The Roots of Stereotype Threat: When Automatic Associations Disrupt Girls’ Math Performance

Silvia Galdi and Mara Cadinu
University of Padova

Carlo Tomasetto
University of Bologna

Although stereotype awareness is a prerequisite for stereotype threat effects (Steele & Aronson, 1995), research showed girls’ deficit under stereotype threat before the emergence of math–gender stereotype awareness, and in the absence of stereotype endorsement. In a study including 240 six-year-old children, this paradox was addressed by testing whether automatic associations trigger stereotype threat in young girls. Whereas no indicators were found that children endorsed the math–gender stereotype, girls, but not boys, showed automatic associations consistent with the stereotype. Moreover, results showed that girls’ automatic associations varied as a function of a manipulation regarding the stereotype content. Importantly, girls’ math performance decreased in a stereotype-consistent, relative to a stereotype-inconsistent, condition and automatic associations mediated the relation between stereotype threat and performance.

Stereotype threat research (Steele & Aronson, 1995) has shown that both adults and children underperform in difficult tests when a negative domain-relevant in-group stereotype is made salient (see Inzlicht & Schmader, 2012, for a review). Despite this overwhelming evidence, the specific requirements for children’s underperformance under stereotype threat are still unclear. With the aim of providing new insights into research on stereotype threat, this study investigates automatic associations as a potential requirement for the emergence of stereotype threat underperformance in children.

Automatic associations are those associations between concepts (e.g., me–woman), or between concepts and attributes (e.g., flower–positive) that come to mind unintentionally when an individual encounters a relevant object, that are difficult to control once they have been activated, and that are not necessarily explicitly endorsed (e.g., Gawronski & Bodenhausen, 2006). Such automatic associations are often contrasted with conscious beliefs, which are those mental contents that an individual explicitly endorses as accurate (e.g., Gawronski & Bodenhausen, 2006). Most measures of automatic associations are based on participants’ performance on computer-based, speeded categorization tasks (see Gawronski & Payne, 2010, for a review). These measures, commonly referred to as implicit measures, differ from self-reports, described as explicit measures, which assess conscious beliefs.

This study employed implicit and explicit measures jointly to show that automatic associations consistent with a negative in-group stereotype may lead to stereotype-induced underperformance at early stages of development, even though children do not possess the cognitive competencies for stereotype awareness yet, and in the absence of evidence that they endorse the stereotype content.

Prerequisites for Stereotype Threat Susceptibility

According to the stereotype threat model, for stereotypes to affect performance, children need to (a) have developed a concept of social categories (category awareness), (b) be able to identify themselves as members of a social category (self-categorization), and (c) know that the in-group category is negatively related to specific domains or attributes (stereotype awareness; Aronson & Good, 2003). When children enter elementary school, they possess the cognitive competencies of category awareness and self-categorization (e.g., Martin & Ruble, 2010) but not stereotype awareness (e.g., McKown & Strambler, 2009).

Research has shown that, between the ages of 3 and 4 years, children become aware of social categories, such as gender and race (e.g., Aboud,
...and are able to identify themselves as members of these categories (e.g., Martin & Ruble, 2010; Quintana, 1998). Moreover, by this age children develop personal stereotypic beliefs about abilities and characteristics of ethnic (Aboud, 1988) and gender groups. For example, they hold personal stereotypic beliefs about gender differences in toy preferences, dressing, and aggressive versus prosocial behaviors (Martin & Ruble, 2010). However, personal stereotypic beliefs, referred to as stereotype endorsement, differ from the knowledge of stereotypes held by others (not necessarily personally endorsed), which is defined as stereotype awareness (e.g., Martinot & Désert, 2007; McKown & Strambler, 2009). Thus, although in many cases personal beliefs overlap with socially shared stereotypes, this does not imply necessarily that young children are aware of stereotypes. Indeed, the literature on children’s social perspective taking (e.g., Selman, 1980), theory of mind (e.g., Perner & Wimmer, 1985), and person perception (e.g., Rhoes & Ruble, 1984) suggests that children develop the cognitive competencies for stereotype awareness only by middle childhood, and that up to then they do not distinguish their personal stereotypic beliefs from others’ beliefs. Consistently, children have been shown to be aware of common ethnic and gender stereotypes about academic abilities by the ages of 8 and 9 years (e.g., McKown & Weinstein, 2003; Quintana, 1998).

The evidence that children do not possess stereotype awareness when they enter elementary school has important consequences. As noted earlier, stereotype awareness is a specific requirement for stereotype threat. Specifically, the stereotype threat model posits that people’s negative stereotypes hamper performance only in situations that induce targets to become concerned about being judged by others on the basis of relevant stereotypes (Steele, 1997). Consistently, research on performance decrements induced by ethnic stereotypes confirms that only children who are aware of broadly held stereotypes are vulnerable to stereotype threat effects (McKown & Strambler, 2009; McKown & Weinstein, 2003). Therefore, in principle we should not expect declines in performance under stereotype threat prior to 8–9 years of age, or even later (Aranson & Good, 2003). Nevertheless, Ambady, Shih, Kim, and Pittinsky (2001) showed that 5- to 7-year-old Asian American girls underperformed on a math task when their gender identity was made salient, as compared to children in a control condition. Similarly, Tomasetto, Alparone, and Cadinu (2011) found that gender identity activation hampered math performance among 5- to 7-year-old Italian girls, and Neuville and Croizet (2007) obtained similar findings among 7-year-old French girls.

The last three studies raise a theoretical paradox: How can stereotype-induced performance decrements be found in girls who do not possess stereotype awareness yet? One could assume that for a negative stereotype to affect performance in children who have not developed stereotype awareness yet, it is sufficient that children hold the personal stereotypic belief that their in-group is less skillful in the relevant domain. Indeed, given that young children do not distinguish their own stereotypic beliefs from others’, and rather assume that their beliefs are shared by others as well (e.g., Augustinos & Rosewarne, 2001), in principle children’s personal negative beliefs about abilities of their in-group could be sufficient to trigger stereotype threat. If this were the case, stereotype endorsement would be the key to identify the sources of stereotype threat in young children.

To date, the potential role of children’s endorsement of the math–gender stereotype as a prerequisite for stereotype threat effects does not fit with the available evidence. For example, Ambady et al. (2001) found that 5- to 7-year-old American girls believe that boys and girls are equal at math (for similar results on Italian children, see Tomasetto et al., 2011); on the contrary, 5- to 7-year-old American boys state that boys are better at math, thus exhibiting in-group favoritism (e.g., Powlisha, 1995; Yee & Brown, 1994). Similarly, other research showed no endorsement of the math–gender stereotype until 8–9 years of age among Italian and French children (Martinot & Désert, 2007; Muzzatti & Agnoli, 2007).

To our knowledge, only one study found stereotype endorsement as early as 6–7 years of age in a Western country (i.e., United States; Cvencek, Meltzoff, & Greenwald, 2011). However, this discrepancy from the other findings might be due to the type of measures used. Whereas all the studies discussed elsewhere in the article assessed the endorsement of the gender stereotype regarding math ability, Cvencek et al. (2011) assessed the endorsement of the stereotype that boys like math and girls like language. Therefore, it is possible that 6- to 7-year-olds already hold the personal stereotype that boys like math, but still do not endorse the stereotype about girls’ and boys’ math ability. Consistent with this reasoning, Steele (2003) found that 6- to 10-year-old children do not endorse the stereotype regarding boys’ and girls’ abilities in math (see also Martinot, Bagès, & Désert, 2012), even...
though they endorse the same stereotype about men and women (stereotype stratification). Thus, to date, there is no evidence that young children endorse the math–gender ability stereotype, at least in Western countries. Nevertheless, research shows that it is specifically the ability component of the math–gender stereotype that affects women’s performance, whereas other stereotypical beliefs (e.g., women are less interested in math) do not trigger stereotype threat effects (Thoman, White, Yamawaki, & Koishi, 2008).

To summarize, young girls show math underperformance before being aware of the math–gender stereotype, and in the absence of evidence that they endorse such belief as a personal stereotype. One possibility to explain this paradox is that previous findings on children’s math–gender stereotype have been based only on self-reports, which may not capture all relevant aspects of the stereotype. Thus, in this research, we used implicit and explicit measures jointly to investigate automatic associations as an alternative route for the emergence of stereotype-induced underperformance in young children.

**Insights From Social-Cognitive Research**

Implicit measures, such as the well-known Implicit Association Test (IAT; Greenwald, McGhee, & Schwartz, 1998), have been developed to assess the strength of automatic associations between concepts or concepts and attributes. These procedures are based on the rationale that individuals should be faster at pairing concepts, or concepts and attributes that are strongly associated in their cognitive map, as compared to those that are weakly or not at all associated. Research has shown that men and women differ in the strength of their automatic associations between gender and academic domains (Nosek, Banaji, & Greenwald, 2002) and that automatic associations consistent with the math–gender stereotype predict attitudes toward math, domain identification, and math performance (e.g., Kiefer & Sekaquaptewa, 2007; Nosek & Smyth, 2011). Together, these results show that automatic associations play an important role in people’s academic achievement, interest, and performance, and that the combined use of implicit and explicit measures may allow researchers to provide useful insights that neither implicit measures nor explicit measures alone would offer.

Theorizing on the meaning of implicit and explicit measures posits that explicit measures reflect more recent as well as newly formed representations that are not strong enough yet to be automatically activated (e.g., Rudman, 2004; Wilson, Lindsey, & Schooler, 2000), whereas implicit measures detect only those highly overlearned associations between concepts whose activation has become automatic over the course of long-term experiences. According to this widespread assumption, in terms of emergence, conscious beliefs reflect more recently formed representations, whereas automatic associations reflect only the older representations. However, an emerging body of research suggests that the opposite may be true as well.

Recent findings showing experimentally induced changes in implicit but not explicit measures (e.g., Gawronski & LeBel, 2008; Olson & Fazio, 2006) suggest that automatic associations may reflect more recently formed representations as compared to the corresponding conscious beliefs. These results are also consistent with studies using implicit and explicit measures in predicting future choices of decided and undecided individuals (for a review, see Gawronski & Galdi, 2011). These studies demonstrate that well-structured automatic associations about a specific object are present also in the cognitive maps of those individuals who, on explicit measures, report being undecided and do not endorse well-defined conscious beliefs yet. These findings come from research on attitudes (i.e., dealing with the affective evaluation of an object; Eagly & Chaiken, 1993), whereas stereotypes are cognitive beliefs about the link between a category and an attribute (Hamilton & Troliar, 1986); nonetheless they suggest that in terms of emergence, automatic associations may precede conscious beliefs. Thus, there is reason to believe that implicit measures can also detect recently formed automatic associations between concepts and stereotypical attributes (e.g., boys–math) that are not reflected on explicit measures yet.

**Insights From Research on Malleability of Automatic Associations**

Other research has demonstrated that external cues (e.g., situational stimuli) may increase or decrease the activation of automatic associations in adults. For example, Dasgupta and Asgari (2004) found that participants exposed to counterstereotypical women showed lower activation of automatic associations consistent with gender–role stereotypes, as compared to control participants. Similarly, women exposed to gender-stereotypical women in TV commercials showed increased activation of automatic associations consistent with the traditional female stereotype, and this higher
activation of automatic associations led to worse math performance (Davies, Spencer, Quinn, & Gerhardstein, 2002). The last results are consistent with research demonstrating that stereotypical automatic associations affect working memory resources needed to perform complex cognitive tasks. Specifically, Forbes and Schmader (2010) found that women trained via an IAT to associate their gender with being good at math showed higher working memory and increased math performance. Taken together, these findings suggest that it may be specifically in automatic associations between group membership and stereotypical attributes, and in the malleability of such automatic associations, where we should look not only to investigate stereotype-induced underperformance but also to reduce stereotype threat effects. Unfortunately, to date no study has tested whether automatic associations are malleable in children as well, or whether changes in activation of stereotypical automatic associations may reflect changes in performance. Therefore, we hypothesized that situational cues making a negative stereotype salient may automatically activate corresponding automatic associations. The activation of such stereotypical automatic associations should in turn affect the performance of children who are stereotype targets, even in the absence of evidence for stereotype endorsement. Conversely, cues challenging the negative stereotype should reduce the activation of corresponding automatic associations, and such a reduction should lead to improved performance.

Aims of This Study

To test the hypotheses mentioned above, we employed explicit and implicit measures jointly to assess two aspects of the math–gender stereotype, stereotype endorsement and automatic associations, and their differential relation with young children’s stereotype threat vulnerability.

Research with children has already used implicit measures to assess automatic associations (e.g., Baron & Banaji, 2006). Regarding math–gender stereotypes, Steffens, Jelenec, and Noack (2010) found stereotypical automatic associations in 9- to 14-year-old girls and no automatic associations for boys at any age. Conversely, Cvencek et al. (2011) found stereotype-consistent automatic associations in both girls and boys as young as 6–7 years of age. However, neither Steffens et al. nor Cvencek et al. assessed either performance or automatic associations under stereotype threat. Therefore, these studies are not directly relevant to our main hypothesis.

To our knowledge, only Ambady and collaborators used an implicit stereotype awareness task (Ambady et al., 2001, p. 387) to assess the math–gender stereotype in a study on stereotype threat in young children. The measure was a memory recall task, in which the experimenter told a story about a student especially good at math, and recorded whether the participant, when repeating the story, used the pronoun he or she to identify the protagonist. However, rather than a measure of stereotypical automatic associations, this task should be considered as an indirect measure of children’s stereotypes. Therefore, it is still unknown whether automatic associations may be responsible for stereotype threat performance deficits in young children.

In this study, we focused on first-grade children for two reasons. So far, the only study showing the presence of automatic associations consistent with gender stereotypes about math and language in young children (Cvencek et al., 2011) considered children from 6 to 7 years altogether (Grades 1 and 2). Second, studies showing stereotype-induced math performance decrements in young girls have addressed 5- to 7-year-old children (Ambady et al., 2001; Tomasetto et al., 2011) or 7-year-olds (Neuville & Croizet, 2007). Thus, the focus on 6-year-olds (Grade 1) allowed us to investigate stereotypical automatic associations as well as stereotype threat effects specifically when children enter elementary school, thus becoming acquainted for the first time with formal teaching of math (at least in the Italian school system).

The study had four goals. First, using a child-friendly version of the IAT (Child–IAT; Baron & Banaji, 2006) we tested whether gender stereotypes about math and language are present as automatic associations in 6-year-olds. Consistent with Cvencek et al. (2011), we expected stereotype-consistent automatic associations for both girls and boys.

Second, we investigated the malleability of children’s automatic associations. It was hypothesized that children’s stereotypical automatic associations would increase or decrease in activation depending on the stereotype content of a prior manipulation task. We predicted an increased activation of stereotypical automatic associations in a stereotype-consistent condition than in a stereotype-inconsistent condition, respectively, confirming or contradicting the traditional gender stereotype about math, with results in the middle in a control condition, in which the math–gender stereotype was not salient.

Third, using an explicit measure, we investigated whether 6-year-olds endorse the belief that boys are
better than girls at math. Three reasons led us to assess stereotype endorsement: (a) children first develop stereotype endorsement and then stereotype awareness (e.g., Aboud, 1988; Martin & Ruble, 2010), (b) 6-year-olds do not possess stereotype awareness yet (e.g., Rholes & Ruble, 1984; Selman, 1980), and (c) children’s personal stereotypic beliefs could be sufficient to trigger stereotype threat, specifically because at this age children assume that their beliefs are shared by others as well (e.g., Augoustinos & Rosewarne, 2001). Consistent with previous research (e.g., Ambady et al., 2001; Muzzatti & Agnoli, 2007), we expected no evidence of endorsement of the math–gender stereotype.

Finally, like in past research on stereotype threat including 6-year-olds (e.g., Tomasetto et al., 2011), we expected girls’ math performance to decrease under stereotype threat, that is, in the stereotype-consistent as compared to the control condition and the stereotype-inconsistent condition, which should lead to the highest performance. Importantly, we predicted the increased activation of stereotype-consistent automatic associations to mediate the decrease in girls’ performance under stereotype threat.

Method

Participants

Two hundred and seventy-six first-grade children (143 girls) participated in the study. All of them were born in Italy and were of typical age for their grade (M = 77.60 months, SD = 0.28). Children attended one of six elementary schools in one of three small towns in the northeast of Italy. Permissions to conduct the study were granted by school principals and parents. Six female experimenters were involved in the data collection, conducted during school hours. All children were tested in the same school period to avoid potential effects of variability in mathematics curricula across classes at the moment of data collection.

Procedure

Children were tested individually in a quiet room of their school, while sitting at a desk facing the experimenter. Each experimental session started by asking participants to color one of three pictures, depending on the experimental condition (stereotype consistent, control, and stereotype inconsistent) to which they were randomly assigned. When children finished coloring, the experimenter asked them to describe the picture, and then left the picture on one side of the desk. After the manipulation task, children were invited to play a computer game (i.e., the Child–IAT) using a laptop computer. Participants were told that they would see pictures during the game, and that they would press the red (A key) or the green (L key) button of the computer board to indicate which picture they saw. After the Child–IAT, children performed eight math calculations (i.e., math test). The experimenter asked one calculation at a time (e.g., “How much is 5 plus 5?”) and children had to respond within 5 s. For each question, the experimenter noted whether the response was correct or not (i.e., incorrect or no response by 5 s), without providing any feedback. Finally, children performed the explicit stereotype-endorsement task. They were shown a picture of a boy and a girl side by side and were told: “These are a boy and a girl. They are 6-year-olds and they are good at school. Is the boy better at math, the girl better at math, or are they the same at math?” Next, the experimenter recorded the response, and participants were thanked, given a candy bar, and dismissed.

Thus, the administration of the implicit measure always followed the experimental manipulation and always preceded the math test followed by the explicit measure. This order of the tasks was chosen because we aimed at testing the effects of the experimental manipulation on automatic associations ruling out the possibility that counterbalancing implicit and explicit measures might weaken the effects of the experimental manipulation on automatic associations. Moreover, there is no evidence that performing the IAT before a self-report induces reactance or assimilation tendencies in the subsequent self-report (Nosek, Greenwald, & Banaji, 2005).

Materials

Experimental manipulation. According to the stereotype threat model, it is the salience of a negative domain-relevant in-group stereotype that impairs targets’ performance. A negative domain-relevant in-group stereotype can be made salient in three ways: (a) describing the task that targets will subsequently perform as diagnostic of the ability related to the negative in-group stereotype, (b) making targets’ in-group salient, or (c) making the content of the negative stereotype salient (Inzlicht & Schmader, 2012). In this study, the manipulation choice was to make salient the stereotype content (math–gender stereotype). Thus, participants were randomly assigned to one of three experimental
conditions by inviting them to color a picture, in which: (a) a boy correctly resolves a math calculation on a blackboard, whereas a girl fails to respond (stereotype-consistent condition); or (b) a girl correctly resolves the calculation, whereas a boy fails to respond (stereotype-inconsistent condition); or (c) a landscape was depicted (control condition).

Implicit measure: The math/language–gender Child–IAT. A Child–IAT (Baron & Banaji, 2006) was used to assess the relative strength of automatic associations between the target category boy and the attribute category mathematics, and the target category girl and the attribute category language, as compared to the opposite pairings (i.e., boy–language and girl–mathematics).

Categories and stimuli for the Child–IAT. Four pictures of math-related objects (i.e., numbers) and four pictures of reading- and writing-related objects (i.e., letters), pretested with first-grade children for familiarity and comprehension, were used as stimuli for the attribute categories mathematics and language. Four face-pictures of boys and four face-pictures of girls represented the target categories boy and girl.

Procedure of the Child–IAT. Children were instructed to respond fast and accurately to three simple-categorization (practice) blocks and two (third and fifth) critical double-categorization blocks. Each practice block included 16 trials; each critical block included 32 trials. On each trial, a target or attribute picture appeared on the screen until participants gave their response. Children categorized each picture by pressing a key on the computer board, the left-hand response A or the right-hand response L key. To simplify the task, the left-hand key (A) was colored in red, and the right-hand key (L) was colored in green. The intertrial interval was 200 ms. A red cross, which remained on the screen for 200 ms, followed incorrect responses.

In the first block of the task, children were presented with pictures for the target categories girl and boy, with each picture randomly presented twice. Participants had to indicate whether the picture on the screen was a boy or a girl by pressing the red key for girl and the green key for boy. In the second block, children were presented with pictures for the attribute categories language and mathematics, with each picture randomly presented twice. Participants had to press the red key when the picture was a reading- or writing-related object and the green key when the picture was a math-related object. In the third double-categorization block, both pictures of boys and girls, and pictures of math-related and reading- or writing-related objects (with each picture representing each category randomly presented twice) appeared on the screen. In this case, children pressed the red key when they saw either a girl or a reading- or writing-related object, and the green key when they saw either a boy or a math-related object. In the fourth block, participants categorized again the pictures representing the categories mathematics and language. However, different from the key assignment in the second block, participants had to press the red key when they saw a math-related object and the green key when they saw a reading- or writing-related object. Finally, in the fifth double-categorization block, children categorized the same pictures of boys and girls and the same pictures of math-related and reading- or writing-related objects. However, participants now pressed the red key when they saw either a girl or a math-related object, and the green key when they saw either a boy or a reading- or writing-related object. Following the procedure employed in the third block, each picture representing each of the four categories was randomly presented twice. The order of the two critical blocks, third and fifth, was counterbalanced across participants to avoid order effects.

Math test. Three days before the data collection, a math test was developed in collaboration with all teachers of the classes participating in the study, to create a set of difficult math calculations taking into account the mathematics achievement of all classes. The math test was a retrieval of numerical facts including five additions and three subtractions (i.e., 5 + 5, 8 – 4, 6 + 4, 10 – 5, 2 + 3, 2 + 2, 6 – 3, and 4 + 5). Children had to resolve each math calculation in 5 s.

Explicit stereotype endorsement. As in Ambady et al.’s (2001) study, children were presented with a photograph of a boy and a girl described as good at school, and had to choose whether the boy or the girl is especially good at math or whether they are equal at math. The two photographs as well as the questions’ wording for the boy or the girl were presented in counterbalanced order.

Results

Preliminary Analyses

Twenty-three girls and thirteen boys were excluded only because of 30% or higher error rates in at least one critical (double-categorization) block of the Child–IAT. Preliminary analyses confirmed that excluded participants were evenly distributed across conditions (i.e., 13 in the stereotype-consistent, 10 in the control, and 13 in the stereotype-inconsistent
conditions), and that their responses did not differ from those of retained children on both the math test and the stereotype endorsement. The final sample included 240 children (120 girls).

Individual scores of automatic associations were calculated by means of the D-algorithm, designed for analyzing data with the IAT (Greenwald, Nosek, & Banaji, 2003). The D-algorithm compares the extent to which performance on the incompatible critical block (i.e., girl–mathematics and boy–language sharing the same response key) is impaired relative to performance on the compatible critical block (i.e., girl–language and boy–mathematics sharing the same response key), taking into account participants’ individual response latencies, standard deviations of latencies, and error rates in each of the two blocks. Scores were calculated so that positive scores reflect stronger boy–mathematics and girl–language automatic associations. To estimate reliability of the Child–IAT, two Child–IAT scores were calculated: one using the first half and the other using the second half of the two critical blocks. Internal consistency was satisfactory (Cronbach’s α = .84).

A one-way analysis of variance (ANOVA) was then conducted on scores of automatic associations using conditions (stereotype consistent, control, stereotype inconsistent), gender (male, female), and the order of administration of the critical blocks (1 = third block: girl–language and boy–math, fifth block: girl–math and boy–language; 2 = third block: girl–math and boy–language, fifth block: girl–language and boy–math) as the independent variables. A main effect for order of administration was found, $F(1, 234) = 6.64, p = .01, \eta^2_p = .03$. However, because order of administration produced no significant interactions (all $p > .09$), it is not further discussed.

For each participant, correct responses to the math test (i.e., correct math calculation in 5 s) were coded +1, and incorrect responses (i.e., no response or incorrect math calculation in 5 s) were coded 0. For each child, responses were then added up in a single math score. To correct for potential variability in mathematics proficiency across classes, math scores were standardized within each class of the six schools. Internal consistency of the math test based on all eight calculations was satisfactory (Cronbach’s α = .89).

Separate one-way ANOVAs were conducted on scores of automatic associations and math scores, using condition (stereotype consistent, control, stereotype inconsistent), gender (male, female), and the schools as independent variables. Schools did not lead to any significant result (all $p > .70$), and thus this variable is not further discussed.

### Table 1

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<td>Math performance</td>
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<td>Explicit stereotype endorsement</td>
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<td><strong>.115</strong></td>
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<td><strong>Boys (n = 120)</strong></td>
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<td>Explicit stereotype endorsement</td>
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Note. Pearson’s r coefficients are reported for automatic associations and math performance. Spearman’s $r_s$ coefficients are reported for the categorical variable explicit stereotype endorsement. *$p < .01$.

Zero-order correlations between all dependent variables (automatic associations, math performance, and explicit math–gender stereotype endorsement), separately for girls and boys across experimental conditions, are presented in Table 1.

### Automatic Associations and Their Malleability

We predicted stereotype-consistent automatic associations for both girls and boys in the control condition, in which the math–gender stereotype was not made salient. In addition, we aimed at testing for the malleability of children’s automatic associations. Higher scores of automatic associations were expected in the stereotype-consistent than in the stereotype-inconsistent condition, with results in the middle for the control condition.

A two-way ANOVA was conducted on scores of automatic associations, with condition (stereotype consistent, control, stereotype inconsistent) and gender (male, female) as the between-participants variables. Results showed a significant Condition × Gender interaction, $F(2, 234) = 6.35, p = .002, \eta^2_p = .05$. To assess the effect of condition within gender, simple-effect analyses were conducted separately for girls and boys. Table 2 presents the average scores of automatic associations in each experimental condition for both boys and girls, together with information about the planned contrasts between the means.

No effect of condition emerged for boys’ automatic associations ($p > .30$). Moreover, one-sample $t$ tests against 0 showed no effect in any condition (all $p > .20$). Conversely, simple-effect analysis on girls’ automatic associations revealed a significant effect of condition, $F(2, 117) = 7.75, p < .01$,
The stereotype-consistent and the control conditions than the stereotype-inconsistent conditions. No effect of the experimental manipulation was found for boys’ automatic associations.

Math Performance

For girls, we expected performance decrements in the stereotype-consistent condition as compared to the control and the stereotype-inconsistent conditions. Conversely, no effect of condition on boys’ math performance was hypothesized.

An ANOVA on math scores, with condition (stereotype consistent, control, stereotype inconsistent) and gender (male, female) as the between-participants variables, was conducted. A Condition × Gender interaction emerged, $F(2, 234) = 4.69$, $p = .010, \eta_p^2 = .04$. Therefore, the effect of condition was tested separately for girls and boys. Simple-effect analyses on boys’ math scores (Table 2) showed that boys performed equally well across conditions ($p > .30$). To the opposite, an effect of condition was found for girls, $F(2, 117) = 3.66$, $p < .03, \eta_p^2 = .03$, linear trend, $p < .01$: Girls underperformed in the stereotype-consistent as compared to the stereotype-inconsistent condition ($p < .03$). On the contrary, math scores in the control and both in the stereotype-consistent and in the stereotype-inconsistent conditions were not different from each other (both $ps > .20$). Thus, whereas the salience of the negative in-group stereotype led girls to perform worse on the math test, the removal of the same stereotype led girls to perform better in the stereotype-inconsistent condition as compared to the stereotype-consistent condition.

Explicit Stereotype Endorsement

To assess stereotype endorsement, participants were shown a picture of a boy and a girl and were asked to say whether the boy or the girl is especially good at math, or whether they are equal. For each child, stereotype-inconsistent response (i.e., the girl is better at math) was coded $-1$, neutral choice (i.e., the boy and the girl are equal) was coded $0$, and stereotype-consistent choice (i.e., the boy is better at math) was coded $+1$. We expected no evidence that children endorsed the math–gender stereotype.

A logistic regression for ordinal dependent measures was performed on children’s choices at the task ($−1 = $ stereotype-inconsistent, $0 = $ neutral, $+1 = $ stereotype-consistent choice), with gender ($0 =$ male, $1 = $ female), condition ($−1 = $ stereotype inconsistent, $0 = $ control, $+1 = $ stereotype consistent), and the product

Table 2
Average Scores of Automatic Associations and Math Scores as a Function of Condition (Stereotype Consistent, Control, Stereotype Inconsistent) for Girls and Boys

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<th>Stereotype consistent</th>
<th>Control</th>
<th>Stereotype inconsistent</th>
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</thead>
<tbody>
<tr>
<td><strong>Girls (n = 120)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Automatic associations</td>
<td>$0.28^a, 0.19^a$</td>
<td>$0.10^b$</td>
<td>$-0.10^b$</td>
</tr>
<tr>
<td>Math test</td>
<td>$-0.56^a, -0.01^ab$</td>
<td>$0.16^a$</td>
<td>$0.73^a$</td>
</tr>
<tr>
<td><strong>Boys (n = 120)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Automatic associations</td>
<td>$0.03^a, -0.05^a$</td>
<td>$0.10^a$</td>
<td>$0.36^a$</td>
</tr>
<tr>
<td>Math test</td>
<td>$0.2^a, 0.05^a$</td>
<td>$-0.03^a$</td>
<td>$0.45^a$</td>
</tr>
</tbody>
</table>

Note. Means within rows not sharing the same subscript are significantly different from each other at the $p < .05$ level (Bonferroni test).

$^a p < .02, ^{**} p < .001.$
tern as predictors. A main effect of gender emerged, Wald \( \chi^2 = 11.49, p < .001 \), indicating that the probability of a counterstereotypical versus neutral versus stereotypical response was not equal for boys and girls. Regardless of condition, 57% of boys and 57% of girls favored their own gender and indicated the boy or the girl, respectively, as the most talented for math. Only 12% of boys and 21% of girls responded that the boy and the girl were the same. Of the remaining children, 22% of girls identified the boy as being better at math, whereas 31% of boys believed that the outstanding math student was the girl. Thus, consistent with predictions, 6-year-olds did not endorse the math–gender stereotype, but simply manifested gender in-group favoritism.

**Mediation Analysis**

Because of null findings for boys on both automatic associations and math scores, a mediation analysis was conducted only for girls to test whether automatic associations mediated the relation between condition and math performance. Given that the predictor (i.e., condition) was a categorical variable with three levels, we created two dummy-coded variables to conduct the mediation analysis (Hayes & Preacher, 2012) with the stereotype-consistent condition as the reference group. Specifically, Contrast 1 tested the effect of the stereotype-consistent (coded 0) versus stereotype-inconsistent (coded 1) condition, with the control condition coded 0. Contrast 2 tested for the residual difference between the stereotype-consistent (coded 0) and the control (coded 1) conditions, with the stereotype-inconsistent condition coded 0.

Consistent with the univariate analyses reported above, the effect of Contrast 1 on performance was significant, \( \beta = .55, t(111) = 3.38, p < .01 \), whereas the effect of Contrast 2 fell short of significance, \( \beta = .34, t(111) = 1.91, p = .06 \). Similarly, the effect of Contrast 1 on automatic associations was significant, \( \beta = -.37, t(111) = 3.56, p < .001 \), whereas the effect of Contrast 2 was not, \( p > .40 \). Moreover, when automatic associations and the two contrasts were entered simultaneously in the model predicting performance, the effect of automatic associations was significant, \( \beta = -.36, t(111) = 2.32, p < .03 \), indicating that automatic associations negatively affect performance. Importantly, the effect of Contrast 1 (i.e., stereotype-consistent vs. stereotype-inconsistent condition) was reduced, \( \beta = .38, t(110) = -2.06, p < .05 \), whereas the effect of Contrast 2 (i.e., stereotype-consistent vs. control condition) remained non-significant, \( \beta = .31, t(111) = 1.77, p = .07 \).

**Figure 1.** Results of mediation analyses testing indirect effects of experimental condition (stereotype consistent = 0, stereotype inconsistent = 1) on math performance via automatic associations in girls (n = 120). *p < .05. **p < .01. ***p < .001.

Figure 1 summarizes results for Contrast 1. To test for mediation, we calculated a bias-corrected 95% confidence interval for the indirect effect (.13, SE = .06) using a bootstrapping technique (Preacher & Hayes, 2008). As the null hypothesis of no mediation states that the indirect effect is 0, the null hypothesis is rejected when the confidence interval does not include 0. In the present analysis, the confidence interval (with 5,000 resamples) for the estimate of the indirect effect of Contrast 1 on performance did not include 0, 95% CI [0.02, 0.28], thus confirming that automatic associations mediated the relation between condition (stereotype consistent vs. stereotype inconsistent) and girls’ performance.

**Supplementary Analyses**

Although main analyses showed that stereotype endorsement did not vary as a function of condition, supplementary analyses were conducted to test whether the relations among condition, girls’ automatic associations, and girls’ math performance were further moderated by stereotype endorsement. Two-way analyses of variance were conducted on both scores of automatic associations and math performance, with condition (stereotype consistent, control, stereotype inconsistent) and explicit stereotype endorsement (stereotype-consistent, neutral, stereotype-inconsistent response) as the between-participants variables. In both ANOVAs, explicit stereotype endorsement yielded no significant effects: The effect of condition was significant on both scores of automatic associations, \( F(2, 111) = 7.76, p < .001 \), and math performance, \( F(2, 111) = 4.12, p < .02 \), and was not further qualified by explicit stereotype endorsement (all ps > .15). However, given that the relatively low number of girls who provided a neutral response or indicated the other gender group as
better at math resulted in unbalanced cell frequencies, this finding could be a consequence of low statistical power. To rule out this possibility, we repeated the same analyses by recoding explicit stereotype endorsement into a dichotomous variable, comparing girls indicating their gender group as better at math with those who either indicated boys as better or provided a neutral response. Results were very similar: The effect of condition remained significant on both automatic associations, $F(2, 114) = 6.83, p < .01$, and math performance, $F(2, 114) = 4.59, p < .01$, and was not further qualified by explicit stereotype endorsement (all $ps > .09$).

We also tested whether automatic associations may act as a moderator, rather than a mediator, of the effect of stereotype activation on girls’ math performance. An analysis of covariance (ANCOVA) was performed on math performance with condition (stereotype consistent, control, and stereotype inconsistent), automatic associations, and the interaction between condition and automatic associations as predictors. The main effect of automatic associations was significant, $F(1, 114) = 5.57, p < .02$, whereas the interaction between condition and automatic associations was not ($p > .20$), thus confirming that automatic associations acted as a mediator of the relation between condition and performance.

Finally, we tested whether automatic associations and stereotype endorsement may interact with each other in determining girl’s vulnerability to stereotype threat. We carried out a three-way ANCOVA on math performance with condition (stereotype consistent, control, stereotype inconsistent), automatic associations, and explicit stereotype endorsement response (stereotype consistent, neutral, stereotype inconsistent) as predictors. Again, only the main effect of automatic associations was significant, $F(1, 114) = 4.01, p < .05$, whereas no other main effect or higher order interaction attained significance (all $ps > .10$).

Although boys showed null findings on all dependent variables, the same supplementary analyses were conducted for them as well. In all analyses, neither main effects nor interactions reached significance (all $ps > .08$).

### Discussion

Although the stereotype threat model identifies stereotype awareness as a requirement for stereotype threat effects, research has shown that gender identity activation affects girls’ math performance before the emergence of stereotype awareness, and in the absence of endorsement of the math–gender stereotype (Ambady et al., 2001; Neuville & Croizet, 2007; Tomasetto et al., 2011). The present research disentangles this paradox and extends the stereotype threat model by demonstrating that automatic associations consistent with a negative in-group stereotype represent a key factor that may trigger stereotype threat in young children.

Consistent with research showing that automatic associations can precede conscious beliefs (e.g., Gawronski & Galdi, 2011), we demonstrated for the first time that girls acquire the math–gender stereotype as automatic associations before its emergence at the explicit level: Despite the absence of evidence that children endorsed the math–gender stereotype, 6-year-old girls, but not boys, even in the control condition (i.e., in the absence of any experimental manipulation aimed at increasing or decreasing the salience of the stereotype) showed stereotype-consistent automatic associations between boy and mathematics, and girl and language. Moreover, consistent with research showing malleability of automatic associations in adults (e.g., Dasgupta & Asgari, 2004), for the first time, malleability of girls’ automatic associations was found. After coloring a drawing of a boy correctly solving a math problem, girls’ stereotypical automatic associations were activated, as compared to the control condition. At the same time, after coloring a picture of a girl succeeding in math, stereotypical automatic associations were reduced.

Importantly, the activation of automatic associations in the stereotype-consistent condition hampered girls’ math performance as compared to the stereotype-inconsistent condition, in which, conversely, the reduced activation of automatic associations led girls to the highest performance. Furthermore, highlighting the role of counterstereotypical information in counteracting stereotype threat effects, these findings are parallel to research showing that providing information about equal gender abilities in math (i.e., stereotype-inconsistent information) is an effective strategy to prevent women’s performance deficits (e.g., Cadinu, Maass, Frigerio, Impagliazzo, & Latiniotti, 2003).

An open issue of this study concerns the potential processes underlying girls’ underperformance in the stereotype-consistent versus -inconsistent condition. Consistent with Forbes and Schmader (2010), one may speculate that activated stereotypical automatic associations in the stereotype consistent condition may have burdened working memory capacity, thus disrupting subsequent math performance.
Conversely, the reduced activation in the stereotype-inconsistent condition may have freed up working memory resources, thus enhancing subsequent performance. However, no such conclusions can be drawn as this study did not test how girls’ automatic associations affect performance. Therefore, a direct test of the working memory hypothesis should be the goal of future studies.

Another potential process underlying girls’ worse performance in the stereotype-consistent than the stereotype-inconsistent condition could be a mere priming effect, which would lead individuals to behave automatically consistent with a cognitively primed associative link. To the contrary, if a priming effect were at work, one should expect underperformance even for boys in response to stereotype-related stimuli. To the contrary, neither boys’ automatic associations nor performance were affected by the activation of the math–gender (counter)stereotype. Thus, differently from a priming effect, we argue that in this study it was the membership in a negatively stereotyped group (whose stereotype has been acquired via automatic associations) that was responsible for girls’ performance deficit under stereotype threat.

Although girls’ automatic associations increased and decreased in activation depending on the stereotype content of the experimental condition, no changes emerged at the level of endorsement of stereotypical beliefs. Consistent with research showing gender in-group bias in young children, the majority of children across conditions indicated their gender as superior in math. We argue that this lack of endorsement of the math–gender stereotype further strengthens the role of automatic associations in the process of stereotype acquisition in children.

Relative to the latest point, the present pattern of findings raises the tricky issue concerning the sources and mechanisms underlying the formation of automatic associations. Up to date, highly influential theorizing has posited that automatic associations stem from attitudes and conscious beliefs that have become overlearned and automatized over time (e.g., Rudman, 2004; Wilson et al., 2000). However, recent research (e.g., Gawronski & Galdi, 2011), as well as the present results, suggests that also other underlying mechanisms may be responsible for the formation of automatic associations. Drawing on the distinction between associative and propositional learning (Gawronski & Bodenhausen, 2006), we argue that the automatic formation of stereotype-consistent associative links in children’s cognitive map could stem from repeated co-occurrences of objects or stimuli in children’s social environment. For example, ample evidence shows that children are sensitive to adults’ nonverbal behavior and that such behaviors, often occurring in automatic and unconscious ways, may represent an important channel through which attitudes are transmitted (e.g., Rudman, 2004; Walden & Ogan, 1988). Thus, even though adults may explicitly encourage nonstereotypical interests in children, they may exhibit different patterns of nonverbal behaviors: Parents may purchase more games or manipulative materials related to math and science for their sons than for their daughters (Jacobs & Bleeker, 2004), or intrude more often in their daughters’ than in their sons’ math homework to offer unsolicited help (e.g., Bahnot & Jovanovic, 2005). As a result, such repeated co-occurrences of objects and events might promote the automatic formation of stereotype-consistent associative links in children’s cognitive maps.

In contrast to girls, boys did not reveal stereotypical automatic associations in any conditions. Consistent with research demonstrating that elementary school boys tend to manifest in-group favoritism regarding both math and language (Steele, 2003), these results could simply reflect the fact that boys showed in-group–serving automatic associations about both math and language domains (Steffens et al., 2010), regardless of the stereotype content conveyed by the experimental condition. Indeed, the presence of in-group-serving boy–mathematics and boy–language automatic associations would result in fast response latencies in both critical blocks of the Child–IAT. Thus, given that the D-algorithm compares the extent to which performance on the incompatible (i.e., girl–math and boy–language sharing the same response key) is impaired relative to the compatible critical block (i.e., girl–language and boy–math sharing the same response key), in-group–serving automatic associations could have led to the small or null score of automatic associations that was found for boys across conditions. However, because both gender stereotypes regarding math and language contribute to the Child–IAT score, and cannot be separated (Nosek et al., 2005), this possibility could not be tested in this study. To our knowledge, only one study used an implicit measure to assess math–gender and language–gender stereotypes separately (i.e., Go-No-Go association task [GNAT]; Nosek & Banaji, 2001) in a sample of 14-year-olds and university students. Consistent with the in-group–serving explanation, Steffens and Jelenec’s (2011) male participants revealed both boys–math stereotypical automatic associations and boys–language counterstereotypical automatic associations. However, as Steffens and Jelenec noted, “the internal
consistency of the GNAT was low . . . and the IAT clearly appears more sensitive” (Steffens & Jelenec, 2011, p. 332). Thus, a goal of future studies should be to test whether other implicit measures that combine the measurement quality of the IAT with the separate measurement of math and language gender stereotypes, such as the GNAT, can be implemented and adapted for use with young children.

Studies on the development of cognitive competencies offer alternative explanations for boys’ lack of automatic associations. For example, previous research has shown earlier knowledge of gender stereotypes (Zosuls et al., 2009) and earlier achievement of gender constancy (Ruble et al., 2007) by girls than boys. At the same time, differences in gender categorization abilities between girls and boys could also be the result of socialization processes. For example, women show stronger automatic associations between the self, their gender, and the in-group gender stereotype as compared to men (Cadinu & Galdi, 2012), and children from low-status groups are more likely to be aware of self-relevant stereotypes than children from high-status groups (McKown & Weinstein, 2003).

Although consistent with Steffens et al. (2010), the result that boys did not manifest stereotypical automatic associations is inconsistent with Cvencek et al.’s (2011) findings, showing stereotypical automatic associations between gender and academic subjects in both 6- to 7-year-old boys and girls. However, this discrepancy might reflect cross-cultural variations in the strength of gender stereotypes at the societal level, which have been found to be associated with either smaller or bigger gender differences in the strength of stereotypical automatic associations (Nosek et al., 2009), as well as in the endorsement of gender stereotypes about academic abilities (e.g., Evans, Schweingruber, & Stevenson, 2002). Moreover, in a study involving Chinese, Japanese, and American children, Lummis and Stevenson (1990) found that whereas American and Chinese 6-year-olds do not believe that there are gender differences in math, 6-year-old Japanese children tend to believe that boys are better than girls at math (see also Del Rio & Strasser, 2013). These results show that cultural differences in the strength of gender stereotypes about academic abilities, in schooling, and in out-of-school experiences, may lead to different acquisition ages of the endorsement of these stereotypes, and suggest that the same could be true regarding the acquisition of stereotypical automatic associations.

In conclusion, this study has the potential to contribute to the stereotype threat model by suggesting automatic associations as a novel prerequisite for stereotype-induced underperformance in young children. Importantly, by showing also that children’s automatic associations are malleable, these findings are promising in terms of interventions to promote gender equality in math and science because they suggest that girls can be protected from the deleterious impact of math–gender stereotypes. Relevant to this claim is a study (Dasgupta & Greenwald, 2001) demonstrating that Caucasian participants exposed to images of admired Black and disliked White exemplars showed lower pro-White automatic associations than participants exposed to images of admired Whites and disliked Blacks. Interestingly, such a decrease in pro-White automatic associations lasted for 24 hr, suggesting that relatively enduring changes in automatic associations can be obtained. If so, repeatedly presenting girls with exemplars of successful women in math and science could promote the reduction in stereotypical automatic associations, long before girls have acquired any awareness or endorsement of the stereotype favoring males in math. This study suggests that this strategy could protect girls’ performance in stereotype-threatening situations and potentially help them to expand their interests toward traditionally male domains.

References


