Where are the Bottlenecks in STEM Majors & Careers in the US?

For Presentation at:

Improving the Diversity of STEMM Talents: K-12 Programmes

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Introduction

- Why are women under-represented in STEM (Science, Technology, Engineering & Math) Majors and Careers?
- Several potential explanations for differences in Majors:
  - Mathematical Ability and/or coursework
  - Interest in STEM subjects
  - Gender bias
- And Careers:
  - Biased evaluation
  - Productivity & Opting out

Introduction

aps
PSYCHOLOGICAL SCIENCE

Women in Academic Science: A Changing Landscape

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Psychological Science in the Public Interest
2014, Vol. 15(3) 75–141
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DOI: 10.1177/1529100614541236
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Overview

- Presenting results from our paper with an emphasis on K-12 bottlenecks
- Examine propensity to study science & mathematics in high school, college and graduate school
- Offer insights from the literature
- Bottom line: Differences in STEM careers start well before college and are related to mathematics coursework in middle & high school.

Organizing Principles

- Grouping all science as STEM is problematic—each discipline has different requirements and features different rates of gender equality.
- What may be true in the US may not be true in other parts of the world.
  - Institutions and cultural attitudes may strongly influence gender differences in STEM careers outside of the US

Organizing Principles

- The Bad News:
  - Difficult to generalize results from one discipline to others;
  - Difficult to generalize results from one country to another.
- The Good News:
  - More research across disciplines, countries and cultures is warranted.

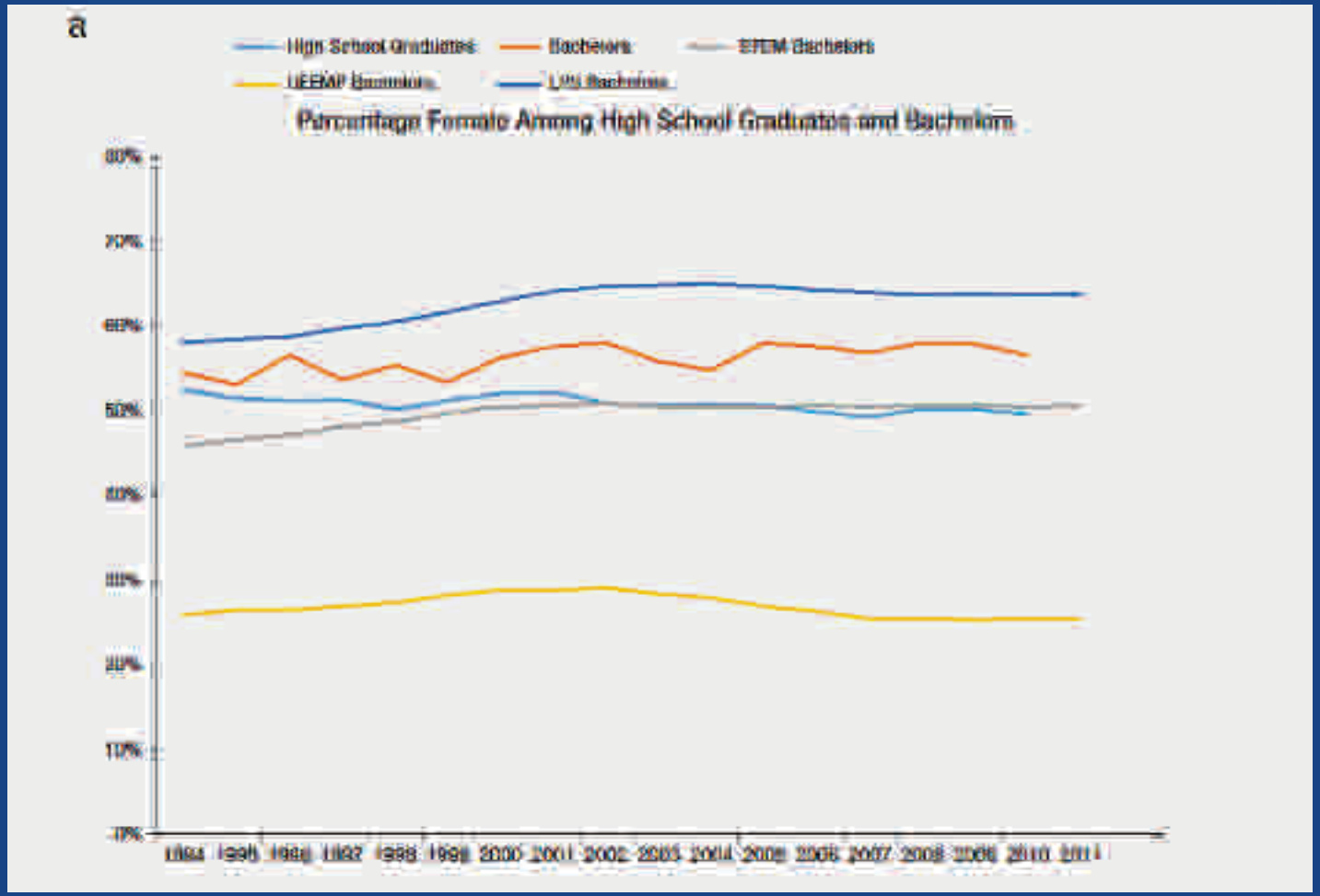
Research Question

- What leads to gender differences in STEM interests and majors?
- When does this occur in the education-workforce continuum?
  - K-12
  - College
  - Graduate School
- Timing will inform interventions

Research Question

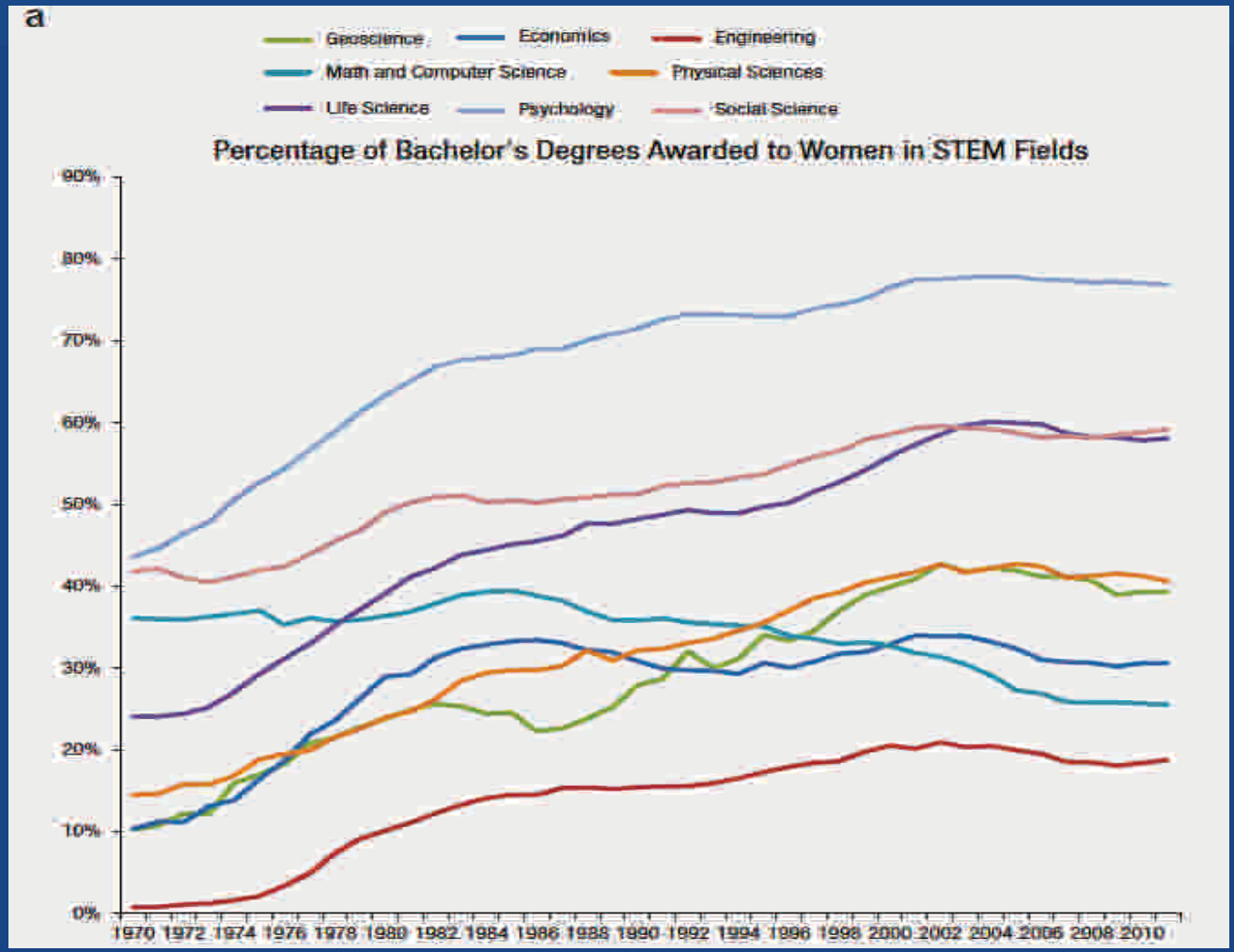
- Data on gender differences in STEM:
  - LPS—Life Science, Psychology & Social Science (excluding Economics)
  - GEEMP—Geoscience, Economics, Engineering, Math & Computer Science & Physical Sciences
- Data Sources:
  - College Majors & PhDs—National Science Foundation
  - Test Scores—College Board

Gender & College Majors



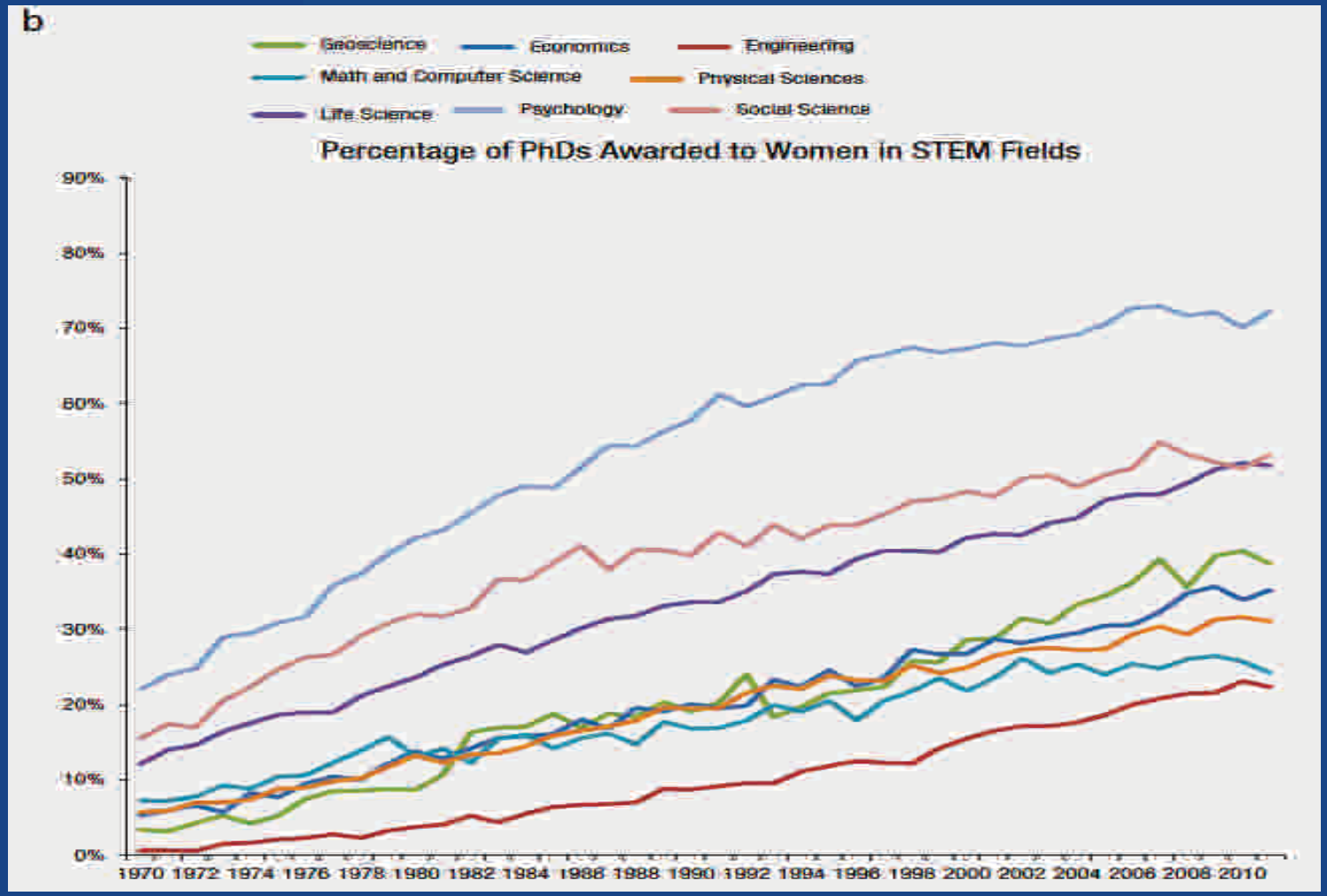
Girls receive 50% of high school diplomas; 55% of bachelor's degrees and 50% of STEM degrees. However, this is driven by LPS. Girls receive less than 30% of GEEMP degrees.

Gender & Undergraduate Major



With the exception of Math & Computer Science, the percentage of bachelor's degrees awarded to women has increased steadily.

Gender & PhDs



Women have increased their representation among PhDs across all disciplines.

What Explains the Gender Gap in Math-Intensive Fields?

- Prenatal/postnatal hormones
- Young adult differences in mathematics ability/coursework
- Stereotype Threat
- Competition
- Bias

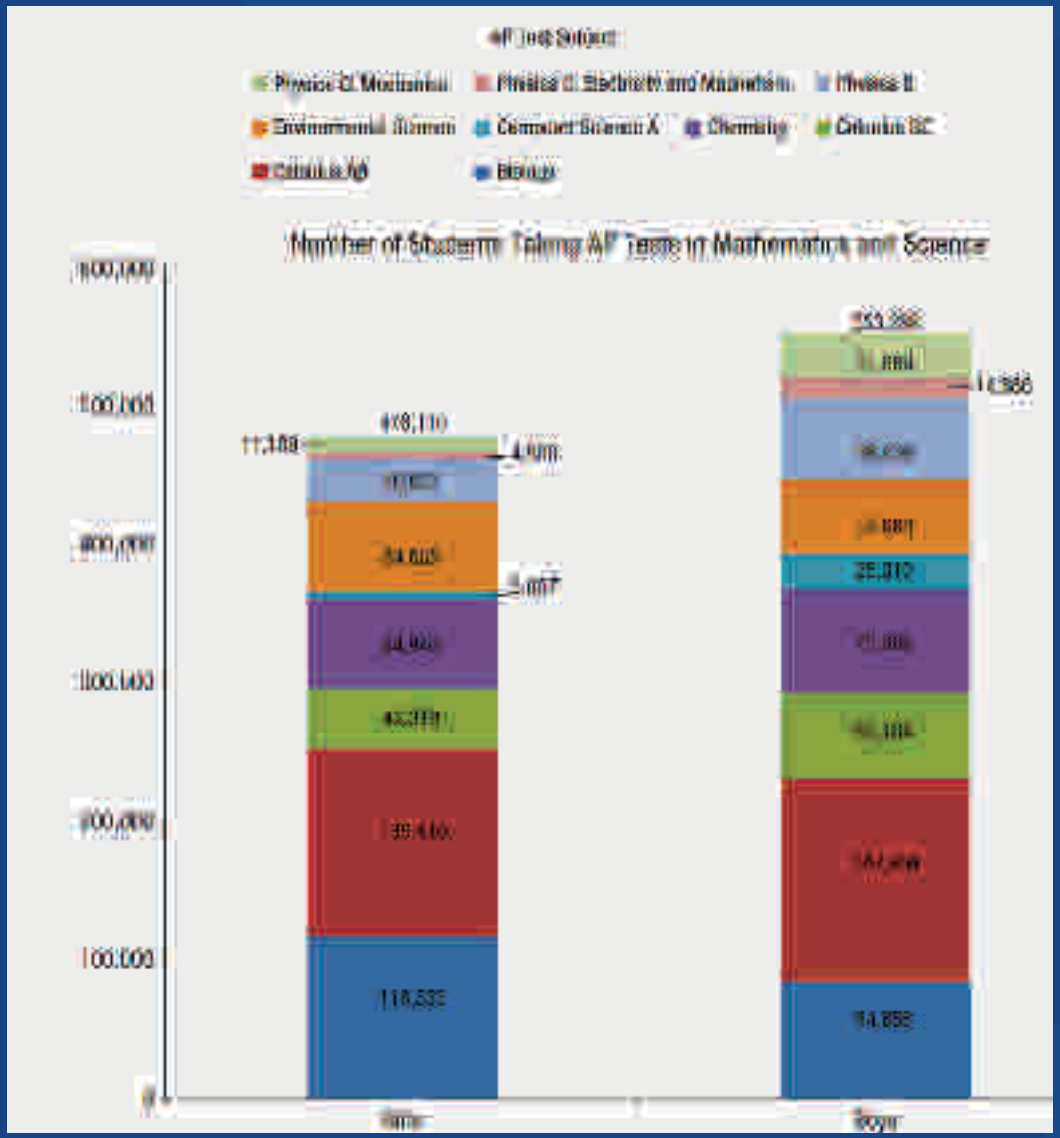
What Explains the Gender Gap in Math-Intensive Fields?

- Prenatal/postnatal hormones
  - Several studies that examine spatial orientation, early crawling and mathematical aptitude.
  - Mixed results
- For the sake of argument & this presentation—assume no genetic differences in average aptitude.

What Explains the Gender Gap in Math-Intensive Fields?

Girls take fewer math courses and have lower math test scores.

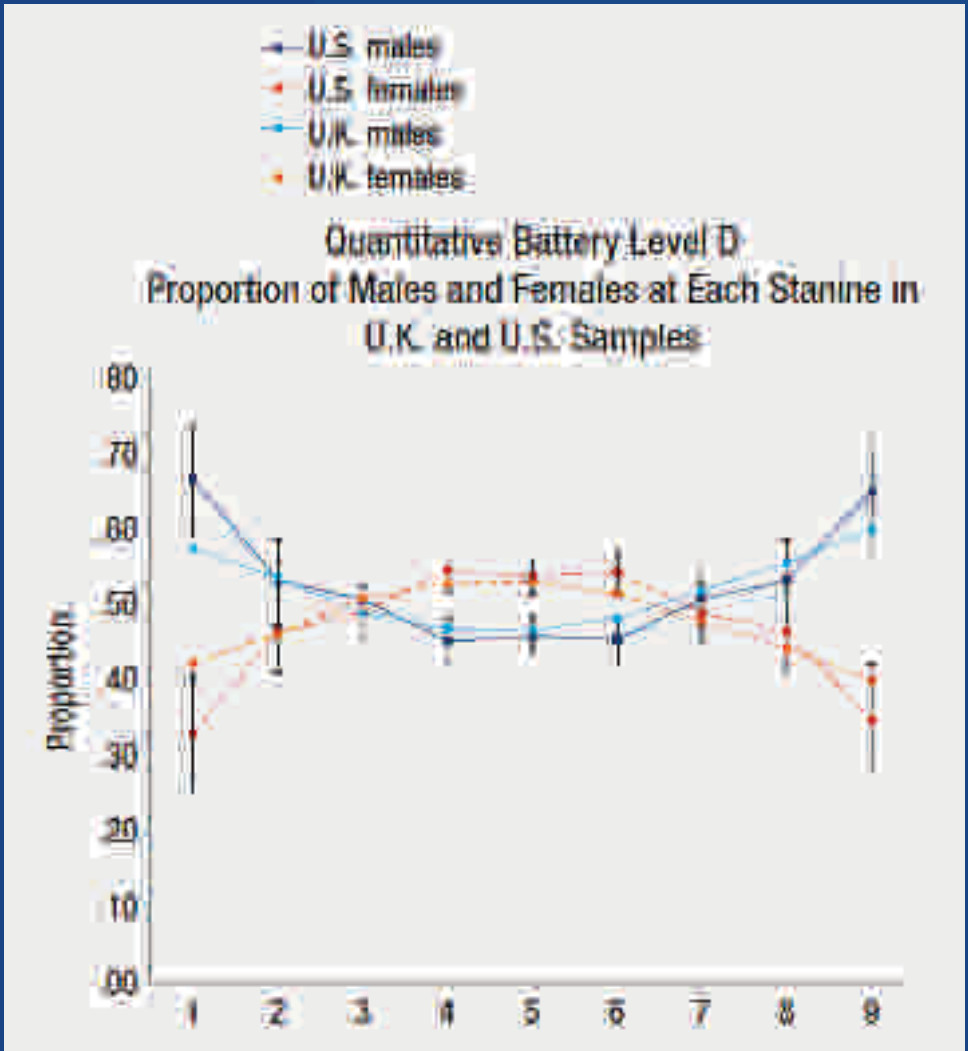
Girls Less Likely to Take Math-Intensive Advanced Placement Exams



75,178 fewer girls take AP exams in STEM.

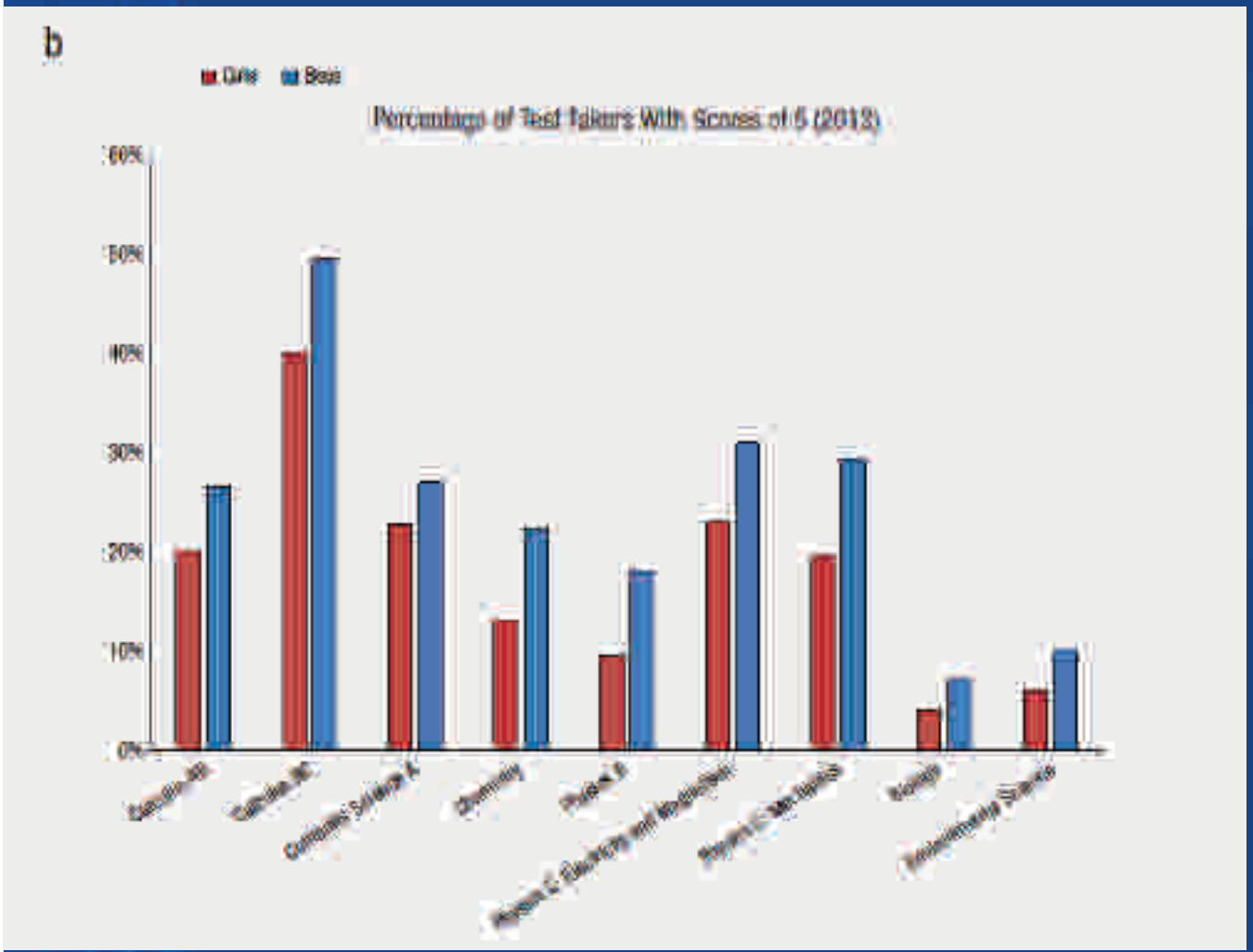
This gap can be fully explained by fewer girls taking the Calculus, Computer Science & Physics exams.

Girls Less Likely to Score in the Right Tail of the Math Distribution



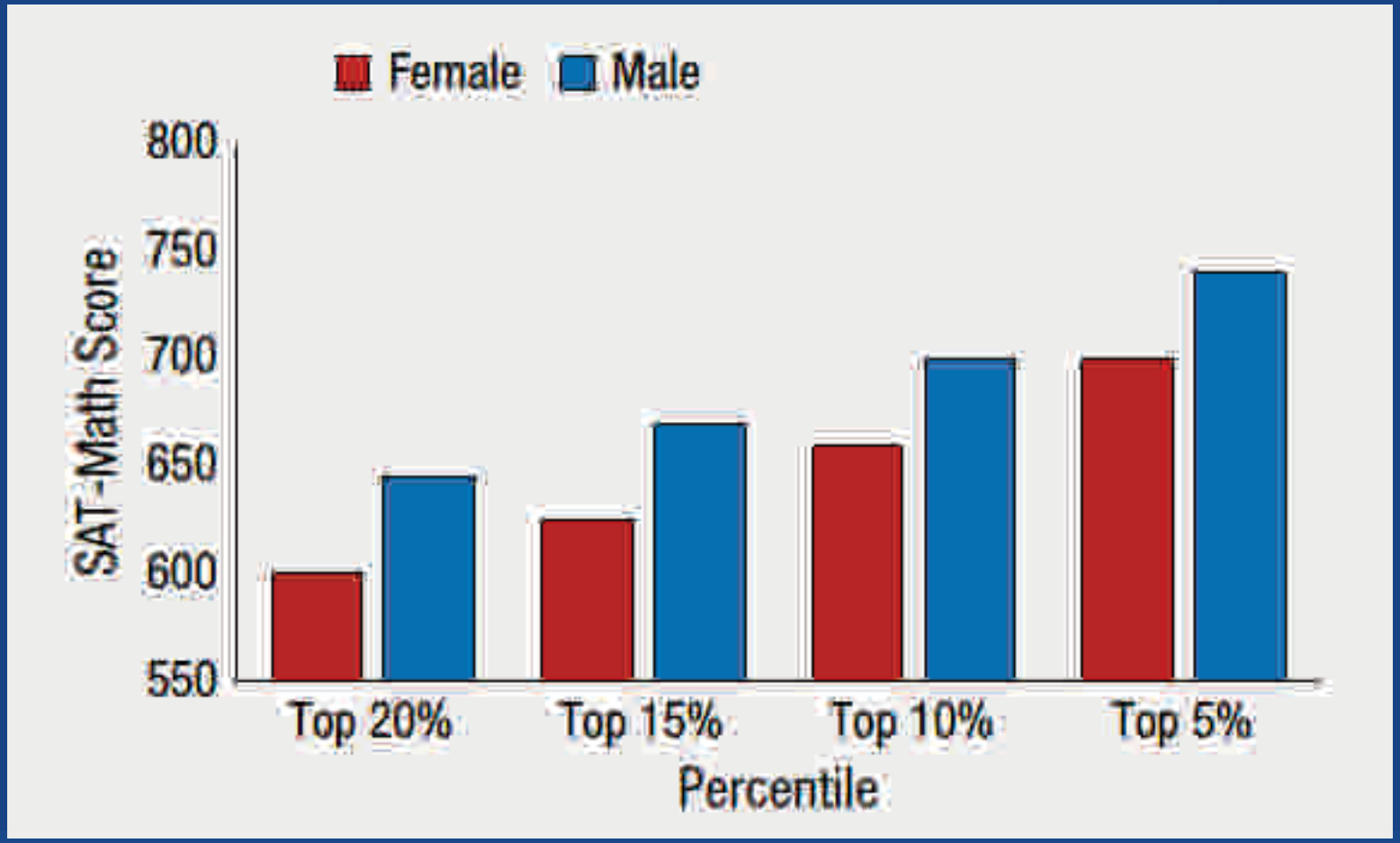
US and UK Girls are less likely to appear in the left and right tails of the math score distribution.

Girls Less Likely to Score in the Right Tail on STEM AP Exams



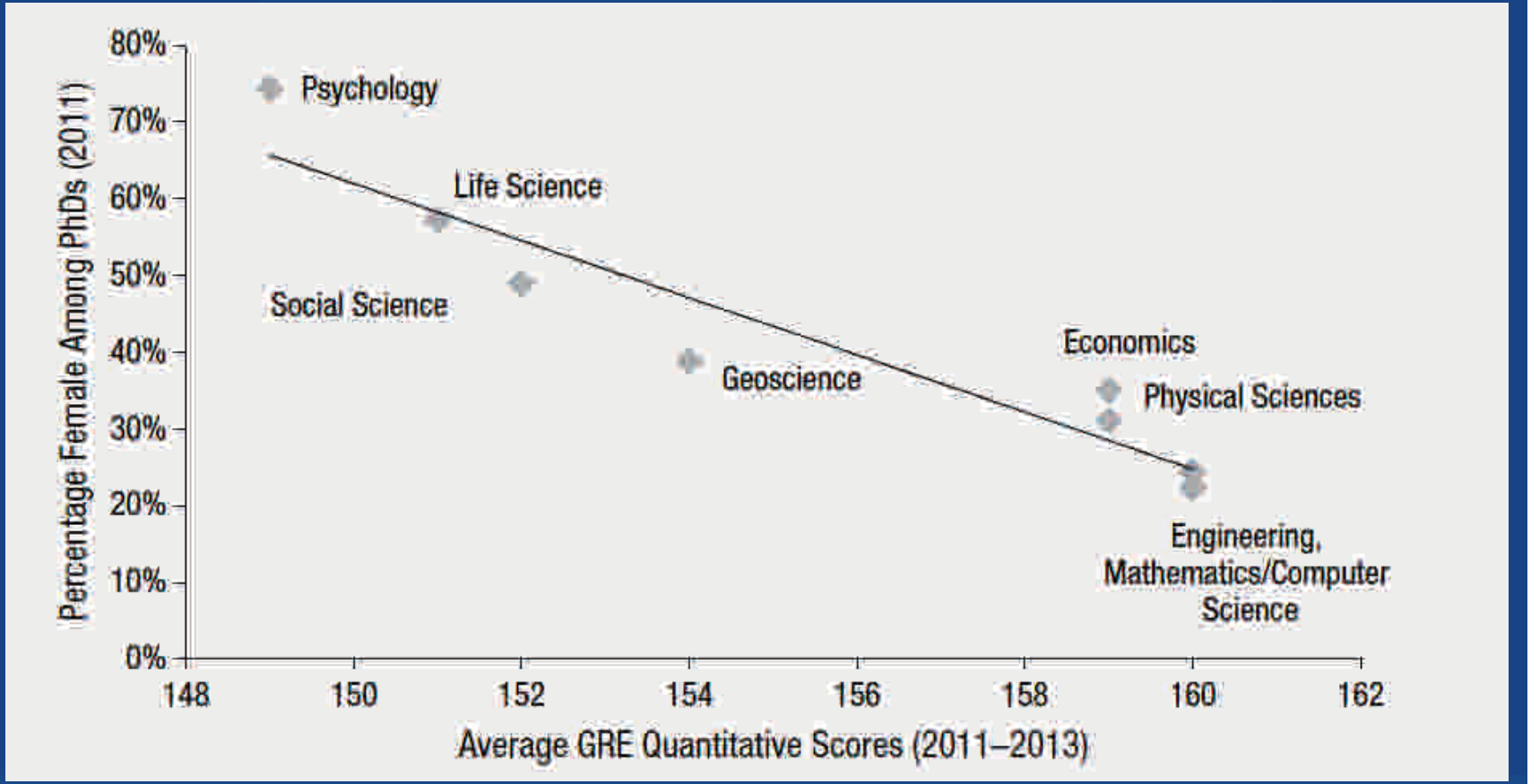
Boys are more likely to receive the top score (5) on all AP STEM exams than girls.

Girls Less Likely to Score in the Top Percentiles of the SAT Exam



The Top Percentiles of Boys have higher SAT Math Scores than the Top Percentiles of Girls

Mathematics Requirements Correlated with Percentage of Female PhDs



Females significantly less likely to obtain PhDs in fields with higher average GRE Quantitative scores.

US Math Facts

- Gender Differences in mathematics achievement emerge in middle school (AAUW 2010)
- Boys are more likely to indicate that they are good at math (Starkey et. al. 2008) and these differences grow larger in high school (AAUW)
- Girls less likely to take Advanced Placement Math-Intensive tests.
- Gender differences in the right tail of mathematics tests are larger
- Math is required to obtain an undergraduate major & PhD in GEEMP courses.

Why Do Fewer Girls Perform Well in Math?

- Stereotype Threat (Claude Steele)
  - Awareness that others expect girls to do poorly in math is sufficient to create anxiety and poor performance.
- Girls Don't Compete (Muriel Niederle & Lise Vesterlund 2010)
  - Girls perform better when competing against other girls & worse where boys outnumber the girls.

Why Do Fewer Girls Perform Well in Math?

- Gender Norms (Devin Pope & J.R. Sydnor 2010)
  - Wide variation in US NAEP Math & Reading Scores across states. In states with more gender equality (e.g. New England) the gender math gap in the right tail is much narrower than in Southern states with more traditional gender norms.

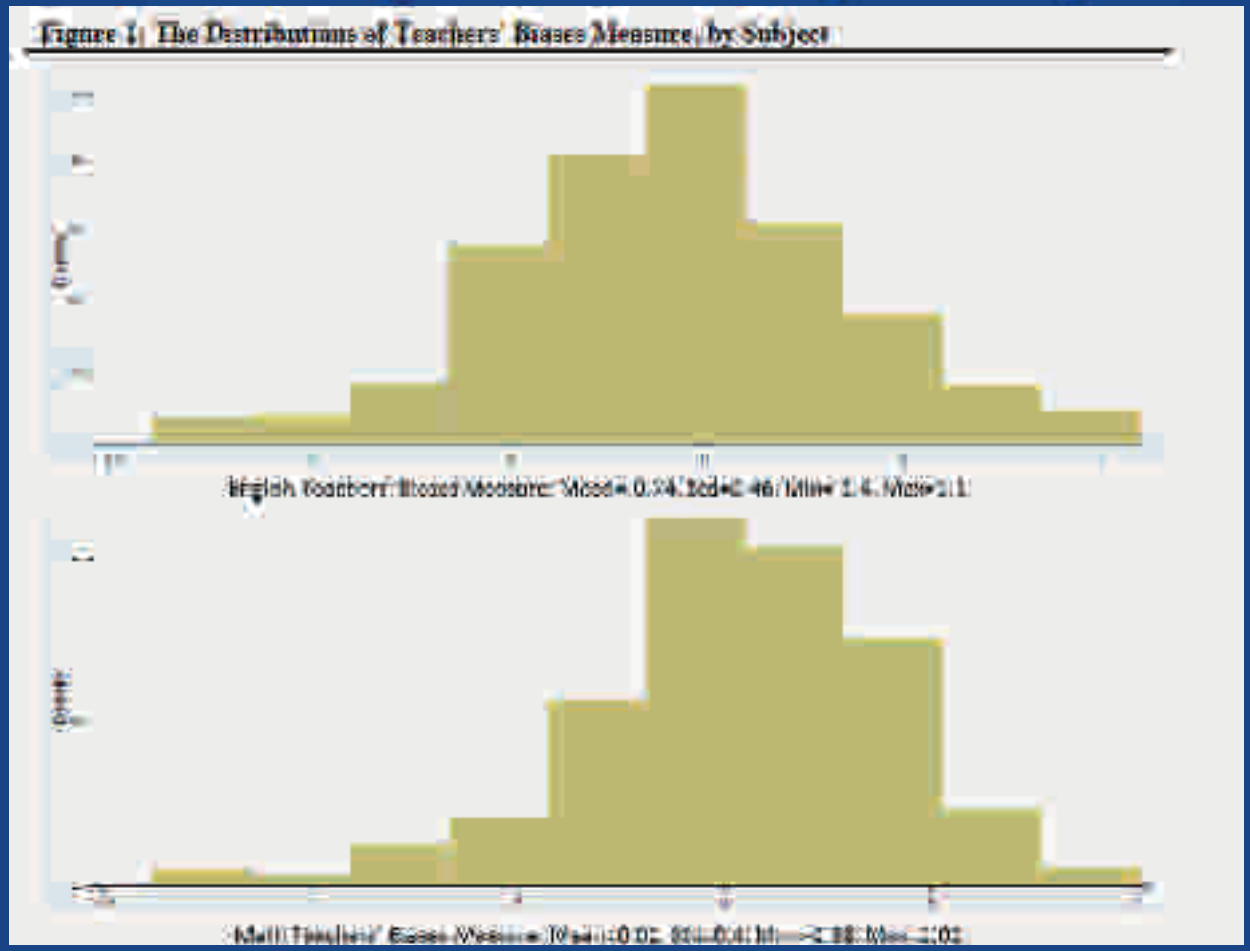
Why Do Fewer Girls Perform Well in Math?

- Teacher's Stereotypical Biases (Lavy & Sand 2015)
- Study based on Israeli schools—
  - Children randomly assigned to teachers
  - Bias identified as the difference in how boys and girls are graded by their teachers and boys' and girls' performance on a "blinded" national exam

Teacher's Stereotypical Biases: Lavy & Sand (2015)

- Grading bias often stereotypical:
  - Girls were favored in English and Hebrew on average
  - Boys favored in mathematics

Teacher's Stereotypical Biases: Lavy & Sand (2015)



English teachers are biased in favor of girls. Little evidence of bias at the mean for math teachers, however, right tail shows significant bias in favor of boys in mathematics.

Teacher's Stereotypical Biases: Lavy & Sand (2015)

"Our results suggest that teachers' biases favoring boys have an asymmetric effect by gender— positive effect on boys' achievements and negative effect on girls'. Such gender biases also impact students' enrollment in advanced level math courses in high school—boys positively and girls negatively. These results suggest that teachers' biased behavior at early stage of schooling have long run implications for occupational choices and earnings at adulthood, because enrollment in advanced courses in math and science in high school is a prerequisite for post-secondary schooling in engineering, computer science and so on."

Why Do Fewer Girls Perform Well in Math?

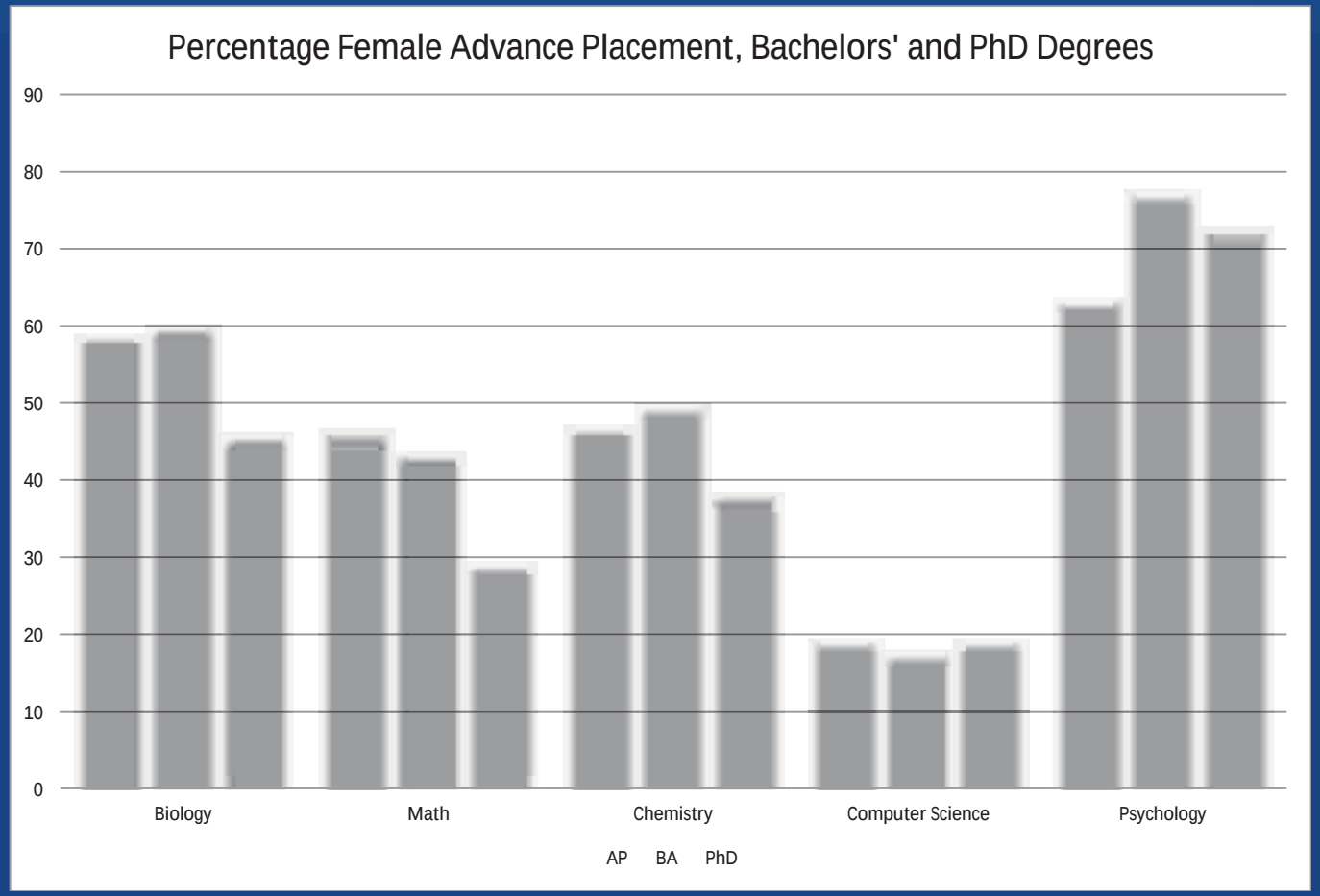
"Square Root of Kids' Math Anxiety: Their Parents' Help" August 24, 2015 ***The New York Times***

- Maloney et. al. (2015) report that math-anxious parents perpetuate math-anxiety in their children if parents help with homework.
  - Evidence of intergenerational transmission of math anxiety.

Why do Fewer Girls Perform Well in Math?

- Myriad reasons: The gender gap in K-12 Mathematics Performance is **Over-Identified.**
- Ceci, Ginther, Kahn and Williams (2014) conclude: Mathematics coursework and performance starting as early as middle school sets girls on different career paths than boys.
- K-12 Mathematical Experiences shape subsequent careers

Relationship between AP, Bachelors' and PhD Degrees



Practically 1:1 correspondence between percentage of girls taking AP exams in course and percentage of Bachelors' degrees awarded.

Conclusions

Girls lag behind boys in mathematics interest and performance in the right tail.

Conclusions

- Evidence that stereotype threat, gender norms, competition, teachers' bias and parental attitudes towards math affect girls' mathematical achievements
- K-12 Mathematics coursework is critically important to pursuing a degree in math-intensive GEEMP fields.
  - Differences happen in K-12 and need to be addressed in K-12

Implications for Gender Differences in GEEMP Careers

Early Intervention to encourage math achievement is key.

As early as elementary school!

Implications for Gender Differences in GEEMP Careers

- Role Model effects are important in college major choice (Carrell, Page & West 2010)
  - We need more women in Academic STEM careers if we want to have more women in STEM
- The teaching of mathematics may dissuade girls from taking additional math coursework.


Thank You
Mahalo
Kiitos
Tack
Toda
Grazie
Obrigado
Thanks
Takk
Gracias
Merci