

## STATISTICS ANXIETY: A MEDIATOR IN LEARNING PROBABILITY

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*The aim of this study was to test a mediation model in which basic probabilistic ability was associated with achievement through statistics anxiety. Results provided evidence that statistics anxiety mediates the relationship between basic probabilistic ability and achievement. More specifically, greater basic ability appears to be negatively related to statistics anxiety, which in turn is negatively related to achievement. Some implications for developing intervention programs could be derived from these findings.*

### INTRODUCTION

The ability to think about uncertain outcomes and to make decisions on the basis of probabilistic information is relevant in many fields, e.g., business, medicine, politics, law, psychology, etc. (see Chernoff & Sriraman, 2014 for a recent review; Gigerenzer, Gaissmaier, Kurz-Milcke, Schwartz & Woloshin, 2007). In the educational domain, teaching students to reason about probabilities is an important objective of statistics classes, and poor probabilistic reasoning skills underlie some of the difficulties that students experience in statistics learning (Konold & Kazak, 2008), along with several other factors that impact on achievement, such as mathematics background (including proportional reasoning and the ability to deal with ratios and percentages), self-confidence, and statistics anxiety.

Statistics anxiety is described as an anxiety encountered when taking statistics in any form, and which appears to involve a complex array of emotional reactions (Onwuegbuzie & Wilson, 2003). More specifically, Zeidner (1991) defined statistics anxiety as feelings of extensive worry, intrusive thoughts, mental disorganization, tension, and physiological arousal when being exposed to statistics content or problems and instructional situations, or evaluative contexts that deal with statistics. Several studies have investigated statistical anxiety antecedents (Onwuegbuzie & Wilson, 2003 for a review) concluding that statistics anxiety is a multi-dimensional construct that it is related to various factors. Among them, situational factors, such as previous math experience and skills (e.g., Baloglu, 2003; Hong & Karstensson, 2002); dispositional factors, such as math self-concept or self-esteem (e.g., Zeidner, 1991), self-efficacy (e.g., Onwuegbuzie, 2003), attitude toward statistics (e.g., Chiesi & Primi, 2010); personal factors, such as age (e.g., Fitzgerald, Jurs & Hudson., 1996) and gender (e.g., Baloglu, 2003; Hong & Karstensson, 2002). Regardless the relationships with mathematical related constructs (e.g., math skills or self-concept), statistics anxiety differs from math anxiety since it includes such additional factors as anxiety over interpretation of data and statistical outcomes, and whereas math anxiety has been defined as anxiety over manipulating numbers, statistics anxiety is closely related to verbal and logical reasoning (Cruise, Cash & Bolton, 1985).

Statistics anxiety is widely spread among students attending graduate programmes that are traditionally qualitative, as degrees in Psychology, Education, Health Sciences (Onwuegbuzie &

Wilson, 2003; Ruggeri, et al., 2008), and it has consequences on their academic performance (e.g., Chiesi & Primi, 2010; Macher, Paechter, Papousek, & Ruggeri, 2011).

Starting from these premises, in this study, conducted with psychology students, we expected that basic proportional and probabilistic reasoning ability might be related to statistics anxiety and achievement in probability (i.e., probability topics that are part of the introductory statistics course for psychology students). Thus, we aimed at testing a mediation model in which basic ability was associated with achievement in probability through statistics anxiety. We expected that lower ability was associated with higher statistics anxiety and, as consequence, with poorer achievement in probability reasoning.

## METHODS

### Participants

Participants were 172 psychology students (mean age = 21.5 years,  $SD = 4.9$ ) attending the University of Florence in Italy and enrolled in an undergraduate introductory statistics course. Most of the participants were women (70%). All students participated on a voluntary basis after they were given information about the general aim of the research.

### Description of the Course

The course covered the usual introductory topics of descriptive and inferential statistics (including basic concept of probability theory and calculus), and their application in psychological research. It was scheduled to take place over 10 weeks, and takes 6 hours per week (for a total amount of 60 hours). During each class some theoretical issues were introduced followed by exercises using by either paper-and-pencil procedure and computer package (*R-commander*).

### Measures and Procedure

The *Probabilistic Reasoning Questionnaire* (PRQ; Primi, Morsanyi & Chiesi, 2014) was designed to measure proportional reasoning and basic probabilistic reasoning ability. The scale consisted of 16 multiple-choice questions. The items included questions about simple, conditional, and conjunct probabilities, and the numerical data are presented in frequencies or percentages. (for example: “A ball was drawn from a bag containing 10 red, 30 white, 20 blue, and 15 yellow balls. What is the probability that it is neither red nor blue?” a. 30/75; b. 10/75; c. 45/75; and “60% of the population in a city are men and 40% are women. 50% of the men and 30% of the women smoke. We select a person from the city at random. What is the probability that this person is a smoker?” a. 42%, b. 50%, c. 85%). A single composite score was computed based on the sum of correct responses. Using item response theory analyses, the scale has been shown to have good psychometric properties (Primi et al., 2014). The PRQ was administered during the first week of the course.

The *Statistical Anxiety Scale* (SAS; Vigil-Colet, Lorenzo, & Condon, 2008; Italian version: Chiesi, Primi & Carmona, 2011) is a self-reported measure consisting 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 .90, .94 and .86. The SAS was completed during the fifth week of the course.

The *Achievement in probability* was assessed with a test conducted at the midpoint (about the sixth week) of the course. The test was run under exam conditions<sup>1</sup> and consisted of four exercises with data presented in a contingency table. Students were requested to read data relying on probabilistic reasoning. A total score (range 0 to 4) was computed based on the sum of correct responses.

## RESULTS

To investigate our hypothesis of the relationships among basic probabilistic reasoning ability, statistics anxiety (total scores and subscales), and achievement, we computed Pearson correlations among these variables. As shown in Table 1, we found a positive correlation between basic probabilistic reasoning ability and achievement, and a negative correlation with statistics anxiety except the *Asking for help* factor. We also found that achievement was significantly negatively correlated with statistics anxiety except for the *Asking for help* factor.

Measures	1	2	2a	2b	2c	3
1. PRQ	--					
2. SAS	<b>-.17*</b>	--				
a. Examination	<b>-.33**</b>	.74***	--			
b. Asking help	<b>.01</b>	.81***	.34***	--		
c. Interpretation	<b>-.24**</b>	.83***	.51***	.53***	--	
3. ACHIEVEMENT	<b>.22*</b>	<b>-.25**</b>	<b>-.24**</b>	<b>-.16</b>	<b>-.20*</b>	--
<i>M (SD)</i>	12.1 (2.7)	71.4 (14.9)	32.4 (5.9)	20.2 (7.2)	18.8 (5.6)	2.8 (1.5)

\*  $p < .05$ ; \*\*  $p < .01$ ; \*\*\*  $p < .001$

Table 1: Correlations between basic probabilistic reasoning ability (PRQ), statistics anxiety (SAS total score and subscales), and achievement .

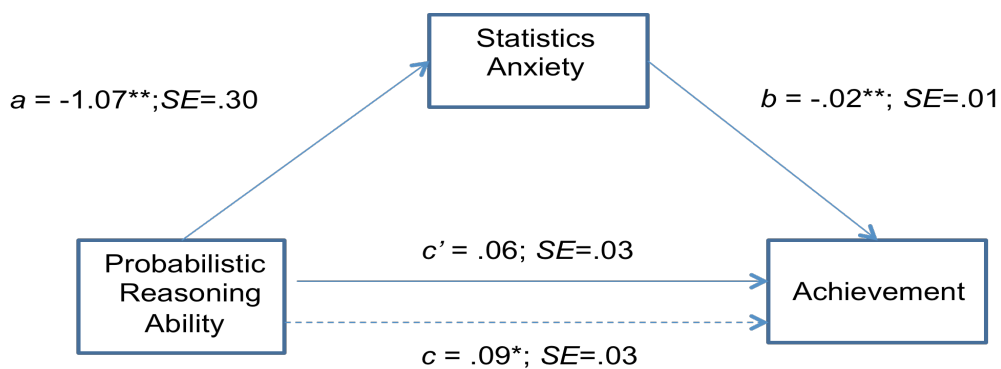
To further understand mechanisms underlying relationships among these variables, we tested a mediation model. Mediation implies a situation where the effect of the independent variable ( $X$ ) on the dependent variable ( $Y$ ) can be explained using a third mediator variable ( $M$ ) which is caused by the independent variable and itself a cause for the dependent variable. By modeling an intermediate variable, the overall effect between  $X$  and  $Y$  can be decomposed into component parts called the direct effect of  $X$  on  $Y$  and the indirect effect of  $X$  on  $Y$  through  $M$  (i.e. the mediated effect).

We used the INDIRECT macro for SPSS (Hayes, 2013) to test the hypothesis that statistics anxiety mediates the effect of basic probabilistic reasoning ability on achievement (Figure 1). Since a mediation analysis traditionally (Baron & Kenny, 1986) requires that the independent variable (i.e.,

<sup>1</sup> The performance of students was assessed through two midterm tests. Students who obtained completely sufficient performances were not required to sit a final examination.

basic probabilistic reasoning) predicts both the mediator (i.e., statistics anxiety) and the dependent variable (i.e., achievement), we excluded from the analysis the *Asking Help* score due to the lack of relationship between probabilistic reasoning and this SAS subscale. Thus, statistics anxiety was measured summing the *Examination anxiety* and *Interpretation anxiety* scores.

We estimated the indirect effect of basic probabilistic reasoning ability on achievement, quantified as the product of the ordinary least squares (OLS) regression coefficient estimating statistics anxiety from basic probabilistic reasoning ability (i.e., Path *a* in Figure 1) and the OLS regression coefficient estimating achievement from statistics anxiety controlling for basic ability (i.e., Path *b* in Figure 1). We tested the hypothesized model using a bootstrapping procedure (with 5000 bootstrap samples) to estimate the 95% confidence interval for the indirect (mediated) effect (for more details, see Preacher & Hayes, 2008). Bootstrapping is a resampling strategies for estimation and hypothesis testing and represent the most trustworthy test for assessing the effects of mediation models overcoming issues associated with inaccurate *p*-values that result from violations of parametric assumptions (Hayes & Scharkow, 2013). Indeed, the bootstrapping procedure is advantageous because it does not impose the assumption of normality of the sampling distribution of indirect effects, and it maintains high power while maintaining adequate control over Type I error rate (MacKinnon, Lockwood, Hoffman, West & Sheets, 2002; MacKinnon, Lockwood & Williams, 2004). The bootstrap test is statistically significant (at .05) if both confidence intervals have the same sign (e.g., both positive or both negative) indicating that zero is not a likely value and therefore the null hypothesis that the indirect effect is zero should be rejected. Results showed a significant positive indirect effect of basic probabilistic reasoning ability on achievement through statistics anxiety (point estimate = 0.3, 95% CI = [0.0085, 0.559]).



Notes: Dotted line *c* denotes the effect of basic probabilistic reasoning ability on achievement when statistics anxiety is not included as a mediator. *a*, *b*, *c*, and *c'* are unstandardized ordinary least squares (OLS) regression coefficients. \**p* < .05. \*\**p* < .01.

Figure 1: Path coefficients for mediation analysis on achievement.

## DISCUSSION

In order to understand the mechanisms underlying the relationship between basic probabilistic reasoning ability and achievement in probability, the aim of this study was to test the mediating role of statistics anxiety. In line with the hypotheses, our study provided evidence that statistics anxiety mediates the relationship between probabilistic reasoning ability and achievement. More specifically, greater basic probabilistic reasoning ability appears to be negatively related to statistics anxiety, which in turn is negatively related to achievement. Based on our findings, the relationship between ability and achievement can be explained by taking into account the mediating role of anxiety.

Some implications for developing intervention programs to improve achievement and prevent failure could be derived from these findings. First of all, students with difficulties in basic probabilistic reasoning should be supported from the start of their courses with specific training activities, e.g., Primi and Chiesi (2013) have provided some evidences that students can both consolidate their abilities and acquire more confidence by incrementing their mathematical prerequisites (i.e., the ability to deal with proportions and percentages) necessary to reason in probabilistic terms. Moreover, it is important to provide students with the resources to cope with statistics anxiety according to its effect on achievement. Unfortunately, less attention in the research has been devoted to reduce statistics anxiety in students. Schacht and Stewart (1990) explored the use of humorous cartoons in statistics classes and they found that this type of humor not only reduced the students' anxiety, but also improved their learning. Others (Wilson & Onwuegbuzie, 2001), found the effect of instructor interpersonal style such conveying a positive attitude, encouragement, reassurances of the students' ability, and acknowledgement of students' anxiety. Additionally, Dolinsky (2001) suggested creating a collaborative environment in which active learning strategies were used as the primary method to teach statistics. Finally, Pan and Tang's (2004) study shows that the combining application-oriented teaching methods with instructors' attentiveness to students' anxiety is a significantly effective way to reduce students' anxiety in learning statistics.

Future studies are required to strength and confirm the current findings. For instance, it would be desirable to verify the adequacy of this mediation model in different sample of students, e.g., students attending different degrees or students who do not attend regularly the course, in order to provide evidence of the generalizability of the present results. Additionally, this mediation model should be tested taking into account other variables, e.g., general math abilities or general test anxiety, in order to provide further insights about the interplay among cognitive and non-cognitive factors acting on probability and statistics achievement. Finally, the intervention strategies proposed in light of these results should be planned and tested.

In sum, the current paper suggests that statistics anxiety mediates the relationship between basic probabilistic ability and achievement. Indeed, the link between probabilistic ability and achievement decreases once the effect of anxiety is taken into account.

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