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Huguet, Pascal; Régner, Isabelle

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Pascal Huguet, Isabelle Régner

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Authors and their affiliations:

Pascal Huguet, Aix-Marseille University & CNRS, France

Isabelle Régner, Aix-Marseille University, University of Toulouse & CNRS, France

Complete contact information for the corresponding author:

Pascal Huguet

Université Aix-Marseille 1, CNRS

Laboratoire de Psychologie Cognitive, Case D

3 place Victor Hugo

13331, Marseille Cedex 3, France

e-mail: Pascal.Huguet@univ-provence.fr

Phone: +33 488 576 888

Fax: +33 488 576 895

Abstract:

The threat of being negatively stereotyped in math impairs performance of highly qualified females on difficult math tests, a phenomenon known as "stereotype threat"—ST. Perhaps more alarmingly, recent studies based on unselective samples of elementary, middle, and high-school students show that ST also operates in girls from the general population. Here we offer first evidence that ST does operate (with large effect sizes) even in middle school girls who deny the negative gender stereotype. Children's beliefs about the two genders' math ability, therefore, do not necessarily moderate their susceptibility to ST, an important issue that remained unclear so far. This new finding is also of great practical significance: School girls' counter-stereotypic beliefs cannot be taken as sufficient evidence for deciding whether the struggle against ST is or is not needed. Appropriate interventions should be the default option when aiming for true gender equality in math and science achievements.

Key Words:

stereotype threat, gender, counter-stereotypic beliefs, stereotypic knowledge

Abstract

The threat of being negatively stereotyped in math impairs performance of highly qualified females on difficult math tests, a phenomenon known as "stereotype threat"—ST. Perhaps more alarmingly, recent studies based on unselective samples of elementary, middle, and high-school students show that ST also operates in girls from the general population. Here we offer first evidence that ST does operate (with large effect sizes) even in middle school girls who deny the negative gender stereotype. Children's beliefs about the two genders' math ability, therefore, do not necessarily moderate their susceptibility to ST, an important issue that has remained unclear so far. This new finding is also of great practical significance: School girls' counter-stereotypic beliefs cannot be taken as sufficient evidence for deciding whether the struggle against ST is or is not needed. Appropriate interventions should be the default option when aiming for true gender equality in math and science achievements.

Counter-stereotypic beliefs in math do not protect school girls from stereotype threat

The recent Nature Commentary by Ben A. Barres "Does Gender Matter?" (Nature 442, 133-136; 2006) and related correspondence (Nature 442, 510 & 868; 2006) reflect how controversial the origin of the gender gap in math and science can be. At the core of the polemic is the fact that gender differences in math ability are claimed to account for both the male advantage on standard math tests and the lack of female advancement in scientific careers. Countering the idea of gender differences in math ability, Barres downplays the male advantage on standard math tests and argues that female underrepresentation in science results from discrimination rooted in negative stereotyping about women's math ability. However, such arguments ignore other important facets of the debate. It is true that there is no male advantage on standard math tests in the general population, at least before adolescence (Hyde & Linn, 2006). From adolescence, however, a small difference favoring boys emerges and the male advantage becomes especially prominent among the highest scoring students (Benbow & Stanley, 1980; Halpern et al., 2007). There is also a male advantage in the general population in some visual-spatial abilities (e.g., mental rotation; see Casey, Nuttall, Pezaris, & Benbow, 1995; Voyer, Voyer, & Bryden, 1995) that may be critical for geometry performance (Halpern et al., 2007). These differences cannot simply be neglected. Likewise, it is true that discrimination *per se* (e.g., setting higher standards for women than for men) merits attention. However, there is ample evidence today that distinct social processes, such as 'stereotype threat' (ST), may contribute not only to the lack of female advancement in scientific careers, but also to the robust male advantage observed among the highest scoring individuals on standard math

tests (Ben-Zeev, Duncan, & Forbes, 2005; Cadinu, Maass, Rosabianca, & Kiesner, 2005; Inzlicht & Ben-Zeev, 2000; Spencer, Steele, & Quinn, 1999; C. Steele, 1997). ST refers to a decrease in test performance in situations where individuals feel threatened by the possibility that their performance will confirm – to others and/or themselves – a negative stereotype about their group abilities (C. Steele, 1997; for reviews, see Ben-Zeev et al., 2005; Schmader, Johns, & Forbes, 2008). This ST phenomenon, which may disrupt women's processing efficiency during test performance (Beilock, Rydell, & McConnell, 2007; Schmader & Johns, 2003; Schmader et al., 2008), cannot be neglected either. ST has proved to be relevant as well for the gender gap on spatial reasoning in the general population (McGlone & Aronson, 2006; Wraga, Helt, Jacobs, & Sullivan, 2007).

Adding further complications to the current debate, ST has been found in the general population with samples of elementary and middle school students (Ambady, Shih, Kim, & Pittinsky, 2001; Muzzatti & Agnoli, 2007), although other recent studies have failed to show any overall gender gap on math tests in the school-age population (Hyde and Lynn, 2006). How can girls be affected by stereotype threat in the absence of a verified performance difference in the general population? ST may operate by maintaining school girls' performance at a suboptimal level, yet this effect may not be strong enough in children to systematically produce the gender gap. Thus, the absence of a gender gap in the school-aged population should not be taken to mean that ST is not operating at all.

This argument is of great practical and theoretical significance. Teachers and policy makers may wrongly infer the absence of ST from the lack of any gender gap in math tests and/or math exams. This inference, in turn, may lead to the problematic conclusion that there is no reason to worry about ST. Inaction is even more likely if girls themselves

overtly deny the negative gender stereotype (for preliminary evidence of explicit deny, see Ambady et al., 2001; Muzzatti & Agnoli, 2007; J. Steele, 2003). Why would teachers and policy makers expend time and energy in the struggle against the negative gender stereotype if female students both get similar math performances as their male counterparts and explicitly endorse counter-stereotypic views?

Of particular interest for the present paper, we just do not know however whether children's beliefs about the two genders math ability moderate their susceptibility to ST. Schmader, Johns, and Barquissau (2004) offered evidence for this moderation in women, with lower ST susceptibility in those denying the negative gender stereotype. Although children's beliefs about the two genders math ability were sometimes assessed (Ambady et al., 2001; Muzzatti & Agnoli, 2007), the moderating role of these beliefs in ST was never tested. In children, therefore, the moderation issue remains unanswered, and the answer is far from being obvious. As pointed out by Schmader et al. (2004), rejecting the stereotype may not always buffer one from ST. After all, the mere knowledge of being negatively stereotyped is thought to be a sufficient condition for ST to occur in both adults and children (McKown & Weinstein, 2003; Spencer et al., 1999; C. Steele, 1997). Furthermore, as noted by Devine (1989), there is strong evidence that stereotypes are well established in children “before children develop the cognitive ability and flexibility to question or critically evaluate the stereotype’s validity or acceptability” (p. 6). Because of this developmental sequence, stereotypes may prevail over newly acquired personal beliefs (Devine, 1989), and so counter-stereotypic beliefs in math may not protect school girls from ST.

Here, we assume that even girls who hold counter-stereotypic views may suffer from ST, provided they know the negative gender stereotype at least implicitly. As showed by Nosek, Banaji, and Greenwald (2002), individuals do not need to be consciously aware of negative stereotypes to be affected by them, which may help explain why children generally distort their self-evaluations in math in the direction of the gender stereotype (Eccles & Bryan, 1994; Frome & Eccles, 1998). In Frome and Eccles (1998), for example, school girls underestimated their math ability (but not their English ability) although they received *higher* math (and English) grades than boys. Because counter-stereotypic beliefs may coexist with stereotypic knowledge at a more implicit level, we reasoned, these beliefs may not protect school girls from ST. Clarifying this important issue would improve our understanding of the very nature of ST in children, a population that has been largely overlooked in the ST literature.

Method

Participants

Participants were 199 middle-school students (92 girls and 107 boys, ages 11 to 13) from eight French public schools located in urban and suburban areas of variable socioeconomic status. The school administrators and parents agreed to let the students participate in a study on "children's academic motivation".

Procedure

Students were met collectively by two experimenters (one male and one female) in their regular classrooms. Each class was divided at random into two mixed-gender subgroups with a virtually equal number of students (10 to 14 students). Students were seated separately to prevent cheating. They were given one and a half minutes to learn a

complex figure (Fig. 1) that had no particular meaning, and then 5 minutes to reconstruct it from memory on paper. This task, which has already proved successful in detecting ST (Huguet & Régner, 2007), taps into skills (i.e., visual-perceptual and visual-spatial) as well as cognitive and meta-cognitive processes (attention, organization, and strategy use) that are basic components of academic performance (Kirkwood, Weiler, Bernstein, Forbes, & Waber, 2001). Students were either told the test would measure their ability in geometry or in drawing. In reality, the task was exactly the same under both labeling conditions. The subgroups and experimenters were randomly distributed across the two task-labeling conditions. Task performance was measured following the classical scoring rules in terms of the number and quality of the units reproduced (assessed by four independent judges unaware of the conditions; interrater reliability $\alpha = .96$).

Students' stereotypic-related beliefs were assessed (as part of a larger questionnaire on 'academic motivation') using items adapted from Schmader et al. (2004). Participants rated the two genders' geometry ability in their age group ("In general, what is the geometry ability of girls your age?"; "In general, what is the geometry ability of boys your age?") from 1: very low to 5: very high. Students also self-evaluated in geometry (and drawing) compared to most of their classmates (from 1: much worse, to 5: much better). Finally, in order to control for identification to geometry (and drawing), students rated the importance they attached to each domain (from 1: not important at all, to 5: very important). All questions were counterbalanced. The questionnaire items were exactly the same for all students, whatever the labeling conditions. All ratings were collected after the task so as not to prime geometry-related cognitions. When each session was over, participants were interviewed to check whether they truly understood the questionnaire items and whether

they maintained their answers (which was clearly the case). They were then carefully debriefed and thanked.

Results

Task Performance

A gender by task-label Analysis of Covariance (ANCOVA) using students' task performance as dependent variable (while controlling for math/geometry grades¹ and the interaction between task label and grades) indicated a significant interaction between gender and task label, $F(1,192) = 8.72, p < .004, p_{rep} = .97, \eta_p^2 = .04$ (Fig. 2). Whereas, for girls, geometry labeling led to worse performance compared to drawing labeling, $F(1,192) = 10.98, p < .001, p_{rep} = .99, d = 0.78$, boys performed equally well in both labeling conditions ($F < 1$). In addition, whereas girls underperformed compared to boys in the geometry labeling condition, $F(1,192) = 4.69, p < .03, p_{rep} = .91, d = 0.51$, they outperformed boys in the drawing labeling condition, $F(1,192) = 4.05, p < .05, p_{rep} = .88, d = 0.50$. This interaction pattern was even stronger when we controlled for the importance students attached to both domains, $F(1,192) = 10.88, p < .001, p_{rep} = .99, \eta_p^2 = .05$.

Beliefs about the Two Genders' Geometry Ability

Ironically, girls' beliefs were on average counter-stereotypic. A repeated-measures ANCOVA was conducted with the two genders' geometry-ability ratings as the repeated measure, student gender, and task label as independent variables, and grades as covariate. This analysis revealed a significant interaction between the repeated measure and gender, $F(1,190) = 10.11, p < .003, p_{rep} = .97, \eta_p^2 = .05$. Whereas girls reported slightly higher geometry ability for girls ($M = 3.68, SE = 0.08$) than for boys ($M = 3.41, SE = 0.09$), $F(1,190) = 4.76, p < .03, p_{rep} = .91, d = 0.37$, boys reported slightly higher geometry ability

for boys ($M = 3.57$, $SE = 0.08$) than for girls ($M = 3.30$, $SE = 0.08$), $F(1,190) = 5.56$, $p < .02$, $p_{rep} = .93$, $d = 0.30$. This interaction still occurred when we controlled for students' task performance, $F(1,189) = 10.15$, $p < .003$, $p_{rep} = .97$, $\eta_p^2 = .05$, so the fact that students made their ratings after the task did not matter. Thus, in their ratings of geometry ability of the two genders, girls expressed counter-stereotypic claims and boys stereotypic claims.

Moderation

More importantly for the present purpose, we tested whether students' beliefs about the two genders math ability moderate the performance pattern. For each moderator (ratings of boys geometry ability, ratings of girls geometry ability, and the difference between these two ratings²), a regression analysis was performed by regressing student performance over gender, task label, moderator, and the interactions between all these variables (while controlling for grades and the interaction between task label and grades). Each predictor was either dummy-coded (Geometry label = 0, Drawing label = 1; girls = 0, Boy = 1) or mean-centered (grades and each moderator). Whatever the moderator, the three-way interaction between gender, task label, and moderator was nonsignificant (averaged p s $> .25$; averaged $p_{rep} < .67$). The difference score between the ratings of the two genders math ability is of critical importance here, as it reflects whether students' beliefs were stereotypic or counter-stereotypic (see Footnote 2). For this reason (and despite the three-way interaction was not significant), we looked at the simple slopes for the regression of performance on this critical score in each of the four conditions. None of these slopes reached even marginal significance ($\beta = .13$, $t = .83$, $p = .41$ for girls in the geometry labeling; $\beta = -.04$, $t = -.28$, $p = .78$ for boys in the geometry labeling; $\beta = -.08$, $t = -.53$, $p = .60$ for girls in the drawing labeling; $\beta = .15$, $t = 1.04$, $p = .30$ for boys in the drawing

labeling). This strengthens that students' beliefs about the two genders math ability did not moderate the performance pattern.

Self-Evaluations

As expected, despite girls held counter-stereotypic beliefs (on average), they underestimated their geometry ability. A gender by task-label ANCOVA using students' self-evaluation in geometry as dependent variable (controlling for math/geometry grades) indicated a significant main effect of gender ($F(1,192) = 7.21, p < .01, p_{rep} = .73, d = 0.30$). Girls ($M = 2.80, SE = 0.07$) self-evaluated more negatively in geometry than did boys ($M = 3.06, SE = 0.07$). This gender effect held even when controlling for students' task performance ($F(1,191) = 7.37, p < .01, p_{rep} = .73, d = 0.30$), so the fact that students self-evaluated after the task did not matter. Furthermore, girls' underestimation of their ability in geometry actually occurred while they obtained *similar* math/geometry grades as boys ($M = 11.55, SD = 3.73$, for girls; $M = 11.99, SD = 3.76$, for boys), $t(196) < 1$. It is noteworthy that the gender effect on self-evaluation was not significant in drawing ($F(1,192) = .16, p = .69, p_{rep} = .55, d = 0.06$), even after controlling for students' task performance $F(1,191) = .15, p = .70, p_{rep} = .55, d = 0.06$. Taken together, these findings can reasonably be taken as indicative of girls' implicit knowledge of the negative gender stereotype in geometry. Also consistent with this idea, girls as well as boys' beliefs about the two genders' geometry ability were *unrelated* to their self-evaluations in this critical domain ($ps > .22$).

Discussion

The present findings show how problematic the negative stereotype concerning female math ability can be for girls at this early stage in their academic life. Their

superiority in the drawing condition shows how much the geometry condition lowered their true potential³. Above all, we have shown middle-school girls' beliefs about the two genders math ability did not moderate their susceptibility to ST. Girls who denied the negative gender stereotype suffered from it nonetheless when they simply believed (even mistakenly) that the task they were going to take measured geometry skills. The very fact that girls underestimated their own ability in geometry (but not in drawing) while obtaining similar math/geometry grades as boys strengthens the idea that ST was operating. Overall, our findings support C. Steele's (1997) original claim that stereotype endorsement is not a necessary condition for ST to occur, which remained unclear in children. Perhaps more importantly, these new findings can be taken as first evidence in the context of ST that stereotypic knowledge—that is integrated early during cognitive development—may prevail over newly acquired personal (counter-stereotypic) beliefs that require higher cognitive maturity (Devine, 1989). Such personal beliefs, therefore, may not be strong enough in children to buffer them from ST. This is the key contribution of the present research. Future research should track changes in stereotypic-related beliefs from childhood to adolescence, and their impact on school girls' susceptibility to ST.

The present results are also of great practical significance. ST is found here in middle-school girls from the general population, and who were similar to boys in their math grades, indicating that for teachers ST is indeed not necessarily visible at the surface. As suggested earlier in the present paper, teachers, but also parents and policy makers, all may take for granted that elementary- and middle-school girls are not susceptible to ST, a fortiori when girls reject the negative gender stereotype. All may conclude that ST-related interventions are useless. Our findings lead to the opposite conclusion: Neither the absence

of gender differences in math performances, nor girls' counter-stereotypic beliefs can be taken as sufficient evidence that ST is not operating. Appropriate interventions should be viewed as the 'default option' when aiming for *true* gender equality in math and science achievements.

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Footnotes

¹ Students' grades were taken from the school records where the math and the geometry components were not distinguished.

² Means and standard errors of the difference score in the ratings of the two genders geometry ability (a negative sign indicates counter-stereotypic beliefs and a positive sign stereotypic beliefs) were as follows: In the geometry condition, $M = -.04$ and $SE = .17$, for girls, and $M = .28$ and $SE = .16$, for boys; in the drawing condition, $M = -.49$ and $SE = .18$, for girls, and $M = .25$ and $SE = .16$, for boys.

³ One may wonder whether girls in the drawing condition benefited from an art-related stereotype favoring their own gender. However, girls did not self-evaluate more positively than did boys in drawing (as one would expect if girls benefited from a positive stereotype in drawing), which can hardly reflect modesty since they were simultaneously able to report higher geometry ability (reported beliefs) for their own gender group (both in the questionnaire and the interviews).

Figure Captions

Figure 1. Adapted from Rey's (1941) Complex Figure.

Figure 2. Student gender by task label interaction on task performance (maximum score = 44). Error bars indicate standard error of the mean.

Figure 1

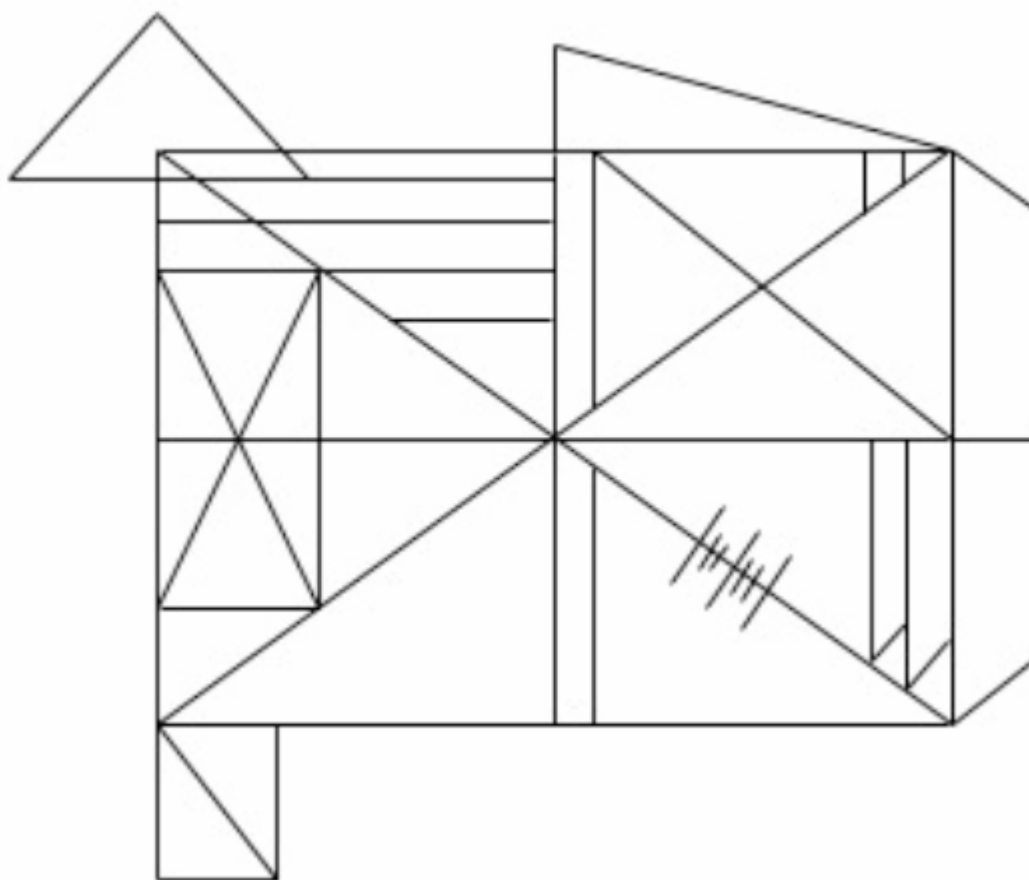


Figure 2

