Does Performance Mirror Ability?
Gender Differences in Attitudes towards Competition

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I. INTRODUCTION

Over the past 60 years there have been substantial improvements in the college preparation of female students and the college gender gap has changed dramatically. Goldin, Katz and Kuziemko (2006) show that female high school students now outperform male students on most subjects, and in particular on verbal test scores. The fraction of male to female college graduates has not only decreased, but reversed itself, and the majority of college graduates is now female.

The gender gap in mathematics has also changed. The number of math and science courses taken by female high school students has increased and the mean and standard deviation in performance on math test scores are only slightly larger for males than for females. Despite minor differences in mean performance, Hedges and Nowell (1995) show that many more boys than girls perform at the right tail of the distribution. Furthermore, over the past 20 years, the fraction of males to females who score in the top 5 percent in high school math has remained constant at two to one (Xie and Shauman, 2003).[1]

Substantial research has been conducted to understand why more boys than girls excel in math. In light of the many dimensions in which girls outperform boys it may seem misplaced to focus on the one dimension in which girls are falling short. Why not examine verbal test scores where female scores are substantially higher than those for males? One reason is that, in contrast to, say, verbal test scores, math test scores serve as a very good predictor of future income. Paglin

[1] The gender ratio becomes more skewed as the performance percentile increases. The gender gap on standardized test of mathematics has been documented for a series of tests, e.g., AP-calculus, SAT-Mathematics, and GRE-Quantitative.

and Rufolo (1990) show that mathematical test scores predict choice of college major and that differences in earnings are largely explained as a return to the use of scarce quantitative abilities.[2]

So why do girls and boys differ in the likelihood that they excel in math? One argument is that boys have and develop superior spatial skills, and that this gives them an advantage in math. An evolutionary argument may be that typical male tasks required greater spatial orientation than typical female tasks. A related argument is that boys tend to engage in play that is more movement oriented and therefore grow up in more spatially complex environments.

This paper explores an alternative explanation for the gender gap in math scores. Test scores may not only reflect the individual's ability but also the manner in which the individual responds to the competitive test-taking environment.

We report on a series of studies that have documented significant and substantial gender differences in the extent to which ability is reflected in a competitive performance. The effects in mixed sex settings range from women failing to perform well in competitions (Gneezy, Niederle and Rustichini, 2003), to women shying away from environments in which they have to compete (Niederle and Vesterlund, 2007). The reported studies suggest that the response to competition differs for men and women, and that gender differences in performance observed in a competitive environment do not represent those in a non-competitive setting. We will use the insights from these studies to argue that the test-taking performance need not reflect the individual's underlying ability, and that the distortion may be particularly large in mathematics.

II. GENDER DIFFERENCES IN COMPETITIVE PERFORMANCE AND SELECTION

II.A. Performance in competitive environments

Clear evidence that incentive schemes may generate gender differences in performance has been shown by Gneezy, Niederle and Rustichini (2003). In an experiment conducted at the Technion in Israel, individuals solve mazes on the internet for 15 minutes under various incentive schemes. Though gender was not explicitly mentioned, they could see one another and determine the gender composition of the group. 30 women and 30 men perform under each incentive scheme, and no one participates more than once.

[2] While studies differ in the degree to which math ability can explain future income, the significant and substantial positive correlation between the two has been documented systematically, e.g., Murnane, Willet and Levy (1995), Grogger and Eide (1995), Weinberger (1999, 2001), Murnane, Willett, Duhaldeborde and Tyler (2000).

In a non-competitive piece-rate environment, participants receive a piece rate payment of $0.5 for every solved maze. The gender gap in performance is small, with men solving an average of 11.2 mazes and women solving 9.7 mazes (see Figure 1).

In a tournament incentive scheme, participants compete in a group of 3 men and 3 women. The participant with the highest performance in each group receives a payment of $3 per maze. The other members of the group receive no payment. Figure 1 shows average performances in the mixed sex tournament. Compared to the piece rate performance, the average male performance significantly increases, while the female performance does not. This creates a significant gender gap in performance of 4.2, which substantially exceeds the average performance difference of 1.5 mazes in the non-competitive environment.

Differences in performance between the piece rate and the tournament can stem from the introduction of competition but also from the fact that the tournament compensation is more uncertain. To determine whether the differential response to competition is driven by gender differences in risk aversion, a random pay scheme was implemented where one of the 3 men and 3 women in each group was selected randomly, after the performance, to receive a payment similar to the tournament payment of $3 for every maze solved. The payment for everyone else was zero. If gender differences in risk aversion played a substantial role, we would expect the random pay treatment to generate gender differences in performance as well.[3] In contrast, Figure 1 shows that average performance is similar to the one in the piece rate.

A final treatment examines performance in single sex tournaments, with 6 men or 6 women in each group. In this case both men and women improve their performance compared to non-competitive incentive schemes. Hence, it is not the case that women are generally unwilling or unable to perform well in competitions. [4] The gender gap in mean performance is 1.7 in the single-sex tournament and 1.5 in both the piece rate and the random-pay treatment. Instead the gender gap is 4.2 in the mixed-sex tournaments, which is significantly higher than in the single-sex tournaments, as well as in the other treatments. Thus, it is not that women cannot compete, but rather that they do not compete well in competitions against men. In fact, if the tournaments

[3] Eckel and Grossman (2008) summarize the experimental literature in economics and conclude that women exhibit greater risk aversion in choices, see also Croson and Gneezy (2009). A summary of the psychology literature is presented by Byrnes, Miller and Shafer (1999). They provide a meta-analysis of 150 risk experiments, and demonstrate that while women in some situations are significantly more averse to risk, many studies find no gender difference.

[4] Gneezy and Rustichini (2004) document results in 40 meter running “competitions” among 10 year olds. Children first run 40 meters separately, and are then paired with the two fastest kids competing against one another and so on. They find no initial gender difference in speed. However, in general boys win the competition against girls, whether the girl was initially slower or faster. In homogenous groups, the winner is about as often the faster or slower kid.

were run only in single sex groups, then one may falsely conclude that men and women have similar responses to competition.

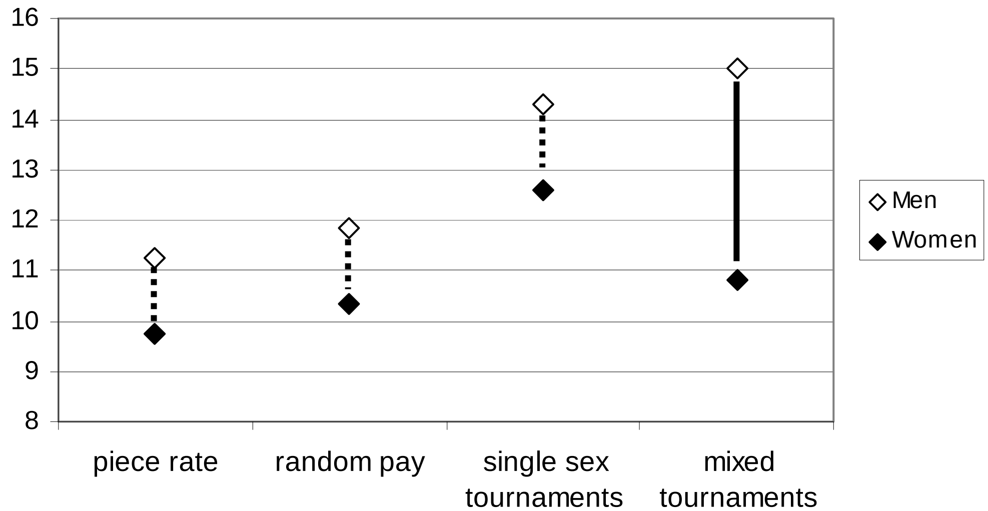


Figure 1
Average performance of 30 men and 30 women in each treatment

II.B. Entering Competitions

Gender differences in attitudes toward competition may not only influence performance in competitive environments, but perhaps more importantly may also affect the decision to enter competitions. If women are uncomfortable performing in a competitive setting then they may be less likely to place themselves in one.

Niederle and Vesterlund (2007) examine whether men and women differ in their willingness to enter a mixed-sex competition. We asked 40 men and 40 women to add up sets of five 2-digit numbers for five minutes under different compensation schemes.[5] Participants were paid for their performance which was measured in each task by the number of correctly solved problems. Participants were not informed of the performance by anyone else until the end of the study, and were told of each compensation scheme only immediately before performing the task.

Participants first perform the task under a non-competitive piece rate where they received 50 cents per correctly solved problem. Subsequently they perform in tournaments of two men and two women. While gender was never mentioned during the experiment, individuals could see their competitors and determine the gender composition of the group. Only the person with the largest number of correctly solved problems was paid and received $2 per correct problem. The other members of the group received no payment. We found no gender differences in

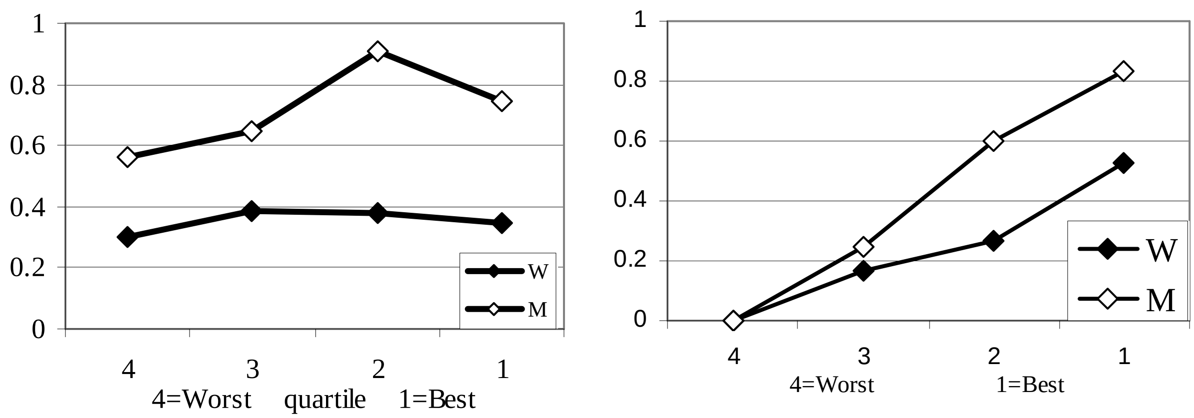
[5] At the end of the experiment we randomly selected one performance to count for payment. The program was written using the software zTree (Fischbacher, 2007).

performance under either of these two compensations. Thus for this very short task of simple math problems men and women did not differ in their ability to compete in mixed sex groups. In fact, for this task, incentives do not seem to have a large impact on performance.

Having experienced both the piece rate and the tournament, participants were asked which of the two compensation schemes they would prefer for their performance on a subsequent 5-minute addition task. To secure that the individual's choice only depends on the participant's beliefs on relative performance, we designed the choice as an individual decision. Specifically, a participant who selected the tournament would win if his or her subsequent performance exceeded the previous competitive performance of the three other group members.

Given the lack of a gender gap in performance, maximization of earnings predicts no gender difference in choice of compensation scheme. However, the majority of men select the tournament and the majority of women select the piece rate. 73 percent of the men and 35 percent of the women enter the tournament. [6]

Figure 2A shows, for each initial tournament performance quartile, the proportion of participants who enter the subsequent tournament. Neither the tournament-entry decisions of men nor those of women are very sensitive to the individual's performance, and independent of the performance quartile, men are much more likely to enter the tournament. The worst performing men enter the tournament more than the best performing women.



Panel A: Conditional on Initial Tournament Performance Quartile

Panel B: Conditional on Believed Performance Rank in Initial Tournament

Figure 2: Proportion Selecting Tournament

[6] Niederle, Segal and Vesterlund (2008) and Dargnies (2009) examine slight modifications to the above design and fully replicate the gender gap in competitive entry. A gender gap in willingness to compete has also been documented by Cason, Masters and Sheremeta (2008), Gneezy and Rustichini (2005), and Gupta, Poulsen and Villeval (2005). Interestingly, Gneezy, Leonard, and List (2008) replicate these finding from the western world in a patriarchal society, but not in a matrilineal one.

To study the impact of beliefs about relative performance, participants were asked to rank their performance in the initial tournament. A correct guess was rewarded by $1. We find that 75 percent of men compared to 43 percent of women guessed that they were the best in their group of four. While both women and men are overconfident, men are more overconfident than women. Figure 2B shows that beliefs predict tournament entry for both men and women, though a substantial gender gap in entry remains. Among those who reported that they thought they were best in their group of four, 80 percent of men enter the tournament compared to only 50 percent of women. This 30 percentage point gender gap in tournament entry remains among those who thought they were second out of four. With 84 percent of participants reporting that they were ranked first or second, it follows that there is a substantial gender gap in competitive entry even conditional on beliefs. Regressions confirm this result when controlling for both performance and beliefs.

Other possible reasons for the different compensation choices by men and women may be that they differ in their attitudes toward risk and feedback on relative performance. The compensation scheme associated with the tournament is more risky and results in the participant receiving feedback on relative performance. In our study we find little evidence that these factors play a role in explaining gender differences in tournament entry. Having controlled for the effects of beliefs, risk and feedback aversion a substantial and significant gender difference remains in tournament entry.[7] We attribute this remaining difference to men and women differing in their attitude towards placing themselves in environments where they have to compete against others.

While women shy away from competition, men appear to embrace it. A consequence is that from a payoff-maximizing perspective too few high performing women and too many low performing men enter the tournament. Thus by selection alone we find very few women succeeding in and winning the tournament.

[7] Instead of directly controlling for risk and feedback aversion, participants make a decision between two incentives schemes which mimics both the payment uncertainty and the provision of feedback in a choice between a piece rate and a competition, without any actual competition taking place. In a final task, participants decide whether they want to apply the piece rate or tournament incentive scheme to their initial piece rate performance. The choice of tournament results in payment only if the participant's piece rate performance exceeds that of the three other members of the group. This choice mimics the first compensation choice, while eliminating the requirement of a subsequent tournament performance. This approach is reminiscent of the choice in Gneezy, Niederle and Rustichini (2003) where the random pay treatment induced risk similar to the competitive payment scheme while eliminating the competitive component. The evidence on the extent to which gender differences in tournament entry is explained by gender differences in risk attitudes is mixed (e.g., Cason, Masters and Sheremeta, 2009, Gupta, Poulsen and Villeval, 2005, Dohmen and Falk, 2006).

II. C. Summary

The studies showed that in mixed sex environments where there appear to be no or small gender differences in ability, men nonetheless outperform women in competitions, and more frequently select a competitive compensation. We can draw a strong parallel between the two research findings by interpreting the lower performance of women in the mixed-sex tournaments in Gneezy, Niederle and Rustichini (2003) as women choosing not to compete. Note that the high female performance in the single sex tournament certainly shows that it is possible for women to perform well in competitions. However, the results of both studies suggest that women may not perform to their maximal ability in the mixed-sex competition.

III. DO TEST SCORES REFLECT ABILITY?

While test scores traditionally were thought to measure an individual's cognitive ability, researchers have come to recognize that test scores are influenced by cognitive as well as non-cognitive abilities (e.g., Cunha and Heckman, 2007, Segal, 2008). In particular, non-cognitive factors such as motivation, drive, and obedience may not only affect an individual's investments in cognitive skills, but also his or her test score performance. In a nice demonstration of the effect of incentives on performance, Gneezy and Rustichini (2000) have participants solve a 20-minute IQ test under varying incentive schemes. They show that performance is lower when individuals are given a low piece rate per correct answer, rather than a high piece rate or even zero payment. This suggests that students who have similar cognitive skills may receive different test scores if they face different incentives associated with a high performance.

A specific non-cognitive skill which may influence test scores is an individual's response to competitive pressure. If the effect were merely a level effect then there would be no need for concern. However, the studies described above show that men and women differ in their response to competitive pressure. Thus we need to use caution when using test scores to make inferences on gender differences in cognitive skills. The specific format of a test may result in gender differences in test scores that need not reflect the magnitude or the direction of gender differences in cognitive ability.

Örs, Palomino and Peyrache (2008) elegantly show the relevance of this point in practice. They examine the performance of women and men in an entry exam to a very selective French business school (HEC) to determine the extent to which the observed gender differences in test scores reflect differential responses to competitive environments rather than differences in actual ability. The entry exam is very competitive, only about 13 percent of candidates are accepted. The results of this exam show that males have higher means and fatter tails than females. This gender gap in performance is compared both to the outcome of the national high school exam, and, for admitted students, to their performance in the first year. While both of these performances are measured in stressful environments, they are much less competitive than the entry exam. The performance of women is found to first-order stochastically dominate that of men, both on the high school exam, and during the first year at HEC. Specifically, females from the same cohort of candidates performed significantly better than males on the national high school graduation exam two years prior to sitting for the admission exam. Furthermore, among those admitted to the program they find that within the first year of the M.Sc. program females outperform males. They conclude that the changes in the gender gap result from men and women differing in their response to competition.[8]

Although no comparable study has been conducted in the US, Örs et al (2008) note that their results are consistent with the observation that female GPAs in both high school and college exceed those of males, when controlling for their SAT scores (e.g. Rothstein 2004).

The findings reported above suggest that caution be used when inferring ability from test scores. However, it still remains a question why this is more of an issue when looking at math rather than say verbal test scores, and why a potential bias in math may be exacerbated at the right tail of the distribution. We will argue that the reason why differential responses to competition may play a larger role in math performance is that gender differences in both confidence and attitudes towards competition are likely to be particularly large on competitive math tests.

III.A. Confidence

Research systematically shows that girls and boys with the same math test scores have very different assessments of their relative ability (e.g., Eccles, 1998). Conditional on math performance boys are more overconfident than girls, and this gender gap is greatest among gifted children (Preckel, Goetz, Pekrun and Kleine, 2008). An explanation for the gender gap in confidence is the strong gender stereotype that boys are better at math. This stereotype is further re-enforced by the fact that the fraction of male teachers in math-intensive courses is higher than

[8] The authors also control for explanations pertaining to risk aversion and specific test taking strategies. Specifically, they find that for each student the variance of grades across different subjects is not higher for male than female students. This excludes a difference in strategies whereby one focuses on a few items intensively rather than studying all items in each field equally. Furthermore, they show that the same differences arise when focusing separately on the math and non-math part of the exam.

for all other classes.[9] A second source through which stereotypes may affect beliefs is shown by Jacobs (1991) who found that mothers who endorsed a male-math stereotype underestimated their daughters' ability in math. These perceptions are particularly important for children as the child's self-evaluation of academic competency appears to be more strongly related to their parent's appraisals of their academic ability than to their actual academic performance.

A literature in psychology, called *stereotype threat theory*, has shown that that a strong stereotype may harm the stereotyped individual's performance on a task even if they do not believe the stereotype, but nonetheless fear confirming it. When presented with a particularly hard test in a subject where males are thought to excel, both men and women may fear failing, but women also fear confirming the negative stereotype. Women experience "stereotype threat" that is experience an additional source of anxiety while performing the task which may cause them to be more prone to "choke under pressure" (Steele, 1997). Spencer et al. (1999) show that stereotype threat can cause women to underperform on math tests and that the gender gap in scores may be removed by informing students prior to taking the test that "the math test had revealed no gender difference in the past." The effect of stereotype threat has been shown to be particularly large for participants who care about the subject of the test, thus it is likely to more strongly affect the test performance of women in the upper tail of the distribution.

The findings by Pope and Sydnor (this issue) are very much in line with stereotypes influencing test performance at the tail. Looking at US data they find large variation in the gender ratios of 8th graders scoring in the top 75th and 95th percentiles of the National Assessment of Educational Progress (NAEP). The test is taken by a sample of children in public schools. Consistent with beliefs influencing behavior they show that in regions where men and women are viewed as more equal there are smaller gender disparities in stereotypically male dominated tests of math and science.

The relationship between perception of women and the math performance gap has also been documented across OECD countries. Guiso, Monte, Sapienza, and Zingales (2008) use the 2003 Programme for International Student Assessment (PISA) evaluating 15-year-old students from 40 countries in identical tests in mathematics and reading. The tests were designed by the OECD to be free of cultural biases. They use several measures for the gender equality of a country, including the World Economic Forum's Gender Gap Index (GGI) (Hausman, Tyson and

[9] Dee (2007) and Carrell, Page, and West (2009) both study the effect of a teachers gender on performance. Having a female math or science teacher improves the female math and science performances, and the effect is particularly large for the gifted female students.

Zahidi, 2006). In countries that score highly on gender equality they find a smaller gender gap in mean math performance as well as in the tail of the distribution.

Looking at the very highest performing women in mathematics, Hyde and Mertz (2009) examine the proportion of women among delegates at the International Mathematical Olympiad (IMO) in the last two decades, for countries that achieved a median rank among the top 30 in recent years. The proportion of women in a countries' IMO team is not correlated with median team rank. However, they find a positive correlation between the percentage of girls in a country's IMO team during the past two decades and its 2007 GGI. To control for the fact that small countries may have more girls in the upper tail than large countries, they also show that there is no correlation between the percentage of girls in the IMO team and the percentage of the world population of that country.

The strong stereotype of male superior math performance may influence the confidence of females and affect their performance on math tests. This effect is likely to be exacerbated for those at the tail of the distribution for whom the fear of confirming the stereotype is particularly large.

III.B. Attitudes towards competition

Why might gender differences in competitive attitudes be more of an issue on math tests? One reason is that more boys select math intensive majors, which in turn increases the fraction of relevant male competitors on math tests relative to that on say verbal tests. As shown by Gneezy et al. (2003) a woman's competitive performance is sensitive to the gender of her competitors. While women succeed when competing in all female groups, this is not the case in mixed-sex groups. To parse the various effects of the gender composition of competitors, Niederle, Segal and Vesterlund (2009) extend the original Niederle and Vesterlund (2007) study. The initial finding that gender differences in confidence and attitudes toward competition help explain tournament entry, led us to examine the compensation choices of men and women in an affirmative-action tournament, where for every two winners we require that at least one winner must be a woman. Such a requirement not only increases the probability that women will win the tournament, it also makes the competition more gender specific. In the affirmative-action tournament a woman will win the competition if she is either the best performing woman or has the second highest performance in the group, a man on the other hand will have to both be the best performing man and have the second highest performance in the group.

More gender specific competitions may affect the decision to enter a tournament since both the gender gap in beliefs as well as in attitudes to competition could be smaller in more gender specific competitions. If women are more comfortable competing against women this may influence their compensation choices.

Participants in the experiment compete in groups of three men and three women. They are presented with two different compensation choices. In the standard tournament choice they choose between a 50-cent piece rate and a tournament where the two participants with the largest number of correctly solved problems each will be paid $1.5 per correctly solved problem and the remaining four members will receive no payment. In the second choice participants instead choose between a 50-cent piece rate and a $1.5 affirmative-action tournament. The two winners of the affirmative-action tournament are the highest performing woman, and the highest performer of the remaining five members of the group.

Our study shows that when women are guaranteed equal representation among winners, more women and fewer men enter competitions and the change exceeds that predicted by the changes in the probability of winning that result from the introduction of affirmative action. The excessive response is explained by changes in beliefs on rank and attitudes toward competition. Specifically men are less over confident and women less reluctant to compete in groups where their own gender is better represented.

The sensitivity to gender composition is also shown by Huguet and Regner (2007). When girls are led to believe that a task measures math ability then they are found to underperform in mixed-sex groups, but not in all-female groups.

The reported studies suggest that a woman's performance and willingness to compete is sensitive to the gender of those she is competing with. If a large fraction of competitors on math tests are male, then gender differences in attitudes towards competition may play a particularly large role, and this effect may be exacerbated at the more male dominated upper tail. This argument is in line with the finding that girls perform better in regions that perceive boys and girls to be more equal (Pope and Sydnor, this issue, Guiso et al., 2008).

IV. CONCLUSIONS

A series of studies have shown that males and females differ in their response to competition. We have argued that such gender differences may cause test scores to magnify and potentially distort underlying gender differences in ability. In light of the role played by beliefs on relative performance and women's sensitivity to competition against men, these factors may be particularly important when assessing ability in mathematics.

So far we have focused on explaining how a differential response to competition may distort test scores relative to the student's present ability. However, such differences are also likely to influence the investment in and selection into male dominated or math intensive fields where there are strong stereotypes on female inabilities. If educational investments vary by gender, and these influence a student's preparedness when taking the test, then it is unlikely that a gender gap in test scores solely reflect gender differences in innate ability (see Cunha and Heckman, 2007).

When studying math investments at the high school level, there is however little evidence that girls on average invest less in math than boys. Goldin et al. (2007) show that girls and boys take advanced math classes at similar rates. Furthermore, Guiso et al (2008) find that if anything girls spend more time on math homework than boys. While these studies demonstrate that on average there are no gender differences in math skill investments, it would be of interest to determine whether the same holds at the upper tail of the distribution.[10]

Advocates for single-sex education have long been arguing that the gender composition in the class room can influence a girl's investment in both math and science. Due to problems of self-selection, that literature remains however, somewhat inconclusive (e.g., Campbell and Sanders, 2002).[11]

Although gender differences in investments are not easy to detect at the high school level there are substantial differences at the college level. However, these differences need not reflect underlying differences in ability. For example, in an experiment using Stanford undergraduates, Niederle and Yestrumskas (2008) show that men select a challenging over an easy task 50 percent more often than women, even when controlling for ability, and beliefs about one's ability. Lefevre et al (1992) and Weinberger(2005) show that among equally gifted students males are many more times likely to select college majors that are considered to be high in math content. In addition the drop-out rate for these majors is much greater for women. While many factors may influence these choices it is informative to examine the way in which women perceive the environment. A report entitled "Women's Experiences in College Engineering" writes that the

[10] Pope and Sydnor (this issue) find that states that have smaller gender disparities in stereotypically male dominated tests of math and science also have smaller disparities in stereotypically female-dominated tests of reading (among children in public schools). Furthermore, both of these variations are correlated with cultural gender attitudes. They conclude that gender differences in math performance are "more likely to stem from stereotyping and the imposition of gender roles, than from broadly better treatment of one sex over the other". Thus, performance differences between boys and girls do not seem to be driven by a preference for or greater return to educational investments by children of a particular gender. However, when looking at data across OECD countries, as opposed to areas across the US, Guiso et al. (2008) find that test scores in math and reading are positively correlated, and that in more gender-equal societies girls perform as well as boys in mathematics and much better than them in reading, compared to countries that are less gender-equal.

[11] Booth and Nolen (2009) examine tournament-entry decision by boys and girls in mixed- or single-sex schools. Their findings suggest that girls from selective single-sex schools are more likely to enter competitions against boys than girls from non-selective mixed-sex schools.

exit of many young women is not driven by ability, but rather that this decision is influenced by women negatively interpreting their grades and having low self-confidence. Furthermore these women mention that negative aspects of their schools' climate, such as competition, lack of support and discouraging faculty and peers, cause them to reevaluate their field of study (Goodman, Cunningham, and Lachapelle, 2002, and Felder et al., 1995, find similar effects).

In conclusion, gender differences in mathematics test scores may not reflect gender differences in mathematical ability. Furthermore, potential gender differences in mathematical ability may not be the most important factor when determining differences in educational and occupational choices between women and men.

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