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Motivational Pathways to STEM Career Choices: Using Expectancy-Value Perspective to Understand Individual and Gender Differences in STEM Fields

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Abstract

The United States has made a significant effort and investment in STEM education, yet the size and the composition of the STEM workforce continues to fail to meet demand. It is thus important to understand the barriers and factors that influence individual educational and career choices. In this article, we conduct a literature review of the current knowledge surrounding individual and gender differences in STEM educational and career choices, using expectancy-value theory as a guiding framework. The overarching goal of this paper is to provide both a well-defined theoretical framework and complementary empirical evidence for linking specific sociocultural, contextual, biological, and psychological factors to individual and gender differences in STEM interests and choices. Knowledge gained through this review will eventually guide future research and interventions designed to enhance individual motivation and capacity to pursue STEM careers, particularly for females who are interested in STEM but may be constrained by misinformation or stereotypes.

Keywords

Career choices; STEM; individual and gender differences; expectancy-value theory

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Despite the United States' significant investment in science, technology, engineering, and mathematics (STEM) education, the size and the composition of the STEM workforce continues to fail to meet demand. In 2012, there were approximately 7.4 million STEM positions in the U.S., and this number is expected to grow to 8.65 million by 2018 (My College Options & STEMconnector, 2012). Unfortunately, STEM employers throughout the U.S. report shortages of skilled workers, raising concerns about the quality of the U.S. educational system and its ability to produce a large enough workforce to fill these positions (U.S. Congress Joint Economic Committee, 2012). Moreover, despite the impressive gains girls and women have made in math and science course enrollment and performance in recent years, concerns remain regarding the number of females pursuing degrees and careers in certain STEM fields (National Science Foundation, 2008, 2011). In primary and secondary school, girls and boys take math and science courses in approximately equal numbers (U.S. Department of Education, 2012) and girls outperform boys in math and

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science courses (Duckworth & Seligman, 2006). However, at the bachelor's level, women earned 27% of degrees awarded in mathematics and computer science, 20% in engineering, and 36% in physical sciences (National Science Foundation, 2011). At the graduate level, females were awarded 30%, 25%, 23%, and 31% of masters and doctorates in mathematics, computer science, engineering, and physical sciences, respectively (National Science Foundation, 2011). Over the past 30 years, researchers have dedicated themselves to studying these differences in career choice. Of these, Eccles' expectancy-value theory provides one of the most comprehensive theoretical frameworks for studying the psychological and contextual factors underlying both individual and gender differences in math and science academic motivation, performance, and career choice (e.g., Eccles, 1994, 2005; Wigfield & Eccles, 2000).

Drawing on work associated with identity formation, achievement theory, and attribution theory, expectancy-value theorists posit that the STEM pathway is composed of a series of choices and achievements that commence in childhood and adolescence. Achievement-related behaviors such as educational and career choice are most directly related to expectations for success and the value attached to the various options perceived as available. These domain-specific competence and task-related beliefs are influenced by cultural norms, behavior genetic, social experiences, aptitudes, and the affective reactions of previous experiences as individuals move through adulthood (Eccles, 1994; Eccles, Wigfield, & Schiefele, 1997). In other words, individual characteristics and experiences associated with STEM-related activities shape the development of self-efficacy, interests, task values, and long-term life goals, which in turn, influence educational and career choices in STEM and non-STEM fields (Eccles et al., 1993; Jacobs et al., 2005). Therefore, it is likely that male and female differences in STEM field selection are associated with gendered differences in these motivational beliefs (e.g., self-efficacy, interests, and task value).

In this article, we conduct a literature review of the current knowledge surrounding individual and gender differences in STEM educational and career choices, using expectancy-value theory as a guiding framework. The term "STEM" refers to the physical, biological, medical, health, and computer sciences; engineering; and mathematics. We also distinguish gaps in the literature, with the hope that this article will be a useful resource in guiding future empirical research. In the first section, we provide a brief overview of expectancy-value theory and its application to understanding individual and gender differences in educational and career choices. We then examine research demonstrating how both intellectual aptitude and achievement motivation may affect young people's math and science outcomes, focusing specifically on academic performance, aspirations, college majors, and occupational choice. In the third section, we review the influence of school, family, and peer experiences, as well as sociocultural and biological factors, on achievement motivation, engagement, and performance. In the fourth section, we highlight the limitations of the extant literature and provide suggestions for advancing current knowledge through future research.

Our goal is not to review the literature in detail; rather, we suggest how insights gained from previous research can contribute to our understanding of the sociocultural, biological, psychological, and contextual factors associated with individual and gender differences in STEM educational and career choices. A better understanding of individual and gender differences in career pathways will aid in the discovery of potential targets for future intervention. Thus, the overarching goal of this paper is to provide both a well-defined theoretical framework and complementary empirical evidence for linking specific external and internal factors to individual differences in STEM interests and choices. Knowledge gained through this review may eventually guide future research and interventions designed to enhance individual motivation and capacity to pursue STEM careers, particularly for females who are interested in pursuing STEM careers but might be discouraged by misinformation or stereotypes.

Section I. Overview of Expectancy-Value Theory

Eccles' expectancy-value theory (Eccles, 1983, 2009) provides a comprehensive framework for the study of educational and career choice based on aptitudes, expectancies, subjective task values, and life goals (see Figure 1). This model has three major components: a ***psychological component*** consisting of competence beliefs, goals, interests, and values; a ***biological component*** consisting of behavior genetic and hormone influences on the development of abilities, competence beliefs, and values; and a ***socialization component*** consisting of social, cultural, and contextual influences on the development of self-beliefs, goals, interests, and values.

According to expectancy-value theory, achievement-related choices (e.g., high school course enrollment and college major selection) and career aspirations and choices are most directly influenced psychologically by ability, perceived competence (e.g., expectations for success), and the subjective task value attached to the various available options. Subjective task value is comprised of *interest value* (liking or enjoyment), *utility value* (the instrumental value of the task for helping to fulfill personal goals), *attainment value* (the link between the task and one's sense of self and identity), and *cost* (the anticipated psychological, economic, and social costs of various possible task or choices). When individuals feel confident that they can learn and be successful in particular subject areas such as math and science, they are more likely to persist and engage in deeper-level cognitive strategies associated with increased academic achievement and course enrollment (Wigfield & Eccles, 2002). Value-related beliefs are predictive of achievement and academic engagement (Schiefele, 2001) but are even stronger predictors of choice behaviors and beliefs such as career aspirations in STEM (Eccles, 2009; Eccles & Wang, 2012; Wang & Eccles, 2013).

Notably, each choice is based on the *relative* subjective task values and expectations for success across the variety of perceived available options at the time. Consistent with the concept "relative or comparative advantage" proposed by economists and sociologists (e.g., Jonsson, 1999), occupational choice depends on relative advantage more than absolute ability. In other words, a boy or girl rationally considers the pros and cons of different educational and occupational choices with regard to their ability, and then decides in favor of whatever choice they believe reasonably maximizes their utility value. A math-capable boy or girl might not choose to pursue coursework or a career in mathematics or science if he or she perceives that the costs in terms of the effort required are too great and not in line with his or her utility value. Therefore, the decision to choose one career over another is influenced by a relative within-person hierarchy of expectations for success and subjective task values across the set of options considered (Eccles, 1994; 2005; 2009). Gaining insight into the development of these relative hierarchies allows us to understand the predictive power of these motivational beliefs in influencing individual educational and occupational choice.

Expectancy-value theory also links individual differences in motivational beliefs to experiences in school, peer, and family contexts. Eccles and her colleagues suggest that teachers, peers, and parents are in a position to create opportunities for students to engage in a variety of STEM and non-STEM related activities through educational experiences, special programs, etc. (Eccles et al., 1993; Eccles et al., 1997; Wang, 2012). These experiences, in turn, provide children or adolescents with information about their competence and emotional memories of various activities. Over time, feedback and memories accumulate to inform the development of competence beliefs and subjective task values. These motivational beliefs are expected to influence engagement in various educational activities, as well as future educational and occupational aspirations (Simpkins, Davis-Kean, & Eccles, 2006). As educational and occupational aspirations begin to emerge and stabilize, they are predicted to influence the value attached to possible educational and occupational choices. Specifically, opportunities to engage in particular activities lead to affective and performance experiences which influence expectancies and subjective task values, which, in turn influence subsequent activity choices (Eccles, 2009; Hamilton & Hamilton, 2006; Jacobs & Eccles, 2000). Over time, these reciprocal, cycling processes are expected to shape career identities and aspirations and the educational choices linked to these aspirations (Arnett, 2004; Hamilton & Hamilton, 2006; Jacobs & Eccles, 2000). Because these psychological processes take place within larger ecological systems, they are expected to be influenced by biological, cultural, and social processes—processes that are linked to behavior genetic, gender socialization, social stratification, opportunity structures, social barriers, responsibilities and demands, and random life events.

Below, we use expectancy-value theory as a guiding framework to a) understand the roles of intellectual aptitudes and motivational beliefs in shaping educational and occupational choices, b) review the ways in which social and cultural experiences influence the development of intellectual aptitudes and motivational beliefs, and c) link the sociocultural, contextual, biological, and psychological factors to individual and gender differences in STEM career interests and choices.

Section II. Links of Intellectual Aptitude and Motivational Beliefs to Performance, and Educational and Career Choices

The extant research shows that intellectual aptitudes and motivational beliefs are strong predictors of activity choice, engagement, and performance (Durik, Vida, & Eccles, 2006; Eccles et al., 1998). Here we review individual and gender differences in math and verbal abilities, competence beliefs, and subjective task values which likely contribute to individual and gender disparities in educational and career choices in STEM fields.

Intellectual aptitudes

Each gender appears to have its unique strengths and weaknesses in intellectual aptitude, with girls possessing stronger verbal skills (Ceci & Williams, 2010b; Hyde et al., 2008; Park et al., 2008) and earning slightly higher grades in high school math and science classes (National Center for Education Statistics, 2012), and boys outscoring girls by a small margin on high-stakes math tests such as the mathematics sections of the Scholastic Assessment Test (SAT) and the American College Testing (ACT) (Halpern et al., 2007). Some researchers suggest that men are biologically primed to outperform women in mathematical tasks, particularly spatial representation tasks in which participants mentally rotate images (Baron-Cohen, 2003), positing that the male superiority in performance is likely responsible for the overrepresentation of men in STEM professions. However, studies have found that spatial ability can be improved with training in both genders (Quaiser-Pohl et al., 2006; Vasta, Knott, & Gaze, 1996). Dramatic increases in the number of girls achieving very high scores on mathematics tests also suggest that ability levels in general are not static, but rather responsive to educational and societal change. Thirty years ago, there were thirteen boys for every girl who scored above 700 on the SAT math exam at age 13; today it is about four boys for every girl (Wai, Cacchio, Putallaz, & Makel, 2010). Moreover, by 2009, approximately 43% of bachelor's degrees and 30% of PhDs in mathematics were awarded to women (National Center for Science and Engineering Statistics, 2012). Taken together, there is no compelling evidence to show that spatial ability accounts for the shortage of women in STEM fields.

The uneven distribution of males and females scoring among the top percentiles of high-stakes standardized math tests has been implicated as a leading reason for female underrepresentation in STEM professions (Benbow et al., 2000). However, some researchers conclude that women's underrepresentation in STEM fields cannot be explained by gender ability differences alone (Feingold, 1992; Wai et al., 2010). For example, statistics have demonstrated that males outnumber females by a ratio of 4:1 in the top 0.01% of SAT-M scores, yet the male-to-female ratio of professors in STEM fields is much larger (Ceci & Williams, 2011). Similarly, when comparing international data, the proportion of males/females scoring in the top 5% and 1% of the distribution varies by country, with females outnumbering males in some nations (Ceci et al., 2009; Guiso, Ferdinando, Sapienza, & Zingales, 2008). Therefore, distribution differences in mathematical ability do not seem to be a leading or sole cause of female underrepresentation in STEM careers (Ceci & Williams, 2011; Wai et al., 2010).

Overall, researchers tend to agree that intellectual aptitude, at least by itself, is not an overriding factor in the underrepresentation of females in math-intensive fields (Baenninger & Newcombe, 1989; Ceci & Williams, 2010a; Hyde et al., 2008; Quaiser-Pohl et al., 2006; Vasta et al., 1996). Aptitude patterns do, however, affect career choice. Specifically, among males and females of comparably high math aptitude, females are likely to outperform males in verbal ability (Park et al., 2008; Wang, Eccles, & Kenny, 2013). This may allow females greater flexibility in career choice than males and therefore, more opportunity to consider both STEM and non-STEM fields (Ceci & Williams, 2010b; Wang et al., 2013). Wai, Lubinski, and Benbow (2005) tracked high math ability individuals that expressed a desire to undertake a college major in either a math or a science area. They later found that many females from this group had switched from math and science majors into non-math-intensive majors such as law. High verbal ability was a predictor of such transitions, which was, on average, as strong as math ability among these female students. A recent study revealed that mathematically capable individuals who also had high verbal skills were less likely to pursue STEM careers than individuals who had high math skills but moderate verbal skills (Wang et al., 2013). One notable finding was that the group with high math and high verbal ability included more females than males. It is plausible that mathematically talented females who are equally verbally talented are drawn to equally ambitious careers outside of STEM fields. These females have the opportunity to weigh the pros and cons of each career pathway, and consider the potential of each to fulfill important life goals.

Beliefs about the malleability of intellectual ability

Individual differences in beliefs about intellectual ability have been linked to motivation and academic performance. When individuals believe that ability is an innate trait, they become frustrated when confronted with a challenging task, give up more easily, and attribute their struggles or failures to a lack of talent (Dweck, 2007). On the other hand, students who view effort and hard work as the determinants of success and intelligence persevere through difficult tasks, have higher motivation for learning, and perform better in school (Dweck, 2007; Good, Aronson, & Inzlicht, 2003). Research has found that girls are vulnerable to these differences in ability beliefs, especially when confronted with challenging tasks in math or science-related fields. For example, girls who attributed intelligence to effort and learning had math grades comparable to those of their male classmates and superior to those of girls who believed ability was a static trait (Blackwell, Trzesniewski, & Dweck, 2007). Additional research implied that the combination of viewing math ability as a trait and stereotype threat (believing girls are not good at math), is a potent mixture for girls, leading to self-defeating beliefs about ability and decreased motivation and interest in pursuing math careers (Dweck, 2007). However, the research on growth mindset is based primarily on short term experimental studies. It is therefore unclear whether individual beliefs about

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malleability of intellectual ability have a cumulative and long term impact on learning motivation and performance. Extensive longitudinal research is needed to link the impact of growth mindset onto educational and career choices.

Ability self-concept

Expectations for success, confidence in one's abilities to succeed, and personal efficacy have emerged as important predictors of behavioral choice (Eccles, 2009; Eccles et al., 1997; Wigfield et al., 2006). Expectations for success vary across subject domains and individuals are more likely to select activities for which they have high expectations for success (Eccles et al., 1998). Extensive research has confirmed the role that poor math self-efficacy or perceived competence plays in female underperformance in mathematics (Durik et al., 2006; Eccles et al., 1998; Valian, 2007). Both girls and boys who rate their math competence highly are more likely to enroll in advanced math courses, choose a quantitative college major, and embark on STEM careers (Dweck, 2008). High-school boys tend to assess their math competence higher than girls with similar math grades and test scores (Correll, 2001; Nagy et al., 2008). However, it is noteworthy that ability self-concept is a necessary but not a sufficient predictor of educational and career choices (Joyce & Farenga, 2000; Shapka, 2009; Updegraff, Eccles, Barber, & O'Brien, 1996; Wang, 2012). Being capable or good at a given activity does not necessarily mean that an individual will pursue the activity or even enjoy it. In addition to confidence in one's abilities to succeed, expectancy-value theory suggests that career choices also depend on the value one attaches to various occupational characteristics.

Interest value

Youth interest in math and science is associated with the number of math and science courses taken in high school and aspirations for math-related careers (Atwar, Wiggins, & Gardner, 1995; Joyce & Farenga, 2000; Meece, Wigfield, & Eccles, 1990). Boys report higher interest in math even though boys and girls regard math as equally important (Frenzel, Goetz, Pekrun, & Watt, 2010; Watt, 2004). Jacobs et al. (2005) found that math interest did not predict involvement in math or science activity; rather, children with higher math ability self-concept were more likely to be interested in math. Girls' interest in math decreases as they move through adolescence while boys' interest remains constant (Eccles & Harold, 1992; Koller, Baumert, & Schnabel, 2001). Interestingly, this pattern holds true for ability self-concept as well. Girls begin to demonstrate progressively lower ability self-concept relative to boys beginning in middle school and extending through high school and college (Pajares, 2005). Expectancy-value theory suggests that interest is influenced by the belief that one can succeed in a given field, explaining the relationship between interest and ability self-concept (Eccles, 1983). Therefore, according to Eccles and others (e.g., Pajares, 2005), interest and ability self-concept are intimately interlinked. As girls tend to have lower math ability self-concepts than boys, their math interest in turn is lowered.

Occupational values

Researchers have found that high school occupational aspirations are predictive of college majors; additionally, gender differences in occupational preferences are also important predictors of female underrepresentation in STEM careers (Ferriman, Lubinski, & Benbow, 2009; Morgan, Gelbgiser, & Weeden, 2013). Many studies indicate that females and males demonstrate different work preferences and occupational aspirations, which are already visible and formed in adolescence (Diekman et al., 2010; Eccles, 2009). Females prefer occupations that allow them to interact with people, whereas males prefer occupations that involve work with objects, machines, and tools (Ruble & Martin, 1998; Su, Rounds, & Armstrong, 2009). Males and females with similar ability profiles achieve college degrees at the same rate, yet mathematically capable females are more likely to pursue pathways in “people fields”, such as in the humanities and biological and social sciences, while mathematically capable males are more likely to prefer STEM fields, such as engineering and physical sciences (Benbow et al., 2000; Lubinski et al., 2001).

Females may gravitate towards “people” careers not just because they are socially inclined, but because their social orientation is towards altruism (Schwartz & Rubel, 2005). Females have been shown to put more value on jobs that allow them to help others and benefit society (communion/affiliative orientation), while males place more value on jobs that allow them to make a lot of money, have power, and become famous (agentic/power-based orientation) (Abele & Spurk, 2011; Freund, Weiss, & Wiese, 2012). Compared to non-STEM careers, math-intensive STEM careers are perceived as more compatible with agentic than communal goals (Diekman, Clark, Johnston, Brown, & Steinberg, 2011). A recent study demonstrated that when a STEM career was presented to females as more communal, their interest in the field increased (Diekman et al., 2010). Indeed, biomedical and civil and environmental engineering attract higher numbers of females than other areas such as mechanical or nuclear engineering (Gibbons, 2009). These findings indicate that gender preferences toward working with people versus objects play a crucial role in females’ underrepresentation in certain STEM fields.

Lifestyle values

Research into the role that priorities play in females’ career decisions indicates that work-family balance is an important factor (Hill, Corbett, & St. Rose, 2010). A ‘family/work dilemma as a collision course’ has been proposed by researchers (Ceci & Williams, 2010b) where a female’s decision to have a family is detrimental to her career in STEM fields. Females place more importance on making occupational sacrifices for the family than males (Eccles et al., 1999). Females have also been shown to prefer more home-centered lifestyles as opposed to work-committed lifestyles, and perceive STEM careers as incompatible with achieving a desired work-family balance (Hakim, 2006). For females who work in STEM fields and take care of a family, it is difficult to attain the same level of productivity as males. For example, research shows that faculty in STEM fields who work more than 60 hours a week are more likely to publish, and that females in STEM fields with children are more likely to work fewer hours (Jacobs & Winslow, 2004). It has also been noted that STEM fields are characterized by rapid change requiring continuous development of technological expertise, perhaps to a greater degree than other fields, thus making it difficult for people to take a leave of absence (such as maternity leave) (Lubinski & Benbow, 2007). These findings may partially explain the gender imbalance in representation in STEM careers.

Summary—Motivational beliefs, which are informed by aptitudes in math and science, competence beliefs, interest, and occupational and life values clearly play a role in the decision to pursue STEM versus non-STEM fields. With regard to the current underrepresentation of women in STEM fields, there are two main psychological factors that influence women’s career decisions: occupational preferences and work/family imbalance. Women appear to be opting out of STEM fields at higher rates than men due to differences in career interests. Women express preferences for working with people, while men prefer working with objects, an interest which is more aligned with STEM work. Women also tend to remove themselves from intensive STEM professions or switch to part-time work when they have children, given that their primary caregiving responsibilities and maternity absences make it more difficult to work long hours and achieve the same level of productivity as their male colleagues. These are sacrifices that men with children rarely have to make. In addition, one important but often overlooked factor is that females are more likely to have both high math and high verbal abilities. These females are more likely to choose careers outside of STEM fields because their high skill levels provide them with more career options. In summary, career preferences and lifestyle values, along with ability pattern differences, appear to be largely responsible for women's and men's differential career choices.

Section III. Links of Sociocultural, Biological, and Contextual Influences to Ability and Motivational Beliefs

Individual motivational beliefs do not develop in a psychological vacuum; rather they develop under the influence of various ecological contexts, including family, peer groups, school, biology, and society at large. Motivational beliefs are influenced by the rules and roles prescribed by these social contexts, many of which pertain to gender. In this section, we examine insight from research on sociocultural and biological influences on STEM motivational beliefs, and focus on how cultural and societal messages of women's respective roles, competencies, interests, and values permeate influential social contexts and reduce women's motivation to pursue STEM careers.

Schools

Throughout childhood and adolescence, individuals spend substantial time in school. Thus, teachers and peers become crucial for understanding the development of children's STEM motivational beliefs (Catsambis, 2005; Eccles & Roeser, 2011; Schnabel et al., 2002). The school environment can provide students with positive social interactions with peers and teachers, opportunities to take ownership of one's learning process, and encouragement to think positively about one's academic abilities, which in turn, affect how students approach their school work (Urdan & Schoenfelder, 2006). School/classroom environments that are sensitive to adolescent developmental needs for competence, autonomy, relatedness, and meaningfulness are positively associated with academic motivation, achievement, and emotional well-being (Deci & Ryan, 1985, 2000; Eccles, 2006; Eccles, Lord, & Buchanan, 1996). In this section, we review the school/classroom factors that may lead to individual and gender differences in STEM subject performance and motivation, focusing primarily on structural and organizational features of the school and on social interactions within the school and classroom.

Classroom structures—The influence of math classroom structural characteristics (e.g., class composition and teacher characteristics) on student achievement is well-documented and consistent across genders (Blatchford, 2003; Roland & Galloway, 2002). For example, students in smaller classrooms tend to perform better on standardized tests and exhibit more achievement growth over time (Arias & Walker, 2004; Nye & Hedges, 2001a, 2001b; Nyhan & Alkadry, 1999). Small class sizes also enhance positive interactions between students and teachers and increase opportunities for individualized instruction (Deutsch, 2003; Haughey, Snart, & da Costa, 2001; Stecher & Bohrnstedt, 2002). Teacher qualifications – such as certification, degree in the subject matter one teaches, and years of teaching experience – are positively linked to teaching effectiveness and student achievement (Akiba, LeTendre, & Scribner, 2007; Koedel, 2009; Powers, 2003). Teacher qualifications tend to be weaker in high poverty classrooms (measured by the percentage of students qualifying for the federal school lunch program). Students in these classrooms are, therefore, at a greater academic disadvantage than their peers studying in more affluent classrooms (Lee, Smith, & Croninger, 1997; National Center for Educational Statistics, 2007). In both high-poverty and high ethnic minority secondary schools, core classes such as math and science are more likely to be taught by out-of-field teachers (The Education Trust, 2008), with few advanced math courses offered, and students at high ethnic minority schools more likely to be taught by novice teachers (Adelman, 2006). Ethnic minority and low SES students who receive less qualified academic training are less likely to have the preparation, competence, or skill to take higher level courses that would prepare them for math or science fields (Balfanz, McPartland, & Shaw, 2002; Peng, Wright, & Hill, 1995).

Curricular differentiation—Learning experiences are affected by curricular differentiation or tracking, due to the quality of education (Oakes, 2005) and the social groups students compare themselves with (Marsh et al., 2008) and interact with (Dishion, Poulin, & Burraston, 2001). Although many researchers believe that tracking is an appropriate method for tailoring the course to individual competence levels (Eccles & Roeser, 2011; Mulkey, Catsambis, Carr, Steelman, & Crain, 2005), evidence reveals inconsistent effects of tracking on math achievement, particularly for highly competent students (Fuligni, Eccles, & Barber, 1995; Gamoran & Mare, 1989). Some research suggests that tracking achieves positive results for high-achieving students placed in high-ability classrooms (Carbonaro, 2005; Frank et al., 2008). However, other research suggests that high-achieving students may suffer self-concept reduction (Marsh et al., 2008; Mulkey et al., 2005) and more negative emotions (Frenzel et al., 2007). Tracking may also play a role in the math gender gap (Gamoran & Hannigan, 2000). For instance, parental influence and teacher perception often influence tracking placements (Useem, 1992), and given that teachers tend to underestimate the math ability of girls relative to boys (Frome & Eccles, 1998), girls may be placed at a disadvantage. Furthermore, tracking is highly dependent on standardized test scores (Useem, 1992) which, in math, are generally lower for girls (Halpern et al., 2007).

Single or co-ed—Single-sex education has been put forward as a possible enabler for the performance of young girls in STEM fields (e.g., Cooper & Weaver, 2003; Mael et al., 2004). An all-girl setting may help girls to overcome gender stereotypes (Feniger, 2011; Inzlicht & Ben-Zeev, 2000); however, findings on the academic outcomes in single-sex versus coeducational environments have been mixed. Some researchers found improved achievement in single-sex schools (e.g., Lee & Bryk, 1986, 1989; Riordan, 1994, 2002; Streitmatter, 1999) and others found no advantages (e.g., LePore & Warren, 1997; Marsh, 1989). One study demonstrated that stereotype-threat conditions diminished girls' geometry test performance in a mixed-sex classroom, but not in a single-sex classroom (Huguet & Regner, 2007). Other studies have found that girls in single-sex schools have higher math achievement than girls in co-educational schools (Cherney & Campbell, 2011; Daly & Defty, 2004; Shapka & Keating, 2003). However, no advantage has been demonstrated for girls in single-sex schools in terms of their math and science enrollment decisions (McEwen et al., 1997), placement in advanced math or science courses (Feniger, 2011), or STEM-related occupational choices (Cherney & Campbell, 2011). Possible explanations for such findings are that single-sex schools are as likely to endorse traditional gender stereotypes as co-ed schools (Patterson & Pahlke, 2011), or that putting young girls in same-sex groups further encourages communal goals and gender normative behaviors (Cherney & Campbell, 2011; Bussey & Bandura, 1999) which may diminish interest in STEM careers (Diekman et al., 2010). Such conflicting evidence leaves the debate on single-sex versus co-ed schools unresolved.

Furthermore, the intersection of ethnicity and single-sex schooling needs to be considered. For example, it is possible that single-sex schooling may benefit White but not African American or Latina girls in math and science performance. Single sex schools may decrease the numerical presence of a given race/ethnicity, and ethnic minority girls may, as a result, experience a heightened sense of disconnectedness due to their increased minority status (Patterson & Pahlke, 2011; Graham & Juvonen, 2002). Furthermore, it is possible that these girls give greater importance to their ethnic identity relative to their gender identity (Corby et al., 2007; Turner & Brown, 2007) lessening any potential positive shared gender effects (Patterson & Pahlke, 2011).

Teachers' differential expectations, treatment, and stereotypes—Teacher expectations may affect students' self-expectations and performance through their impact on competence beliefs (Metheny, McWhirter, & O'Neil, 2008; National Research Council, 2004). Teachers vary in their expectations for the achievement of individual students and these beliefs are related to differential treatment and achievement outcomes (Hattie, 2009; Jussim & Harber, 2005; Turner & Patrick, 2004). However, it is important to note that teacher-expectancy effects are mediated by teacher-student interactions (Jussim, Eccles, & Madon, 1996). For example, a teacher might respond to low expectations for a student by providing the support and structure needed to foster the student's sense of competency and ability (Eccles, 2009). Although literature on differential expectation has shown these effects to be small, on average (Jussim & Harber, 2005), it may have substantial cumulative negative effects on the motivation and achievement of students from stigmatized groups, including girls in math and science (Green, 2002; Jussim et al., 1996). Indeed, females are more likely than males to be harmed by low teacher expectations of math performance (McKown & Weinstein, 2002; Wang, 2012).

Discriminatory treatment of girls in math class has also been reported. Teachers tend to ask girls fewer direct and open questions and give them less praise (Becker, 1981). Some research indicates that teachers single-out girls with high math ability, providing them with even less praise than girls with low math ability (Parsons, Kaczala, & Meece, 1982). It has been suggested (but not yet tested) that lack of praise could cause low self-efficacy in exam-taking situations (Ceci & Williams, 2010b). A 1992 American Association of University Women (AAUW: Bailey et al., 1992) report concluded that boys receive more attention and esteem-building encouragement from teachers; that classroom activities were generally more male-oriented; and that teacher-student interactions in science class were particularly favorable towards boys. However, more studies need to be undertaken on classroom dynamics. Although extant research suggests that boys receive greater attention overall, much of this attention may be negative, such as criticism for misbehaving (Beaman, 2006).

Teachers' implicit gender-stereotypes predict differential teacher expectations for male versus female students (Chalabev, Sarrazin, Trouilloud, & Jussim, 2009). Much research has focused on the stereotypes that teachers have surrounding girls' ability in math and science fields (for a review, see Li, 1999). Teachers tend to stereotype math as a male domain and attribute boys' successes and failures to ability, while attributing girls' successes and failures to effort (Fennema et al., 1990; Keller, 2010; Tiedemann, 2002). Even high achieving females are seen as less logical, less independent in math, and liking math less than their equally achieving male counterparts (Fennema et al., 1990). Tiedemann (2000) found that teachers believed girls profit less than boys from additional effort in math, and that math is more difficult for girls than boys. Furthermore, research indicates that the more a teacher stereotyped math as a male domain, the more strongly his/her students also endorsed the math gender stereotype (Keller, 2010).

Teacher goal-structure and mindset—Teachers' pedagogical goal orientation and beliefs about the nature of ability are important in determining students' motivation patterns (Eccles & Roeser, 2011). Students in classrooms with an emphasis on mastery-goal structure are more interested in increasing their competence and mastering the material (Friedel et al., 2007; Roseth, Johnson, & Johnson, 2008); whereas students in classrooms with an emphasis on performance-goal structure are concerned with demonstrating their competence or avoiding revelation of their incompetence (Meece, Anderman, & Anderman, 2005; Turner & Patrick, 2004). As adolescents transition into secondary school, they encounter classroom structures that are increasingly performance oriented (Midgley, 2002; Roeser et al., 2002). In relation to mathematics, it is believed that the American educational system's emphasis on test-taking, accountability, and standards forces teachers to stress performance over mastery in math class (Midgley, Kaplan, & Middleton, 2001). This may be particularly challenging for girls, who are generally more mastery-oriented, and tend to cope less well with performance-goals than boys (for a review, see Midgley, et al., 2001).

Dweck (2006) suggests that underlying beliefs about the nature of intelligence influence teacher endorsement of mastery versus performance goals. Teachers (and students) who think of intelligence as a malleable quality tend to emphasize mastery-goals, whereas those who think of intelligence as a fixed trait emphasize performance-goals. These beliefs further affect achievement motivation. An intervention teaching students that intelligence can be developed promoted a positive change in math class motivation and math grades, whereas the reverse was true for a control group (Blackwell et al., 2007). This may be particularly important for enhancing the performance of young girls in math. Indeed, Grant and Dweck (2003) illustrate that in a pre-med chemistry course, males outperformed females who viewed intellectual ability as a fixed entity. Females who believed that intellectual ability could be developed actually outperformed males (Grant & Dweck, 2003). Valian (2007) suggests that the U.S. school system adopts a 'fixed mindset', where ability is treated as an innate, unchanging entity. She argues that the gender differences within Japanese students' math achievement are smaller compared to American students, because the Japanese system promotes a 'growth mindset'. These findings suggest that girls' beliefs (and those of their teachers) regarding the innateness of math ability could be a potential factor or intervention point in influencing girls' math performance. However, it is noteworthy that some recent international research contradicts the research findings from the United States. For example, Singaporean and Finnish girls both outperform everyone else in the world in math and science yet neither are particularly growth-minded (Gonzales et al., 2008; Luo, Paris, Hogan, & Luo, 2011; Provasnik et al., 2012). More cross-cultural and cross-country comparison studies are needed to investigate whether the impact of a growth mindset is consistent across cultures and countries.

General Teaching Practices—Research on achievement motivation (e.g., Pascarella & Terenzini, 1991; Wigfield, Eccles, & Pintrich, 1996; Wigfield et al., 2006) suggests that certain aspects of teaching practices foster student motivation and achievement in math, including the use of real-world and challenging tasks (e.g., the relevance of the material to the students' lives), provision of opportunities to engage in self-generated academic work, classroom organization (e.g., whole class instruction, ability grouping, cooperative learning groups), and the use of evaluation practices emphasizing effort and improvement over normative ability. For example, competence beliefs can be supported through the provision of opportunities to be successful at challenging tasks and the use of evaluative feedback that emphasizes effort rather than ability (Linnenbrink & Pintrich, 2003; Patrick et al., 2007). Students feel more confident about their ability to learn math and complete math activities successfully when cooperating with others rather than working on their own, due to the greater array of resources upon which to draw (Ryan & Patrick, 2001).

Similarly, subjective task values can be increased by providing students with choices through self-generated tasks, making clear ties between course material and everyday life, creating opportunities for students to be actively involved in learning by working in groups, doing hands-on activities, engaging in group discussion, and working with peers (Bergin, 1999; Durik & Eccles, 2006; Gentry & Owen, 2004; Tyson, Linnenbrink-Garcia, & Hill, 2009; Vekiri, 2010). In particular, encouraging students to make connections between their lives and science lessons can increase both course interest and grades for students with low success expectations (Hidi & Harackiewicz, 2000; Hulleman & Harackiewicz, 2009).

Unfortunately, recent research suggests that math teachers do not always have the same understanding as their students regarding what is ‘real world’ or ‘practical’ (Appleton & Lawrenz, 2011), indicating that more class time should be spent discussing students’ ideas on how to connect their life experiences to classroom mathematics or science activities.

Interpersonal Relationships—Classrooms are inherently social places, and in contrast to the considerable attention given to instructional characteristics, the influence of interpersonal relationships on achievement motivation has been given little examination (Connell & Wellborn, 1991; Covington, 2002). Researchers have focused more on teachers than on peers as socializing agents of motivation and engagement, particularly in math and science fields. Below we focus on peer interactions in addition to teacher-student relationships.

Teachers: Teachers can facilitate a positive social classroom environment by acting as a source of support for their students, and by sending positive messages about the nature of student-student relationships (Patrick & Ryan, 2005). Positive interpersonal relationships with teachers have been associated with high grade point averages (Goodenow, 1993), greater compliance with teacher expectation (Birch & Ladd, 1997), higher academic motivation (Maehr, 1991; Stipek, 2002), and increased classroom engagement (Furrer & Skinner, 2003; Roorda et al., 2011; Van Ryzin, 2011). Teacher support may be particularly important for student engagement and motivation in math. Since students typically attribute math performance to ability (Schoenfeld, 1992; Stoldosky, Salk, & Glassner, 1991), they are more likely to attribute difficulties to lack of ability. Therefore, supportive teachers who deemphasize relative ability patterns and prevent students from undermining one another are likely to facilitate math motivation and performance (Ryan & Patrick, 2001). Gregory and Weinstein (2004) found greater growth in math achievement for adolescents who felt their teachers offered praise, listened, and were interested in their students. A recent study (Crosnoe et al., 2010) showed that the achievement gap between high and low math skill children who entered elementary school was narrowed in classes with inference-based instruction and non-conflictual relationships with the teacher. The achievement gap, however, stayed the same between children who received inference-based instruction but had conflictual relationships with the teacher. In addition, female teacher support is especially crucial for young girls in math and science, in which the teacher has the capacity to function as a role model or mentor for young girls (Buday et al., 2012).

Peers: The norms and characteristics of peers profoundly influence adolescent academic achievement, beliefs, and behaviors (Berndt & Murphy, 2002; Ryan, 2001, Wang & Eccles, 2012; Wentzel, 1998). Friendships characterized by self-disclosure, pro-social behavior, and support are linked to increased involvement in school, whereas friendships characterized by conflict, rivalry, and rejection are associated with disengagement from school (Garcia-Reid, 2007; Juvonen, Wang, & Espinoza, 2011). In a series of studies of naturally occurring peer groups, Kindermann (1993, 2007) found that youth who associate with highly engaged peers increase their own engagement over time. The peer group is also an important influence on math motivation, and popularity of engaging in math and science (Frank et al., 2008). For example, peer encouragement of science achievement is related to positive attitudes toward science among adolescents (Stake, 2006), and youth with peers who are supportive of science are more likely to imagine themselves as future scientists relative to those who do not have science-supportive peers (Stake & Nickens, 2005).

Peer support may be particularly important for adolescents in math and science due to an increased desire to conform to peer norms during adolescence (Crosnoe et al., 2008). Leaper, Farkas, and Brown (2012) recently found girls’ perceived peer support of math and science to be positively related to their math and science motivation. Girls have closer and smaller networks of friends, whereas boys have wider networks of friends with whom they are less emotionally involved (Davies & Kandel, 1981; Giordano, 2003; Van Houtte, 2004). As such, these different peer groups may produce some gender variability in their math trajectories. In addition, Frank et al. (2008) found that compared to boys, girls were particularly responsive to social norms related to math course taking in their peer groups, leading to homogeneity within groups and heterogeneity between groups. Crosnoe et al. (2008), however, found that the influence of close friends' math achievement on girls' and boys' math course-taking patterns was characterized more by similarity than by difference. Overall, the research specific to peer effect on student motivation and achievement in math and science is limited and inconsistent.

Summary: As a central developmental context, we must be careful not to underestimate the influence that the school has on student motivational beliefs. As the preceding section suggests, the school's influence is complex and multi-faceted, impacting students through various delivery mechanisms. These are, most notably, through school/classroom structural mechanisms (e.g., class sizes, high teacher education), teacher instructional practices (e.g., cooperative environment, authentic instruction), and positive interpersonal relationships with teachers and peers, which have been shown to influence student achievement and motivation. Each of these school/classroom features can positively impact both male and female students, resulting in increases in academic performance and motivation for both genders. However, a recent study indicates that females' interest in math and science was mainly sparked by school-related activities, while most males recounted self-initiated activities (Maltese & Tai, 2011). Thus, when STEM-related structural features of the school, instructional techniques, and/or teacher-student relationships are lower in quality, females may be more susceptible than their male counterparts to disengage from math and science classes. Given the complex interplay of school factors influencing STEM motivational beliefs, there are a myriad number of ways to pursue the application of preventative interventions. Future research examining these school and classroom dynamics should inform the development and application of these interventions to improve STEM representation for girls and women. The following section will address how families may also influence individual and gender differences in motivation to pursue STEM careers.

Family

The family is the most important setting outside of the school in shaping student motivational beliefs (Wigfield et al., 2006; Xie & Shauman, 2003). Parents influence their children's academic motivation, achievement, and educational and career interests through the home environments they create, the values they endorse, and the experiences they provide (Holland, 1985; Spera, 2005). Here, we focus on family background characteristics, parental beliefs about math and science, and math and science specific behaviors. Examining all three socializing agents recognizes the many ways family characteristics influence student motivation and achievement in math and science.

Family demographic characteristics—Family income, structure, parent education, and community characteristics have all been shown to have an effect on children's academic motivation and achievement (Eccles, 2009). Studies show that high socioeconomic status (SES) is associated with higher math test scores (Coley, 2002; Gregory & Weinstein, 2004; Papanastasiou, 2000) and greater likelihood of completion of advanced math classes (Sciarra, 2010). Highly educated, high earning parents are more likely to provide greater learning opportunities and better quality educational interactions at home. For example, high SES parents have a better understanding of how to maneuver the educational system (Castambis, 2005), such as knowing how to communicate with teachers, discussing their child's math track, and getting their child into high ability math groupings (Useem, 1992), which is necessary for positive STEM trajectories. Accessing or providing educational resources is often an uphill battle for both low SES parents and single-parents due to financial constraint (Hampden-Thompson & Johnston, 2006). Psychological stressors such as working long hours with little financial gain may diminish the ability of these parents to engage with their children to promote high achievement motivation and performance in different subject domains (Eccles, 2009). Moreover, community characteristics such as a dangerous and resource-poor neighborhood could also function as psychological stressors for both parents and children, weakening motivation for academic success (Eccles, 2009; Greenman, Bodovski, & Reed, 2011).

Social class differences could also reflect differences in parental beliefs and behaviors toward education (Ceci & Williams, 2010a). Davis-Kean et al. (2003) found that SES, and in particular parent education, exerts its influence on child achievement through parental educational attainment expectations. Parental education can also influence quality of educational interactions in the home. For example, mothers with more math preparation and more math self-confidence are more effective at conveying mathematical content and scaffolding their children in math-learning (Hyde et al., 2006). High poverty, high unemployment, and low-education families tend to employ fewer education-oriented practices with their children (Greenman et al., 2011). In addition, Grauca, Ethington, and Pascarella (1988) demonstrated an indirect positive influence of fathers' and mothers' college education on adolescents' perceptions of women's educational attainment and choice of STEM careers. Having a highly educated parent also predicted females' decisions to major in science (Ware, Steckler, & Leserman, 1985). It is possible that highly educated parents have less conventional beliefs about appropriate career choices for females and are consequently more willing to encourage their daughters in nontraditional pursuits (Ware et al., 1985).

For both genders, SES may also dictate college major choice so that economic returns are optimized. Lower SES children tend to choose higher paying fields such as technical, life/health sciences, and business over humanities and social science/education majors (Ma, 2009). Interestingly, females from lower SES backgrounds are as likely as males to choose these higher paid professions, indicating that family SES trumps gender for lower SES females. Hence, it is possible that SES outweighs the effects of gender role socialization in influencing divergent career paths. Stressing the financial gains associated with math-intensive careers could positively influence the STEM trajectories of young women (and men) from lower SES backgrounds. For example, degrees in engineering and computer science typically lead to higher pay than degrees in social science, humanities, and education (Arcidiacono, 2004; Berger, 1988; Black et al., 2003; Gilbreath & Powers, 2006). Female and minority engineers and computer scientists also earn substantially more than comparable females and minorities in business and finance, and as much as or more than lawyers and health care practitioners (Oh & Lewis, 2011).

Specific parental beliefs, attitudes, and values toward math and science— Parental beliefs about their child's math ability and the value they put on math generally influence their own behavior as well as the motivation and later career choices of their children (Andre, Whigham, Hendrickson, & Chambers, 1999; Bleeker & Jacobs, 2004; Simpkins, Fredricks, & Eccles, 2012; Spera, 2005; Tenenbaum & Leaper, 2003). Parents who endorse math and science gender stereotypes are likely to underestimate their daughters' ability and overestimate their sons' ability in these areas (Eccles & Jacobs, 1986; Frome & Eccles, 1998; Tiedemann, 2000; Yee & Eccles, 1988). Furthermore, mothers' lack of endorsement of math gender-stereotypes appears to moderate girls' vulnerability to stereotype threat more strongly than that of fathers' (Simpkins et al., 2012). Recent research shows that the performance of girls whose mothers strongly rejected the math-gender stereotype does not decrease under a stereotype threat condition (Tomasetto, Romana, & Cadinu, 2011). Conversely, daughters of mothers with traditional gender stereotypes are less likely to choose physical science careers over traditional careers such as nursing (Jacobs & Bleeker, 2004). These findings suggest that parental beliefs influence youth ability beliefs which, in turn, impact their future achievement and career choices (Eccles et al., 1982; Gunderson et al., 2012).

Parental endorsement of a growth versus fixed mindset in math learning has also been examined in regard to gendered differences in children's math achievement. Although some research indicates that parents tend to attribute girls' math performance to hard work whereas boys' math performance is attributed to ability, findings have been inconsistent (Eccles, Jacobs, & Harold, 1990; Raty et al., 2002; Yee & Eccles, 1988). Several researchers found that parental expectations of math ability tend to be lower for daughters than for sons, and parents put less value on the importance of their daughters' participation in math and science (Hyde, Fennema, Ryan Frost, & Hopp, 1990; Fredricks, & Eccles, 2005; Simpkins et al., 2012). In contrast, some studies show that parents do not favor sons over daughters in valuing math achievement (Catsambis, 1994; Penner, 2008). Dweck and her colleagues have extensively examined the detrimental effects of learning through a fixed mindset, which attributes success to an innate ability, and not to effort. For example, children praised for intelligence are more concerned with performance goals than children praised for effort, who are more likely to stress learning or mastery goals (Mueller & Dweck, 1998). After experiencing failure children with a fixed mindset demonstrate less task persistence, less task enjoyment, lower ability attributions, and worse task performance than children praised for effort. Interventions targeting students' ability beliefs have been shown to promote a positive change in math motivation and math grades (Blackwell, Tresniewski, & Dweck, 2007). More research is needed, however, to determine if long-term effects on occupational trajectories result from promoting mastery over performance orientation, and whether these interventions can increase female interest in pursuing math and science careers.

Specific parental behaviors toward math—Beliefs and values affect behavior, and parents can encourage children's math and science motivation through multiple methods (Jacobs & Eccles, 2000). For example, parental role-modeling influences children's task involvement and values indirectly through observational learning. When children observe their parents engaging in a math activity and believe their parents value and enjoy math, they are more likely to imitate and integrate these values and behaviors into their own repertoire (Bandura & Walters, 1963). In addition, motivational strategies adopted by parents directly influence their children's math and science involvement. For example, task intrinsic motivational practices, including encouragement of children's pleasure, curiosity, persistence, and task involvement throughout the learning process, appear to positively impact math and science motivation for children and youth ages 9 – 17, whereas extrinsic motivational practices, such as using external rewards and consequences, appear to have an adverse effect (Gottfried et al., 2009).

Parents often provide experiences for their sons and daughters that are gender specific (Eccles, 1983; Jacobs & Bleeker, 2004; Jodl, Michael, Malanchuk, Eccles & Sameroff, 2001), leading to different knowledge, expectations, preferences, and abilities (Leaper, 2002; Serbin et al., 1990). For instance, parents who endorse academic gender-stereotypes are more likely to engage in uninvited intrusions during homework with their daughters than their sons. Uninvited homework assistance may undermine children's confidence in the domain of study, and girls have been found to be more sensitive to such intrusions (Bhanot & Jovanovic, 2005). It is possible that the intrusive support during math homework reminds girls of their minority status and conveys the stereotype that girls are not as competent in math as boys (Bhanot & Jovanovic, 2005). Further research suggests that parents provide

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fewer math and science opportunities for their daughters (Bleeker & Jacobs, 2004; Jacobs et al., 2005). Activities provided by parents have been the most consistent predictors of involvement and interest in math several years later (Jacobs & Bleeker, 2004). Numerous studies demonstrate that parents explain science processes in more detail to their sons than to their daughters, and the amount of ‘science talk’ has been shown to predict comprehension of science readings two years later (Crowley, Callanan, Tenenbaum, & Allen, 2001; Tenenbaum, Snow, Roach, & Kurland, 2005). Such differential treatment likely contributes to the gender gap in STEM pathways given that parental math and science behaviors are closely linked to children’s classroom engagement, career interests, and choices in STEM (Turner, Steward, & Lapan, 2004).

Summary: In this section, we examined the role that the family can play in influencing both individual and gender differences in STEM motivational beliefs and achievement. Research suggests that differential parental beliefs, expectations, and treatment of sons and daughters may promote a gender divide in math and science motivational beliefs. These parental behaviors may reinforce negative stereotypes that lead to the belief that math ability is an innate trait as opposed to a set of skills that can be mastered through practice. Parents may foster early interest in science and math with girls and boys by providing more opportunities to develop and explore their interests (e.g., purchasing science kits, trips to museums, etc.), avoiding the labeling of STEM-related activities as male activities, and emphasizing performance as opposed to innate intelligence in math ability. Parental beliefs, practices, and resources are, however, impacted by demographic characteristics such as SES. Low-income families, for instance, often lack resources and connections that higher income families utilize to promote math and science learning among their children. However, as research suggests, one potential method to promote STEM careers within lower SES families may be to highlight the financial security and stability of the field. Entrenched stereotypes and beliefs transmitted to children may also be targeted through awareness campaigns which would gradually change perceptions of math and science as male-oriented activities. Naturally, it is difficult to discuss the importance of family on influencing math achievement, motivation, and interests without also exploring the impact of behavior genetics on these processes. Given the high correlation between environment and genetic expression, and the cyclic manner in which experience and brain structure shape one another and human behavior over time, the model would be incomplete without incorporating a biological component. The following section, therefore, focuses on how biological differences in prenatal testosterone exposure and brain lateralization may differentially impact male and female math achievement and interests in pursuing STEM careers.

Biological Influences on Ability and Motivation

In addition to the impact of motivational beliefs and social contexts in shaping male and female STEM inclinations, biological differences in hormone levels and brain organization have been attributed to the underrepresentation of women in STEM. Supporters of these biological theories suggest that men have evolved superior spatial abilities, which ultimately contribute to lower relative female performance in math and science as well as lower female participation in STEM fields (Baron-Cohen, 2003). Although there may be underlying biological differences in quantitative ability between males and females, it is important to note that the research on gender differences to date has been mostly inconclusive (Ceci, Williams, & Barnett, 2009). Below we summarize the recent research on how differences in hormone levels and brain lateralization may differentially impact mathematical ability and interest between the sexes.

Hormone levels—Research on hormone differences has mainly focused on prenatal differences in testosterone exposure and postnatal differences in activation of testosterone and estrogen (e.g., puberty), with a general assumption that prenatal testosterone enhances spatial ability by influencing neural pruning processes that lead to enhanced lateralization in the male brain (Baron-Cohen, Knickmeyer, & Belmonte, 2005). On average, males tend to have lower neuronal density in the corpus callosum relative to females (Davatzikos & Resnick, 1998; Gong, He, & Evans, 2011), leading them to rely more strongly on their right hemisphere to process spatial information, which is considered a more efficient process than the bilateral approach that females rely upon (Gur et al., 2000; Vogel, Bowers, & Vogel, 2003). However, research on the links between testosterone and spatial ability has largely supported an inverse-U relationship, in which higher amounts of testosterone within the distribution are associated with diminished spatial ability (Brosnan, 2006). Among clinical populations, research has found that women with congenital adrenal hyperplasia (CAH; a genetic condition resulting in excessive production of androgens [male sex hormones]) had superior spatial abilities compared to women without the condition, and men with CAH had lower abilities than unaffected men (Hampson & Altmann, 1998; Hines et al., 2003). However, other studies have reported no differences in spatial ability between individuals with CAH and unaffected controls (Malouf, Migeon, Carson, Petrucci, & Wisniewski, 2006; Ripa, Johannsen, Mortensen, & Muller, 2003), leading to further lack of clarity in the role that testosterone may play in supporting spatial ability.

Additionally, some researchers have proposed that testosterone may actually affect quantitative performance and STEM participation by differentially shaping preferences, interests, and experiences between males and females. For instance, development of masculine features and appearance brought about by CAH in girls may influence the way peers and adults treat them, thereby encouraging more “masculine” girls to participate in games or activities that support or enhance spatial abilities (Berenbaum & Resnick, 2007). This assumption would support a biological × environment interaction in which hormones and social contexts simultaneously impact development of spatial ability. However, little support has been found to suggest that an external marker for prenatal testosterone exposure, 2D/4D ratios (length of the second or index finger divided by the length of the fourth or ring finger; on average men have ratios of 0.98 and females have ratios of 1), are associated with spatial ability and STEM-linked career interests (Alexander, 2006; Puts, McDaniel, Jordan, & Breedlove, 2008; Weis, Firker, & Hennig, 2007). Similarly, researchers have dispelled the assumption that infant girls are programmed to show more interest in people, while male infants are more object-focused, citing methodological limitations and contradictory findings (Spelke, 2005). Therefore, more research on the role of hormones on spatial ability is warranted.

Brain lateralization—Research on gender differences in cerebral organizational has found that male spatial abilities are mainly housed within the right hemisphere, whereas females draw upon both hemispheres during spatial tasks. This results in greater lateralization for the male brain, which is assumed by many to be the optimal processing system for high spatial performance (Gill & O’Boyle, 1997). However, some studies connecting gender and handedness with spatial abilities (on average, left-handers have less lateralized brains than right-handed individuals) have demonstrated inconsistent findings regarding the benefits of lateralization on spatial performance (Annett, 1992; Casey & Brabeck, 1989; Halpern, 2000; Harshman, Hampson, & Berenbaum, 1983; Johnson & Harley, 1980). Some researchers have shifted their focus to examining gendered differences in strategy, pointing out that males use more efficient strategies when solving spatial problems (Heil & Jansen-Osmann, 2008). Although this does not prove that biological differences do not exist, when females are instructed to use more effective strategies their spatial performance greatly improves, lending additional support to the importance of sociocultural contexts in reducing the gender gap (Spelke, 2005).

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Summary: Although biological differences in androgen levels and brain organization may influence the gender gap in math and science ability, the current research has been largely inconclusive. While some studies have detected positive relationships among prenatal testosterone, brain lateralization, and spatial ability, other studies have reported contradictory or inconsistent findings. Interpretation of this research is further complicated by the fact that the impact of sociocultural factors on spatial ability cannot be separated from the genetic influences (Ceci et al., 2009).

In most studies, the male advantage has been established by examining distribution differences in means and variances between males and females. However, distribution differences do not prove that biology is more responsible for male quantitative superiority than sociocultural influences. The matter is not only complicated by the difficulty separating biological effects from environmental effects, but by the difficulty establishing causal links between the two (e.g., brain organization influences experience and experience also influences brain organization). Even recent international research has generated skepticism over the importance of biology in determining math ability, as findings demonstrate that girls outperform boys in math and science in several countries; the size of gender discrepancies varies widely by country; and that cultural factors, such as stereotypes and gender inequality, are related to the magnitude of these gender gaps (Else-Quest, Hyde, & Linn, 2010; Nosek et al., 2009; Penner & CadwalladerOlsker, 2012; Provasnik et al., 2012). These data suggest that sociocultural factors are more important determinants of mathematical skill than genetic endowment, and that more research examining the complex interplay of biological, psychological, and environmental factors is warranted. Regardless, as biology offers up genetic potentialities that can be either fulfilled or hindered by variations in environmental contexts, it is important that we include the recent research on how hormone levels and brain lateralization may influence math ability and motivation. The following section discusses the larger cultural and social issues that influence girls' motivation to pursue STEM careers.

Sociocultural Influences on Ability and Motivation

Socialization and cultural norms shape the values, beliefs, and choices of young people. In particular, cultural histories related to gender influence the cognitive, social, and emotional development of children and play a role in their academic identity formation (Ferrari & Mahalingam, 1998). Gender stereotypes, for example, are widely held beliefs regarding which activities boys or girls are more likely to excel at, or in which activities they should/should not participate. Discriminatory treatment, often stemming from stereotypes, is a societal barrier to males and females that can prevent them from pursuing certain career pathways. In this section we provide an overview of the literature in this area.

Gender stereotypes—Stereotypes are judgments about the abilities or attributes of individuals based on their membership in a social group (Ruble, Cohen, & Ruble, 2001). Gender stereotypes have the capacity to encourage or discourage students from making choices that do not align with proscribed gender roles in society (Eagly, 1987; Eccles, 1987; Raty et al., 2002). Research demonstrates that triggering negative gender stereotypes can be detrimental for the performance of girls in tests of mathematics and spatial reasoning (Aronson, 2002; Aronson & Steel, 2005; Steele, Spencer, & Aronson, 2002). Studies have shown that children are aware of math-related gender stereotypes (Steel, 2003) and that exposure to female role models in math can improve performance on math tests and invalidate these stereotypes (Marx & Roman, 2002; McIntyre, Paulson, & Lord, 2003). In addition, stereotypes erode female math self-efficacy and identification with math-related fields (Steele, 1997), likely causing them to identify with and pursue non-STEM pathways (Eccles et al., 1999). Even young women who select math-intensive majors have difficulty self-identifying with math if they implicitly stereotype math as a masculine field (Nosek, Banaji, & Greenwald, 2002). Researchers suggest that while performing well in math class may now be stereotypically feminine (girls now do as well as boys), pursuing math careers remains a gender role 'violation' for women (Cheryan, 2012). Cheryan (2012) suggests that stereotypes surrounding math related careers are a likely barrier to the recruitment of young women. Qualities valued in women, such as high social skills and altruism, are not considered compatible with STEM fields (Diekman et al., 2010), which are viewed as male-dominated, socially isolated, and technology-focused fields (Barbercheck, 2001; Steele, 2003). Such stereotypes may also explain why women are more interested in some STEM fields (e.g., biology and medicine) over others (Cheryan, 2012).

Stereotype-threat (ST) refers to a threat of underperformance when an individual's stereotyped category (i.e., race minority or gender) is made salient. Research suggests that when a stereotyped individual feels stressed during a testing situation, resulting physiological responses lead to increased cortisol production which may undermine intellectual performance (Ben-Zeev et al., 2005). After experiencing repeated failures or threats of failure in a stigmatized domain, a process of disidentification is believed to take place (Schmader, Johns, & Barquissau, 2004; Steele, 1997), where the domain in question will be removed from the individual's self-concept. Girls have been shown to attain higher performance when their gender was not made salient or when they were primed with a biography of a successful woman prior to the examination (Dar-Nimrod & Heine, 2006; Lesko & Henderlong Corpus, 2006; McIntyre, Paulson, & Lord, 2003; Spencer, Steele, & Quinn, 1999). Similarly, girls who ticked the gender box after completing the SAT examination in advanced calculus scored significantly higher than their counterparts who indicated their gender before commencing the exam (Lewis, 2005). Math-gender stereotypes have been demonstrated in children as young as 6-years-old (Cvencek, Meltzoff, & Greenwald, 2011). Indeed, beliefs about ability do not appear to moderate susceptibility to ST, as it has been shown to operate amongst middle school girls who deny negative stereotypes about girls and math (Huguet & Regner, 2009). A recent study demonstrated that girls' STEM test preparation was impaired by ST (Appel, Kronberger, & Aronson, 2011), suggesting that the learning process can also be affected by ST.

Gender discrimination—Discrimination often has roots in negative stereotypes. A line of inquiry into gender discrimination in STEM fields has mostly focused on professional settings. Some research indicates that women have more difficulty than men obtaining funding for fellowship applications (Trix & Psenka, 2003; Wenneras & Wold, 1997) and getting hired by search committees (Steinpreis, Anders, & Ritzke, 1999). However, other researchers have found no evidence for discrimination against women in the hiring process (Committee on Gender Differences, 2010) or in having grant applications approved (Marsh, Bornmann, Mutz, Daniel, & O'Mara, 2009). More recently, Ceci and Williams (2011) extensively reviewed research on gender discrimination in the workplace and found methodological flaws in most of these studies. When researchers employed more sophisticated analyses and held confounding variables such as place of employment (teaching-oriented university versus research-oriented university), job position, and access to resources constant, a pattern emerged reflecting minimal or nonexistent gender differences in rates of manuscript publication, grant acceptance, and hiring for postdocs or faculty positions (Ceci & Williams, 2011). These findings led Ceci and Williams (2011) to conclude that although gender discrimination was once a leading explanation for female underrepresentation in STEM careers, it is no longer a viable reason for present-day women. One study further reports that STEM faculty believe that women's underrepresentation in STEM fields is not due to bias against women, but rather to less female interest in engineering and the physical sciences (Gross & Simmons, 2007).

Ceci and Williams (2010b) suggest that although there may not be a sex bias in the workplace, there could in fact be a bias against mothers and especially mothers with young children. They argue that there is a distinction between an employer who discriminates on the basis of gender outright and an employer who uses gender as an indicator of someone who will be unable to work as many hours or be as committed as an individual without children. Although further research is needed to validate their assertion, we do know that being a numerical minority in work can activate gender stereotypes (Eagly & Carli, 2008; Taylor & Fiske, 1978). In the male-dominated STEM fields, it is possible that a particular social identity threat is posed to women scientists and engineers. This may not be discrimination per se but it is likely that for many females, male-dominated STEM fields are not perceived as welcoming and they do not feel they 'fit'. These findings suggest that increasing the number of female role models and positive STEM experiences will increase the likelihood that women will pursue STEM careers (Richman, vanDellen, & Wood, 2011). It is also important to note that although overt gender discrimination may not explain women's underrepresentation in math and science, perceived discrimination stemming from negative stereotypes might. Therefore, it is important that future research focus on how girls' and women's perceptions of discrimination may negatively impact their motivation to pursue STEM professions, which may prove more useful than analyzing actual discrimination statistics.

Family formation, childrearing, and work-home balance—Lifestyle preferences associated with family formation and childrearing have been proposed as a prevailing cause of female underrepresentation in the math and sciences (Ceci & Williams, 2010b; Ceci & Williams, 2011). Although women may freely choose to have children and forego their careers to focus on caregiving, cultural norms have traditionally deemed women responsible for the home/family and men responsible for income/finances. As the number of dual-earner household incomes has increased since past decades, the pressures of balancing work/family responsibilities have become a challenge for many women. In fact, research suggests that women, unlike men, are less likely to "have it all," making career sacrifices for the sake of their families and vice versa. For example, female scholars are less likely than male scholars to be married and have children, while women with children tend to work fewer hours than men with children and women without children (Jacobs & Gerson, 2001; Jacobs & Winslow, 2004). However, these statistics do not imply that women with children work less hours than men overall; they actually work more. In fact, when time devoted to careers, domestic chores, and caregiving were totaled, women with children reported working an average of 13 more hours/week than men with children (Jacobs & Winslow, 2004). Despite the great strides women have made in joining the professional workforce in the last 50 years, cultural norms still seem to dictate that women should be responsible for the bulk of the childrearing and housework (National Research Council, 2003). Women scientists, therefore, may feel an external pressure to sacrifice work for their families, which could explain why women are more likely than men to leave tenure-track and postdoc positions in STEM fields (Ceci et al., 2009).

Cultural norms—Culture and ethnicity influence values, goals, and general belief systems, and subsequently impact parents' behaviors and children's motivations (Garcia-Coll & Pachter, 2002). Individual cultural values (e.g., familism and gender role beliefs) may impact the pursuit of math and science (Knight, Bernal, Cota, Garza, & Ocampo, 1993). For instance, familism is thought to underlie Latino adolescents' high academic values (Fulgini, & Pedersen, 2002). In addition, traditional gender roles are more strictly adhered to in Latino culture. Latina youth often feel pressure to abandon college aspirations in order to fulfill traditional female roles within the family (Fuligni, Yip, & Tseng, 2002; Taningco, Mathew, & Pachon, 2008). In addition, Martin (2000, 2006) found that African

American students were less likely than other ethnic groups to relate their math grades to their sense of academic values, and more likely to associate them with their racial/ethnic identities.

Asian American students have been shown to demonstrate superior math performance in comparison with majority European American students (e.g., Chen & Stevenson, 1995; Huntsinger, Jose, Liaw, & Ching, 1997; Huntsinger et al., 2000). Huntsinger et al. (2000) found that Chinese American parents were more likely than European American parents to structure their children's time to a greater degree, use more formal teaching methods, and assign their children more homework. Other research suggests that, compared to Japanese parents, European American parents overestimate their children's abilities and are more satisfied with school performance that falls below their expectations (Crystal & Stevenson, 1991). Asian parents appear to emphasize effort as opposed to American parents who tend to emphasize ability (Li, 2005; Stevenson et al., 1993). These findings suggest that cultural norms need to be taken into account when investigating the motivational beliefs contributing to STEM decisions.

Although considerable attention has been given to ethnicity differences in educational attainment, few studies have investigated how gender and ethnicity interact to contribute to gender differences in STEM participation (Hill, Corbett, & St. Rose, 2010). For example, African American parents have lower general school achievement expectations of their sons than their daughters (Wood, Kaplan, & McLoyd, 2007), and young African American males perform worse than females in all subjects, including math (American Association of University Women, 1998), reversing the predominant gender pattern. Young African American females express more interest in STEM fields than young White females (Hanson, 2004), and male African American and Latino adolescents express career aspirations in math and science comparable to their European American male peers, despite the notable achievement differences (Riegle-Crumb et al., 2010).

In addition, gender and ethnicity may interact to put some groups at a 'double' disadvantage. Latina girls, for example, may face negative stereotypes regarding both their ethnic and gender competence in math and science (Bouchey & Harter, 2005; Brown & Leaper, 2010). Further investigation into the interactive effects of gender and ethnicity on STEM choice is needed. However, it is important to note that inequity of resource allocation or learning opportunity (Gregory & Weinstein, 2004; Perna et al., 2009) is also bound to play a role in the underrepresentation of both minority males and females in STEM related fields. Identifying the factors that contribute to gender, SES, and ethnic underrepresentation is an important step in addressing the pervasive underrepresentation of these groups in STEM fields (Gregory & Weinstein, 2004).

Summary: Social factors, including stereotypes and discrimination, and cultural factors, such as norms, are macro-influences on the motivation of young girls and boys to pursue STEM pathways. These factors impact female motivations in various ways, by influencing the beliefs and behaviors of parents, teachers, and peers as well as exerting influence on youth themselves (e.g., portrayals of women in films and on television). The power of these cultural factors resides in their reach, given that these values, attitudes, and practices are able to influence multiple microsystems simultaneously to directly affect how females self-identify with math and science. Most researched and perhaps most clear, are gender stereotypes, which appear to define math and science as male-oriented activities. Along with the actual dominance of men in STEM professions, gender stereotypes lend themselves to a general societal feeling that women do not belong in STEM fields. The final section will discuss limitations of the current research and suggest new directions that the field should pursue.

Section V. Future Directions and Conclusions

Career choices within STEM

Researchers have identified a wide array of factors underlying both individual and gender differences in math and science achievement motivation, performance, and educational and career choice. Although recent work on motivational beliefs leading to STEM occupational choices has begun to include self-efficacy, interest, values, and identity processes as key mediators (Benbow et al., 2000; Betz, 2007; Ceci & Williams, 2007, 2010b; Eccles, 2009; Hullaman et al., 2008; Lubinski et al., 2006), little of this work has focused on the different occupational choices within STEM (e.g., physical sciences versus biological sciences). There have been major efforts to increase the participation of women in STEM over the last 40 years, yet females are still more likely to pursue degrees and occupations in the biological, health, and medical sciences than in the engineering, physical, and computer sciences (National Center for Education Statistics, 2007). It is unclear which motivational factors attract women to certain STEM fields such as medicine and biology versus other STEM fields such as engineering, physical, and computer sciences (Ceci & Williams, 2010b). Study of field distinctions within STEM will help to provide a more nuanced understanding of individual and gender differences in career development, career planning, and decision making. Since career choice is made at the individual level, it is critical to model the social and psychological processes that lead to career decisions during secondary school. This will allow us to differentiate the career paths of students with early STEM interests who either pursue or do not pursue STEM careers, as well as those with little early interest in STEM who either do or do not end up in STEM paths.

Early school and classroom experiences

Most studies have focused on enrollment and experiences in college, despite the fact that educational and career aspirations surface in late childhood and early adolescence (Eccles, Vida, & Barber, 2004; Wang, 2012). The majority of students who pursue STEM degrees make that choice before they enter college and that choice is related to a growing interest in math and science in elementary school (Maltese & Tai, 2011). Researchers have also identified the period of middle school as a particularly important time for choosing to pursue STEM versus non-STEM careers (Maltese & Tai, 2010; Tai, Liu, Maltese, & Sandler, 2006). The career aspirations formed in middle and high school initiate the academic pathways that lead to STEM college majors (Eccles et al., 2004; Morgan et al., 2013). Once a student begins college, switching into STEM fields, especially the physical, computer, and engineering sciences, becomes difficult due to the constrained and prescribed curricula in these subjects. Thus, it is important that we understand the early school experiences and motivational processes that lay the groundwork for selecting a rigorous trajectory of secondary school math and science courses as well as pursuing math and science college majors.

Historical changes

Comparing the beliefs and occupational choices of different generations of students will help to understand historical changes in K-12 graders' educational and occupational trajectories. This is particularly relevant for girls, as traditional explanations for the dearth of women in STEM careers have centered on gender discrimination, negative stereotypes of female mathematical ability, and a sense of isolation or lack of belonging (Ceci et al., 2011). However, as previously addressed, the most relevant explanations are lack of interest, family caregiving responsibilities, and differences in ability patterns (Ceci & Williams, 2011). Although career preferences and family obligations may play a larger role in influencing female career decisions than gender discrimination (Ceci & Williams, 2010b), this does not mean that perceived discrimination and stereotype-threat have no effect on present-day women's career choices. Generational comparisons in STEM attitudes and beliefs will allow researchers to determine career barriers that still persist and need to be addressed (e.g., family/work balance issues), and other areas that may be improving (e.g., greater number of girls expressing interest in math and science).

Affective experiences

Researchers have found that the motivational beliefs individuals attach to specific subject areas (e.g., their intrinsic interest in the subject; the utility value they see in taking the course; and the importance they attach to excelling in the subject area) predict future course enrollment, continuing motivation, and enrollment decisions (Eccles, Barber, & Jozefowicz, 1999; Meece, Wigfield, & Eccles, 1990; Wigfield, 2004). However, the role of personal daily emotional experience in the development of motivational beliefs and engagement in STEM areas remains unclear. According to flow theory, flow experience occurs when skills are neither overmatched nor underutilized to meet a given challenge (Csikszentmihalyi, 1997). The balance of challenge and skill is very delicate; both must become more complex in order to sustain the feeling of flow. This balance can be easily disrupted leading to different affective states: apathy (i.e., low challenges, low skills), anxiety (i.e., high challenges, low skills), or relaxation (i.e., low challenges, high skills), and very dynamic (high challenges, high skills).

Moreover, recent theoretical and empirical advances in psychology and neurobiology suggest that our current understanding of achievement motivation pays inadequate attention to emotion (Damasio, 1999; Forgas, 1995). An extensive body of research attests that human emotion is likely to influence the processes underlying motivation (Erez & Isen, 2002) and constitutes an important source of influence on human thought and behavior (Haidt, 2000; Izard, 1993). However, adolescents' daily emotional experiences are still largely neglected in the empirical research of achievement motivation. Future research should investigate whether particular emotional experiences (e.g., feeling happy or sad; frustrated or exhilarated) indirectly influence engagement and aspirations by affecting the motivational beliefs and anticipated emotional outcomes involved in making discrete academic and career choices.

Peer effects

Although studies have shown that family and school contexts shape academic performance and motivation, there has been far less work examining peer effects, despite the fact that peers strongly influence adolescent behaviors. Recent research suggests that girls whose friends emphasize the importance of math and science achievement, downplay or devalue the importance of English, and vice versa (Leaper et al., 2012). Future research on how peers integrate and juxtapose English and/or math and science identities is warranted. In addition, given that much of the extant research on peer relationships has relied on self-reports of perceived social support rather than actual peer influences, the use of multiple informants and peer network approaches in future studies will advance this line of inquiry. It is also necessary to examine the relative influences of peer, teacher, and parent relationships over the secondary school trajectory, investigating the progression and potential change and network interactions in such trajectories.

Person-centered approach

Researchers have relied on variable-centered rather than person-centered approaches to studying student achievement and motivation in STEM domains, and in so doing, have overlooked existing subgroups. Recent studies have identified different profiles and patterns of student motivation by using person-centered approaches (Li & Lerner, 2011; Wang & Peck, 2013). For instance, some youth begin with an interest in math and science but then lose it over time, while others maintain consistent interest in math and science. It is likely that educational and career choices would differ between these two contrasting profiles. Focusing on general, average trends would mask this heterogeneity. Similarly, the main components of values driven motivation may vary, leading to divergent educational and career choices. For example, one student may find math useful for increasing employment opportunities while another student is intrinsically interested in math. It would be interesting to examine whether both utility value and intrinsic value motivate students to pursue STEM-related careers. A person-centered approach to examining student achievement motivation would allow us to distinguish the career paths of those with or without early STEM interests. Understanding these subgroups will enhance our ability to design targeted interventions for improving participation in STEM. It will also allow us to determine if there are particular patterns of motivational beliefs that facilitate or undermine individual success and pursuit of STEM-related careers.

Biological considerations

Researchers have conducted a great deal of research on how biological constraints may operate to produce gendered differences in spatial ability between males and females. However, although gender differences in hormone levels, hemispheric specialization, and mathematical strategies may influence the gender gap in spatial ability, there is little that can be gleaned from the current findings with regard to how potent these biological factors are (Ceci et al., 2009), especially given that they cannot be separated from environmental factors. This is particularly relevant given that substantial variability in international samples indicates that sociocultural factors cannot be discounted as powerful influences of gendered ability differences. Specifically, more research investigating how biological, psychological, and sociocultural factors interact to influence achievement is needed. Under what conditions do individuals with less hemispheric specialization and high or low 2D/4D ratios (proxy for prenatal testosterone levels) achieve high spatial ability scores? Were these high achievers raised in high SES families, taught by highly motivated and supportive teachers and parents, or did they develop high interest and self-efficacy in math and science? In line with our suggestion for more person-centered research, clusters or profiles of individuals could be created to examine how different combinations of biological, psychological, and sociocultural characteristics interact to impact ability patterns and career choices. Although such studies will not succeed in resolving the nature or nurture debate regarding the extent to which biology versus sociocultural factors determines intellectual ability, they can provide greater insight into which psychological and environmental assets may ameliorate or buffer the effects of genetic predispositions.

Intervention

Although a number of studies have contributed to the understanding of gender disparities in STEM fields, there has been relatively little intervention work to remedy the dearth of female participation in these disciplines. The majority of research-based preventative programs have focused on increasing youth learning motivation as a way to reduce the risk of academic failure and high dropout rates, rather than specifically promoting greater interest and motivation in math and science (e.g., Balfanz, Herzog, & Mac Iver, 2007; Felner, Seitsinger, Brand, Burns, & Bolton, 2007). In recent years, there have been a few successful experimental studies and small scale interventions which support the idea that women’s views of STEM disciplines are responsive to intervention techniques.

Some studies have sought to alter men and women’s views of STEM disciplines indirectly by targeting the behaviors of parents and teachers. For example, in one study, researchers provided brochures and a website to parents of adolescents with information on how to communicate the importance of STEM careers and demonstrate the value of these courses and career choices in daily life (Harackiewicz, Rozek, Hulleman, & Hyde, 2012). Students in the experimental group enrolled in a greater number of math and science courses than the control group. There was also an indirect relationship between intervention status and greater student utility value for math and science coursework, through mothers' utility value and conversations about the importance of math and science.

Another intervention focused on increasing student interest and motivation in psychology college course enrollment by having students write personal essays about the relevance of the course material in their daily lives (Hulleman, Godes, Hendricks, & Harackiewicz, 2010). Students in the experimental group reported an increased interest in the course material and increased utility value for psychology compared to the control group. A similar intervention was conducted with high school students, and found that students with low expectations for success reported increases in science motivation when asked to reflect on how their science courses were relevant to their lives (Hulleman & Harackiewicz, 2009). Similarly, other interventions have found that when science teachers adopted a classroom structure that was sensitive and supportive to the needs of their female students, those students displayed more positive attitudes and interests towards science (Mason & Kahle, 1989).

Some experimental studies have focused on directly altering women's beliefs about their abilities and roles in society. For instance, studies have demonstrated that eliminating or buffering the stereotype threat prior to a mathematical assessment can increase female performance on the assessment relative to male performance (Campbell & Collaer, 2009; Martens, Johns, Greenberg, & Schimel, 2006). Another study found that providing writing exercises that prompt women to select and write about values that are important to them (e.g., family and friends), a values affirmation exercise, obtained higher grades in a college physics course and reduced the gender gap in course performance relative to a control group (Miyake et al., 2010). The findings were especially pronounced for females who espoused stereotypes that men are better at math than women. Others have shown that interaction with female professional role models in STEM careers can also lead to an increase in self-efficacy and positive attitudes toward STEM careers through a sense of connectedness and self-identification with the role models (Cheryan, Siy, Vichayapai, Drury, & Kim, 2011; Stout, Dasgupta, Hunsinger, & McManus, 2011).

Despite the encouraging findings of these studies, there is still little known about what specific attributes of an intervention would be most beneficial in supporting women's aspirations to pursue STEM careers. Will researchers find the largest payoffs by targeting women's attitudes (interests, motivation, self-efficacy, utility value) directly, indirectly through altering the socialization and instructional practices of parents and teachers, or a combination of both? Additionally, there is scant research indicating what type of intervention would be necessary for achieving long-term changes in attitudes and behaviors toward STEM fields. Many of the existing experimental studies only examined immediate alterations in attitudes and performance following exposure to the intervention. It is unclear if these changes persisted over time to produce meaningful modifications in women's career goals. More longitudinal work is needed in addressing individual beliefs and attitudes (e.g., malleability of intellectual ability, stereotype threat) to better understand whether these experimental findings will actually have a cumulative impact. Before that, it may be premature to develop interventions based on short term experimental findings.

Furthermore, most of the experimental work has been conducted on adolescents and young adults who have already developed many preconceived notions about STEM coursework and may self-select out of these classes. There is far less experimental or intervention work focused on increasing elementary and middle school students' interests and motivations in pursuing math and science. Intervening to alter career choices at younger ages may provide a greater payout in the long-run; further research is needed to address these concerns. Exploring interventions targeting individual's attitudes towards math and science represents an important next step for future work in this field.

Ethnic and SES differences

A final issue that should be addressed is the tendency for researchers to attribute the underrepresentation of females in STEM disciplines solely to gender differences, and to overlook other factors, such as race/ethnicity and SES, which also affect students' academic motivation and performance. For example, according to statistics released by the National Center for Education Statistics (National Center for Education Statistics, 2012), in the 2009–2010 academic year, only 8.3% and 6.8% of all STEM (includes biological and health sciences) bachelor's degrees were obtained by African American and Hispanic students, respectively, as opposed to 70.5% obtained by White students. As degrees in STEM fields become more advanced, these figures decline. Only 7.6% and 4.9% of African Americans received master's and doctoral degrees, respectively, and 4.7% and 4.1% of Hispanics received master's and doctoral degrees, compared to 55.9% and 62% of Whites. Among African Americans, there is a gender gap in post-secondary STEM degrees that largely favors women over men: 64.3% and 35.7% for bachelor's, 70.6% and 29.4% for master's, and 65.6% and 34.4% for doctoral degrees. In addition, as detailed earlier in this review, SES is a strong predictor of academic performance, with individuals from higher SES backgrounds demonstrating greater achievement in math (Coley, 2002; Gregory & Weinstein, 2004). There is also research that suggests that the male advantage in spatial tasks only exists among middle and high SES children, with no differences found between low SES boys and girls (Levine, Vasilyeva, Lourenco, Newcombe, & Huttenlocher, 2005). Therefore, it is important that future intervention work addresses the multiple socio-cultural factors that may affect an individual's academic and career choices. Particularly, the compounded stereotypes that some individuals face (e.g., Latina and African American women) in STEM fields dominated by European American men need to be addressed to increase diversity in these disciplines.

Summary—Although there has been a great deal of research conducted in the area of individual and gender differences in STEM and non-STEM occupational choice, more fine-grained studies employing person-centered, strengths-based approaches, extensive longitudinal follow-ups, and intervention work are needed. Math and science achievement, course enrollment patterns, and emotions of early adolescents must be taken into account as well. Further, given the increasing diversity of the U.S. population in recent decades, creating interventions to increase female and minority representation in STEM professions will become even more crucial in the coming years. Until we fully understand the intricate dynamics of young people's math and science decisions, and the factors influencing them, harnessing the full potential of our young people for an effective STEM work force, specifically women and minorities, will prove difficult. However, we must be cautious about our efforts to increase STEM participation. Individuals must be free to choose the career pathway that best suits their needs, values, and interests. The goal is to increase interest in pursuing STEM careers, not to coerce or pressure individuals to enter these fields, or make mathematically talented men and women regret their decisions for choosing non-STEM occupations. In addition, we acknowledge that underrepresentation can go both ways. Men underachieve in coursework and are underrepresented in certain STEM areas. Therefore, interventions should not only be designed to enhance female interest in physical science, computer science, and engineering, but also to enhance male interest in biological and health sciences.

Conclusion

Increasing the number and representation of females in STEM fields is crucial to increasing the size of this workforce to meet U.S. demands in the coming years. It is thus important to understand the barriers and factors that influence individual educational and career choices and how classrooms, peers, and families influence these outcomes. This paper reviewed potential predictors, moderators, and mediators of STEM educational and occupational choices which are amendable to future interventions. This research also enhances our capacity to support developing interest and value among individual students in STEM education, career choices, and placements. This is important because it provides an opportunity to understand from a theory- and evidence-based perspective what works to increase the scientific talent pool.

Research has demonstrated that individual differences in motivation beliefs can impact career choices. Over time individuals develop ideas about their own aptitude levels in various subjects, allowing for self-appraisal of competencies. Individuals that view themselves as highly competent in a subject area will be more likely to develop an interest in that area and pursue it as a career. While the gender gap in math performance has been declining in recent decades, differences in career interests and lifestyle values between males and females explain the large number of highly competent women bowing out of STEM fields. Women report a greater propensity toward working with people and valuing jobs that are more flexible and accommodating to their childrearing responsibilities. Unfortunately, current research suggests that STEM fields are perceived by women as being object-oriented, male-dominated, and not family friendly—issues that have yet to be addressed on a meaningful level.

Although strengthening girls' math ability and confidence at earlier ages is a worthwhile endeavor, it is important to tap into the already-existing potential of females who are both mathematically and verbally skilled. One way might include increasing these intellectually capable women's interest in math and science, and ensuring that females are well informed of the diverse options available in various STEM careers. Conveying that math and science careers have a beneficial impact on society and involve work with people, may allow math-competent females to better equate the utility of these careers with their personal goals and values. Exposing math- and verbal-capable females to STEM role models during secondary school may also increase female interest in pursuing STEM fields.

In addition, research also addresses the importance of school and family contextual factors in shaping academic performance and motivation. Although the focus of this paper has been predominantly on increasing female participation in STEM professions, the characteristics of the school and home environments featured in this review influence STEM motivations for both genders. Not surprisingly, higher quality features of these environments are all related to students' motivation for learning and academic performance. Enhancing any of the features mentioned in this review should positively impact both male and female attitudes and value of learning in math and science.

There is also evidence of gendered differences in hormone production and brain organization, although the link between these differences and math ability remains unclear. Some researchers have suggested that the evidence supports a genetic predisposition for males to possess superior spatial and quantitative reasoning skills, citing greater exposure to prenatal testosterone and greater right hemispheric lateralization as congruent with elevated performance in spatial ability. Other researchers have noted that links among androgen levels, cerebral organization, and spatial ability do not consistently support a male advantage, and stress that sociocultural factors have a much larger impact on both female underperformance in math and science and female underrepresentation in STEM careers. Cross-cultural research comparing the gender gap across nations corroborates these assumptions by demonstrating that female quantitative performance varies by societal perceptions of male/female status, equality, and stereotypes that are embedded within the larger cultural context. Further research on how environmental and psychological factors interact with biology to produce high mathematical ability is warranted and necessary.

Gender socialization and cultural norms influence values, interest, and beliefs about STEM careers. Although negative stereotypes and cultural values often linger for generations before noticeable changes begin to emerge, there are ways to reduce discrimination and make STEM careers more appealing to women. Providing more leadership and advancement opportunities and allowing more flexibility for women of childbearing years (Stewart & Lavaque-Manty, 2008) are some of the possibilities that may encourage women to rethink the gender stereotypes affiliated with math and science careers. In addition, some researchers have proposed that women may actually be more productive at work when their children are older. Therefore, universities should extend tenure and grant deadlines and allow part-time start-up for tenure-track positions (which will eventually turn into full-time) for women with newborns and young children (Ceci & Williams, 2011; Long, 1992). Hopefully, such flexible measures will provide an incentive for women to remain actively involved in math and science and prevent the loss of talented and highly skilled women from these fields. However, it is important to keep in mind that not all women who have children work part-time, and not all women who exit STEM fields are mothers, so incentives to stay within the profession may need to be tailored to meet individual needs.

A final caveat, however, is that if career choices reflect personal interests, it is not recommended that males or females be forced to pursue any specific careers in which they show no interest. Free will in choosing careers should never be suppressed or undermined, and if males or females with high math ability choose to pursue other fields due to greater interest in those areas, then no attempt should be made to redirect them to STEM careers (Ceci & Williams, 2011). Instead, interventions should focus on instilling in girls (and boys) that there are no limits to their career pursuits, and removing societal (e.g., stereotypes and discrimination) and biological (e.g., optimal childbearing years coinciding with strict tenure deadlines) barriers that constrain women with children in the workplace (Ceci & Williams, 2011). In this way, girls and women with burgeoning STEM interests may be more motivated to choose and stay within these fields (Wai et al., 2010). The goal is to emphasize options, specifically for members of historically disenfranchised groups which may not consider enrolling in STEM professions. Ultimately, choices should be made freely, and not limited by any cultural, societal, or biological barriers.

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Highlights

- Linking contextual and psychological factors to individual differences in STEM
- Expectancy-value theory and its application to understanding individual choices
- Intellectual aptitude and motivational beliefs affect individual's STEM outcomes
- The influence of educational experiences on intellectual aptitude and motivations
- Suggestions for advancing current knowledge through future research

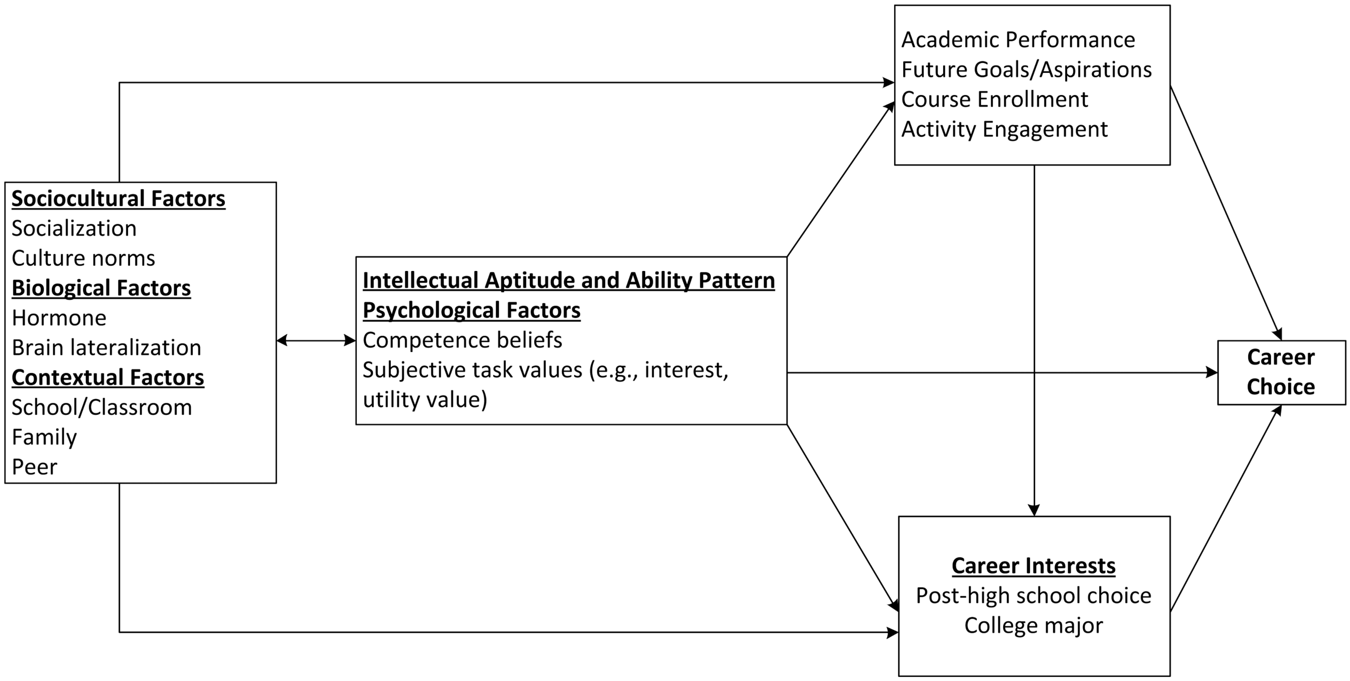

Figure 1.
Theoretical Model of Career Choices