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The effects of attitude towards Statistics and Math knowledge on Statistical anxiety: A path model approach

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1. Introduction

Academic well-being is an important task to achieve at all educational stages. Specifically, the well-being of university students and their academic performances are negatively affected by stress and anxiety. The discomfort that some students feel in regard to Math or Statistics has a great impact on them. In literature this is referred to as statistical anxiety (SA). SA can be defined as *"the feeling of anxiety encountered when attending a statistics course or doing statistical analyses"* (Cruise, Cash & Bolton, 1985, p.92). In particular, since Statistics has been introduced in many university curriculum programs, including many humanities courses, such as psychology, political sciences or sociology, in recent years statistical anxiety has been widely studied. Students who attend non-mathematics programs consider Statistics as a burd (Sesé, Jiménez, Montaño & Palmer, 2015) and exhibit higher SA levels. They are made weary by anything related to mathematics and believe that Statistics is not important for their degree programs and careers. SA negatively affects students' statistics examinations: higher levels of SA lead them to lower performance (Galli, Chiesi & Primi). Due to SA great impact on students' academic well-being and performance, several studies have focused on this topic and classified SA antecedents into situational factors (e.g. math skills, previous statistical experience), dispositional factors (e.g. attitude toward statistics, self-concept and self-efficacy) and demographic factors (e.g. gender, age). In a study with undergraduate psychology students Chiesi and Primi (2010) examined the students' grade of achievement in a preliminary statistics course taking into account cognitive factors (e.g. math background) as well as non-cognitive factors (e.g. attitude towards statistics measured before and after the introductory course) and SA. They showed that SA directly depends on math knowledge and pre-course attitude, which, in turn, influence post-course attitude along with SA. Finally, students' grade of achievement was explained by post-course attitude and math knowledge. Sesé et al. (2015) confirmed the influence of the math background on SA and attitude towards Statistics. On the other hand, the math background only had an indirect effect on students' performance, through attitude. Moreover, several authors showed that gender was one of the most important demographic variables: some studies have highlighted that females experienced higher level of SA than males (see among the others Baloğlu, Deniz & Kesici, 2011). However, other authors did not report any significant differences between genders (e.g. see Baloğlu, 2003). To measure the construct of SA, the Statistical Anxiety Rating Scale (STARS) was used. This psychometric instrument is one of the most common and widely used tool to assess SA (Cruise et al., 1985).

Data collected in the context of the ALEAS (Adaptive LEArning in Statistics; https://aleas-project.eu/wordpress/) ERASMUS+ project were used in this work to explore the antecedents of SA in undergraduate students enrolled in the psychology course at Federico II University of Naples. In addition to the variables discussed above, in this study we also considered as antecedents of SA the high school final mark and the past experience with Statistics.

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In particular, we tested the following hypotheses:

Hypothesis 1. Gender, high school final mark, math comprehension and math background affect both the attitude towards Statistics and the levels of statistical anxiety;

Hypothesis 2. Past experience with Statistics and attitude towards Statistics predict statistical anxiety.

2. Material and methods

Participants and procedure

The participants were N = 100 undergraduate students, enrolled in the psychology course at Federico II of Naples and thus involved in an introductory statistics course. Sample's age ranged from 18 to 27 (mean = 19.53, sd = 1.4). The students involved were predominantly female (81%) and came from different types of high schools (24% scientific studies, 38% humanistic studies, 38% others). High school final mark's median was 86 over 100. At the beginning of the course researchers administered the questionnaire in the classroom and answers were collected in a paper-and-pencil form.

Questionnaire

The questionnaire was structured in three sections. The first included questions about demographic variables, type of degree, high school final mark, math comprehension, and past experience with Statistics. Math comprehension was evaluated using the single 5-point (1 = 'Strongly disagree' to 5 = 'Strongly agree') Likert-type item '*During math lessons I can understand even the most difficult concepts*', whereas past experience with Statistics was measured asking students if they were ever enrolled in a statistical course before (dichotomous item). In the second section attitude towards Statistics and SA were assessed using the STARS (Cruise et al., 1985). Students answered on a 5-point Likert scale ranging from 1 = 'Strongly disagree' to 5 = 'Strongly agree' (for attitude) and from 1 = 'No anxiety' to 5 = 'Very high anxiety' (for anxiety). Both subscales scored Cronbach's alpha = 0.92. The last section, aimed at evaluating the students' math background, included twenty multiple choice questions; 7 of these, concerning operations and set theories, were selected from the scale for Mathematical Prerequisites for Psychometrics (Galli et al., 2008); the others, about relations and fractions, were selected from university entrance exams. Cronbach's alpha was 0.61.

Statistical analysis

Statistical analyses were performed using the R statistical software. Since Cronbach's alpha ensured the internal consistency reliability of the measures, each variable was defined as the score sum of the corresponding item set. Math background scores were computed using 2PL IRT model (Bartolucci, Bacci & Gnaldi, 2015). To test our hypotheses path analysis based on maximum likelihood estimation (Duncan, 1966) was carried out using the `lavaan` package. Goodness-of-fit was evaluated using the following fit indices: the Chi-square (χ^2), the Comparative Fit Index (CFI), the Tucker-Lewis Index (TLI), the Root Mean Square Error of Approximation (RMSEA), and the Standardized Root Mean Square Residual (SRMR) [1].

[1] Good model fit was defined by the following criteria: RMSEA values of about 0.08 or below, SRMR values less than about 0.08, CFI values of about 0.95 or above, and TLI values above about 0.90.

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3. Results and discussion

Participants showed, in general, medium-low levels of SA, which are mainly related to subscale ”Test and Class”, and little negative attitude towards Statistics, as shown in Table 1. It is worth noting that since the STARS is not a diagnostic scale there is no threshold value to discriminate pathologically high levels of anxiety. About math comprehension, only 14 out of 100 stated that they can understand even the most difficult concepts during Math lessons. Finally, most participants (85%) claimed that they had never studied Statistics before.

STARS	No. of item	Range	Q1-Q3	M (SD)	M/No. of item
Anxiety					
Interpretation	11	11-55	20-30	25(7.9)	2.27
Test and Class	8	8-40	24-32	27.4(6.3)	3.42
Fear of Asking for Help	4	4-20	7-10	8.6(2.9)	2.15
Attitude					
Worth of Statistics	16	16-80	36-45	40.7(10.23)	2.54
Computation Self-Concept	7	7-35	17-23	20.55(5)	2.94
Fear of Statistics Teachers	5	5-25	10-15	12.84(3.6)	2.57

Table 1: Quartiles, Means and Standard Deviations of STARS subscale scores.

Our hypothesized model is shown in Figure 1 including standardized regression coefficients. All fit indices pointed to a good fit of the model: χ^2 = 1.083 ($p = 0.3$), CFI = 0.999, TLI = 0.986, RMSEA = 0.029, SRMR = 0.017. As it can be seen in Figure 1, results show that math background not affect attitude towards Statistics nor statistical anxiety. Math comprehension has a negative impact on both attitude towards Statistics ($\beta = -0.45$, $p < 0.01$) and SA ($\beta = -0.34$, $p < 0.01$), whereas high school final mark variable only affects SA ($\beta = 0.20$, $p < 0.05$). Contrary to our hypotheses, past experience with Statistics and gender have no significant effect on SA.

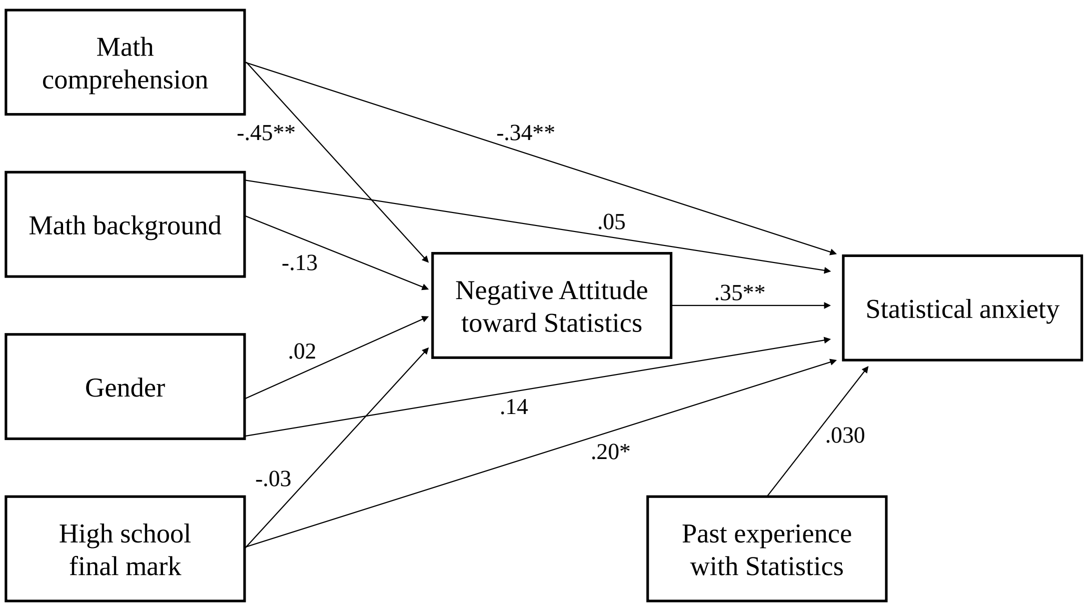

Figure 1: Path analysis diagram with standardized regression coefficients. $*p < 0.05$; $**p < 0.01$.

Our results confirmed evidences from the literature. Believing that Statistics is useless, not feeling comfortable with studying it and not being sure of one's mathematical knowledge are all factors that increase the SA. Negative attitude towards Statistics was the most influential antecedent of SA, followed by math comprehension. The results with regard to gender and math background did not confirm our hypotheses: females did not experience higher levels of statistical anxiety than males, and lack of math background did not affect attitude towards Statistics nor SA. Moreover, what is interesting is the effect of the high school final mark on SA regardless of the type of high school attended: in fact, SA increases according to the high school final mark. We believe that clever students have generally higher levels of anxiety, regardless of the subject taken into consideration, and this may be related to their own perfomance expectation. This relationship should be further studied with a larger sample to obtain more robust estimates. We believe, however, that the number of subjects participating in the project will get higher, which will increase the size of the collective, thus increasing the efficiency of our estimates. Finally, the relevance of the effect of SA on academic performance and well-being led researchers to explore the efficacy of different teaching techniques on reduction of students' SA. Among these, there are the use of real-life data, active learning activities, and humorous cartoons (Lesser & Pearl, 2008). Also ALEAS ERASMUS+ project takes part in this scenario. In fact, the aim of the project is to provide students with a technological platform for self-guided learning of statistics, in order to offer personalised learning paths so as to influence their SA in a positive way.

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