TECHNICAL COMMENT

WOMEN IN SCIENCE

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

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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

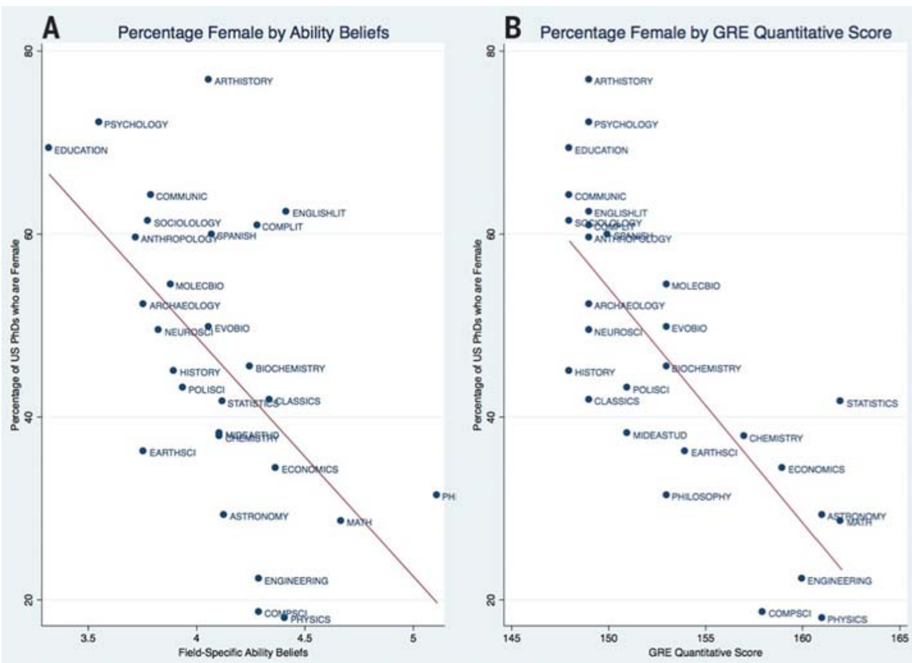

Fig. 1. Relationship between percentage female, ability beliefs, and quantitative scores. (**A**) Correlation between the percentage of U.S. Ph.D.s who are female and field-specific ability beliefs. (**B**) Correlation between the percentage of U.S. Ph.D.s who are female and GRE quantitative score. [Data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

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

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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
SOCIOLOLOGY	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

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