The gender gap in mathematics self-assessment: evidence from twins

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Introduction

- Across a range of countries, contexts, and domains, men have been found to exhibit higher degrees of confidence in their ability than women (Briel et al. 2021; Reuben, Sapienza, and Zingales 2015).

- Especially true for STEM subjects and mathematics
  - Not only do girls assess their mathematics ability lower than boys, but this contributes to later gender gaps in math performance (Bharadwaj et al. 2016).
  - The confidence gap also contributes to the gender pay gap within STEM jobs (Sterling et al. 2020)

- The gender gap in math performance has received much scholarly attention
  - It emerges in school: zero when kids enter school, gradually grows (Fryer and Levitt 2010; Penner and Paret 2008) and stays relatively small on avg (0.05-0.11 SD) throughout high school (Kahn and Ginther 2017)
  - Cultural beliefs and gender (in)equality plays a large role (Nollenberger et al. 2016) in math performance, as well as preferences about competition (Niederle and Vesterlund 2010) and math anxiety (Zhang et al. 2019)
Self-assessed math ability (SAMA) and gender

- We know much less about why the gender gap in self-assessed math ability (SAMA) emerges
  - Students’ attitudes toward mathematics are influenced substantially by their parents’ perceptions of the difficulty and usefulness of math (Eccles and Jacob 1986)
  - Learning environment matters (Quinn, 2021): clarity of assessment criteria, teacher support, students involvement
  - Women assess their abilities below men’s because of stereotyped gender identities, ”stereotype threat” (Steele and Aronson 1995).
Our contribution to the literature

- First, we show that the gender gap in SAMA persists even after controlling for math grades given by teachers, math test scores, measures of verbal and non-verbal cognitive abilities, birth order, birth weight and twin fixed effects, i.e. shared genetic and environmental background. Objective skills only explain 14-26% of the gender gap in SAMA.

- Second, we show that the gender gap in SAMA is even higher among opposite-sex twins than among non-related boys and girls.

- Third, we test three potential channels
  - parental assessments (explains a further 23% of the gender gap)
  - gender roles in the home (no effect)
  - within-twin peer effects (no effect)
Data

- We use data on twins born in the UK from the Twins Early Development Study (TEDS) (Rimfeld at al. 1998)

- Born in 1994-1996 in England and Wales

- TEDS collects rich longitudinal information on cognitive and non-cognitive skills, parental background and educational outcomes.

- Using data of twins allows us to control for shared genetic and parental backgrounds of boys and girls.

- Twin samples are not representative of the population, which might hinder the external validity of our results.

- (Usual problems: attrition, non-response)

- Our estimation sample includes those who have non-missing data for the variables we use at age 9 (4,309) and age 12 (3,923) (overlap: 899 obs)
Self-assessed math abilities

- Three survey questions taken at age 9 and 12. How good you think you are at
  - solving number and money problems.
  - doing Maths in your head.
  - multiplying and dividing.

- There are five ordinal answers to each: very good; quite good; doing OK; not so good; not good at all, coded from 1 to 5. The average of the three answers is provided in the data.

- Age 9: parental and teachers’ assessment

- Math liking scale (”How much do you like...”)
Objective math abilities

- Math levels. Teachers provided evaluations of students at age 9 and 12 according to National Curriculum levels (1 to 5) for three aspects of math: using and applying mathematics; number and algebra; shapes, space and Measures. Thus, the overall score goes from 3 to 15 and its standardized value is provided in the data.

- Math test scores. At age 12, study members also completed an Internet-based math test.
Control variables and potential channels

- Cognitive abilities: verbal skills and non-verbal cognitive skills at age 9 and 12.

- Whether individual i is the elder twin; whether individual i was born with higher weight; birth weight in grams.

- Having a male co-twin

- Having not-twin brothers, sisters

- Highest parental education in four categories

- Twin peer effects: whether individual had higher math level than their twin

- Measures of gender roles in the home: (1) whether mother worked in managerial position; (2) whether mother needed special qualification for her job; (3) whether mother had A-levels or above.
Empirical methods

- OLS regressions

\[ \text{sama}_{i,j} = \alpha + \beta_{OLS} \times \text{female}_{i,j} + \beta \times X_{i,j} + \nu_i + u_{i,j}, \]

where

- \( i \) represents twin pairs
- \( j \) stands for the individual within a twin pair
- \( \text{female}_{i,j} \) captures whether individual \( i \) is female
- \( X_{i,j} \) is a matrix of control variables
- \( u_{i,j} \) is the usual error term, robust and clustered within twins.

- Twin FE models

\[ \text{sama}_{i,j} = \alpha + \beta_{FE} \times \text{female}_{i,j} + \beta \times X_{i,j} + \nu_i + u_{i,j}, \]

where

- \( \nu_i \) is the twin-pair fixed effect.
The distribution of SAMA over math levels (age 9)
The gender gap in Math (standardized measures)
Estimation results (age 9)

OLS models
- Raw gender gap
- + Math levels
- + cognitive skills and controls
- + parental assessment
- + teacher's assessment
- + twin peer effects
- + parental educ and gender roles
- + liking Math

FE models
- Raw gender gap
- + Math levels
- + cognitive skills and controls
- + parental assessment
- + teacher's assessment
- + twin peer effects
- + liking Math
Conclusions and discussion

- We find that objective skills only explain 14-26% of the gender gap in SAMA.

- Parental assessments (conditional on objective skills) explain a further 23%

- We do not find evidence for the role of gender roles or peer effects

- Interestingly, parental education does not raise SAMA

- The gender gap in SAMA is even larger among opposite sex twins than among non-related boys and girls (Potential explanation: in-utero testosterone exposure (Gielen and Zwiers 2018). But, the gender in parental assessment is also larger...)
How to go on?

- We need to understand more what we are measuring exactly with parental assessment and liking math

- Handling non-response and attrition

- Thinking about how to capture gender roles in the home better (proxy for preference for boys: firstborn is a girl a la Dossi et al 2019)

- To try female*parental assessment interactions - parental assessment might matter for girls more (Hildebrand et al 2022)

- To try female*math level interactions - objective skills might matter less for girls (Cho 2017)
Thanks for your attention!
Appendix
### Descriptive statistics, age 9

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
<th>N</th>
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<td>SAMA, age 9</td>
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<td>Better at Math than twin, age 9</td>
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<td>0.00</td>
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<td>Birthweight, grams</td>
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<td>Mother has managerial job</td>
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<td>0.00</td>
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### Descriptive statistics, age 12

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<td>12.25</td>
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<td>1.00</td>
<td>-4.16</td>
<td>1.90</td>
<td>3,923</td>
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<td>Better at Math than twin, age 12</td>
<td>0.23</td>
<td>0.42</td>
<td>0.00</td>
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<td>1.00</td>
<td>-2.33</td>
<td>1.55</td>
<td>3,922</td>
</tr>
<tr>
<td>Heavier twin at birth</td>
<td>0.47</td>
<td>0.50</td>
<td>0.00</td>
<td>1.00</td>
<td>3,923</td>
</tr>
<tr>
<td>Elder twin</td>
<td>0.50</td>
<td>0.50</td>
<td>0.00</td>
<td>1.00</td>
<td>3,923</td>
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<td>Birthweight, gramms</td>
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<td>595.88</td>
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<td>0.46</td>
<td>0.00</td>
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<tr>
<td>Has sister</td>
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<td>0.45</td>
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<td>3,923</td>
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<td>Female*male twin</td>
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<tr>
<td>Mother has managerial job</td>
<td>0.11</td>
<td>0.31</td>
<td>0.00</td>
<td>1.00</td>
<td>3,923</td>
</tr>
<tr>
<td>Mother needs qualification</td>
<td>0.25</td>
<td>0.43</td>
<td>0.00</td>
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<tr>
<td>No qual or low-grade CSE/GCSE</td>
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<td>0.44</td>
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<td>3,917</td>
</tr>
<tr>
<td>A-level or below degree</td>
<td>0.29</td>
<td>0.46</td>
<td>0.00</td>
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<td>3,917</td>
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<tr>
<td>Degree</td>
<td>0.35</td>
<td>0.48</td>
<td>0.00</td>
<td>1.00</td>
<td>3,917</td>
</tr>
</tbody>
</table>
The distribution of SAMA over math levels (age 12)
The role of parental education in Math outcomes, age 9
Estimation results (age 12)