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the nature and development of math-gender stereotypes in children. There has been progress in theory, measurement, and experimental data. This entry summarizes recent progress with respect to four interrelated topics: (1) findings concerning gender gaps in mathematics, (2) theories suggesting that cultural math-gender stereotypes contribute to such gaps, (3) measurement techniques assessing children's beliefs about math-gender stereotypes, and (4) empirical results showing when and how cultural math-gender stereotypes may influence children's developing math self-concepts.

Overview

In psychological models of human social cognition it has proved useful to distinguish stereotypes from self-concepts. The first has to do with beliefs about a social group; the latter has to do with beliefs about one's self. Stereotypes can be thought of as associations between concepts that represent social groups and attributes. For example, the belief that math is associated with males is a stereotype (note that stereotypes can be "true" or "false" at the group level). A self-concept includes the association between the concept *self* and other attributes (e.g., a math self-concept can be characterized as "I identify with math"). Stereotypes and self-concepts are related but distinct concepts. A stereotype is a belief about a group of individuals (that may or may not include the self), whereas self-concept is a belief about the self, an identity one holds. If a child believes that boys as a group are better in math than girls, the child is demonstrating a stereotype. If a girl believes that she herself is a math person, that is a self-concept; we can say that the child identifies with math. Recent empirical tests of cultural stereotypes about mathematics have usefully made the distinction between math stereotypes and math self-concepts, which has helped clarify many debates that were engendered when this distinction was not so clearly drawn.

Math-Gender Gap

The gender gap in mathematics performance has narrowed significantly in the past 2 decades. In K-12 education, girls receive higher classroom

MATH-GENDER STEREOTYPES IN ELEMENTARY SCHOOL CHILDREN

Stereotypes are mental images of qualities characterizing members of a social group without regard to individual variation. This entry focuses on the development of stereotypes in children. It specifically examines the pervasive American stereotype that boys, more than girls, are identified with mathematics. In this entry, the term *math-gender stereotype* is used to indicate the belief that math is predominantly a male domain. Stereotypes are distinguished from *self-concepts*. These terms are often confused in the learning sciences, but they can be usefully differentiated in ways that allow for new empirical progress. Self-concepts concern the self (e.g., *I am a math person*), whereas stereotypes refer to a social group (*boys do better at*). A central empirical question is how cultural stereotypes influence children's developing self-concepts. This entry emphasizes the new discoveries in developmental and social psychology concerning

grades in mathematics than boys, and many standardized assessments in the United States indicate that girls score just as high as boys in mathematics. Nevertheless, a gender gap in participation exists at the top of math-intensive fields (e.g., doctoral degrees awarded) and fewer women than men enter math-intensive jobs in the workforce such as engineering or computer science.

During elementary school years, there also exists a gender gap in children's perceptions of math ability—children's math self-concepts: Girls rate their math ability lower than boys do. Such lower perceptions of girls' math ability have been documented as early as first grade and are found throughout elementary and middle school. Importantly, girls do not rate themselves lower than boys at everything. For example, girls usually rate themselves higher than boys in terms of competence for reading and music. These differences in math self-concepts cannot be explained based on math performance alone, because the ratings exist during elementary school when girls' grades in mathematics are higher than boys and they are not behind boys on standardized test scores.

Theories About Math–Gender Stereotypes

Societally held math–gender stereotypes have a negative impact on female students in several ways. First, math–gender stereotypes negatively impact the way female students think about themselves as math learners: Girls identify less with mathematics than boys. Second, math–gender stereotypes negatively impact the math performance of girls: When math–gender stereotypes are activated (e.g., by having a student indicate her gender on the test form prior to her taking a standardized math test), female students perform worse than male students (see the section “Stereotype Threat”). Third, math–gender stereotypes lower female students' stated interest and participation in mathematics: Middle school girls who hold stronger math–gender stereotypes report stronger intentions to drop math in high school than middle school boys do. At least three leading psychological theories have been advanced to explain the way societally held math–gender stereotypes permeating the child's culture begin to influence the self-concepts of the individual learner.

Balance Theory

Gender stereotypes about mathematics influence the way children think about themselves. Children are not simply aware of cultural stereotypes as they apply to other people and groups. They apply stereotypes to themselves. The strongest evidence for the influence of math–gender stereotypes on the emergence of self-concepts is based on a classic theory in social psychology called *balance theory*. Within this framework, the associations among concepts tend to self-organize on principles of consistency often identified as *cognitive balance* (the theory is a close relative to cognitive dissonance theory, another well-known idea from adult social psychology).

According to the theory, people strive to maintain psychological balance among their beliefs, attitudes, and behaviors. In adults, this simple idea was used to show how gender identity and gender stereotypes combine to perpetuate gender differences in the aspirations to participate in academic disciplines, such as careers in math-intensive fields. Past empirical research with adults has shown that there is a tendency to think that if I am a female (gender identity), and females in my culture do not do math (a cultural stereotype), then I will not do math (a self-concept).

Recent studies have shown a similar operation of cognitive balance in children in Grades 1 through 5. This work with elementary school children reveals that pervasive societal stereotypes connecting boys (more than girls) to mathematics begin to affect children's self-concepts, academic performance, effort, and aspirations in elementary school. Moreover, the cultural stereotypes about math are assimilated as early as second grade and can exist even outside conscious awareness or control in young children. These implicit cultural stereotypes can have particularly far-reaching effects, as described in the following.

Stereotype Threat

The impact of culturally held math–gender stereotypes on children's actual performance on assessments of mathematics is well documented, and a mechanism has been put forward by the social psychologist Claude Steele. He and his colleagues called this effect *stereotype threat*. According to the stereotype threat model, the

poor performance of girls in mathematics may in part be due to anxiety that girls experience in test-taking situations. When taking a test in mathematics, female students enter the test situation concerned that a poor performance on their part will confirm a culturally held stereotype about mathematical inferiority of females. As a result, they experience stereotype threat, which saps mental energy, attention, and effort and thereby disrupts their performance on a mathematics test. An influential network of experimental studies by Steele and other social psychologists has confirmed the powerful grip of stereotype threat in adults, in K-12 students, and even in preschool-age children.

Research on stereotype threat in children has shown that Asian American girls as young as 5 years of age performed significantly worse on a mathematics test when their gender identity was activated (by being asked to color a picture of a girl holding a doll) relative to a control group (children who were asked to color a landscape scene). Strikingly, the 5-year-old Asian American girls performed better on a mathematics test when their ethnic identity was activated (by being asked to color a picture of two Asian children eating rice with chopsticks), compared with a control group who had neither identity activated. These results clearly indicate that positive and negative self-relevant stereotypes can impact girls' performance on a math test as early as 5 years of age and, moreover, do so at an implicit level.

Substantial experimental evidence has accumulated for the applicability of this stereotype threat model to other social groups beyond gender (e.g., race, ethnicity, socioeconomic social-class groups) and to a wide range of domains beyond mathematics (e.g., sports, general intelligence, and entrepreneurship).

Expectancy-Value Models

Beyond performance itself, gender stereotypes about mathematics also influence children's participation and interest in the math-intensive domains. Expectancy-value models put forward by Jacque Eccles and colleagues are designed to explain this. According to Eccles's influential theory, socialization processes linked to gender (e.g., learning of cultural gender roles associated with

specific occupations) have an impact on emerging math self-concepts by influencing children's motivation. Expectancy-value theories argue that children's educational and occupational choices and their aspirations for the future are influenced by cultural schemas. Math-gender stereotypes are a part of a larger cultural schema about gender and are assumed to exert a direct influence on children's developing views about themselves and mathematics.

The expectancy-value model theorizes that the choices children make and the things they do depend on at least two factors. The first factor is the subjective expectancy of attaining an outcome. For example, if you want to predict whether a student will enroll in advanced mathematics courses in high school, you would want to know how likely the student thought it was that she would complete those courses. The second factor is the positive value placed on attaining the outcome. In the case of the student taking advanced mathematics courses in high school, you would also want to know the value that student places on successfully completing those courses.

These two factors are assumed to combine in a multiplicative fashion: If either of the two factors (i.e., expectancy or value) is set to zero, the goal will not be adopted. A student who sees no possibility of completing advanced mathematics courses in high school will not enroll in those courses (regardless of how much she values completing those courses). Similarly, if the student sees no value in completing advanced mathematics courses, she will not enroll in those courses (regardless of how likely she sees herself as succeeding). Math-gender stereotypes are said to influence both expectancy and subjective task value; in both cases, relationships are mediated through components of ability self-concepts. According to this developmental theory, the choices children make about how to spend their time and effort lead, over time, to significant differences between genders in life-long achievement-related patterns.

Measuring Math-Gender Stereotypes

Children's stereotypes can be measured either explicitly or implicitly, and the measurement of

implicit stereotypes has been advancing rapidly with interesting empirical results. During the administration of explicit measures, the child is aware of what is being assessed and is asked to provide verbal answers in the form of a self-report. For example, marking answers on a questionnaire about how strongly you agree with the statement “Boys are better than girls in mathematics” would be a self-report measure about math–gender stereotypes. In contrast, implicit measures do not involve verbal self-report and do not require that the child is consciously aware of what is being assessed.

Explicit Measures

When asked directly, using an explicit verbal self-report, children often deny holding math–gender stereotypes. Similar findings hold true for adults: Relatively few people explicitly endorse math–gender stereotypes. However, it is quite possible that people, including children, possess negative stereotypes but are reluctant to express those stereotypes to the interviewer because doing so would be socially inappropriate (social psychologists refer to this as *social desirability effects*). In very young children there are further concerns about how they interpret the verbal question and their linguistic skills in providing answers that require more than simple responses.

Implicit Measures

Implicit measures are less susceptible to artifacts (such as social desirability) that can distort the verbal report that participants give to an interviewer or on a questionnaire. To assess these implicit representations, categorization tests are typically used that require fast responses to tap more automatic and implicit processes (these tests are often called *implicit association tests*, IATs). Stereotypes may be activated automatically without intention or control, and the newer implicit tests seek to tap this level of processing. In adults, implicit measures of stereotypes predict real-world behavior to a remarkable degree. More importantly, the predictive validity of implicit measures often exceeds that of explicit measures, particularly in cases for which socially desirable responding plays a role.

Consequences of Math–Gender Stereotypes

The interplay among math–gender stereotype, math self-concepts, and math performance has recently been studied using both implicit and explicit measures in elementary and middle school samples in the United States, Germany, and Italy. Three main findings are (1) elementary school children already hold stereotypes, (2) culturally derived stereotypes influence children’s developing math self-concepts, and (3) stereotypes influence children’s confidence and subsequent enrollment in mathematics courses.

Math Self-Concepts

Recent research in the United States revealed two findings. First, as early as second grade, children demonstrate the American cultural stereotype that math is for boys. Second, boys identify with math more strongly than do girls (a stronger math self-concept). The interesting developmental question is how the culture’s prevailing stereotypes about mathematics ability influence children’s emerging math self-concepts. In terms of developmental changes, the results obtained with the American sample suggest that stereotypes are acquired first and then subsequently influence self-concepts: Children who strongly identify with their gender (strong gender identity) are more likely to internalize cultural stereotypes about their gender (math–gender stereotypes), which in turn influences their math self-concepts. This developmental pathway is generally in line with the theory of cognitive balance, which holds that self-concepts emerge to seek balance between socially held views about the groups to which one belongs and one’s developing internal concepts.

Math Confidence

The findings from the Italian sample demonstrated lower levels of self-confidence in mathematics in elementary school girls: Italian girls evaluated themselves less confidently in mathematics than boys did, despite having an equal performance. Moreover, when math–gender stereotypes were made very salient, there was a decrease in the performance of girls in Grade 5. In specific experimental conditions in which girls were reminded that females are underrepresented

in mathematics, the performance of the girls dropped precipitously to become lower than that of boys. This decrease in performance of 10-year-old girls is consistent with Steele's stereotype threat model.

Math Enrollment

The results obtained with a German sample of adolescent girls (Grades 7 and 9) show that implicit math–gender stereotypes predicts enrollment preferences. This suggests that implicitly held stereotypes may be a factor in the dropout of female students from math-intensive fields. This would be consistent with the expectancy-value model and the notion that real-world choices can be influenced by automatic, implicitly held stereotypes that are assimilated from the culture. As Eccles and colleagues have pointed out, cultural messages about career choices picked up by children may be incomplete or inadequate, and in absence of clear information about available occupational choices, children may rely on media portrayals (which are often gender stereotyped) or the frequency of encountering counter-stereotypical models in their environment (which are often absent). These messages may be implicit, but they still influence real-world choices in the present and aspirations for the future.

Implications for Theory and Policy

Taken together, the findings from young students from the United States, Italy, and Germany all show that culturally shared math–gender stereotypes influence gender differences in math self-concepts and mathematics participation in elementary and middle school children. Because crucial career choices and aspirations begin to be made during school years, it is important to consider children's and adolescents' implicit math–gender stereotypes, which can play a role in undermining females' mathematical performance and enrollment choices. Moreover, these effects are not confined to just the three Western countries discussed above. In a cross-national comparison of 34 countries, country-level measures of math–gender stereotypes predicted country-level gender gaps in eighth-grade mathematics achievement—stronger societal stereotypes against females doing

mathematics were correlated with a larger gap between boys' and girls' actual mathematics performance. These results suggest the possibility of a damaging role of societally held stereotypes in creating or supporting these gender differences as children develop (although in large correlational studies, causation is not established and follow-up work on causal mechanisms is warranted).

Societal gender imbalances, such as underrepresentation of women in mathematics degree programs and careers, may arise from a combination of societal influences (cultural stereotypes about gender roles) and intrapersonal cognitive factors (tendency to achieve a cognitively balanced state). Moreover, stereotype threat and expectancy-value models come into play even in childhood inasmuch as gender gaps in performance and confidence can result from a combination of both affective factors (anxiety, self-expectancies, and value attributed to mathematics) and social factors (e.g., gender stereotyping, and attitudes of parents and teachers). In summary, the empirical findings demonstrate that culturally derived stereotypes exert influence on children's developing math self-concepts as early as elementary school years, prior to ages at which any differences in math achievement emerge. Intervention programs aimed at changing the ideas of parents, teachers, and students about gender and mathematics might profitably be directed at very early stages in development.

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See also Achievement Gap; Early Childhood Education and Gender; Gender Equity and Mathematics Education; Gender Issues in Higher Education; Gender Similarities Hypothesis; Life-Long, Life-Wide, and Life-Deep Learning; Math Anxiety and Gender; Science, Technology, Engineering, and Math (STEM) Majors and Women; Standardized Testing and Standards; Stereotype Threat

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