

## TECHNICAL COMMENT

## WOMEN IN SCIENCE

# Comment on “Expectations of brilliance underlie gender distributions across academic disciplines”

Donna K. Ginther<sup>1,2\*</sup> and Shulamit Kahn<sup>3</sup>

Leslie *et al.* (Reports, 16 January 2015, p. 262) concluded that “expectations of brilliance” explained the gender makeup of academic disciplines. We reestimated their models after adding measures of disaggregated Graduate Record Examination scores by field. Our results indicated that female representation among Ph.D. recipients is associated with the field’s mathematical content and that faculty beliefs about innate ability were irrelevant.

We read Leslie *et al.*’s paper (1) with great interest, having completed a review on academic women in science, technology, engineering, and mathematics (STEM) disciplines with our colleagues Stephen Ceci and Wendy Williams (2). Leslie *et al.* showed that “women are underrepresented in fields whose practitioners believe that raw, innate talent is the main requirement for success” and argued that this is “because women are stereotyped as not possessing such talent.” We reexamined this conclusion and found that their results were not supported by the data once disaggregated Graduate Record Examination (GRE) scores were included in the model. Female representation was associated with the field’s math-intensive content—especially relative to the field’s verbal content—and, controlling for this, faculty beliefs about innate ability were irrelevant.

This is not to say that we think beliefs about ability are unimportant—quite the opposite. We return to this after critiquing Leslie *et al.*’s empirical results.

Reading Leslie *et al.*, we were immediately struck by the similarity between its Fig. 1 (graphing fields by percentage female and ability beliefs) and figure 9 in our own work (2) (graphing percentage female and average GRE quantitative scores). Below, we replicated these figures for 28 of the 30 fields used in Leslie *et al.*, excluding two fields for which we could not match GRE scores. The correlation between the percentage of female Ph.D.s and GRE quantitative score was  $-0.79$  ( $P < 0.0001$ ), whereas the correlation with ability beliefs was a much smaller  $-0.58$  ( $P = 0.0012$ ) in these 28 fields.

We therefore performed our own regression analysis using Leslie *et al.*’s survey data merged

with data on the 2011–2013 GRE scores (3). We included three GRE variables by field (identified as the person’s desired area of study): the field’s average quantitative GRE score, the field’s average GRE verbal score, and the ratio of the quantitative to verbal scores. We add this ratio because research has shown (4, 5) that math ability relative to verbal ability (what economists refer to as a comparative advantage in mathematics) is an important influence on a person’s choice of major or occupational field.

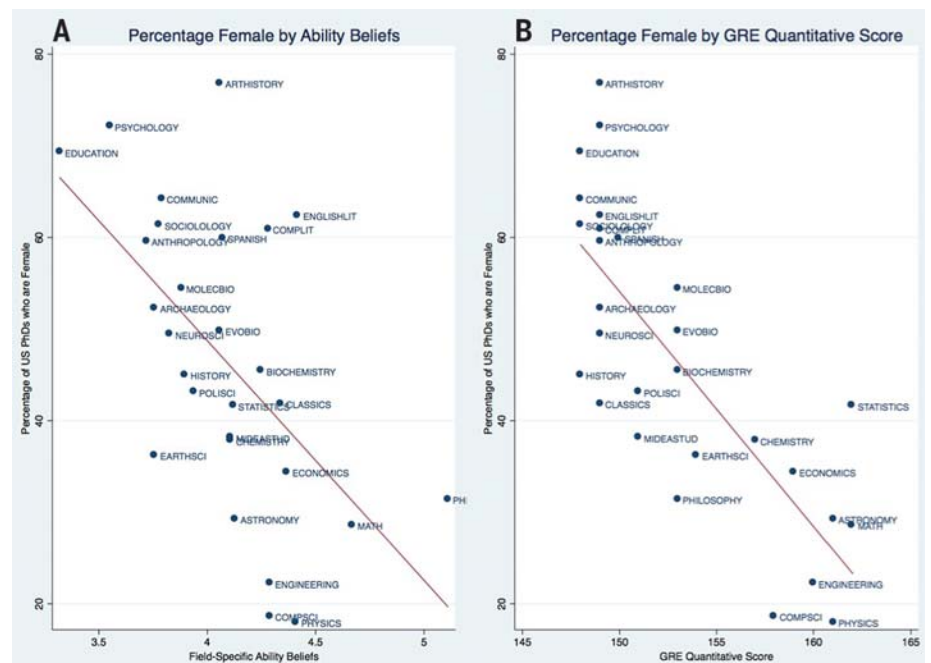
Before we present our results, we note that Leslie *et al.* did compare the percentage female with the composite GRE scores—averaging standardized quantitative, verbal, and analytical

writing scores—and found no significant correlation. However, we found that it is not overall ability, but mathematical ability, especially relative to verbal ability, that predicted female representation.

We identified GRE scores for 28 of the 30 fields addressed by Leslie *et al.*. They had only matched 18 (6). As examples, we classified molecular biology as “biological and biomedical sciences” and Spanish as “foreign languages and literatures.” We could not match GRE scores for the fields of linguistics and music composition.

In the first column of Table 1, we replicated Leslie *et al.*’s final analysis (model 5) for all 30 fields (presenting standardized coefficients and *t* statistics, as they did). For comparison with our later results, in the second column, we reestimated this model using the 28 fields with GRE scores. In the third column, we introduced the separate GRE scores and the ratio of GRE quantitative and verbal scores. We observed that the GRE quantitative score was positively associated with women in these fields (11.98,  $P = 0.08$ ), whereas the GRE verbal score ( $-6.92$ ,  $P = 0.07$ ) and the ratio GRE scores ( $-15.16$ ,  $P = 0.07$ ) were negatively associated with the percentage of female Ph.D.s. These coefficients were jointly significant ( $P = 0.02$ ), and the adjusted  $R^2$  increased from 0.494 in Leslie *et al.*’s model 5 to 0.645. Most notably, we found that adding these variables rendered the coefficient on field-specific ability beliefs insignificant and decreased the magnitude of its effect by two-thirds.

We were also concerned that the number of respondents per field in (1) differed widely, from 8 to 143. We therefore weighted both their model 5 and our version by the number of observations



**Fig. 1. Relationship between percentage female, ability beliefs, and quantitative scores.** (A) Correlation between the percentage of U.S. Ph.D.s who are female and field-specific ability beliefs. (B) Correlation between the percentage of U.S. Ph.D.s who are female and GRE quantitative score. [Data from (1) and (3).]

<sup>1</sup>Department of Economics, Center for Science, Technology and Economic Policy, Institute for Policy and Social Research, University of Kansas, Lawrence, KS 66045, USA.

<sup>2</sup>National Bureau of Economic Research, Cambridge, MA 02138, USA. <sup>3</sup>Questrom School of Business, Boston University, Boston, MA 02215, USA.

\*Corresponding author. E-mail: dginther@ku.edu

**Table 1. Estimates of the impact of field-specific beliefs and GRE scores on the percentage of U.S. Ph.D.s who are female.** *T* statistics in brackets.

| Variables                         | (1)<br>Model 5     | (2)<br>28 Fields   | (3)<br>Add GRE<br>scores | (4)<br>Weighted    | (5)<br>Weighted and<br>GRE scores | (6)<br>Drop<br>ratio |
|-----------------------------------|--------------------|--------------------|--------------------------|--------------------|-----------------------------------|----------------------|
| STEM indicator                    | -0.28<br>[-1.07]   | -0.39<br>[-1.41]   | -0.04<br>[-0.14]         | -0.20<br>[-0.83]   | 0.02<br>[0.10]                    | -0.12<br>[-0.47]     |
| Field-specific<br>ability beliefs | -0.56**<br>[-3.44] | -0.51**<br>[-2.99] | -0.16<br>[-0.80]         | -0.55**<br>[-3.37] | -0.03<br>[-0.13]                  | -0.32<br>[-1.60]     |
| On-campus hours<br>worked         | 0.02<br>[0.08]     | -0.01<br>[-0.04]   | -0.25<br>[-1.08]         | 0.002<br>[0.01]    | -0.04<br>[-0.20]                  | -0.03<br>[-0.16]     |
| Selectivity                       | 0.24<br>[1.55]     | 0.11<br>[0.62]     | 0.07<br>[0.49]           | 0.24<br>[1.58]     | 0.16<br>[1.11]                    | 0.12<br>[0.75]       |
| Systemizing versus<br>empathizing | -0.06<br>[-0.24]   | -0.05<br>[-0.18]   | 0.19<br>[0.69]           | -0.12<br>[-0.51]   | -0.16<br>[-0.62]                  | 0.08<br>[0.31]       |
| GRE quantitative<br>score         |                    |                    | 11.98<br>[1.83]          |                    | 14.29*<br>[2.39]                  | -0.55*<br>[-2.31]    |
| GRE verbal score                  |                    |                    | -6.92<br>[-1.92]         |                    | -7.39*<br>[-2.49]                 | -0.04<br>[-0.30]     |
| Ratio: GRE<br>quantitative/verbal |                    |                    | -15.16<br>[-1.93]        |                    | -17.13*<br>[-2.48]                |                      |
| Observations                      | 30                 | 28                 | 28                       | 30                 | 28                                | 28                   |
| Adjusted <i>R</i> -squared        | 0.494              | 0.494              | 0.645                    | 0.634              | 0.749                             | 0.685                |
| <i>R</i> -squared                 | 0.582              | 0.588              | 0.750                    | 0.697              | 0.823                             | 0.766                |

\*\*\**P* < 0.001; \*\**P* < 0.01; \**P* < 0.05

in each field. This weighting changed their estimates very little (column 4). In our version (column 5), it made all GRE variables significant and reduced the coefficient on the field-specific ability beliefs to basically zero ( $-0.03$ ,  $P = 0.89$ ).

Finally, in column 6, we drop the GRE ratio as a test. This is a less accurate fit than column 5 ( $F = 6.15$ ,  $P = 0.02$ ). The coefficient on the quantitative GRE score is negative and significant ( $-0.55$ ,  $P = 0.03$ ). The coefficient on ability is not ( $P = 0.13$ ).

We conclude that Leslie *et al.*'s work has not convincingly identified a robust association, let

alone a causal relationship, running from beliefs about innate ability to the percentage of female Ph.D.s in a given field. While field-specific ability beliefs were negatively correlated with the percentage of female Ph.D.s in a field, this correlation is likely explained by women being less likely than men to study these math-intensive fields, combined with the fact that people in these fields are more likely to believe that ability is innate. As other evidence reviewed in (2) has shown, math ability relative to verbal ability is particularly important in decisions to enter math-intensive fields, consistent with the finding that

the ratio of GRE quantitative to verbal ability was negatively associated with the percentage female ( $-17.13$ ,  $P = 0.02$ ) in our preferred specification (column 5). Table 2 contains data that we included and used in the preceding analysis.

Moreover, as our recent survey article (2) indicated, there is considerable evidence that it is not the stereotypical beliefs of college faculty that are the core reason that women do not enter math-intensive fields. Rather, it is the stereotypical beliefs of the teachers and parents of younger children that become part of the self-fulfilling belief systems of the children themselves from a very early age (7).

That said, we surely agree with the sentiment that all children, and girls in particular, should be taught that life—and math—is 99% perspiration. Numerous educational experiments have shown that if a person believes in their own ability to learn material, they will master that material (8, 9). This is particularly crucial in STEM disciplines, where women continue to be underrepresented. If girls believe they can, they can.

#### REFERENCES AND NOTES

1. S. J. Leslie, A. Cimpian, M. Meyer, E. Freeland, *Science* **347**, 262–265 (2015).
2. S. J. Ceci, D. K. Ginther, S. Kahn, W. M. Williams, *Psychol. Sci. Public Interest* **15**, 75–141 (2014).
3. Educational Testing Service, GRE Guide to Use of Scores, 2013–2014; [www.ets.org/s/gre/pdf/gre\\_guide.pdf](http://www.ets.org/s/gre/pdf/gre_guide.pdf).
4. M. T. Wang, J. S. Eccles, S. Kenny, *Psychol. Sci.* **24**, 770–775 (2013).
5. D. Lubinski, C. P. Benbow, *Perspect. Psychol. Sci.* **1**, 316–345 (2006).
6. Although their text says that they matched 19 fields, their supplementary materials show GRE composite scores for 18.
7. V. Lavy, E. Sand, National Bureau of Economic Research Working Paper #20909 (2015).
8. C. J. Good, J. Aronson, M. Inzlicht, *J. Appl. Dev. Psychol.* **24**, 645–662 (2003).
9. C. Bagès, D. Martinot, *Br. J. Soc. Psychol.* **50**, 536–543 (2011).

#### ACKNOWLEDGMENTS

We acknowledge financial support from NIH grant 1R01AG36820-01.

20 February 2015; accepted 29 May 2015  
10.1126/science.aaa9632

**Table 2. Variables added to the analysis.** We added the following variables: *s\_e*, indicator for STEM used by (1); *stem*, NSF's definition of STEM disciplines; *greverbal*, average GRE verbal score by field; *grewriting*, average GRE writing score by field; *ratio*, ratio of GRE quantitative score/GRE verbal score by field; *number*, number of survey respondents by field in (1); *inours*, fields with nonmissing GRE scores.

| Discipline   | gremath | stem | s_e | greverbal | grewriting | ratio    | number | inours |
|--------------|---------|------|-----|-----------|------------|----------|--------|--------|
| ANTHROPOLOGY | 149     | 1    | 0   | 156       | 4.1        | 0.955128 | 69     | 1      |
| ARCHEOLOGY   | 149     | 1    | 0   | 156       | 4.1        | 0.955128 | 30     | 1      |
| ARTHISTORY   | 149     | 0    | 0   | 156       | 4.1        | 0.955128 | 29     | 1      |
| ASTRONOMY    | 161     | 1    | 1   | 156       | 3.9        | 1.032051 | 35     | 1      |
| BIOCHEMISTRY | 153     | 1    | 1   | 153       | 3.9        | 1        | 29     | 1      |
| CHEMISTRY    | 157     | 1    | 1   | 153       | 3.8        | 1.026144 | 83     | 1      |
| CLASSICS     | 149     | 0    | 0   | 157       | 4.2        | 0.949045 | 24     | 1      |
| COMMUNIC     | 148     | 1    | 0   | 151       | 3.8        | 0.980132 | 43     | 1      |
| COMPLIT      | 149     | 0    | 0   | 157       | 4.2        | 0.949045 | 43     | 1      |
| COMPSCI      | 158     | 1    | 1   | 148       | 3.3        | 1.067568 | 47     | 1      |
| EARTHSCI     | 154     | 1    | 1   | 154       | 3.9        | 1        | 54     | 1      |
| ECONOMICS    | 159     | 1    | 0   | 154       | 3.9        | 1.032467 | 85     | 1      |
| EDUCATION    | 148     | 0    | 0   | 151       | 3.8        | 0.980132 | 58     | 1      |
| ENGINEERING  | 160     | 1    | 1   | 150       | 3.5        | 1.066667 | 103    | 1      |
| ENGLISHLIT   | 149     | 0    | 0   | 157       | 4.2        | 0.949045 | 66     | 1      |
| EVOBIO       | 153     | 1    | 1   | 153       | 3.9        | 1        | 27     | 1      |
| HISTORY      | 148     | 0    | 0   | 156       | 4.1        | 0.948718 | 101    | 1      |
| LINGUISTICS  |         | 1    | 0   |           |            |          | 39     | 0      |
| MATH         | 162     | 1    | 1   | 154       | 3.8        | 1.051948 | 133    | 1      |
| MIDEASTUD    | 151     | 0    | 0   | 156       | 4.2        | 0.967949 | 8      | 1      |
| MOLECBIO     | 153     | 1    | 1   | 153       | 3.9        | 1        | 60     | 1      |
| MUSICTH      |         | 0    | 0   |           |            |          | 28     | 0      |
| NEUROSCI     | 149     | 1    | 1   | 150       | 3.7        | 0.993333 | 42     | 1      |
| PHILOSOPHY   | 153     | 0    | 0   | 160       | 4.4        | 0.95625  | 58     | 1      |
| PHYSICS      | 161     | 1    | 1   | 156       | 3.9        | 1.032051 | 104    | 1      |
| POLISCI      | 151     | 1    | 0   | 156       | 4.2        | 0.967949 | 112    | 1      |
| PSYCHOLOGY   | 149     | 1    | 0   | 152       | 3.9        | 0.980263 | 143    | 1      |
| SOCIOLOGY    | 148     | 1    | 0   | 152       | 3.9        | 0.973684 | 117    | 1      |
| SPANISH      | 150     | 0    | 0   | 155       | 4          | 0.967742 | 22     | 1      |
| STATISTICS   | 162     | 1    | 1   | 154       | 3.8        | 1.051948 | 28     | 1      |

## Comment on "Expectations of brilliance underlie gender distributions across academic disciplines"

Donna K. Ginther and Shulamit Kahn

*Science* **349** (6246), 391.  
DOI: 10.1126/science.aaa9632

### ARTICLE TOOLS

<http://science.sciencemag.org/content/349/6246/391.2>

### RELATED CONTENT

<http://science.sciencemag.org/content/sci/349/6246/391.3.full>  
<http://science.sciencemag.org/content/sci/347/6219/262.full>

### REFERENCES

This article cites 6 articles, 1 of which you can access for free  
<http://science.sciencemag.org/content/349/6246/391.2#BIBL>

### PERMISSIONS

<http://www.sciencemag.org/help/reprints-and-permissions>

Use of this article is subject to the [Terms of Service](#)