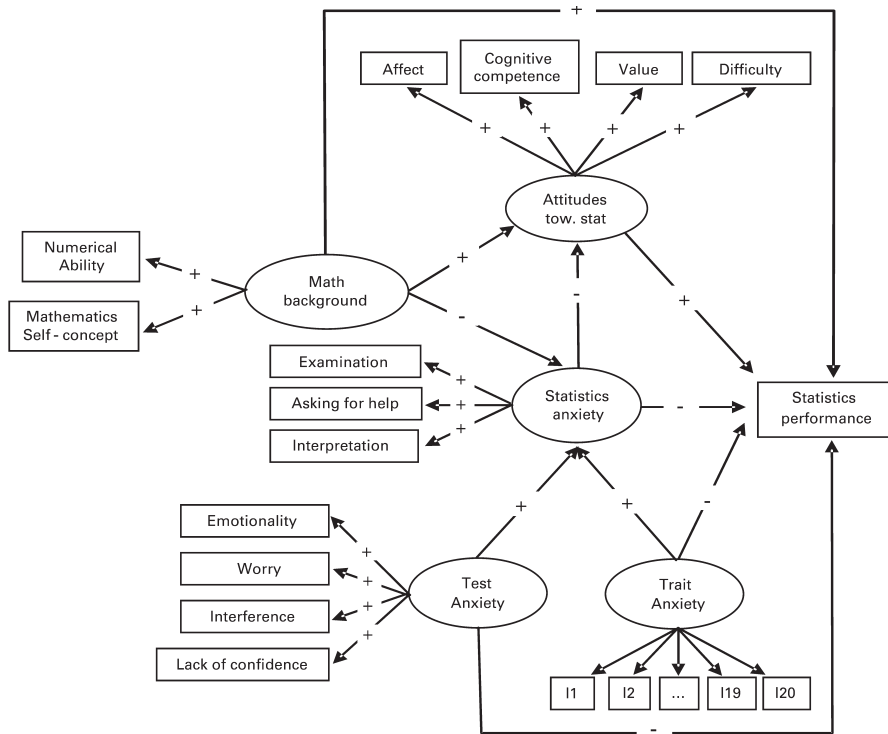
Figure 1. Initial model of statistics performance (Model A).

are not present in the model because its relationship with statistical performance were not significant at the exploratory stage of the study. The model makes attitudes toward statistics play an essential role as the stronger direct predictor of performance, even greater than statistics anxiety. The aim of the study was to fit the model and to discuss results according previous literature findings.

Method

Participants

The sample consisted of 472 university students (124 males,

348 females) from three different majors of the Health Sciences (psychology, nursing and physiotherapy) of the Balearic Islands University. All participants were enrolled in a common course whose core competencies were related to Statistics and only basic mathematical ability is needed. Age ranged from 17 to 54 years (M = 22.54; SD = 6.33), and the median of the distribution was 20 years (81.9% ranged from 17 to 25). Participation was completely voluntary and without any incentives, and the battery of tests was administered during a session of practical classes of the subject. All students attending the class agreed to participate in the study. Participants represent the 85.7% of the total number of enrolled students. These data on participation and representativeness minimize the potential effect of self-selection bias.

Measures

Numerical ability was measured with a subscale of the last version of DAT-5 (Bennett et al., 1990) and adapted to Spanish context by TEA Ediciones (2006). It contains 40 items with 5 multiple choice response and only one correct option, as for example: If $2x^2 + 6x = 2x^2 + 3x + 5$, then x is equal to (a) –2.5, (b) –5/4, (c) –1, (d) 0.6, or (e) Any of them is correct. The time limit for completing the test is 20 minutes. Reliability and validity evidences for this DAT5 subscale is generally limited to: (a) reliability studies (ranging from .80 to .90) (Psychological Corporation, 1991); (b) correlations with other psychometric instruments oriented to measure the same or similar constructs (ranging from .65 to .90) (Snow & Swanson, 1992), and (c) studies that obtained very good results about its role as a predictor of academic performance (Brown & Lent, 2012; Psychological Corporation, 1991). Reliability coefficient (test-retest procedure) for the Spanish adapted version was .81 (TEA Ediciones, 2006).

A single-item indicator for measuring the *mathematics self-concept* was included. The item content was operationalized as: "How do you score yourself on a scale from 0-10 on your academic background in mathematics throughout your life?" This item tries to measure the self-perceived students' mathematics competence. It is known in the literature that the use of single-item scales in empirical research should be approached with carefulness. The use of such measures should be limited to special circumstances (Diamantopoulos, Sarstedt, Fuchs, Wilczynski, & Kaiser, 2012).

Given that the main goal of this research is more to obtain empirical evidences about the main effects in a nomological net rather than to go deeply into the measurement models, it could be sufficient to consider a single global question that makes the respondents to "consider all aspects and individ-

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ual preferences of the certain aspects of the construct being measured" (Nagy, 2002, p. 79). Thus, respondents can assess with a single rating the more relevant aspects of their academic background in mathematics and ignore the non-relevant ones (De Boer et al., 2004). Bivariate relationships with the other constructs in the model showed behavior under hypothesis: positive with attitudes toward statistics factors' (ranging from .20 to .51), numerical ability (.35), and achievement (.39); and negative with test anxiety factors' (ranging from –.12 to –.25), and statistics anxiety factors' (ranging from –.16 to –.26).

Trait anxiety was measured with the Spanish adaptation of the State-Trait Anxiety Inventory (STAI) (Spielberger et al., 1988), composed by 20 items with a four-point Likert scale. Spanish adaptation obtained test-retest reliability for the anxiety-trait of .81, and Cronbach's alpha oscillated between .83 and .92. Alpha coefficient of this study was .89. Many studies support adequate STAI validity evidences (Kabacoff, Segal, Hersen, & Van Hasselt, 1997; Novy, Nelson, Goodwin, & Rowzee, 1993; Okun, Stein, Bauman, & Silver, 1996; Spielberger & Reheiser, 2004; Tilton, 2008).

Test anxiety. The German Test Anxiety Inventory (TAI-G) (Hodapp, 1991) is an adaptation of the Test Anxiety Inventory (TAI) (Spielberger, 1980). This study used the Spanish adaptation of the TAI-G (Sesé et al., 2010) with 30

items with a four-point scale and a four-factor structure: *emotionality* (8 items), *worry* (10 items), *interference* (6 items), and *lack of confidence* (6 items), with reliability coefficients of 0.87, 0.86, 0.81 and 0.86, respectively. Evidences of criterion validity for the four factors regarding other variables like statistics anxiety (.58), trait anxiety (ranging from .31 to .36), emotional intelligence (ranging from –.24 to –.37), and achievement (ranging from –.22 to –.33) were also obtained. Adequate construct validity evidences were obtained by Keith et al. (2003) using a cross-sectional and longitudinal confirmatory factor models approach.

Statistics anxiety. The Statistical Anxiety Scale (SAS) (Vigil-Colet et al., 2008) is a self-reported measurement of 24 items with a five-point rating scale. The SAS has a three-factor latent structure: *examination anxiety* (8 items, e.g., "Studying for examination in a statistics course"), *asking for help anxiety* (8 items, e.g., "Asking the teacher how to use a probability table"), and *interpretation anxiety* (8 items, e.g., "Trying to understand a mathematical demonstration"). Vigil-Colet's et al. (2008) study showed reliability values of .87, .92 and .82 for the three factors, respectively, and in turn, the present study obtained reliability coefficients of .91, .93 and .84. Adequate properties of reliability and validity for the SAS have been recently tested (Chiesi, Primi, & Car-

mona, 2011; Oliver, Sancho, Galiana, & Cebriá, 2014).

Attitudes towards statistics are measured with the Survey of Attitudes Toward Statistics (SATS-28) (Schau et al., 1995), with 28 seven-point Likert-type items and four scales: *Affect* (six items, e.g., "I like statistics"), that measures positive and negative feeling concerning statistics; *cognitive competence* (six items, e.g., "I can learn statistics"), that measures attitudes about intellectual knowledge and skills when applied to statistics; *value* (nine items, e.g., "Statistics is not important in my life"), that measures attitudes about the usefulness, relevance, and worth of statistics in personal and professional life; and *difficulty* (seven items, e.g., "To learn statistics requires a lot of discipline"), that measures attitudes about the difficulty of statistics as a subject, the perception of the task demand. Reliability coefficients obtained in several studies ranged from .80 to .89 for *affect*, .77 to .88 for *cognitive competence*, .74 to .90 for *value*, and from .64 to .81 for *difficulty*. Ramirez, Emmioğlu and Schau (2010) encouraged researchers to use the SATS-28 due to its good psychometric properties and its congruence with the Expectancy-Value Model (Eccles et al., 1983). Recently, Nolan, Beran, and Hecker (2012) found that SATS-28 was the only instrument focused on attitudes toward statistics with an adequate psychometric behavior regarding all subtypes of external validity (convergent, discriminant, and predictive) after a meta-analytic review. This study used the Spanish adaptation of SATS-28 (Carmona & Moreno, 1999). Reliability coefficients obtained in this study were .88 for *affect*, .90 for *cognitive competence*, .92 for *value*, and .85 for *difficulty*.

Academic performance was assessed with a score the students achieved on the first statistics exam conducted at the midpoint of the course. The exam consisted of a number of theoretical questions and a number of numerical exercises. Multiple-choice responses scale with four alternatives an only one correct answer for each question was implemented. Error correction formula for guessing was applied only to theoretical questions. The Spanish University grading scale (0-10 points) was used and the students' grades were obtained from official transcripts. Access to qualifications was allowed by the students when they agreed to participate in the study, according with the Spanish Data Protection Act.

Procedure

All students enrolled in an introductory statistics course common for psychology, nursing and physiotherapy grades were asked to participate voluntarily in the study. The statistics course is introductory and therefore it does not require prior statistical training. Questionnaires were administered during

a unique session corresponding with a scheduled practical class of the subject. Time needed to complete them ranged from 60 to 75 minutes, including the standard time of up to 20 minutes for completing the numerical ability subscale. The physical development of the survey followed the principles of cognitive ergonomics to reduce perceptual difficulties and fatigue of the participants. Survey administration was scheduled three weeks before the first exam of the course at the semester's midpoint to avoid that anxiety measures were greatly increased and would generate a ceiling effect and to minimize attrition. Confidentiality was ensured and all the requirements established by the bioethical commission for studies with human beings at the University of the Balearic Islands were complied.

Statistical analysis

Preliminary descriptive statistics determined reliability coefficients, descriptive statistics, and correlations between observed variables. A set of confirmatory factor analysis to test the fit of the measurement model was undertaken. Then, multivariate normality tests to assess the underlying statistical assumptions of SEM estimation methods were performed with PRELIS 2 program. Although the data did not manage to fulfill the assumption of multivariate normality, a small degree of deviation (skewness and kurto-

sis z values below |1.00|) did not invalidate the use of the maximum likelihood method with LISREL 8.80 software (Jöreskog & Sörbom, 2006). Covariance errors between items were not implemented for the estimated model.

To assess overall fit of the model, χ^2, the relative/normed χ^2 to degrees of freedom (*df*) ratio, the Root Mean Square Error of Approximation (RMSEA) and its 90% Confidence Interval (with a *p*-value related to RMSEA < .05), the Standardized Root Mean Squared Residual (SRMR), the Comparative Fit Index (CFI) and the Goodness of Fit Index (GFI) were the used indices. A model can be considered to fit the data if χ^2 is non-significant, χ^2/df < 3, RMSEA < .05, SRMR < .08, and CFI and GFI ≥ .95 (Hu & Bentler, 1999; Schreiber, Stage, King, Nora, & Barlow, 2006). Finally, to test single parameters, the 5% significance criterion was adopted (i.e., *t*-value of parameters of 2.00).

Results

Preliminary analyses

In the preliminary descriptive statistics for each item included in the structural equation model, skewness ranged from –.69 to 0.81 and kurtosis from –.89 to 1.04. In addition, relative multivariate kurtosis value of 1.05 indicating no serious deviations from multivari-

Table 1

Descriptive Statistics, and Bivariate Correlations Between the Variables Included in the Structural Model

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Numerical ability	–														
2. Math self-concept	.35**	–													
3. Affect	.28**	.51**	–												
4. Cognitive competence	.30**	.55**	.75**	–											
5. Value	.19**	.16**	.37**	.40**	–										
6. Difficulty	.17**	.27**	.48**	.56**	.18**	–									
7. Examination anxiety	–.20**	–.26**	–.47**	–.43**	–.09*	–.35**	–								
8. Asking for help anxiety	–.02	–.15**	–.35**	–.32**	–.07	–.20**	.45**	–							
9. Interpretation anxiety	–.18**	–.25**	–.44**	–.45**	–.12*	–.31**	.54**	.61**	–						
10. Trait anxiety	–.06	–.05	–.21**	–.24**	–.05	–.14**	.37**	.38**	.37**	–					
11. Worry	–.08	–.03	–.18**	–.15**	–.03	–.16**	.54**	.28**	.32**	.42**	–				
12. Emotionality	–.08	–.08	–.28**	–.25**	–.04	–.17**	.59**	.34**	.36**	.50**	.61**	–			
13. Interference	–.12**	–.24**	–.36**	–.41**	–.15**	–.25**	.44**	.31**	.42**	.50**	.45**	.49**	–		
14. Lack of confidence	–.01	–.25**	–.28**	–.01	.10*	.05	.40**	.38**	.37**	.54**	.31**	.48**	.42**	–	
15. Statistics performance	.26**	.39**	.48**	.45**	.20**	.27**	–.27**	–.20**	–.23**	–.02	–.06	–.06	–.28**	–.08	–
Variable rank	0-40	0-10	0-24	0-24	0-36	0-28	8-40	8-40	8-40	0-60	10-40	8-32	6-24	6-24	0-10
Mean	15.86	6.26	8.18	11.65	15.02	15.28	30.93	16.86	16.56	27.80	29.65	18.85	12.01	13.75	6.35
SD	6.30	1.48	2.75	2.32	2.96	2.53	6.77	7.24	6.10	4.75	5.96	6.40	4.17	7.56	2.67

** *p* < .01.   * *p* < .05.

ate normality. Moreover, univariate and multiscatter plots and further visual inspection of data did reveal neither univariate or multivariate outliers nor missing values, and consequently, both deletion and imputation of data were not necessary. Descriptive statistics and a correlation matrix between observed variables of the model are shown in Table 1.

Structural model

The instruments' measurement model was tested prior to fit the structural model. It is important to ensure that there are not parts of the model with a poor functioning that could affect the overall fit of the structural model. Confirmatory Factor Analysis (CFA) was implemented to contrast the good fit of the latent variables: *Math background*, *Trait Anxiety*, *Test Anxiety*, *Statistics Anxiety*, and *Attitude toward Statistics*. No special problems with multivariate normality appeared previous to the models estimation. CFA results were adequate for the five measures according with its latent factor model, and all standardized factor loadings were statistically significant and in any case greater than .50. Psychometric behavior of the single-item indicator measuring Mathematics self-concept was also adequate. According with these results for the measurement model, no relevant problems were encountered to estimate the fit of the structural model.

Structural model results were reported according to recommendations of Schreiber et al. (2006). The initial model (Model A) showed inadequate fit to the data. The chi-square index was statistically significant (χ^2 = 2366.27, *df* = 518, *p* < .0001), χ^2/df was greater than 3 (4.57), RMSEA was clearly greater than .05 (RMSEA = .09) with a *p* (RMSEA < .05) < .0001, and both CFI (.93) and GFI (.77) below the .95 cutoff value for good fit. AIC obtained a value of 2520.67. Only SRMR obtained an acceptable value of .07. Coefficients path from math background, test anxiety, trait anxiety and statistics anxiety to performance, and the path from trait anxiety to statistics anxiety were non-significant. Consequently, trait anxiety was removed along with all non-significant coefficients paths. This reduced model (Model B) was then estimated (see Figure 2).

Results for Model B yielded an overall adequate fit to data (χ^2 = 168.41, *df* = 66, *p* < .0001), χ^2/df was lower than 3 (2.55), RMSEA stood at the cutoff for good fit (RMSEA = .05) with a *p* (RMSEA < .05) = .12 (CI 90% RMSEA: .05; .07), both CFI (.98) and GFI (.95) were also indicative of good fit as SRMR (.04). The AIC for this model was 246.41. Model comparison was statistically significant ($\Delta\chi^2$ = 2197.86, *df* = 452, *p* < .0001) and the best fitted model (model B) was selected. Estimated power using RMSEA was .99 (Preacher & Coffman,
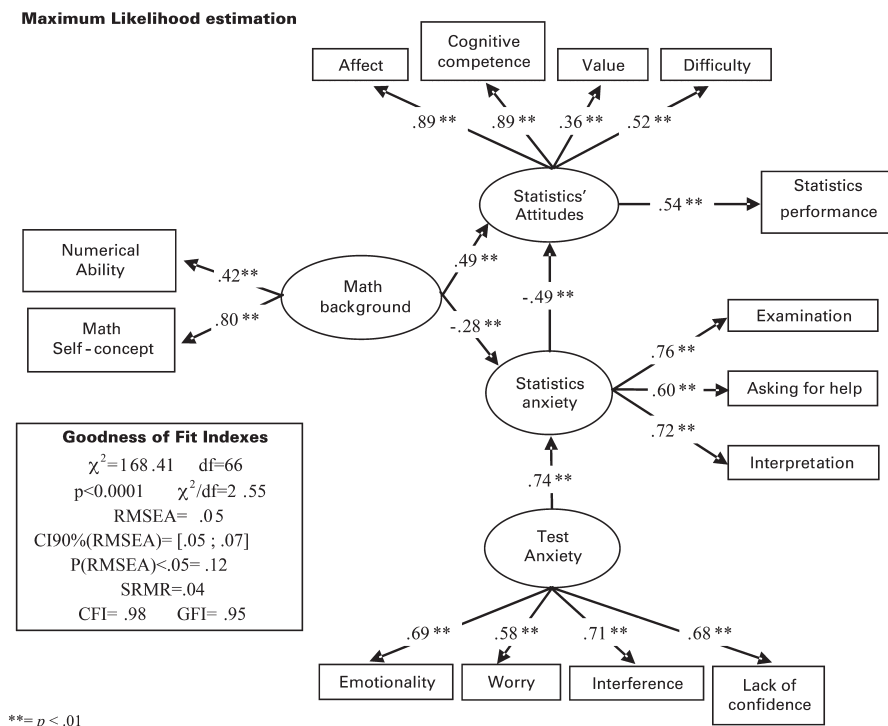
Maximum Likelihood estimation

Figure 2. Best fitted model (Model B) on statistics performance, standardized path coefficients, and goodness of fit indices.

2006). All path coefficients were statistically significant ($p < .01$). As expected, math background had a positive direct effect on attitudes (.49) and negative on statistics anxiety (−.28). A very strong positive relationship was found between test anxiety and statistics anxiety (.74), which was also related to attitudes (−.49). Finally, attitudes were directly and positively related to statistics performance (.54). Moreover, math background, test anxiety and statistics anxiety had indirect effects on performance (.34, −.19 and −.26, respectively). Correlations between exogenous variables, numerical background and test anxiety, was −.33 ($p < .01$). Model B explained 28.89% of the variance of statistics performance, the 75.36% of statistics anxiety, and the 72.08% of attitudes toward statistics.

Discussion

The aim of the present study was to test a SEM model including math background, trait anxiety, test anxiety, statistics anxiety and attitudes toward statistics as potential predictors for statistics performance. Math background, a latent variable composed by a measure of numerical ability and a self-perceived measure about mathematical self-competence, had a positive direct effect on attitudes toward statistics and a negative direct effect on statistics anxiety, consistent with previous research (Chiesi & Primi, 2010; Hood et al., 2012; Lalonde & Gardner, 1993; Nasser, 2004; Sorge et al., 2002; Tempelaar et al., 2007). However, math background only had an indirect effect to performance through attitudes. Furthermore, test anxiety had a strong positive direct effect on statistics anxiety, very consistent with literature findings that considered statistics anxiety as a more specific form of test anxiety (Stöber & Pekrun, 2004). But the effect from trait anxiety to statistics anxiety was non-significant, according to Rindermann and Neubauer (2001), and especially by Vigil et al. (2008). Moreover, both trait anxiety and test anxiety had no direct effect on statistics performance, according with previous studies (Finney & Schraw, 2003; Furnham & Chamorro-Premuzic, 2004; Hair & Hampson, 2006; Macher et al., 2012; Onwuegbuzie & Daley,

1999; Onwuegbuzie et al., 1995; Vigil et al., 2008).

Direct relationship between statistics anxiety and performance was statistically non-significant, as it was obtained by several studies (Budé et al., 1997; Chiesi & Primi, 2010; Lalonde & Gardner, 1993; Nasser, 2004; Tempelaar et al., 2007), but in contrast to Onwuegbuzie (2003) and Tremblay et al. (2000). However, statistics anxiety appeared as a direct predictor of attitudes, which in turn had a direct effect on performance. Results add empirical evidence about the existence of an indirect effect of anxiety on performance through attitudes. The more important role of attitudes toward statistics as a statistics performance predictor has been recently established (Chiesi, & Primi, 2010; Nasser, 2004; Ramírez et al., 2012).

In conclusion, empirical evidences show that the only direct effect on statistics performance came from attitudes, which in turn received direct effects from math background and statistics anxiety, and indirect effects from test anxiety throughout statistics anxiety. Thus, students with a better statistics performance should be those with more positive attitudes toward statistics, which in turn could be increased by higher levels of math background and by lower levels of test anxiety and statistics anxiety.

Some implications for developing intervention programs could

be derived from these findings. In line with Chiesi and Primi (2010) and Hood et al. (2012) suggestions, math background and attitudes toward statistics could be considered as main targets for improving performance. It is also important to provide students with the resources to cope with test anxiety according to the strong direct effect on statistics anxiety. To implement specific leveling courses about basic mathematical skills for students with lower numerical abilities, previous to the start of the official statistics courses would be useful. In parallel, but not directly derived from the model implications, it could be necessary to make students recognize statistics applicability, not so much to carry out research (also), but to be able to understand the scientific knowledge and its progress. In this sense, the coordination of the educational systems should enable the mainstreaming of statistical contents in non-statistics subjects so as to facilitate students to use statistics applied to a wide range of areas of their future professional activity (Slootmaeckers, 2012). In this way, students may increase the probability "to complete their courses able to engage in statistical thinking" (Ramírez et al., 2012, p. 65). If these two actions were complemented with reducing test anxiety, and consequently, statistics anxiety, statistics performance improvement could be an attainable goal, as a strong hypothesis of the fitted model.

Although the model has obtained adequate fit results, the main limitation of this study was not considering changes that attitudes toward statistics may suffer during the course. A major challenge is to generate longitudinal models that could be sensitive to both intra-course changes and the temporal stability of statistics learned skills. A cohort design could replicate the findings of this study, but from a dynamic and more complex theoretical perspective. A longitudinal design would allow obtaining evidence about the directionality of effects and ensure the arguments for developing and implementing psychodidactic intervention programs. Another limitation is referred to the sample characteristics and its generalizability power. Finally, the use of single-item indicators like the proposed by Benson (1989) or by Bandalos, Yates and Thorndike-Crist's (1995) could be implemented for future research.

Although these limitations, results of this study have shown a significant association pattern between test anxiety, statistics anxiety, attitudes toward statistics and math background in relation to statistics performance. The evidences reinforce the view of Ramírez et al. (2012):

People forget what they do not use. But attitudes "stick." Positive attitudes keep us using what we have learned. They also encourage us to seek opportunities to learn more. It is for these reasons that

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students' attitudes are the most important and influential outcome

from introductory statistics courses (p. 67).

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