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FEMINIST FORUM

New Directions for Research on the Role of Parents and Teachers in the Development of Gender-Related Math Attitudes: Response to Commentaries

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Abstract We frame our response to the commentaries by Cheryan (2011), Lane (2011), and Shapiro and Williams (2011), in terms of two broad points made by Lane (2011). First, we agree that the various constructs that we termed "math attitudes"—including math-gender stereotypes, math anxiety, math self-concepts, and achievement motivation in math—are in fact distinct (Gunderson et al. 2011b). Nevertheless, we argue that investigating common mechanisms underlying the transmission of these constructs from adults to children is a productive approach because it can lead to general interventions to boost children's performance and dispositions toward math. Second, we argue that research on the development of gender-related math attitudes exists at the intersection of multiple research areas, including research on attitudes (broadly defined), math, gender, social learning, and child development, and that drawing on well-developed theories in these areas can lead to novel research questions and predictions. The three excellent commentaries broaden the scope of our article on gender-related math attitudes to include the transmission of implicit attitudes from adults to children, stereotype threat, and gender roles in math-related careers (Cheryan 2011; Gunderson et al. 2011b; Lane 2011; Shapiro and Williams 2011).

Keywords Math attitudes · Gender stereotypes · Math anxiety · Parents · Teachers · Math

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Introduction

The goal of our target article was to explore how parents and teachers influence girls' development of negative beliefs about, and affective stances toward, math (Gunderson et al. 2011b). Our review brought together several bodies of literature which are relevant to this issue and which operate largely in isolation, including research on expectancy-value theory, math anxiety, implicit theories of intelligence, and the development of gender cognitions. As in any article with limited space, we made decisions about what to include and what not to include in our paper. The three commentaries on our target article help expand the scope of our discussion by suggesting additional, potentially fruitful ways to think about how girls' attitudes toward math develop (Cheryan 2011; Lane 2011; Shapiro and Williams 2011). Below we comment on the commentaries, framing our response in terms of the two broad points brought up by Lane (2011).

First, we address the issue of construct specificity, discussed in Lane (2011), since it bears on our use of the term "attitude" throughout this paper. As Lane (2011) pointed out, and as we discussed in our target article (Gunderson et al. 2011b), being specific about theoretical constructs (attitudes, stereotypes, self-concepts, anxieties, identities, etc.) is critical for understanding the causes, social transmission, and potential relief of negative dispositions toward math.

Second, we discuss the import of applying previous findings from established theories to the specific problem at hand. We do so by first discussing how research on attitudes, child development, and social learning can be extended to apply to issues of math and gender. Specifically, we discuss ways in which research on the social transmission of implicit theories of intelligence (reviewed in Gunderson et al. 2011b) and on the

intergenerational transmission of implicit attitudes (reviewed in Lane 2011) can generate new hypotheses when applied to math and gender.

Lastly, we discuss how research on attitudes, math, and gender in adult populations can be extended to questions about the early development and potentially the early amelioration of gendered math attitudes. Specifically, we discuss ways in which the adult literatures on math anxiety (reviewed in Gunderson et al. 2011b), stereotype threat (reviewed in Shapiro and Williams 2011) and perceptions of math-oriented careers by males and females (reviewed in Cheryan 2011) can lead to interesting and novel directions for developmental research.

Construct Specificity in Pursuit of Mechanisms

In the target article, we defined our use of the term "math attitudes" as "a cluster of beliefs and affective orientations related to mathematics, such as math anxiety, math-gender stereotypes, math self-concepts, and attributions and expectations for success and failure in math" (Gunderson et al. 2011b, this issue). Lane (2011) points out that this definition is imprecise for two reasons. First, the term "attitude" has a specific meaning in previous social psychological literature: an attitude is typically defined as an affective evaluation indicating favor or disfavor toward an entity (Eagly and Chaiken 1993). We have used the term "attitude" in a much broader sense and it is possible that our non-traditional usage could cause some confusion about our meaning. Therefore, in this commentary we will refer to the specific construct in question (e.g., stereotype, self-concept, etc.) whenever possible. Nevertheless, for consistency with the target article, we will continue to refer to these constructs as "math attitudes" in cases where it is useful to discuss them as a group.

The second, more substantive, concern Lane (2011) brings up is that grouping constructs such as math anxieties, stereotypes, self-concepts, affective stances, attributions, and expectations together under the umbrella term "math attitudes" obscures the fact that each construct can have different causes, consequences, and methods of relief. Our purpose in creating an umbrella term to refer to these constructs was to show how an important set of mediating factors that develop in early childhood can all be influenced by parents and teachers, and may all ultimately lead to gender differences in math and STEM participation. We nevertheless firmly agree with Lane (2011, this issue) that these constructs are "theoretically and psychometrically distinct." As we stated in the target article, we believe that these distinctions are especially important for understanding the mechanisms by which math attitudes can be passed from adults to children:

> Investigating the mechanisms of transmission between adult and child is a complex task, especially since adults can have a number of different types of math attitudes, including math-gender stereotypes, gender-biased math expectancies, math anxieties, math self-concepts, math self-efficacy, and beliefs about math as a stable trait. Each of these attitudes may lead to several different adult behaviors during interactions with children, which may in turn affect children's stereotypes, anxieties, self-concepts, trait beliefs, and achievement (Gunderson et al. 2011b, this issue).

Our focus in the target article was to explicate the various methods by which children's dispositions towards math are influenced. This is fruitful since it allows us to identify some common behavioral mechanisms by which these various constructs are passed on from adults to children. That is, by using our umbrella term, "math attitudes," we are able to look across constructs often studied in isolation and ask whether or not there are commonalities by which transmission from teachers and parents to children occurs.

We proposed three such common mechanisms: direct teaching, differential treatment of boys and girls, and modeling. Lane (2011) further proposed nonverbal behavior as a candidate mechanism based on previous research showing that adults can "catch" implicit attitudes by viewing nonverbal behaviors (Weisbuch et al. 2009) and that children can recognize anxiety based on nonverbal cues (Fluck et al. 2001). We agree that nonverbal behaviors are a likely mechanism, and would further ask whether these nonverbal behaviors are directed differentially toward boys and girls (differential treatment) or are more likely to be understood and adopted by children who identify with the adult (modeling).

Our proposal that considering behavioral mediators could simplify research on the intergenerational transmission of gendered math attitudes rests on the premise that different aspects of adults' math attitudes can manifest themselves behaviorally in the same ways. For instance, a teacher with high math anxiety, low math self-efficacy, or low math self-concept might display any of these math attitudes in the same way, such as by modeling general negativity (verbally and/or nonverbally) during math lessons. This hypothesis is based on research showing that, in many cases, distinct psychological constructs affect behavior via a common underlying mechanism. As just one example, test anxiety, math anxiety, and stereotype threat, although distinct psychological constructs, have been shown to affect performance through a similar underlying cognitive mechanism: an online decrement in working memory capacity due to worries and ruminations about the task at hand (e.g., Beilock 2008; Schmader and Johns 2003). Identifying the commonalities between distinct psychological constructs (in this case, the

common cognitive mechanism leading to performance deficits) has the advantage of allowing for the development of interventions that carry benefits across various sources of stress for which a common underlying cognitive mechanism has been identified—e.g., test anxiety (Ramirez and Beilock 2011) and math anxiety (Park et al. 2011).

Identifying commonalities in how the different constructs that make up our umbrella term, "math attitudes," are transferred from adult to child and impact children's math achievement, holds promise for designing general interventions that boost children's performance and dispositions toward math. Of course, an approach that embraces the complexity of the issue is also likely to yield important theoretical and practical insights. Such an approach would consider the distinct behavioral effects of each construct, the interactions between constructs, and the individual effects of each construct on girls versus boys.

Shapiro and Williams (2011) illustrated the complexity of the mechanisms through which adults' math attitudes can affect children by discussing multiple ways in which teachers' math confidence might impact students' math performance. Previous research has found that higher math anxiety among female teachers was associated with lower math performance among female students (Beilock et al. 2010). However, Shapiro and Williams (2011) suggested that having a female teacher who is highly confident in math could also have negative effects on female students. In particular, female students may find their teachers' confidence threatening, perhaps because they feel that their teacher strongly cares about the image of women in STEM fields and the students are worried about letting their teacher down. Similarly, Shapiro and Williams (2011) proposed two alternate hypotheses regarding the impact of male teachers' confidence on female students' performance. On the one hand, a highly math-confident male teacher could have a positive impact on female students if the teacher communicates inclusiveness for women in his teaching. On the other hand, a highly math-confident male teacher might activate the stereotype that men are better than women at math, inducing stereotype threat in his female students and decreasing their performance. As this example shows, knowing the math attitude of an adult (e.g., high math confidence) does not guarantee clear predictions about whether and how that attitude will affect children. Rather, we need to investigate the behaviors associated with this attitude in adults as well as how these behaviors are received and interpreted by children in order to fully understand attitude transmission.

Applying General Theories to a Specific Problem

The commentaries, especially Lane (2011), also emphasized the utility of drawing on broad, well-established theories in order to generate predictions about the specific problem at hand. The focus of the target article—the intergenerational transmission of gendered math attitudes—exists at the intersection of five major research topics: attitudes (broadly defined), math, gender, child development, and social learning. We argue that most of the new directions for research proposed in the target article and commentaries fall into two categories. The first category includes research that has historically focused on child development, social learning, and attitudes, but has not focused as extensively on math or gender. This category includes research on how parents' praise influences children's implicit theories of intelligence and on how implicit attitudes are transmitted from adults to children. The second category includes research that has historically focused on math, gender, and attitudes, but has not focused as extensively on child development or social learning. This category includes research on math anxiety, stereotype threat about gender and math, and gender role beliefs about math careers. In each case we will illustrate how novel research questions can be generated by extending previous findings in new directions.

Extending Research on Attitudes, Child Development, and Social Learning to Math and Gender

In the target article, we discussed research on praise and implicit theories of intelligence, a well-developed general theory that has not yet been applied to issues of math and gender. Previous research has shown that adults give less process-directed praise to girls than to boys, and that girls subsequently are more likely to endorse the view that traits are fixed and respond negatively to challenges (Gunderson et al. 2011a). We hypothesized that these differences in how adults praise boys versus girls may be most pronounced in a gender stereotyped domain such as math, and that this may lead girls to have particularly negative views of challenges in math (Gunderson et al. 2011b).

In her commentary, Lane (2011) proposed that research on how children "catch" implicit attitudes from adults can yield new predictions about the intergenerational transmission of attitudes about math and gender. First, Lane (2011) pointed out that all adults are not equal in the eyes of children—children are more likely to adopt the implicit attitudes of adults whom they like or with whom they identify. For example, children's implicit racial biases were only related to their parents' implicit racial biases when children were highly identified with the parent (Sinclair et al. 2005). As applied to math and gender, this suggests that children should pick up positive or negative affective orientations toward math from adults with whom they identify. If these findings also extend to the social transmission of math anxiety, then girls' identification with their female teachers may also explain our results demonstrating that

only girls developed math-gender stereotypes in response to female teachers' math anxiety (Beilock et al. 2010). It also indicates that this social transmission may not work for all students and teachers—if children only pick up these math attitudes from adults with whom they identify, then girls who do not identify strongly with their teachers (or perhaps identify more strongly with their mothers who are not math anxious) should be buffered from the negative effects of teachers' math anxiety.

Lane (2011) also points out that mothers have special status in prior research on the transmission of implicit attitudes from parents to children. For example, in the domains of racial preferences and attitudes toward smoking, children's implicit attitudes were correlated with their mothers' but not their fathers' implicit attitudes (Castelli et al. 2009). However, since math is a domain that is stereotyped according to gender, there are multiple competing hypotheses about how these previous findings might apply to the transmission of math attitudes from parents to children. One possibility is that mothers may have a privileged status, and children may be more likely to adopt their mothers' attitudes toward math rather than their fathers'. Another possibility is that there may exist interactions between parent and child gender where, for example, girls may adopt their mothers' attitudes while boys adopt their fathers' attitudes toward math. A third possibility is that the impact of mothers' and fathers' attitudes on children's math attitudes will be mediated by how strongly individual children identify with each parent, consistent with the findings of Sinclair et al. (2005).

Extending Research on Math, Gender, and Attitudes to Apply to Child Development and Social Learning

In the target article, we discussed how math anxiety, which has been studied extensively in adults, can be studied in the context of child development and the social learning of math attitudes. Specifically, we described recent research showing that female teachers' math anxiety relates to girls' math-gender stereotypes and math achievement (Beilock et al. 2010). While this study begins to address how math anxiety among adults affects children's development of math attitudes and math competence, there are still many unanswered questions. For example, what specific behaviors mediate the relation between teachers' math anxiety and girls' adoption of math-gender stereotypes? Since previous research shows that math anxiety leads to on-line decrements in working memory capacity due to worries and ruminations about the task at hand (e.g., Beilock 2008), these worries may disrupt teachers' confidence and ability to effectively teach math (Battista 1986; Brady and Bowd 2005; Thompson 1984), which in turn may affect the amount of time they spend planning mathematics lessons as well as their ability to adequately address children's questions (Swetman et al. 1993). Teachers may also manifest non-verbal behaviors that are indicative of anxiety (e.g., frequent self-touching; Shreve et al. 1988) and more overt negative behaviors like communicating their private thoughts out loud (e.g., "I was never really good at math", "This is really hard"). These are just a few examples of how prior research on math anxiety in adults can lead to specific, testable hypotheses about how teachers' own math anxiety may affect children.

Shapiro and Williams (2011) argued that a second research area, math-gender stereotype threat (ST), should be brought to bear in researching the development of gendered math attitudes. We agree that extending research on ST to ask questions about child development and the social transmission of math attitudes can create useful new directions for research. Shapiro and Williams (2011) reviewed previous research on the environmental cues that can induce ST: focusing on gender identity, being in a gender minority, interacting with someone who holds a negative stereotype, and being explicitly reminded of a stereotype.

These findings that Shapiro and Williams (2011) point to with adults provide a starting point for asking questions about the role of stereotype threat in children's development of gendered math attitudes. Previous research has shown that activating gender identity by coloring a picture of a girl (Ambady et al. 2001) and being explicitly reminded of a stereotype can activate ST in preschool-aged children (Cimpian 2010). While this literature confirms that children are susceptible to stereotype threat, little work has investigated how children come to a more general awareness of math-gender stereotypes or come to endorse these stereotypes, which often serve as a trigger for stereotype threat. One recent study shedding some light on this question found that girls' vulnerability to stereotype threat was moderated by mothers', but not fathers', endorsement of gender stereotypes about mathematics ability (Tomasetto et al. 2011). This and other work (e.g., Beilock et al. 2010) provide useful starting points for examining how children acquire and endorse these stereotypes to begin with. Of course, it is also possible that parents and teachers are not creating these stereotypes in children's minds but simply serving to confirm or reinforce stereotypes that are being primarily acquired through other sources (e.g., Weisbuch et al. 2009). Indeed, our social media is saturated with messages that explicitly communicate such negative stereotypes. In fact, several retail stores recently received public scrutiny over the decision to market t-shirts to girls that read, "I'm too pretty to do math" and "I'm too pretty to do homework so my brother has to do it for me" (Beilock 2011).

Shapiro and Williams (2011) also point out that the multi-threat framework, which distinguishes between self-as-source and other-as-source ST, provides additional directions for research. In self-as-source ST, girls believe that

boys are better than girls at math, and are thus threatened by their own stereotype. In other-as-source ST, girls do not necessarily believe the stereotype themselves, but are threatened because of their awareness that someone else holds the stereotype. Thus, as Shapiro and Williams (2011) point out, even if girls do not themselves believe the stereotype that boys are better than girls at math, they might still be subject to ST from parents and teachers who hold the stereotype. While the target article focused on how children develop negative math attitudes (including stereotypes) which may subsequently impact their math achievement, Shapiro and Williams (2011) highlight that, in some cases, adults' stereotypes might directly affect girls' performance without affecting girls' stereotypes.

Cheryan (2011) adds another area of relevant research to the discussion, arguing that male and female gender roles can help explain why women choose not to enter math-related careers. Female gender roles specifically value "attending to appearance, being socially skilled, and helping others" and "being communal, including interacting with and helping others and having a family and raising children" (Cheryan 2011, this issue). Moreover, math-related careers, especially in engineering and computer science, are stereotyped as masculine and are viewed as incongruent with female gender roles (e.g., Diekman et al. 2010). Again, this research has been conducted with adult populations, primarily college students. Applying this research to child development and social learning can lead to interesting new research questions and insights. For example, at what age do people learn these stereotypes about careers in engineering and computer science? Once children form these stereotypes, how malleable are they, and does this depend on the age of the child? Do children learn these stereotypes from parents and teachers, and/or from peers and other cultural models such as television and movies? Do children's career aspirations already reflect these stereotypes at a young age, with girls shying away from career aspirations in engineering or computer science even in elementary and middle school?

Other Relevant Research Areas

Most of the research discussed in the target article and the commentaries falls into the two categories described above. However, several other areas of research in psychology are applicable to the problem at hand. As just one example, in the target article we discussed research on the development of gender cognitions, where previous studies have shown that children's rigidity in applying gender stereotypes (e.g., agreeing that certain activities are for "only boys" or "only girls") peaks at ages 5 to 7 (e.g., Martin and Ruble 2004). We hypothesized that children who are at this peak may be more susceptible to messages from adults about math and gender than children who have passed this peak (Gunderson et al. 2011b). This is just one example of how research on stereotypes, gender, and child development can be extended to apply to math and social learning.

Conclusion

The study of the intergenerational transmission of gendered math attitudes sits at the intersection of a number of relevant research literatures. In order to build a thorough understanding of the phenomenon, we agree with the advice of Lane (2011), that researchers must be narrow while still being broad. As stated in the target article and as reiterated here, being narrow (in terms of identifying specific theoretical constructs, such as math anxiety, stereotypes, identity, and self-concepts, that may be transmitted from adults to children) is important for predicting how adults who hold these constructs might behave in ways that affect the development of these constructs and related math achievement in children (Gunderson et al. 2011b). In addition, being broad (in terms of identifying relevant research literatures that can be applied to the topic of gendered math attitudes) is critical for generating new hypotheses without reinventing the wheel. In fact, this was the purpose of the target article, in which we proposed ways that previous research on math anxiety, implicit theories of intelligence, and gender rigidity can lead to new predictions about how children develop gendered math attitudes (Gunderson et al. 2011b).

The three excellent commentaries add to the scope of our target article by proposing additional relevant research literatures, including the transmission of implicit attitudes from adults to children, stereotype threat, and gender roles in math-related careers (Cheryan 2011; Lane 2011; Shapiro and Williams 2011). Together with the target article, this work has generated a number of new research questions that we hope will inspire new and productive lines of inquiry into the intergenerational transmission of gendered math attitudes. Ultimately, we hope that this research will have a positive impact on math performance, math course-taking, and the pursuit of math-related career paths among both women and men.

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