Not Lack of Ability but More Choice : Individual and Gender Differences in Choice of Careers in Science, Technology, Engineering, and Mathematics

Ming-Te Wang, Jacquelynne S. Eccles and Sarah Kenny

Psychological Science published online 18 March 2013
DOI: 10.1177/0956797612458937

Research Report

Not Lack of Ability but More Choice: Individual and Gender Differences in Choice of Careers in Science, Technology, Engineering, and Mathematics

Psychological Science
XX(X) 1–6

DOI: 10.1177/0956797612458937
pss.sagepub.com

Ming-Te Wang[1,2], Jacquelynne S. Eccles[1], and Sarah Kenny[1]
[1]Applied Developmental Psychology, University of Pittsburgh, and [2]Institute for Social Research, University of Michigan

Abstract

The pattern of gender differences in math and verbal ability may result in females having a wider choice of careers, in both science, technology, engineering, and mathematics (STEM) and non-STEM fields, compared with males. The current study tested whether individuals with high math and high verbal ability in 12th grade were more or less likely to choose STEM occupations than those with high math and moderate verbal ability. The 1,490 subjects participated in two waves of a national longitudinal study; one wave was when the subjects were in 12th grade, and the other was when they were 33 years old. Results revealed that mathematically capable individuals who also had high verbal skills were less likely to pursue STEM careers than were individuals who had high math skills but moderate verbal skills. One notable finding was that the group with high math and high verbal ability included more females than males.

Keywords

STEM, gender difference, career development, career choice, math ability, sex differences, adolescent development

Received 6/1/12; Accepted 7/3/12

Although the gender gap in mathematics (e.g., number of math courses taken and performance in those courses) has narrowed in recent decades, females continue to be less likely to pursue science, technology, engineering, and mathematics (STEM) careers than their male counterparts (Ceci & Williams, 2007; National Science Foundation, 2011). Researchers have provided different explanations for the underrepresentation of females in the STEM fields, including gender differences in math ability, ability self-concepts, interests, and occupational and lifestyle values and preferences (Ceci, Williams, & Barnett, 2009; Eccles, 2009; Eccles, Barber, & Jozefowicz, 1999; Ferriman, Lubinski, & Benbow, 2009). These researchers have shown that math ability, at least by itself, is not the overriding factor in the underrepresentation of females in math-intensive fields.

Researchers have also shown that among males and females with comparable outstanding aptitude in math, females are likely to outperform males in verbal ability (Park, Lubinski, & Benbow, 2008). This pattern of ability differences may allow females more career choice than males and, thus, more opportunity to consider careers in both STEM and non-STEM fields (Ceci & Williams, 2010). Frome, Alfeld, Eccles, and Barber (2006) and Wai, Lubinski, and Benbow (2005) found that "math-able" females were more likely than their math-able male peers to change their college major from a STEM-related major to an equally intellectually challenging but less math-intensive major, such as law. High verbal ability was a predictor of these changes; on average, students who switched from STEM to non-STEM college majors had verbal ability as strong as their math ability.

In addition, research has suggested that people compare their performance across different domains to reach conclusions about their relative abilities (Marsh, 1986, 1990). A study by Marsh (1986) involving an internal-external comparison model showed that individuals with better math skills have higher math-ability self-concepts but slightly lower English-ability self-concepts, and those with better English skills have higher English-ability self-concepts but slightly lower math-ability self-concepts. Indeed, Marsh (1990) also found that ability self-concept was extremely sensitive to even small differences in frames of reference. Therefore, it is plausible that individuals

Corresponding Author:
Ming-Te Wang, Applied Developmental Psychology, 5940 Wesley W. Posvar Hall, University of Pittsburgh, Pittsburgh, PA 15260
E-mail: mtwang@pitt.edu

with high math and moderate verbal ability have higher math-ability self-concepts than individuals with high math and high verbal ability do, and therefore feel more confident in choosing STEM-related careers.

Career aspirations based on individual aptitudes, interests, and values are formulated during adolescence and shape the academic choices that lead to the STEM career pipeline (Eccles, Vida, & Barber, 2004; Wang, 2012). It is difficult for students to initiate a STEM career trajectory after starting college because STEM curricula are very constrained and prescribed. The identification of high-school ability patterns that predict future career choices will help increase understanding of what influences individuals to choose or reject STEM occupations. In the study reported here, we investigated the association between math and verbal competencies in high school and later occupational choices. We examined three specific aspects of this association: First, we looked at whether individuals with high math and high verbal ability in 12th grade are more or less likely to choose a STEM occupation by age 33 years, compared with those with high math and moderate verbal ability (after controlling for math and English competencies, ability self-concepts, interests, occupational and lifestyle values, number of math courses taken, and family background variables). Second, we examined whether females are more likely than males to have high ability in both math and English. Third, we asked whether the effect of ability pattern varies by gender and by ability self-concepts.

Method

Participants

The initial sample consisted of 1,655 intellectually able, college-bound U.S. students drawn from a national longitudinal study. These students were surveyed in 1992, when they were in 12th grade, and again in 2007, when they were 33 years old. A total of 1,490 (90%) of the 1,655 eligible students completed the 2007 telephone interviews, which required them to update their educational and occupational history from high school through the time of the survey. Only students who participated in both waves of data collection were included in this study. None of the measures used in this study showed a significant difference between students who participated in both waves and those who dropped out after the first wave. All participants had received a 4-year college degree by the second wave. The participants included in our analysis were 49% female and 51% male. A total of 75% were European American, 12% were African American, 8% were Asian, and 5% were Hispanic.

Measures

Occupation. Participants' occupations at age 33 were self-reported in the 2007 telephone interview. We coded jobs that involved the mathematical, health, biological, medical, physical, computer, and engineering sciences as STEM occupations.

Intellectual aptitude. We used scores on the SAT, a widely used standardized achievement test, to assess participants' verbal and math abilities in 12th grade.

Covariates. We controlled for several important confounds that are highly related to individual career choices in math-intensive fields: family socioeconomic status, math courses taken, and motivational beliefs and values (Ceci et al., 2009; Eccles, 2009; Eccles et al., 1999; Ferriman et al., 2009). Measures of parental education and family income were collected from parents' reports, and the number of math courses each student took between 10th grade and 12th grade was collected from high-school records. We assessed participants' motivational beliefs and values in 12th grade using scales measuring ability self-concepts in math and English, interest in math and English, lifestyle values (i.e., relative importance of family obligations vs. work and careerism), and occupational values (i.e., being people oriented vs. being thing oriented). The math- and English-ability self-concept scale included six items (three per domain; math: $\alpha = .92$; English: $\alpha = .90$) assessing self-perceived abilities and expectancy for success in math and English (e.g., "I am good at math"). The scale assessing interest in math and English included eight items (four per domain; math: $\alpha = .90$; English: $\alpha = .88$) focusing on whether participants liked math-related activities (e.g., "I generally have fun when I am learning math") and English-related activities. For both the self-concept scale and the interest scale, scores ranged from 1 to 7, with 7 representing either a *great deal* or *very much*.

To assess lifestyle values, we used six items on the relative importance of family and career ($\alpha = .78$; e.g., "I would readjust my work schedule to meet the needs of my family" and "I want to do my best in my job even if this means working overtime"); the rating scale ranged from 1 (*strongly disagree*) to 5 (*strongly agree*). Occupational values were also assessed with four items ($\alpha = .84$; e.g., "I prefer a job that gives me an opportunity to be directly helpful to others" and "I prefer a job that involves operating machinery"); the rating scale ranged from 1 (*not important*) to 5 (*extremely important*). See Table 1 for descriptive characteristics of the sample, including data on these covariates.

Results

We performed a latent profile analysis of math and verbal scores to identify five 12th-grade competence profiles (Akaike's information criterion = 7,145.57, Bayesian information criterion = 7,395.13, entropy = .85): high math and high verbal ability ($n = 298$; 63% females, 37% males),

Table 1. Descriptive Characteristics of the Sample and Tests of the Difference Between the High-Math Ability Groups

Independent variable	High-math/ high-verbal group	High-math/moderate-verbal group	Difference test
Mean math score (12th grade)	720 (14)	721 (13)	$t(669) = 0.96$
Mean verbal score (12th grade)	696 (18)	655 (22)	$t(669) = 25.96^{***}$
Mean number of math courses taken (10th–12th grade)	4.38 (1.72)	4.40 (1.64)	$t(669) = 0.14$
Mean motivational beliefs and values (12th grade)			
Math-ability self-concept	5.93 (1.14)	6.05 (1.02)	$t(669) = 1.29$
Math interest	6.02 (1.12)	6.10 (1.17)	$t(669) = 0.81$
English-ability self-concept	5.96 (1.07)	5.23 (1.21)	$t(669) = 7.33^{***}$
English interest	5.77 (1.13)	5.37 (1.15)	$t(669) = 4.05^{***}$
Value family needs	4.57 (1.10)	4.35 (1.08)	$t(669) = 2.33^{*}$
Careerism	4.65 (1.02)	4.68 (1.05)	$t(669) = 0.37$
Value working with people	4.03 (1.03)	3.78 (1.12)	$t(669) = 2.98^{**}$
Value working with things	3.51 (1.11)	3.79 (1.16)	$t(669) = 3.17^{**}$
Male (%)	37	70	$\chi^2(1, N = 671) = 54.25^{***}$
Log mean family income	10.53 (0.76)	10.56 (0.78)	$t(669) = 0.51$
Mean parents' education (years)	11.23 (3.11)	11.25 (3.08)	$t(669) = 0.08$
STEM occupation at age 33 (%)	34	49	$\chi^2(1, N = 671) = 12.08^{***}$

Note: Standard deviations are in parentheses. STEM = science, technology, engineering, and mathematics.
$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

high math and moderate verbal ability (n = 373; 30% females, 70% males), moderate math and moderate verbal ability (n = 402; 45% females, 55% males), low math and high verbal ability (n = 298; 70% females, 30% males), and low math and low verbal ability (n = 119; 39% females, 61% males). See Figure 1 for the percentage of each group that chose a STEM career. We then compared the two groups containing the highest percentage of individuals engaged in STEM occupations at age 33—those with high math and high verbal abilities and those with high math and moderate verbal abilities. We conducted a logistic regression to examine whether individual ability pattern (high math and high verbal ability vs. high math and moderate verbal ability) was predictive of having a STEM occupation (after controlling for math and verbal ability, motivational beliefs and values, number of math courses taken, and family background variables), and whether the effect of ability pattern varied by gender and ability

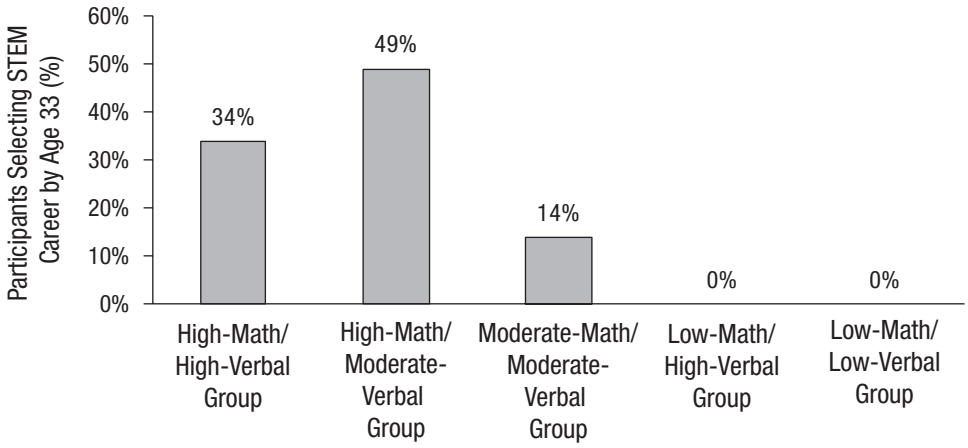

Fig. 1. Percentage of participants who selected careers in science, technology, engineering, and mathematics (STEM) by age 33 years as a function of their math- and verbal-ability pattern in 12th grade. All paired comparisons revealed significant differences between groups ($p < .05$), except for the comparison between the low-math/high-verbal group and the low-math/low-verbal group.

self-concepts. To account for missing data, we used full information maximum likelihood estimation as implemented in Mplus 6.1 (http://www.statmodel.com).

Individuals in the high-math/high-verbal ability group were less likely to have chosen STEM occupations by age 33 than those in the high-math/moderate-verbal ability group, $\beta = -0.201$, $SE = 0.10$, $p < .05$. The high-math/high-verbal ability group included more females than males, and the high-math/moderate-verbal ability group included more males than females, $\chi^2(1, N = 671) = 54.25$, $p < .001$; however, there were no gender differences in math and verbal scores within these two groups. As shown in Table 2, females were less likely than males to choose STEM occupations (Steps 1 and 2), but the gender effect on selection of a STEM occupation diminished when the ability-pattern variable was added to the model (Step 3). This finding suggests that ability-pattern differences partially accounted for the gender difference in selection of a STEM occupation. Finally, however, the effect of ability pattern did not differ by gender but did differ by math-ability self-concept (Step 4). Specifically, the likelihood of choosing STEM occupations was similar for females and males in the high-math/high-verbal ability group. However, participants with better math-ability self-concepts were more likely to select STEM occupations, and math-ability self-concepts had a stronger impact on participants in the high-math/moderate-verbal ability group than on those in the high-math/high-verbal ability group.[1]

Discussion

These findings suggest that students' math- and verbal-ability patterns in 12th grade predict their occupations at age 33, above and beyond the contributions of math and verbal ability, ability self-concepts, interests, occupational and lifestyle values, and family education and income. Mathematically capable individuals who were also high in verbal skills were less likely to pursue STEM careers than

Table 2. Results of the Logistic Regression Analysis: Predictors of Choice of a STEM Occupation

	Regression coefficient (β)				
Predictor	Step 1	Step 2	Step 3	Step 4	Odds ratio
Math score (12th grade)	0.417 (0.06)***	0.402 (0.06)***	0.400 (0.06)***	0.399 (0.06)***	1.490
Verbal score (12th grade)	–0.136 (0.08)	–0.117 (0.09)	–0.112 (0.09)	–0.110 (0.09)	0.896
Number of math courses taken (10th–12th grade)	0.437 (0.10)***	0.420 (0.11)***	0.418 (0.11)***	0.415 (0.11)***	1.514
Motivational beliefs and values (12th grade)					
Math-ability self-concept	—	0.519 (0.08)***	0.514 (0.08)***	0.376 (0.09)***	1.456
Math interest	—	0.062 (0.07)	0.060 (0.07)	0.059 (0.07)	1.061
English-ability self-concept	—	–0.089 (0.07)	–0.086 (0.07)	–0.087 (0.07)	0.917
English interest	—	–0.077 (0.08)	–0.075 (0.08)	–0.075 (0.09)	0.928
Value family needs	—	–0.084 (0.10)	–0.083 (0.10)	–0.082 (0.10)	0.921
Careerism	—	0.022 (0.07)	0.021 (0.07)	0.022 (0.07)	1.022
Value working with people	—	–0.472 (0.12)***	–0.463 (0.12)***	–0.467 (0.12)***	0.627
Value working with things	—	0.401 (0.10)***	0.388 (0.10)***	0.398 (0.10)***	1.489
High-math/high-verbal group (12th grade)	—	—	–0.255 (0.10)*	–0.201 (0.10)*	0.818
High-Math/High-Verbal Group × Math-Ability Self-Concept (12th grade)	—	—	—	0.197 (0.09)*	1.218
Male	0.517 (0.13)***	0.338 (0.14)*	0.197 (0.15)	0.195 (0.15)	1.215
Family income (log mean)	0.495 (0.06)***	0.476 (0.07)***	0.475 (0.07)***	0.473 (0.07)***	1.605
Parents' education (years)	0.501 (0.08)***	0.485 (0.08)***	0.483 (0.08)***	0.481 (0.08)***	1.618
Constant	0.678 (0.11)***	0.628 (0.12)***	0.625 (0.12)***	0.619 (0.12)***	1.857

Note: Standard errors are in parentheses. $N = 671$. Math and verbal test scores were standardized. STEM = science, technology, engineering, and mathematics. Non-STEM occupations were coded as 0, and STEM occupations were coded as 1. High math plus moderate verbal ability was coded as 0, and high math plus high verbal ability was coded as 1. The four steps had the same outcome variable (STEM occupation vs. non-STEM occupation). In Step 1, we included demographic information, math and verbal scores, and course enrollment. In Step 2, we added motivational beliefs and values. In Step 3, we added the ability-pattern variable. In Step 4, we added the interaction term between ability pattern and math-ability self-concept.
*$p < .05$. ***$p < .001$.

individuals with high math skills but moderate verbal ability. Students with high math and high verbal abilities presumably have a greater range of both STEM and non-STEM career opportunities to choose from, compared with their peers who have high math ability but moderate verbal ability. Notably, the high-math/high-verbal ability group included more females than males. This is an important finding that contributes to current understanding of females' underrepresentation in STEM fields.

We found that math-ability self-concepts had a stronger impact on choice of a STEM occupation for students in the high-math/moderate-verbal ability group, compared with those in the high-math/high-verbal ability group. It is possible that frame-of-reference effects (i.e., influence of internal comparison of abilities in a given domain) encouraged the high-math/moderate-verbal ability group to gravitate toward STEM fields. Studies have shown that individuals with better math skills have higher math-ability self-concepts but slightly lower English-ability self-concepts, and that individuals with better English skills have higher English-ability self-concepts but slightly lower math-ability self-concepts (Marsh, 1986, 1990). Consequently, it is possible that weakened English-ability self-concepts caused students in the high-math/moderate-verbal ability group to rely more heavily on their math skills and to give math a more integral role than English in their developing identity.

Our study provides evidence that it is not lack of ability that causes females to pursue non-STEM careers, but rather the greater likelihood that females with high math ability also have high verbal ability and thus can consider a wider range of occupations than their male peers with high math ability, who are more likely to have moderate verbal ability. It is also important to acknowledge the potential frame-of-reference effects that may lead students with high math and moderate verbal ability to feel more confident in their math ability than in their verbal ability. A large body of research suggests that individuals are more likely to choose a given pathway if they believe in their capacity to succeed in that area (Dweck, 2008; Eccles, 2009; Pajares, 2005). It is possible, therefore, that heightened math-ability self-concepts draw individuals with high math and moderate verbal ability toward STEM occupations. In the same vein, it is likely that individuals with high math and high verbal ability (who in this study were predominantly female) believe in their potential to succeed in both STEM and non-STEM occupations. These individuals may also feel they are in a position to consider how a STEM or a non-STEM occupation will fulfill their life goals and values (Eccles et al., 1999).

Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

Note

1. We also tested the following interaction effects: High-Math/High-Verbal Ability Group × Math Interest, High-Math/High-Verbal Ability Group × English-Ability Self-Concept, High-Math/High-Verbal Ability Group × English Interest, High-Math/High-Verbal Ability Group × Value Working With People, High-Math/High-Verbal Ability Group × Value Working With Things, High-Math/High-Verbal Ability Group × Male. None of these were significant.

References

Ceci, S. J., & Williams, W. M. (2007). *Why aren't more women in science? Top researchers debate the evidence*. Washington, DC: American Psychological Association Press.

Ceci, S. J., & Williams, W. M. (2010). Sex differences in math-intensive fields. *Current Directions in Psychological Science*, *19*, 275–279.

Ceci, S. J., Williams, W. M., & Barnett, S. M. (2009). Women's underrepresentation in science: Sociocultural and biological considerations. *Psychological Bulletin*, *135*, 218–261.

Dweck, C. S. (2008). *Mindsets and math/science achievement*. New York, NY: Carnegie Corp. of New York–Institute for Advanced Study Commission on Mathematics and Science Education.

Eccles, J. S. (2009).Who am I and what am I going to do with my life? Personal and collective identities as motivators of action. *Educational Psychologist*, *44*, 78–89.

Eccles, J. S., Barber, B., & Jozefowicz, D. (1999). Linking gender to education, occupation, and recreational choices: Applying the Eccles et al. model of achievement-related choices. In W. B. Swann, J. H. Langlois, & L. A. Gilbert (Eds.), *Sexism and stereotypes in modern society: The gender science of Janet Taylor Spence* (pp. 153–192). Washington, DC: American Psychological Association Press.

Eccles, J. S., Vida, M. N., & Barber, B. (2004). The relation of early adolescents' college plans and both academic ability and task-value beliefs to subsequent college enrollment. *Journal of Early Adolescence*, *24*, 63–77.

Ferriman, K., Lubinski, D., & Benbow, C. P. (2009). Work preferences, life values, and personal views of top math/science graduate students and the profoundly gifted: Developmental changes and gender differences during emerging adulthood and parenthood. *Journal of Personality and Social Psychology*, *97*, 517–532.

Frome, P. M., Alfeld, C. J., Eccles, J. S., & Barber, B. L. (2006). Why don't they want a male-dominated job? An investigation of young women who changed their occupational aspirations. *Educational Research and Evaluation*, *12*, 359–372.

Marsh, H. W. (1986). Verbal and math self-concepts: An internal/external frame of reference model. *American Educational Research Journal*, *23*, 129–149.

Marsh, H. W. (1990). Influences of internal and external frames of reference on the formation of math and English self-concepts. *Journal of Educational Psychology*, *82*, 107–116.

National Science Foundation. (2011). *Women, minorities, and persons with disabilities in science and engineering*. Arlington, VA: Author.

Pajares, F. (2005). Gender differences in mathematics self-efficacy beliefs. In A. M. Gallagher & J. C. Kaufmann (Eds.), *Gender differences in mathematics: An integrative psychological approach* (pp. 294–315). Cambridge, England: Cambridge University Press.

Park, G., Lubinski, D., & Benbow, C. P. (2008). Ability differences among people who have commensurate degrees matter for scientific creativity. *Psychological Science*, *19*, 957–961.

Wai, J., Lubinski, D., & Benbow, C. P. (2005). Creativity and occupational accomplishments among intellectually precocious youths: An age 13 to age 33 longitudinal study. *Journal of Educational Psychology*, *97*, 484–492.

Wang, M. T. (2012). Educational and career interests in math: A longitudinal examination of the links between classroom environment, motivational beliefs, and interests. *Developmental Psychology*, *1*, 1–22.