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Understanding the Paradox in Math-Related Fields: Why Do Some Gender Gaps Remain While Others Do Not?

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Abstract Despite the ubiquity of harmful math attitudes that disadvantage girls, girls are now performing just as well as boys in math in the U.S. (Hyde et al. 1990; Hyde et al. 2008). At the same time, stark gender disparities remain in who chooses to pursue math-related careers (National Science Foundation 2009). Why have gender disparities persisted in some math-related domains but not others? I suggest that considering the extent to which math-related domains are stereotyped as masculine can help explain why women do not seek out math-related careers, even as they perform just as well in math. Changing current stereotypes of math-related careers to make them less incongruent with the female gender role may help to recruit more women into these careers.

Keywords Gender disparities · Stereotypes · Underrepresentation · Gender roles · Education

Introduction

As Gunderson et al. (2011) note, there is a paradox in contemporary gender disparities in math-related fields within the U.S. Despite the ubiquity of harmful math attitudes that disadvantage girls, girls are performing just as well as boys (Hyde et al. 1990; 2008). At the same time, stark gender disparities remain—and in some cases, have become even worse—in decisions to enter math-related careers (Ceci et al. 2009; National Science Foundation 2009). Why are women in the U.S., who perform just as well as men in math, avoiding math-related careers?

Considering the extent to which math-related domains and outcomes are stereotyped as incompatible with the female gender role can help elucidate why some math-related gender disparities continue to persist within American society even as others have been eliminated. Specifically, I suggest that while *doing well* in math classes may now be stereotyped as feminine, *seeking out* math-related careers is still a gender role violation for women. I conclude this article with a series of recommendations to change current stereotypes associated with math-related fields in order to encourage more women to choose math-related careers.

Where Do Math-Related Gender Gaps Persist?

There is no longer any difference in standardized test scores in math between boys and girls all the way through high school (Hyde et al. 2008), and girls and women receive *better* grades in their high school and college math courses than boys in the U.S. (Benbow and Stanley 1982; Bridgeman and Wendler 1991; Kimball 1989; Stockard and Wood 1984; Stout et al. 2011). However, women are still much less likely than men to choose math-related majors and careers. For instance, in computer science and engineering, women receive fewer than 25% of undergraduate and graduate degrees in the U.S. (National Science Foundation 2009) and hold only 29% of information technology jobs (The Council of Economic Advisers 2000). How do we make sense of why gender disparities have been eliminated in some math-related outcomes but not others?

One possibility suggested by Gunderson et al. (2011) is that that the social transmission of harmful beliefs about

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math—including math anxiety, math-gender stereotypes, attributions for success and failure in math, and beliefs about math intelligence—from parents and teachers to children early in childhood contribute to subsequent gender disparities in math-related fields. A great deal of empirical research makes it clear that these harmful math attitudes are powerful determinants of subsequent behaviors and outcomes: They depress women's math performance (e.g., Spencer et al. 1999), steer women away from math-related fields (e.g., Davies et al. 2002), and hinder their self-assessments of math ability (e.g., Correll 2001). However, what is less clear is why these beliefs lead to gender disparities in some math-related outcomes (e.g., major/career choices) but not others (e.g., performance in math classes). To explain the current state of gender disparities in math, I propose that considering the extent to which these outcomes are stereotyped as incongruous with the female gender role can help us understand why some traditionally male-dominated domains have progressed toward gender equality more rapidly and easily than others.

Are Math-Related Careers Stereotyped as Masculine?

As Gunderson et al. (2011) note, performance differences have been eliminated, yet women continue to forsake math-related careers at higher rates than men. Current stereotypes about *the people* and *the work involved* in math-related careers may be barriers to effective recruitment of women.

Stereotypes about the People in Math-Related Fields

Like all social groups, academic majors are subject to stereotypes, or mental representations of the group's characteristics (Allport 1954; Katz and Braly 1933; Lippman 1922; Oakes et al. 1994). Some of these stereotypes are representative of a majority of members and can be critical to membership (e.g., knowing calculus), while others are more peripheral and can in fact be less accurate (e.g., liking science fiction). Contemporary stereotypes about the people in math and science fields include being male, socially isolated, and focused on technology (Barbercheck 2001; Steele 2003). Furthermore, these stereotypes are pervasive across ages, genders, and racial groups in the U.S. (Barman 1999; Finson 2003; Fort and Varney 1989; Schibeci and Sorensen 1983) and are also seen abroad (Buldu 2006; Chambers 1983; Newton and Newton 1988). Although many stereotypes of the people in math-related fields are exaggerated and inaccurate (Borg 1999; Pion and Lipsey 1981), they endure as the dominant representation of the people who work in these fields.

Current stereotypes about the people in math-related careers can be contrasted to qualities that are valued in women, including attending to appearance, being socially skilled, and helping others (Cejka and Eagly 1999; Diekman et al. 2010; Eagly and Steffen 1984). As a result, when these math-related stereotypes are salient, women, but not men, conclude that they share little in common with the people in the fields and that they do not belong in them (Cheryan et al. 2011a, 2009). For instance, undergraduate women who had a brief two-minute interaction with a male or female computer science major who embodied current computer science stereotypes (e.g., a t-shirt stating "I code therefore I am") were less interested in pursuing computer science and anticipated being less successful in the field than women who encountered a male or female computer science major who did not embody computer science stereotypes (Cheryan et al. 2011a, c). Similarly, women who were exposed to an introductory computer science classroom containing objects stereotypically associated with computer scientists (e.g., Star Trek posters, videogames) expressed less interest in majoring in computer science, felt less belonging in computer science, and believed they would be less successful in computer science compared to women who were exposed to the same classroom containing non-stereotypical objects (e.g., art posters, water bottles). The more women perceived the stereotypical environment as masculine, the less interested they were in it. Men's interest and anticipated success were not similarly compromised by exposure to computer science stereotypes (Cheryan et al. 2011b, c, 2009). Stereotypes of the people in math-related fields are particularly harmful for women because they interfere with women's sense of belonging in these fields and deter them from pursuing these fields.

Stereotypes about the Work Involved in Math-Related Careers

Students also hold stereotypes about the work in math-related careers (Diekman et al. 2010). Below I discuss two perceptions of the work in math-related careers that may be powerful impediments to women's interest: 1) the goals that math-related careers are perceived as fulfilling, and 2) the perceived hours required in math-related careers. The incompatibility of these perceptions with the female gender role provides a basis for understanding why they may be a greater hindrance to women's participation than men's participation.

The female gender role directs women toward being communal, including interacting with and helping others (Cejka and Eagly 1999; Diekman et al. 2010; Diekman and Eagly 2008; Eagly 1987) and having a family and raising children (Eagly and Wood 1999; Tittle 1986). Compared to men, women have a greater tendency to value communal careers that involve social interaction and helping humanity (Lippa 1998; Morgan et al. 2001) and are less willing to enter careers that are perceived as incongruous with these goals (Diekman et al. 2010; Jones et al. 2000). The male gender role, in contrast, encourages men to pursue careers that grant them agency, most commonly in the form of status and financial gain (Cejka and Eagly 1999; Eagly 1987). Through a process of socialization, these prescribed roles become enacted by men and women (Diekman and Eagly 2008). Although women have increasingly adopted agentic goals (Diekman and Eagly 2000; Twenge 1997), communal goals continue to be more important for women than for men (Diekman et al. 2010; Eagly and Wood 1999; Lippa 1998; Morgan et al. 2001).

Math-related careers are perceived as less compatible with communal goals (i.e., helping and working with others) than other traditionally male-dominated careers, such as being a physician or lawyer (Diekman et al. 2010). This is unfortunate because stereotypes of math-related careers are largely inaccurate (Borg 1999; Pion and Lipsey 1981). Many in math-related careers such as computer science and engineering argue that their fields are fundamentally about helping society and involve frequent collaborations with others. Unfortunately, students do not appear to be getting this message. Their inaccurate perceptions may explain why computer science and engineering continue to be male-dominated while medical and law schools have achieved gender parity (Darves 2005; National Science Foundation 2009).

Stereotypes about the time intensity of math-related fields may also contribute to women's underrepresentation. Being a mother is an important future goal for many women (Eccles 1986), and women expect to devote more time to their families than men do (Hakim 2000). Math-related careers are perceived (accurately or not) as hard-driving careers that require a significant number of hours (Poole 1994; as cited in Kendall 1999). Women may preemptively choose careers that are seen as more compatible with having a family (Eccles 1986). Men, on the other hand, whose careers tend not to be compromised to the same extent by having a family (Ceci et al. 2009), may see pursuing a math-related career and having a family as more compatible. However, note that women have selected other careers in recent decades that are perceived as requiring significant hours (e.g., medicine; Darves 2005). Because medicine is perceived as fulfilling communal goals (Diekman et al. 2010), women may be interested in entering the medical profession despite the perceived long hours. Perhaps if math-related careers could broaden their image to include communal goal fulfillment, they might also successfully attract more women, regardless of the hours required.

Stereotypes of math-related fields may also explain why women are interested in some math-related fields (e.g., architecture) more than others (e.g., computer science) (U.S. Department of Education 2006). Math-related fields such as computer science and engineering are perceived as less likely to fulfill communal goals (i.e., helping humanity and having interpersonal interactions) than other math-related fields that have attracted more women in recent decades, such as medicine and architecture (Diekman et al. 2010). Moreover, the association of some math-related careers, such as physics, with war and destruction may be particularly problematic for women's participation in these fields (Jones et al. 2000). Future work should assess whether differences in women's interest across these fields can be explained by their differing stereotypes about these careers.

In sum, women's underrepresentation in math-related careers is due in part to current stereotypes about the people and the work involved in these fields. These stereotypes negatively influence women's sense of belonging and expectations for success and pressure them to choose careers that do not violate social expectations. Note that this analysis does not imply that *all* women are turned away by the stereotypical image of math-related fields. There are undoubtedly some women who embrace the field despite or even because of the stereotypes. However, there are many other women (and men) who are steered away from these fields because of their stereotypes of them. Broadening the image of who belongs in math-related fields may thus be a crucial step in reducing gender disparities in math-related fields.

Is Doing Well in Math Classes Stereotyped as Feminine?

As Gunderson et al. (2011) point out, women continue to be targeted by gendered math attitudes that disadvantage them and advantage men. However, high school girls perform just as well as boys on standardized tests of math ability (Hyde et al. 2008) and consistently receive higher grades in math than their male peers (Epstein et al. 1998; Marsh and Yeung 1998). As undergraduates, women obtain grades in college math courses that are just as high as men's grades (Bridgeman and Wendler 1991; Stout et al. 2011). In fact, women outperform men in many subjects throughout school (Epstein et al. 1998), and undergraduate women now outnumber undergraduate men, receiving 57% of college degrees (National Center for Education Statistics 2001). Women's academic successes in recent decades have not gone unnoticed by the public, causing some to speculate that men might now be the disadvantaged gender (e.g., Pollack 1999; Rosin 2011). How have these gains by women occurred, especially in a domain in which harmful stereotypes about women's abilities in quantitative fields persist?

Although formal education was once the exclusive domain of men, good performance in school may now be stereotyped as more feminine than masculine. Doing well in school involves completing homework, studying, being organized, and exercising discipline in class—behaviors that are considered feminine (Epstein et al. 1998; Skelton 2001; Van Houtte 2004). Women and girls may thus be more likely to enact these behaviors, and they may be reinforced for doing so. Indeed, girls who do well in school are *more* popular with their peers than girls who underperform, while boys who do well in school are *less* popular with their peers than boys who underperform (Adler et al. 1992; Epstein 1998). The fact that academic achievement is now perceived as compatible with the female gender role may explain why the gender gap in math performance has been closing in recent decades.

One question to consider is the causal direction of the effect: whether a feminization of academic achievement caused the reduced the gender gap in math performance, or whether the reduced gender gap in math performance caused academic achievement to be considered feminine. Evidence exists for both paths. Altering stereotypes of an academic field to be less masculine increases women's motivation to participate in that field (e.g., Cheryan et al. 2009; Ridgeway 2011). In addition, when women enter a field, stereotypes associated with that field also become more feminine (Misa 2010; Phillips and Austin 2009). This suggests that male-dominated domains could begin the process of welcoming women by altering their masculine stereotypes, and the process would perpetuate itself as more women enter the domain.

Reducing Gender Disparities: Broadening the Image of Math-Related Fields

Thus far, I have reviewed evidence suggesting that women have the necessary math skills to choose math careers yet forgo these careers because math-related careers are stereotyped as masculine. Attracting more women into fields where they are underrepresented may necessitate replacing current stereotypes of these careers with an image that is more compatible with how women see themselves (Heilman 1983). Two reports are relevant to efforts to broaden stereotypes of math-related fields. The first, called *Changing the Conversation: Messages for Improving Public Understanding of Engineering* (2008) and released by the National Academy of Engineering, states that "the engineering community should engage in coordinated, consistent, effective communication to 'reposition' engineering" (p. 99–100). The other report, entitled *The Land of Plenty: Diversity as America's Competitive Edge in Science, Engineering and Technology* (2000) and released by the Congressional Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development, calls for "efforts to transform the image of the SET [science, engineering, and technology] professions and their practitioners so that the image is positive and inclusive" (p. 5). These repositioning efforts are consistent with the research reviewed here arguing that changing the image of math-related careers to a less masculine image may help to draw more women into them.

What does it mean to change stereotypes to make them less masculine? One obvious answer, though one that might be difficult to implement, is to change the association of these fields with males. Male dominance is part of the reason women have not entered math-related fields in large numbers (Heilman 1983; Inzlicht and Ben-Zeev 2000; Murphy et al. 2007; Sekaquaptewa and Thompson 2003), but this gender imbalance does not explain how other historically male-dominated fields (e.g., medicine, law) managed to attract a significantly greater proportion of women in recent decades (Darves 2005; National Science Foundation 2009). Women's calculations about whether they fit into a particular career depend on more than simply the sex of the typical person in that career. Other attributes associated with the people in math-related careers (e.g., physical appearance, hobbies, traits) can also discourage people from entering those careers (Cheryan et al. 2009). The fact that most people in math-related careers are male is clearly important. However, the type of males that they are assumed to be could play an equally important role in shaping women's attitudes toward these fields (Cheryan et al. 2011a, c).

Broadening current stereotypes of math-related fields using role models, the media, and environments may help to recruit more women into them. Efforts are underway to disseminate a new image of math-related careers by bringing engineers into high school classrooms (e.g., MIT's Women's Initiative) and holding summer camps (e.g., Microsoft Digigirlz) that expose girls to a variety of math-related careers available to them in industry. Programs such as these successfully broaden students' stereotypes of the people in these fields (Bodzin and Gehringer 2001; Finson et al. 1995; Smith and Erb 1986). For instance, Flick (1990) found that fifth-graders who met scientists and visited their laboratories generated less stereotypical images of scientists than those who had not interacted with scientists. Notably, exposure to both male and female role models who do not fit the stereotypes can have a beneficial effect on women's interest and anticipated success in these careers (Cheryan et al. 2011a, c; see also Guan and Jain 2011).

Interventions in the media that depict a greater variety of people in math-related fields could also help loosen the association between math-related careers and males. Children report that their primary sources for information about what scientists are like are television, movies, and magazines (Fort and Varney 1989; Steinke et al. 2007). The media often depicts people in math-related careers in a highly stereotypical manner (Kendall 1999; Schibeci 1986;

see also Steinke 2005). For instance, CBS's popular television show *Big Bang Theory* (http://www.cbs.com/primetime/big_bang_theory/) profiles graduate students in physics and computer science who fit current stereotypes in their appearance, hobbies, and social relationships. Advertisements, such as Best Buy's Geek Squad, similarly portray White men who fit current stereotypes. Students who are exposed to these media depictions may come to believe that these characteristics are not only typical but even required of those in the field.

Exposing students to math-related environments can also communicate a broader image of these fields (Cheryan et al. 2009). Classroom and department environments are particularly important sites of stereotype transmission because they are where many students are first exposed to topics like computer science. Environmental interventions can involve both changing current math-related environments to be less stereotypical and exposing students to math-related environments that are already non-stereotypical. University of Washington's Computer Science and Engineering department, for instance, recently redesigned their building to be a "people place" with bright airy interiors, numerous spaces for collaboration, and many non-stereotypical design elements, such as art and nature posters (Cohoon 2011). These changes have been positively received by students and faculty because they help to project an image of their field that goes beyond current stereotypes. Redesigning virtual educational environments (e.g., online classrooms) to portray a broader image of math-related fields also has positive consequences for women's interest, sense of belonging, and expected success in those fields (Cheryan et al. 2011b).

Women may also become more interested in math-related careers if gender roles are relaxed to enable them to select careers that deviate from female gender role prescriptions. Providing more support and resources for women to engage in gender role-consistent behaviors (e.g., caretaking) without having to take away from their careers could change perceptions of math-related careers to make them more compatible with having a family. Finally, arming women with individual strategies could help women negotiate the incompatibility between masculine fields and their gender role. For instance, to address the double bind that characterizes women who are competent in a masculine domain as lacking warmth, Eagly and Carli (2007) in their book *Through the Labyrinth* recommend that business women "finesse the double bind to a certain extent by combining assertive task behavior with kindness, niceness, and helpfulness" (p. 164). To address the work-family conflict, Sheryl Sandberg, Chief Operating Officer of Facebook, advises women to avoid the temptation to "leave before you leave," or opt out of a career in anticipation of having a family (Sandberg 2009). Achieving gender equality in math-related careers may require broadening stereotypes to change perceptions of math-related fields or providing more support for women to manage current gender role pressures.

Conclusions

Women continue to choose math-related careers at significantly lower rates than men do. This is despite gender parity in math performance in high school and college. What could explain this paradox? I suggest that math-related careers are stereotyped as masculine whereas performing well in math is stereotyped as feminine. The more a domain is stereotyped as masculine, the less belonging women feel in that domain. This analysis could help us understand why women continue to choose math-related careers at a lower rate than would be predicted by their performance. Changing stereotypes of math-related careers may help attract more women into them.

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