The Impact of Gender Stereotypes on Mathematical Performance: Why We Don't See 50/50

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A particularly prevalent stereotype in Western society is that men are, on average, simply better at mathematics than women (Jacobs & Weisz, 1994; Kurtz-Costes, Rowley, Harrus-Britt, & Woods, 2008; Reuben, Sapienza, & Zingales, 2014). Numerous studies have shown that it is not uncommon for parents, teachers and students, both male and female, to subscribe to this belief (Jacobs & Weisz, 1994; Jacobs, 1991; Kiefer & Sekaquaptewa, 2014; Kurtz-Costes et al., 2008; Li, 1999; Lightbody & Durndell, 1996; Marsh, Trautwein, Lüdtke, Köller, & Baumert, 2005; Reuben et al., 2014). In spite of the popularity of this explanation, there is little empirical support for a consistent mathematical performance gap. While some have reported a slight male advantage in late-adolescence (Leahey & Guo, 2001), the majority of research studies examining male and female elementary and high school students often fail to find a significant mathematical performance difference (Campbell, Hombo, & Mazzeo, 2000; Jacobs, 1991; OECD, 2014), and several studies have even reported a slight female advantage (Jacobs, 1991; OECD, 2014).

This stereotype may be at least in part caused by the overall lack of female interest in mathematical careers (Reuben et al., 2014; Schreiner & Sjøberg, 2005; Turcotte, 2011). While female university enrollment has been steadily increasing over the years (Borzelleca, 2012; Turcotte, 2011), with women currently making up almost 60% of the undergraduate student body (Turcotte, 2011), this trend is not universal across all fields. While there is a strong female representation in social, biological and environmental studies - in some cases even outnumbering men (Lightbody & Durndell, 1996; Schreiner & Sjøberg, 2005; Turcotte, 2011; Zafar, 2009) – there are surprisingly few women showing interest in science, technology, engineering, and mathematical (STEM) fields of study (Reuben et al., 2014; Schreiner & Sjøberg, 2005; Turcotte, 2011).

This begs the question of why women are not showing interest in STEM-related careers, despite showing equal ability to men (Campbell, Hombo, & Mazzeo, 2000; Jacobs, 1991; Performance & Volume, 2014). This underrepresentation of half of the human population is problematic in a world growing increasingly dependent on scientific study. This paper will attempt to answer this question specifically in relation to mathematical study. To do this I will begin by exploring how sex stereotype may impact mathematical learning in both genders, and demonstrating a reciprocal connection between sex stereotypes and choices made in regards to their career and education. Suggestions for how to potentially resolve this problem will be discussed.

A recent ROSE study (Sjøberg & Schreiner, 2010) evaluated the opinions of adolescents towards science and technology (S&T) from over 40 countries. They found that the overall attitude towards S&T among adolescents was positive, and few gender differences existed. Despite this, fewer girls wished to pursue S&T in the future careers. Often students want to pursue a career that they are passionate about (Schreiner & Sjøberg, 2005; Sjøberg & Schreiner, 2010). This is particularly the case for girls (Sjøberg & Schreiner, 2010). While both genders had a positive view of S&T, girls were significantly more likely than boys to state that they found S&T to be less interesting than other subjects, and thus were less interested in pursuing S&T professionally (Schreiner & Sjøberg, 2005; Sjøberg & Schreiner, 2010). Similar gender trends have been found in past research (Lightbody & Durndell, 1996).

Lightbody and Durndell (1996) conducted a study to examine what factors may contribute to sex differences in career choice. They tested this by having male and female participants evaluate four vignettes of fictional students who were having difficulty deciding between a socially- or technically-oriented careers. The students outlined in these vignettes could be either male or female, and could describe either a social or a technical personality. Participants were to decide whether they believed the student would choose either a technical or social career, and whether this was the "best choice" or not. If believed the student would not make the best choice, they were asked to explain why they thought so. While most students were able to match the personality in their vignette to the congruent career, regardless of student sex, almost a quarter believed the student would choose an incongruent career (e.g., a technical personality opting for a social career). Interestingly, most of the participants who chose the incongruent career stated that this would not be the best, demonstrating that they were still capable of recognizing the "correct" option. When asked why they believed the student would choose what they believed to be the wrong option, the most common factor was parental pressure. This was the case for both women (i.e., a technically-oriented women choosing a social career) and women (i.e., a socially-oriented man choosing a technical career).

Parental influence has consistently been shown to significantly influence a child's sense of mathematical self-concept. Several studies have shown that parental adherence to traditional gender stereotypes in mathematics interacts with the child's gender (Jacobs, 1991; Kurtz-Costes et al., 2008). While boys demonstrated elevated self-concept of their mathematical abilities when parents adhere to traditional gender stereotypes, girls demonstrate decreased self-concept

(Jacobs, 1991; Kurtz-Costes et al., 2008). This effect is also true when examining gender stereotype beliefs of teachers (Li, 1999). These differences in self-concept remain even after controlling for mathematical performance (Kurtz-Costes et al., 2008; OECD, 2003; Parsons, Adler, & Kaczala, 1982), demonstrating that the lack of confidence in female students is not due to a lack of ability.

While children are perceptive enough to detect more explicit endorsement of gender stereotypes in adults (Kurtz-Costes et al., 2008), implicit stereotype endorsement may be the greater impacting factor for children's mathematical self-concept (Kiefer & Sekaquaptewa, 2014; Kurtz-Costes et al., 2008; Reuben et al., 2014). A recent study by Kiefer and Sekaquaptewa (2014) sought to examine the differential influence of explicit and implicit gender stereotypes on female math performance among a group of female calculus students. Researchers measured both explicit and implicit stereotype endorsement of sex stereotypes, as well as how much participants identified with their gender (i.e., how much being a woman mattered as a part of their identity). These measures were then related their mathematical performance and whether they would like to continue to pursue math as a career. Researchers found no significant effect of explicit stereotypes on either math performance, or the attractiveness of math as a future career. In contrast, implicit stereotype endorsement was found to be associated with both poorer math performance, and lower interest in pursuing a career in math. Furthermore, those who reported a high degree of gender identification showed greater susceptibility to these stereotypes, and were more likely to underperform and show a lack of interest in a career in math. This may contribute to the slight gender gap seen once students enter high school by causing girls to take fewer math courses once math becomes an elective (Leahey & Guo, 2001).

As a result of these stereotypes, female university students with superior math abilities may try to distance themselves from their gender identity in order to minimize their own associations with the stereotype (Kiefer & Sekaquaptewa, 2014). This alarming trend can be seen as early as middle school, where young girls who are skilled in math may deemphasize their group membership in order to justify their skills (Kurtz-Costes et al., 2008). For example, Kurtz-Costes and colleagues reported one girl who said "girls are not good in mathematics and science, but I'm not like other girls" (Kurtz-Costes et al., 2008, p. 403).

While an argument could be made that the high gender identification among women is reflective of maternal drives, and they simply want to leave room in their lives for family, this

explanation ultimately falls short. There is no lack of women studying biological and environmental studies (Lightbody & Durndell, 1996; Schreiner & Sjøberg, 2005; Turcotte, 2011; Zafar, 2009), which still require a significant commitment on their part. If maternal concerns were the reason for the lack of women in math, these other careers should show a similar deficit.

These findings regarding the influence of implicit stereotypes are problematic, as implicit stereotypes are more difficult to address as teachers and parents may be unaware they are using them, and propagate much more easily among children (Kiefer & Sekaquaptewa, 2014; Kurtz-Costes et al., 2008; Reuben et al., 2014). A simple way which these implicit stereotypes may spread is through differences in regards to what parents and teachers attribute mathematical success to in boys and girls. When boys are successful in math, parents often attribute this to the child's natural mathematical ability, stating that the boy needs less effort in order to success in math (Parsons et al., 1982; Smith, Jussim, & Eccles, 1999). In contrast, girls' success in math is more often attributed to hard work and hours spent studying (Parsons et al., 1982; Smith et al., 1999). Interestingly, the opposite is true when attributing reasons for failure. When boys fail in math, parents often attribute this to a lack of motivation or effort, while failure in girls is instead attributed to a lack of ability (Dweck, Davidson, Nelson, & Enna, 1978). Though this may be done in order to spare the feelings of the members of the "fairer" sex, this may do more harm than good an ultimately harm their confidence in their mathematical abilities.

Interestingly, in addition to a negative impact on female self-concept, traditional sex stereotypes also seem to cause parents and teachers to overrate the mathematical abilities of male students (Li, 1999), which may contribute to males developing an inflated perception of their own abilities. Evidence for this inflated self-concept comes from a recent study by Reuben et al. (2014), who found that on a mathematical task where men and women performed equally, men tended to significantly overestimate their future performance on the task, while women underestimated future performance. Another group of participants in this study, referred to as "employers" were asked to select a candidate who they believed will have better future performance on the same mathematical task. They found that these employers were likely to believe these self-accounts, and often selected men based on these bolstered estimates of future performance (Reuben et al., 2014). Furthermore, even when the employers were provided with objective reports of the past performance of the participants on this task, employers demonstrated a reluctance to select the woman candidate, even if she outperformed the man. This reluctance

was especially present in employers with stronger sex-biases (Reuben et al., 2014). Reuben et al. interpreted these findings as potentially contributing to the relative lack of female presence in STEM careers by inflating male numbers.

Thus this paper has presented evidence from past research that female participation in mathematical study is being discouraged by gender stereotypes of female inferiority. Even when female mathematical performance is on par with male performance, women appear to be discouraged from pursuing a career in math. This may be through explicit adherence to these gender in parents or teachers, or more implicit stereotypes which children perceive in adult behavior, such as differential attributions of success and failure (Jacobs, 1991; Kurtz-Costes et al., 2008; Leahey & Guo, 2001; Li, 1999; OECD, 2003; Parsons et al., 1982; Reuben et al., 2014), damaging their mathematical self-concept. We have also shown that female students are not the only ones impacted by these gender stereotypes, as males also feel greater pressure to pursue more technically-oriented careers (Lightbody & Durndell, 1996).A number of studies have proposed ways in which we may counter these gender stereotypes.

One interesting example comes from a study by Johns, Schmader and Martens (2005), who had men and women perform the same standardized math test. These participants were divided into three groups. The first groups was simply told that they were going to be completing a problem-solving test in order to assess general cognitive processes. The second group was told that they were going to be performing a math test, and that the purpose was to assess differences in male and female math performance. This was done to remind participants of the stereotype in order to determine the detrimental impact of the stereotype on math performance. The third group was also told that they were to be completing a math test to assess gender differences. However, this group also included instructor intervention, where the instructor calmly explained to the participants the adverse effects of the stereotype threat, and that any anxiety they feel during the tets is likely due to this threat. When participants were told they were completing a simple problem solving test, male and female performance did not differ significantly. However, when presented with the stereotype threat of the second condition, female mathematical performance suffered, and their performance was significantly lower than male performance. However, when the stereotype threat was paired with instructor intervention, researchers found that female performance again did not differ from male performance. Thus, Johns and colleagues

(2005) found that one effective method for countering the detrimental effects of gender stereotypes is to simply inform people of these detrimental effects.

Researchers have also recommended to parents and to be wary of their attributions of mathematical success in their children. If a child demonstrates superior ability, they should recognize and encourage this, regardless of the gender of the child (Parsons et al., 1982; Smith et al., 1999).

Another interesting finding comes from a study by Blanton, Christie and Dye (2002). They found that women were given an example of a same-sex individual who out-performed their male cohorts on mathematical performance seemed to energize performance and improve overall female performance on the mathematical task. Therefore one potential avenue for countering sex stereotypes in popular culture is to provide females with a role model who can energize and motivate performance. There is no shortage of famous living scientific role models for men and boys (eg., William "Bill" Nye, Neil DeGrasse Tyson, Carl Sagan, Stephen Hawking, etc.) Perhaps by promoting the work of successful female scientists we can dispel these stereotypes and possible narrow the gap between men and women working in STEM.

However, it is important to note that in light of all the evidence of the negative impacts of gender stereotypes in regards to mathematical ability, it is important not to forget that some of these differences in career paths may still be due to simple differences in priorities and interest. Lightbody and Durndell (1996) pointed out that the female presence in biological and social sciences shows that they are more than capable of succeeding in highly competitive fields common (Lightbody & Durndell, 1996; Schreiner & Sjøberg, 2005; Turcotte, 2011; Zafar, 2009). Female personalities tend to be more socially-oriented, preferring to work alongside other people (Schreiner & Sjøberg, 2005; Sjøberg & Schreiner, 2010; Yazilitas, Svensson, de Vries, & Saharso, 2013). Given their common perception of those in STEM-related fields as asocial (Lips, 1992, as cited in Lightbody & Durndell, 1996, p. 136), it is entirely possible that many decide not to pursue a mathematical due to a lack of interest. While it is beyond the scope of this paper to discuss whether women are more socially- and environmentally-oriented by nature or nurture (or, more likely, a combination of the two), it is clear that it is playing a role female education and career choices.

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