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# Gender differences in attitudes toward statistics: Is there a case for a confidence gap?

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*Female students tend to underestimate their abilities and to have more negative attitudes toward quantitative disciplines when compared to male students. In teaching statistics this concern has to be taken into account since it may create an obstacle for learning. The aim of the present study was twofold: to test if women had less confidence and more negative attitude than men regardless their actual abilities, and to investigate if achievement in statistics was affected by these factors controlling for gender. Results showed that women did not differ in their abilities but showed less confidence and more negative attitudes when compared to men. Moreover, confidence and attitude played a role on achievement in women but not in men. The importance of enhancing attitudes toward statistics in female students was discussed.*

**Keywords:** Statistics education, attitudes toward statistics, gender differences.

## INTRODUCTION

Since statistical literacy is a key ability expected of citizens in information-laden societies, and is deemed a necessary component of adults' numeracy and literacy (Gal, 2002), it is crucial to develop students' statistical learning. To accomplish this goal, i.e., to provide students with tools for understanding data-related arguments, building intuition about data, and making reasoned judgments and decisions in their professional and private lives, statistics has been included into a wide range of university programs. Thus, in many countries students progressing towards a degree other than statistics have to pass at least a compulsory statistics exam, and concerns related to teaching and learning statistics are internationally shared (for a review see, e.g., Zieffler et al., 2008).

In teaching statistics in postsecondary education gender might be a relevant factor since, although all students experience stress and difficulties in learning statistics, female students are more likely to feel uneasy in dealing with this discipline. Indeed, they tend to underestimate their abilities and to have more negative attitudes toward quantitative disciplines when compared to male students. For instance, referring to mathematics, it has been shown that women's self-efficacy is consistently and significantly lower than those of men (e.g., Pajares & Miller, 1994; Stevens, Wang, Olivarez, & Hamman, 2007) regardless their actual ability (Quest, Hyde, & Linn, 2010). This phenomenon, called the *confidence gap* (Sadker & Sadker, 1994), emerges during the high school years and impacts on the subsequent scholastic/academic choices, i.e. female students tend to avoid scientific secondary and postsecondary degrees and prefer non-mathematical ones (e.g., Halpern et al., 2007).

Nonetheless, female students enrolled in non-mathematical degrees such as Psychology, Education, and Health Sciences encounter statistics courses in their programs. Thus, it is likely that their *confidence gap* might affect their approach to a discipline like statistics. Indeed, it has been widely demonstrated that, along with cognitive components (e.g., mathematical knowledge and general scholastic background), non cognitive factors play a determinant role in learning statistics (Chiesi & Primi, 2010; Harlow, Burkholder, & Morrow, 2002; Nasser, 2004; Schutz, Drogsz, White, & Distefano, 1998; Tempelaar, Van Der Loeff, & Gijssels, 2007; Tremblay, Gardner, & Heipel, 2000; Wisenbaker, Scott, & Nasser, 2000). Among the non cognitive factors, large attention has been paid to the attitudes toward statistics that include a self-confidence dimension (e.g., the trust in one's own knowledge and skills when applied to statistics) along with measures of feelings concerning statistics, and beliefs about the usefulness and the difficulty of statistics.

Starting from these premises, the present study aimed to investigate the relationship between attitudes toward statistics and achievement in male and female psychology students attending introductory statistics courses. In detail, the aim of the present study was twofold: to test if females showed more negative attitudes toward statistics (and, specifically, less self-confidence) than males, and to investigate if attitudes affected their achievement. These relationships were investigated controlling for the students' actual ability, i.e., mathematical basics deemed necessary for introductory statistics courses.

As refers to the first aim, literature on gender differences in attitudes toward statistics reports contradictory results. Some authors reported that men expressed more positive attitudes toward statistics than women (e.g., Auzmendi, 1991; Tempelaar & Nijhuis, 2007). Others found no gender differences (e.g., Estrada, Batanero, Fortuny, & Díaz, 2005; Judi, Ashaari, Mohamed, & Wook, 2011; Martins, Nascimento, & Estrada, 2011; Schau, Stevens, Dauphinee, & Del Vecchio, 1995; Wisenbaker et al., 2000). Some others have reported more positive attitudes for women (e.g., Mahmud & Zainol, 2008; Rhoads & Hubele, 2000). Assuming that those differences might be partially related to the sample characteristics (engineering students, economic students, psychology students, pre-service teachers), and referring to the above mentioned literature on the *confidence gap*, we hypothesized that psychology female students had more negative attitude toward statistics than their male counterpart, and, specifically, they show less confidence in their knowledge and skills when applied to statistics.

From a different perspective, i.e., the “stereotype threat” theory (Spencer, Steele, & Quinn, 1999), it could be argued that since psychology female students are not confronted with many male students, they should have higher confidence and more positive attitudes. Indeed, the “stereotype threat” refers to the concern that is experienced when one feels at risk of confirming, as self-characteristic, a negative stereotype about one's group. Given the stereotype concerning gender and math ability - that propose that women have less mathematical aptitude than men - several studies suggest that gender differences in math performance occur in environments in which gender identity is salient, e.g., a class with a majority of male students is sufficient to create a threaten-

ing environment for female students. Nonetheless, in this stage of our research, we were interested in measuring students' competence and attitudes at the beginning of the course in order to highlight the way in which the students start to deal with statistics. As such, in line with previous studies (e.g., Chiesi & Primi, 2010; Nasser, 2004; Schutz et al., 1998) we assume that their initial attitudes do not depend on the current educational context, but on their previous experience with quantitative disciplines during the high school. Additionally, as reported by Hyde and colleagues (2008) and Quest and colleagues (2010) for mathematics, we hypothesized that, regardless gender similarities in abilities, women had less confidence and overall more negative attitude toward statistics than men.

Concerning the second aim, we investigated the relationships among mathematical competence, attitudes and achievement in men and women. Referring to literature on cognitive and non cognitive factors influencing statistics achievement, we hypothesized that mathematical knowledge has an effect on achievement (e.g., Chiesi & Primi, 2010; Harlow et al., 2002; Schutz et al., 1998; Tremblay et al., 2000; Wisenbaker et al., 2000), and, referring to the literature on female students' attitudes toward the quantitative disciplines (e.g., Hyde et al., 1990; McGraw et al., 2006; Pajares & Miller, 1994; Stevens et al., 2007), we hypothesized that attitudes, and especially self-perceived competence, might impact on women' performance differently than in men.

## METHOD

### Participants

Participants were 179 psychology students enrolled in an introductory statistics course at the University of Florence in Italy. The course was compulsory for first year students that represent the majority of the sample (91.3%). The course was scheduled to take place over 10 weeks, at 6 hours per week (for a total amount of 60 hours). It covered the usual introductory topics of descriptive and inferential statistics, and their application in psychological research. During each class some theoretical issues were introduced followed by examples and exercises. Students were requested to solve exercises by paper-and-pencil procedure (no computer package was used), and then solutions were presented and discussed.

Participants' age ranged from 19 to 54 with a mean age of 22.0 years ( $SD = 5.26$ ). Female students were 113 ( $mean\ age = 21.9, SD = 4.77$ ) and male students were 68 ( $mean\ age = 22.7, SD = 6.24$ ). All students participated on a voluntary basis after they were given information about the general aim of the investigation (i.e., collecting information to improve students' statistics achievement).

### Measures and procedure

In a previous study (Chiesi & Primi, 2010), we provided evidence that some mathematical basics are needed for introductory courses and to measure them we developed the *Prerequisiti di Matematica per la Psicometria (PMP)* scale (Galli, Chiesi, & Primi, 2011). The contents were defined on the basis of the basic mathematics abilities requested to solve descriptive and inferential statistics problems. The PMP is composed of 30 multiple choice (one correct out of four alternatives) questions including fractions, set theory (inclusion-exclusion, and intersection concepts), first order equations, relations (between numbers that range from 0 to 1 and numbers expressed in absolute values), and probability (base-rates, independence notion, disjunction and conjunction rules). Fractions are employed both in descriptive and inferential statistics tasks (e.g., to compute the standard deviation, as well as the  $t$  or  $z$  values). Equations are required, for instance, in the standardization procedure and in regression analysis. Establishing relations between numbers is necessary to compare the computed and critical value in the hypothesis testing. Set theory principles help to understand probability rules, and basics of probability are the prerequisite of the hypothesis testing. A single composite, based on the sum of correct answers, was calculated (range 0–30).

Attitude toward statistics was measured administering the 28-item version of the *Survey of Attitudes toward Statistics (SATS)* (Schau et al., 1995; Italian version: Chiesi & Primi, 2009). We chose SATS since it was proved to be invariant respect to gender (Hilton, Schau, & Olsen, 2004), i.e., equally suitable for male and female respondents, and because it assesses four attitudes dimensions including a self-confidence dimension. In detail, *Cognitive Competence* subscale (6 items) measures students' attitudes about their intellectual knowledge and skills when applied to statistics (e.g. "I can learn statistics"); *Affect* subscale (6 items) measures positive and negative feelings concerning

statistics (e.g. "I feel insecure when I have to do statistics problems"); *Value* subscale (9 items) measures attitudes about the usefulness, relevance, and worth of statistics in personal and professional life (e.g. "Statistics is worthless"); *Difficulty* subscale (7 items) measures students' attitudes about the difficulty of statistics as a subject (e.g. "Statistics is a complicated subject"). The scale contains Likert-type items using a 7-point scale ranging from *strongly disagree* to *strongly agree*. Responses to negatively scored items were reversed, and then scores were obtained for each subscale, with higher ratings representing more positive attitudes. In the present sample, Cronbach's alphas for the four subscales were: *Cognitive Competence* = .76, *Affect* = .80, *Value* = .74 and *Difficulty* = .65.

Students were administered the SATS and the PMP in this order during the first day of class. The questionnaires were introduced briefly to the students and instructions for completion were given. Answers were collected in paper-and-pencil format and the time needed to complete them ranged from 25 to 40 minutes.

To measure achievement, we employed a midcourse test developed to monitor learning during the course and administered toward the end of the fifth week of the course. The test was composed as follow. Students were given a data matrix (3–4 variables, 10–12 cases) and referring to it they had to solve two problems (e.g., report frequency and percentage distributions, construct a two-way table, draw graphs, compute central tendency, spread and association measures) by paper-and-pencil procedure without the support of a statistics computer package. Additionally, they had to answer two open-ended questions (e.g., to define the measures of central tendency, to interpret the meaning of  $z$  values or percentiles). All the items pertained to contents covered in class. The test was timed (1 hour) and books and notes were not allowed to be used. For each problem the score ranged from 0 to 3: 0 = totally incorrect or not solved; 1 = partially solved; 2 = almost solved; 3 = completely solved. For each question the score ranged from 0 to 2: 0 = totally incorrect or no answer; 1 = partially answered; 2 = correctly answered. Two assistant teachers, preliminary trained, scored the tasks. The scores were aggregated in a single measure (range 0–10).

**RESULTS**

*Gender difference in mathematical knowledge, attitudes, and achievement.* All descriptives are reported in Table 1. No gender differences were found in mathematical knowledge ( $t(177) = 1.10, p = .271$ ) and in the *Value* scores ( $t(158) = -0.45, p = .97$ ). In contrast, differences were found in *Cognitive Competence* ( $t(158) = 2.05, p < .05, d = .31$ ), *Affect* ( $t(158) = 3.68, p < .001, d = .55$ ), and *Difficulty* scores ( $t(158) = 2.13, p < .05, d = .32$ ) indicating that men were more confident about their own capabilities, had more positive feelings toward the discipline, and deemed the discipline less difficult than women. Concerning achievement, differences between male and female students were not statically significant ( $t(155) = 1.38, p = .17$ )

*Gender difference in the relationships among mathematical knowledge, attitudes, and achievement.* We investigated if mathematical knowledge and attitudes were related to achievement looking at the Pearson product-moment correlations separately in male and female students (Table 2). Males' achievement was related to mathematical knowledge whereas it was not related to attitudes toward statistics with the only exception of a small correlation with the *Cognitive*

*Competence* dimension. Females' achievement was related to mathematical knowledge and to attitudes toward statistics with the exception of the *Value* dimension.

Since in both gender groups mathematical knowledge was related to attitudes and achievement, the correlations between them might be biased. Therefore, partial correlations were computed controlling for mathematical knowledge. For the male students the correlation with the *Cognitive Competence* score was not significant ( $r = .04, p = .83$ ) once the effect of mathematical knowledge was controlled. Instead, for the female students the correlations between achievement and *Affect* ( $r = .24, p < .05$ ) was still significant, as well as the correlations between achievement and *Cognitive Competence* ( $r = .37, p < .01$ ).

*Mathematical knowledge, Affect, and Cognitive Competence as predictors of achievement in female students.* To establish the relative impact of mathematical knowledge, *Cognitive Competence*, and *Affect* on achievement in women, regression hierarchical analyses were run (Table 3). In the first step, the mathematical knowledge, and, in the second step *Cognitive Competence* and *Affect* were added as predictors. The

	Males		Females	
	M	SD	M	SD
PMP	23.71	4.34	22.90	4.94
SATS-Cognitive Competence	31.59	6.67	29.70	5.43
SATS-Affect	26.00	6.93	22.27	6.63
SATS-Value	46.00	8.20	46.05	7.54
SATS-Difficulty	25.91	5.62	24.30	4.49
MT	6.34	2.25	5.77	2.19

**Table 1:** Means and standard deviations of mathematical knowledge (PMP), attitudes toward statistics (SATS) subscales, and achievement (midcourse test = MT) for Males and Females

	Males					Females				
	1	2	3	4	5	1	2	3	4	5
1. PMP										
2. SATS-CC	.40**					.35**				
3. SATS-A	.13	.81**				.33**	.72**			
4. SATS_V	.22*	.54**	.55**			.07	.39**	.44**		
5. SATS-D	.34*	.66**	.74**	.38*		.26*	.55**	.68**	.25*	
6. MT	.46**	.22*	.05	-.06	-.01	.52**	.48**	.36**	.07	.25*

\*\* Correlation is significant at the 0.01 level (2-tailed) \* Correlation is significant at the 0.05 level (2-tailed)

**Table 2:** Intercorrelations between mathematical knowledge (PMP), attitudes toward statistics (SATS subscales: A= Affect; CC= Cognitive Competence; V=Value, D= Difficulty), and achievement (midcourse test = MT) in Males and Females

two dimensions of attitudes toward statistics were kept separate to avoid multicollinearity due to the high correlation between them ( $r = .72$ ) that makes difficult to estimate the single contribution of each one when kept together in the same analysis. Results showed that the mathematical knowledge was a significant predictor ( $F(1,79) = 29.35, p < .001$ ) that accounted for the 27% of the variability in achievement. Adding separately at the two dimensions of attitudes, results showed that the model was significant both when *Cognitive Competence* was included ( $F(2,78) = 22.78, p < .001$ ), and when *Affect* was included ( $F(2,78) = 17.53, p < .001$ ). In both cases, they contributed significantly to explain achievement along with mathematical knowledge. Nonetheless, *Affect* explained only an additional 4% whereas *Cognitive Competence* accounted for an additional 10% of the variability in achievement.

## DISCUSSION

The current study aimed at investigating the interplay among previous competence, attitudes, and achievement in statistics and taking into account gender-related differences. In detail, the first aim was investigating gender differences in attitudes toward statistics and the relationships with mathematical competences. As expected (and in line with Auzmendi, 1991; Tempelaar & Nijhuis, 2007), when compared to men, women were less confident about their own ability in dealing with statistics, perceived it more difficult, and had more negative feeling about the discipline. However, the present results shows that these differences were not related to different mathematical knowledge since any gender differences were detected in mathematical basics deemed necessary for introductory statistics courses. The second aim concerned the predictive role of mathematical knowledge and attitudes toward statistics on achievement. Confirming previous results, the *Cognitive Competence*, *Affect* and *Difficulty* components, but not the *Value* one, were related to achievement (Tempelaar et al., 2007; Wisenbaker et al., 2000), as well as mathematical knowledge (e.g.,

Chiesi & Primi, 2010; Harlow et al., 2002; Schutz et al., 1998; Tremblay et al., 2000; Wisenbaker et al., 2000). Concerning gender differences, as expected, gender induced changes in the relationships between achievement and its predictors. More in detail, mathematical knowledge was the only significant predictor for men, whereas – along with mathematical knowledge – the *Affect* and *Cognitive Competence* attitude components had an additional effect on performance for women. That is, low self-perceived abilities accounted for worse achievement, and more negative affect was associated to lower achievement (and vice versa). In particular, *Affect* had a smaller effect than *Cognitive Competence*.

Given these findings, it becomes important to identify methods for counteracting female students' tendency to underestimate their competence and to have negative feeling toward the discipline. In this way it could be possible to promote a better approach to the discipline and, as a consequence, a better performance. Specifically, it might be useful to arrange activities during the course in which students could realize that they can master the topics, develop confidence, perceive the subject easier, and reduce negative feelings toward the discipline. Thus, future researches might be conducted collecting repeated measures of attitudes from the beginning to the end of the course in order to monitor changes that might be due to the course itself and to specific activities implemented by teachers and tutors.

The present study has some limitations that we have to take into account when interpreting the results. First, we used the midcourse test score as indicator of achievement. For the purpose of the present investigation, we deemed this measure as an adequate indicator but it could be interesting to take into account the final examination's grades to better ascertain the role of attitudes on general achievement. In doing that, it should be necessary, as stated above, to monitor the changes in the attitudes that could occur during

Predictors	$\beta$	$t$	$p$	$R^2$	$R^2$ change	$F$ change	$p$
Step 1: PMP	.52	5.42	<.001	.27	-	-	-
Step 2a: PMP + SATS-A	.45 .21	4.52 2.10	<.001 <.05	.31	.04	4.43	<.05
Step 2b: PMP + SATS-CC	.40 .33	4.20 3.48	<.001 <.01	.37	.10	12.09	<.01

**Table 3:** Hierarchical regression analyses on statistics achievement for Females. PMP = mathematical knowledge, SATS-A = Affect, SATS-CC = Cognitive Competence

the course, i.e., to have a measure of the student's attitudes at the end of the course, just before to take the final exam. Additionally, given the relevance of the self-confidence dimension (i.e., the trust in one's own knowledge and skills when applied to statistics) more attention should be paid in investigating more in detail this aspect, for instance using instrument to measure specifically the student's confidence in solving successfully typical statistic tasks. Finally, the present research was conducted with Italian psychology students and this may limit the generalizability of the current findings. Thus, future investigations should be conducted with different student populations to provide further evidence.

## REFERENCES

- Auzmendi, E. (1991, April). *Factors related to attitude toward statistics: A study with a Spanish sample*. Paper presented at the annual meeting of the American Educational Research Association, Chicago, IL.
- Chiesi, F., & Primi, C. (2009). Assessing statistics attitudes among college students: Psychometric properties of the Italian version of the Survey of Attitudes toward Statistics (SATS). *Learning and Individual Differences, 19*, 309–313.
- Chiesi, F., & Primi, C. (2010). Cognitive and non-cognitive factors related to students' statistic achievement. *Statistics Education Research Journal (SERJ), 9*, 6–26.
- Estrada, A., Batanero, C., Fortuny, J. M., & Díaz, C. (2005). A structural study of future teachers' attitudes towards statistics. In *Proceedings the IV Congress of the European Society for Research in Mathematics Education* (pp. 508–517).
- Gal, I. (2003). Teaching for statistical literacy and services of statistics agencies. *The American Statistician, 57*(2), 80–84.
- Galli, S., Chiesi, F., & Primi, C. (2011). Measuring mathematical ability needed for "non- mathematical" majors: The construction of a scale applying IRT and differential item functioning across educational contexts. *Learning and Individual Differences, 21*, 392–402.
- Harlow, L. L., Burkholder, G. J., & Morrow, J. A. (2002). Evaluating attitudes, skill, and performance in a learning-enhanced quantitative methods course: A structural modelling approach. *Structural Equation Modeling, 9*, 413–430.
- Halpern, D. F., Benbow, C. P., Geary, D. C., Gur, R., Hyde, J. S., & Gernsbacher, M. A. (2007). The science of sex differences in science and mathematics. *Psychological Science in the Public Interest, 8*, 1–51.
- Hilton, S. C., Schau, C., & Olsen, J. A. (2004). Survey Attitudes Toward Statistics: Factor structure invariance by gender and by administration time. *Structural Equation Modeling, 11*(1), 92–109.
- Judi, H.M., Ashaari, N.S., Mohamed, H., & Wook, T.M.T. (2011). Students profile based on attitude towards statistics. *Procedia Social and Behavioral Sciences, 18*, 266–272.
- Martins, J., Nascimento, M., & Estrada, A. (2011). Attitudes of teachers towards statistics: A preliminary study with Portuguese teachers. In *Proceedings of Seventh Congress of the European Society for Research in Mathematics Education (CERME 7)*. Rzeszow, Poland: University of Rzeszow and ESRM.[Online: [http://www.cerme7.univ.rzeszow.pl/WG/5/CERME\\_Martins-Nascimento-Estrada.pdf](http://www.cerme7.univ.rzeszow.pl/WG/5/CERME_Martins-Nascimento-Estrada.pdf)].
- Mahmud, Z., & Zainol, M.S. (2008). Examining postgraduate students' perceived competency in statistical data analysis and their attitudes toward statistics. *International Journal of Education and Information Technologies, 1*, 79–86.
- Nasser, F. (2004). Structural model of the effects of cognitive and affective factors on the achievement of Arabic-speaking pre-service teachers in introductory statistics. *Journal of Statistics Education, 12*(1). [Online: [www.amstat.org/publications/jse/v12n1/nasser.html](http://www.amstat.org/publications/jse/v12n1/nasser.html)]
- Pajares, F., & Miller, M. (1994). Role of Self-efficacy beliefs and self-concept beliefs in mathematics problem-solving: a path analysis. *Journal of Educational Psychology, 86*, 193–203.
- Quest, N.M., Hyde, M., & Linn, J. (2010). Cross-National patterns of gender differences in mathematics: A meta-analysis. *Psychological Bulletin, 136*, 103–127.
- Rhoads, T. R., & Hubele, N. F. (2000). Student attitudes toward statistics before and after a computer-integrated introductory statistics course. *IEEE Transactions in Education, 43*, 182–187.
- Sadker, M., & Sadker, D. M. (1994). *Failing at fairness: How America's schools cheat women*. New York: Scribner.
- Schau, C., Stevens, J. J., Dauphinee, T. L., & Del Vecchio, A. (1995). The development and validation of the survey of attitudes toward statistics. *Educational and Psychological Measurement, 55*, 868–875.
- Schutz, P. A., Drogosz, L. M., White, V. E., & Distefano, C. (1998). Prior knowledge, attitude, and strategy use in an introduction to statistics course. *Learning and Individual Differences, 10*, 291–308.
- Spencer, S.J., Steele, C.M., & Quinn, D.M. (1999). Stereotype threat and women's math performance. *Journal of Experimental Social Psychology, 35*, 4–28.
- Stevens, T., Wang, K., Olivárez, A., Jr., & Hamman, D. (2007). Using self-perspectives and their sources to predict the mathematics enrolment intentions of women and men. *Sex Roles, 56*, 351–363.
- Tempelaar, D. T., & Nijhuis, J. F. (2007). Commonalities in attitudes and beliefs toward different academic subjects. In M. K. McCuddy, H. van den Bosch, J. W. B. Martz, A. V. Matveev, & K. O. Morse (Eds.), *Educational innovation in economics*

*and business X: The challenges of educating people to lead in a challenging world* (pp. 225–250). Berlin: Springer.

- Tempelaar, D. T., van Der Loeff, S. S., & Gijsselaers, W. H. (2007). A structural equation model analyzing the relationship of students' attitudes toward statistics, prior reasoning abilities and course performance. *Statistics Education Journal*, 6(2), 78–102.
- Tremblay, P. F., Gardner, R. C., & Heipel, G. (2000). A model of the relationships among measures of affect, aptitude, and performance in introductory statistics. *Canadian Journal of Behavioral Science*, 32, 40–48.
- Wisembaker, J. M., Scott, J. S., & Nasser, F. (2000, July/August). *Structural equation models relating attitudes about and achievement in introductory statistics courses: A comparison of results from the U.S. and Israel*. Paper presented at the 9<sup>th</sup> International Congress on Mathematics Education, Tokyo, Japan.
- Zieffler, A., Garfield, J., Alt, S., Dupuis, D., Holleque, K., & Chang, B. (2008). What does research suggest about the teaching and learning of introductory statistics at the college level? A review of the literature. *Journal of Statistics Education*, 16(2), 1–23.