Can attitudes towards statistics mediate the relationship between math anxiety and statistics anxiety? A multiple mediation model with Italian university students

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Literature underlines the need to more deeply investigate the relationship between mathematics anxiety (MA) and statistics anxiety (SA), especially in terms of possible mediation/moderation analyses. In this study, conducted with 221 Psychology students (70% females; mean age = 20.99; SD = 4.56), we examined the extent to which high levels of MA make students more likely to have higher levels of SA through attitudes towards statistics, intended as a multidimensional concept. To test the hypothesis, we developed a model with multiple parallel mediators where MA was the independent variable; Affect towards statistics and perceived statistics Difficulty were the mediators; and SA was the dependent variable. Results revealed a significant positive indirect effect of MA on SA through Affect and Difficulty. More specifically, greater MA appears to be negatively related to Affect and Difficulty, which in turn are negatively related to SA.

Keywords: Math anxiety, attitudes towards statistics, statistics anxiety, indirect effect.

Introduction

An increasing number of degree programs are making statistics courses mandatory for university students. However, students in nonmathematical disciplines (e.g. psychology) find statistics course as a negative experience and frequently experience feelings of apprehension and personal threat, which affects performance negatively (Tremblay et al., 2000). Some researchers have described statistics anxiety (SA) as arising from an individual's exposure to content, problems, instructional situations, or evaluative contexts with respect to statistics (Macher et al., 2015; Malik, 2015). It corresponds to feelings of extensive worry, intrusive thoughts, mental disorganization, tension, and physiological arousal. A consistent negative relationship has been found between SA and statistics achievement finding that students who experience higher levels of SA tend to have lower performance on a statistics examination (Hanna & Dempster, 2009; Onwuegbuzie, 2003; Tremblay et al., 2000).

Math anxiety (MA), defined as an adverse emotional reaction to math or the prospect of doing math and a state of nervousness and discomfort brought upon by the presentation of mathematical problems (Ashcraft & Moore, 2009), has been investigated as one of the antecedents of SA (Baloglu, 2004).

Although many researchers found a significant positive relationship between SA and MA, the relationship was moderate, and MA, at a maximum, explained less than 50% of the variance in SA (Baloglu, 2001). Taken together, these results suggested that SA is related to, but distinct, from MA. Among the dispositional antecedents of SA, attitudes towards statistics have been also investigated. Negative attitudes towards statistics are relate to higher level of SA (Chiesi & Primi, 2010; Kesici et al., 2011). Recent findings support that positive attitudes towards statistics could alleviate the adverse

effects of SA on students' academic performance (Najmi et al., 2018). González and colleagues (2016) found that students who showed confidence in their competence for statistics learning and believe statistics courses and content are valuable, experienced less anxiety during class sessions.

Currently, research on SA has been hampered by the lack of distinction between SA and related variables, such as MA and attitudes towards statistics (Chew & Dillow, 2014). Consequently, it remains unclear whether different dimensions of the antecedents would collaborate, and whether interactive effects on the formation of SA would be formed because of such collaboration. In sum, it is necessary to investigate deeply if any kind of mediator or moderating variable lies between MA and SA.

In this study we examined the extent to which high levels of MA make students more likely to have higher levels of SA through attitudes towards statistics. We hypothesized that students who suffer from MA would develop negative attitudes towards statistics, as they saw it very similar to mathematics as experienced at the high school. Consequently, they are more likely to also develop anxiety with respect to statistics. To test this hypothesis, first we investigated the relationships between the multidimensional concept of attitudes towards statistics with MA and SA. As a subsequent step, we developed a mediation model in which MA was considered the independent variable, the facets of statistics attitudes as the mediators, and SA was the dependent variable.

Method

Participants

Participants were 221 Psychology students (70% females; mean age = 20.99; *SD* = 4.56) attending the University of Florence in Italy, who enrolled in an undergraduate introductory statistics course, that is compulsory at the Schools of Psychology. The high proportion of females reflect the gender distribution of Psychology students. Participants were first year students who did not have previous experience with the discipline at the university level. Fifty percent of students came from a scientific or technical and professional high school, whereas the remaining students attended non-scientific high school. Italian indications generally report that, overall, students attending lyceums and technical schools should be able to identify and summarize descriptive statistics and to understand the concept of sampling. No particular statistics contents are specified in the math curriculum of vocational institutes. However, a considerable amount of variability exists across the Italian high schools in the kind of topics addressed in the various disciplines.

Measures and Procedure

Participants completed the measures individually in an online self-administered format when they were in the class during the first week of the introductory statistics course. All students participated on a voluntary basis after they were given information about the general aim of the study. First, socio-demographic information (gender, age, and high school degree) was requested. All participants completed the following scales in a random order.

The *Abbreviated Math Anxiety Scale* (AMAS; Hopko et al., 2003; Italian version: Primi et al., 2014) measures MA experienced by students in learning and test situations. Participants were required to

respond based on how anxious they would feel during given events (for example, "*Listening to another student explain a math formula*") by using a 5-point response scale (ranging from *strongly agree* to *strongly disagree*). High scores on the scale indicate high MA. A single composite score was obtained, based on participants' ratings of each statement. In the present sample, McDonald's ω was .891 (95% CI [.878, 904]).

The *Statistical Anxiety Scale* (SAS; Vigil-Colet et al., 2008; Italian version: Chiesi et al., 2011) is a self-reported measure consisting of 24 items with a five-point rating scale. The SAS has a three-factor 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*"). High scores on the scale indicate high SA. A single composite score was obtained, based on participants' ratings of each statement. McDonald's ω was .934 (95% CI [.930, .945]).

The *Survey of Attitudes Towards Statistics* (SATS; Schau et al., 1995) is a Likert-type instrument with seven response possibilities for each statement ranging from *strongly disagree* to *strongly agree*. The first version of the SATS consisted of four subscales: (a) Affect (six items): positive and negative feelings concerning statistics (e.g., "*I will like statistics*"); (b) Cognitive Competence (six items): attitudes about intellectual knowledge and skills applied to statistics (e.g., "*I can learn statistics*"); (c) Difficulty (seven items): attitudes about the difficulty of statistics as a subject (e.g., "*Statistics formulas are easy to understand*"); and (d) Value (nine items): attitudes about the usefulness, relevance, and worth of statistics in personal and professional life (e.g., "*Statistics should be a required part of my professional training*"). Afterwards (Schau, 2003), two subscales were added to the instrument: Interest (four items), students'individual interest in statistics (e.g., "*I am interested in using statistics*"); and Effort (four items), the amount of effort students spend on learning statistics (e.g., "*I plan to work hard in my statistics course*"). We administered the SATS-36-pre version as we conducted the survey during the first weeks of the course. We used the Italian version of the SATS (Chiesi & Primi, 2009), and we translated the added items of the Interest and Effort dimension through a back-translation method. A translation from English into Italian was first conducted and this version was back-translated into English by an English mother tongue teacher. The two English forms (the original one and the back-translated one) were compared to verify the similarity of the Italian and the original version. A strong correspondence was observed between the two forms, indicating that the Italian version of the SATS added subscales can be considered consistent with the original ones. Omega values for each subscale ranged from .610 (95% CI [.479, .700]) to .889 (95% CI [.850, 914]).

Results

To investigate our hypotheses of the relationships between MA, attitudes towards statistics, and SA, we computed bivariate correlations among these variables (Table 1). As predicted, MA was significantly and positively associated with SA. Moreover, all the facets of attitudes towards statistics were significantly negatively related to both MA and SA, except for Effort.

Table 1: Means, Standard Deviations, and Intercorrelations Among Variables Investigated

	1.	2.	3.	4.	5.	6.	7.	8.
1. Math anxiety	-	-.55***	-.49***	-.34***	-.17*	-.21**	.08	.59***
2. Affect		-	.76***	.59***	.41***	.44***	-.01	-.59***
3. Cognitive Competence			-	.49***	.43***	.42***	.06	-.48***
4. Difficulty				-	.13	.13	-.26***	-.45***
5. Value					-	.64***	.22***	-.29***
6. Interest						-	.38***	-.25***
7. Effort							-	.03
8. Statistics anxiety								-
M	23.94	3.51	4.28	3.19	5.32	4.84	5.97	72.78
SD	6.84	1.14	1.02	.67	.81	1.11	.86	16.07

*p<.05, **p<.01, ***p<.001

Then, we conducted a linear regression analysis considering SA as dependent variable and MA and the dimensions of attitudes towards statistics that were significantly related to SA as independent variables. Results showed that the variables that had a significant effect on SA were MA – positively related – and attitudes towards statistics in terms of affect and difficulty, negatively related to the dependent variable. Overall, this regression model was significant, and it explained about 48% of the variance.

Table 2: Linear regression analyses with Statistics Anxiety as dependent variable

	B	*β*	*T*	*p*
Math anxiety	.91	.39	6.30	<.001
Affect	-3.71	-.26	-2.85	.005
Cognitive Competence	.42	.03	.33	.742
Difficulty	-4.04	-.17	-2.60	.010
Value	-2.43	-.12	-1.78	.076
Interest	.36	.02	.36	.720

$F(6,204) = 31.05$, $p < .001$, $R^2 = .48$ Adj, $R^2 = .46$

Based on these results, we hypothesized that students with higher MA would be more likely to have higher SA because of their decreased attitudes towards statistics in terms of affect and as a difficult subject. To test these predictions, we developed a model with multiple parallel mediators where MA was the independent variable; Affect and Difficulty were the mediators; and SA was the dependent variable. We used the PROCESS macro for SPSS (Hayes, 2023) to test our mediation hypothesis (Model 4) with 5,000 bootstrap samples and 95% confidence intervals. We found a significant positive indirect effect of MA on SA through Affect (point estimate = .164, 95% CI = [.081, .254]) and Difficulty (point estimate = .051, 95% CI = [.004, .106]). A non-significant difference was found in the size of the two indirect effects [contrast effect: .112, 95% CI = [-.009, .239]. In Figure 1 we reported the paths among the variables.

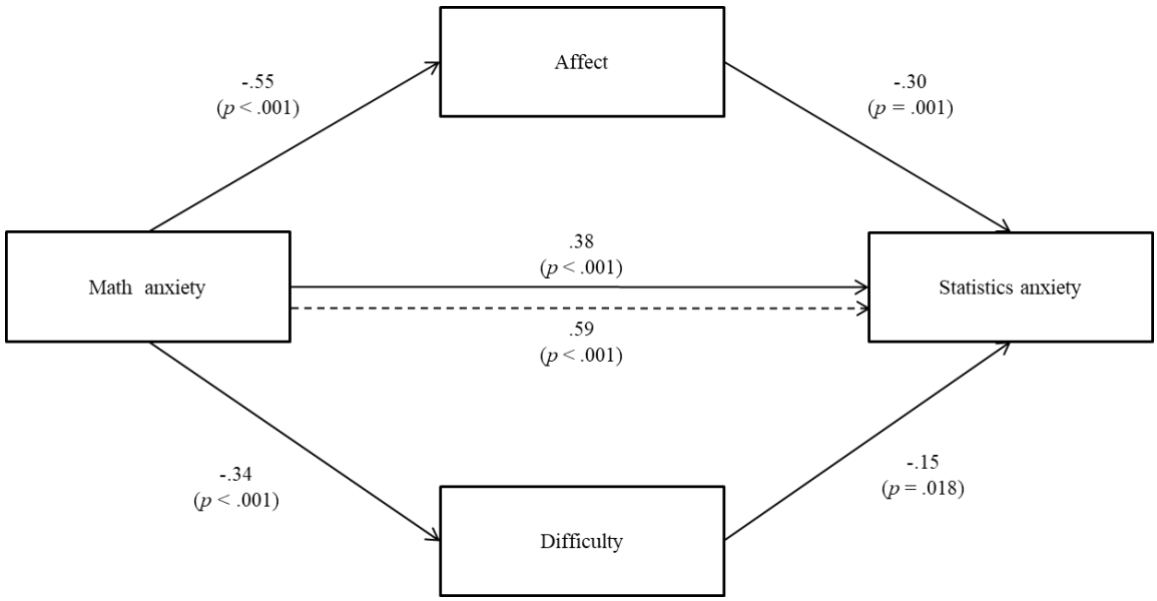

Figure 1: Path coefficients for mediation analysis. Dotted line denotes the total effect (c) of math anxiety on statistics anxiety, i.e., the effect when Affect and Difficulty are not included as mediators. Continuous line represents the direct effect (c') of math anxiety on statistics anxiety controlling for the mediators. The parameters are standardized.

Discussion

The aim of this study was to provide further insight into the mechanisms underlying the relationship between SA and its antecedents. Indeed, the results showed that MA and SA are two separate concepts and MA contributes with high and significant weight to SA. These results are in line with studies that conceptualized SA as a different construct from MA because statistics involves different cognitive processes and requires more than manipulation of mathematical symbols (Praechter et al., 2017). Furthermore, our results confirmed, in line with a previous study (Baloglu & Kocak, 2006), that MA

is an antecedent and hence a predictor of SA, showing that students with lower MA at beginning of the course showed lower SA.

Additionally in order to understand the mechanisms underlying the role of MA and SA, we investigated the relations among these variables with attitudes towards statistics as the mediator. Results provided evidence that Affect and Difficulty mediate the relationship between MA and SA. More specifically, greater MA appears to be negatively related to Affect and Difficulty, which in turn are negatively related to SA. Based on our findings, the relationship between MA and SA can be explained by taking into account the mediating role of attitudes towards statistics in particular Affect and Difficulty experienced that are more related to the students' feelings during the course comparing to the other attitudes components that are more related to socio-cognitive aspect of attitude.

Conclusion

In conclusion, results confirmed the distinction between SA and MA. Based on the results, as the effect of MA on SA remains significant controlling for the mediators, it would be useful to focus the attention both on the independent variable of our mediation model (i.e., MA) and not only on the mediators (i.e., Affect and Difficulty), instructors are advised to support students with MA from the beginning of their courses; for instance, they should be supported with specific training activities to acquire more confidence in their mathematical abilities and reduce their negative feeling towards math. Additionally, the emphasis on mathematics in a statistics course should be reduced. Although formulas and calculations might help students understand statistics, they might aggravate the situation because students have to deal with MA in addition to SA. In this regard, an idea should be to organize some periodical self-evaluation texts for the students throughout the course with the aim of consolidating the math prerequisites necessary for doing well in statistics, without attributing a grade for this performance, but by accompanying this activities with a feedback directed to reinforce in case of the correct responses and to explain the mistakes/misconceptions underlying the possible erroneous responses. Moreover, the attention on MA should be focused also during the period of high schools, in order to prevent arising levels of anxiety when the students arrive to the university. With that aim, training courses for high school teachers are needed.

These results underscore the importance and potential advantage of distinguishing between SA and attitudes towards statistics. Findings suggest the need to focus the attention non only on MA but also on attitudes towards statistics, especially on Affect and Difficulty, the dimensions that mediate the effect of MA on SA. This means that specific educational activities would be useful in university contexts with the aim of reducing the perception of statistics tasks as sources of difficult cognitive tests and negative feelings. In this regard, periodically, during the course, enjoyable and engaging activities such as games and cooperative learning activities could be organized. Moreover, as correlational analyses showed that all the components of attitude towards statistics are related to SA, and also reciprocal bivariate associations exist among some of the SATS dimensions, it would be important to broadly work on this construct in order to maximize the beneficial impact of these educational activities. Finally, the current paper suggests that SA should be investigated as a multidimensional construct related to different factors. In future studies it would be relevant consider

situational factors as previous math experience and skills and dispositional factors such as math self-concept or self-esteem.

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