Research Article

A THREATENING INTELLECTUAL ENVIRONMENT: Why Females Are Susceptible to Experiencing Problem-Solving Deficits in the Presence of Males

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Abstract—*Does placing females in environments in which they have contact with males cause deficits in their problem-solving performance? Is a situational cue, such as gender composition, sufficient for creating a threatening intellectual environment for females—an environment that elicits performance-impinging stereotypes? Two studies explored these questions. Participants completed a difficult math or verbal test in 3-person groups, each of which included 2 additional people of the same sex as the participant (same-sex condition) or of the opposite sex (minority condition). Female participants in the minority condition experienced performance deficits in the math test only, whereas males performed equally well on the math test in the two conditions. Further investigation showed that females' deficits were proportional to the number of males in their group. Even females who were placed in a mixed-sex majority condition (2 females and 1 male) experienced moderate but significant deficits. Findings are discussed in relation to theories of distinctiveness, stereotype threat, and tokenism.*

Females currently are a small minority of students and researchers in the natural and physical sciences. A recent National Science Foundation (1996) report showed that females constitute 35% of undergraduate students enrolled in physics, math, and computer science classes; 16% of undergraduate students enrolled in engineering classes; and less than 10% of graduate students in physics and engineering. Moreover, this report showed that females suffer from higher attrition rates in their academic careers than do males, so that by the time women reach the workplace, they occupy only 22% of jobs in mathematical and scientific domains. Does females' problem-solving performance diminish when they are placed in an environment in which males outnumber them? If so, are such performance deficits specifically linked to domains that are associated with negative stereotypes about females' intellectual capacity? Examining these questions can inform theories of how social stereotypes affect the intellectual processing of individuals who are the targets of these stereotypes, as well as educational practice.

Being outnumbered may cause females to suffer from *stereotype threat*, which is a situational phenomenon that occurs when targets of stereotypes alleging intellectual inferiority are reminded of the possibility of confirming these stereotypes (Aronson et al., 1999; Aronson, Quinn, & Spencer, 1998; Spencer, Steele, & Quinn, 1999; Steele, 1997; Steele & Aronson, 1995). The experience of stereotype threat may, in turn, interfere with intellectual performance, especially when individuals are highly identified with success and achievement in the given domain. For example, Spencer et al. (1999, Experiment 3) showed that high-achieving females performed significantly worse than males on a standardized math test when the stereotype about their math ability was made salient. Saliency was manipulated by informing participants that the test they were about to take had previously elicited sex differences, presumably differences favoring males. These findings are relevant to explaining sex differences on the math subtest of the Scholastic Assessment Test (SAT; see Brown & Josephs, 1999), because females who are highly identified with pursuing a college education may underperform as a result of heightened test anxiety and loss of motivation due to stereotype threat. The effects of stereotype threat on academic achievement have been demonstrated across different stereotyped groups, such as African Americans (Steele & Aronson, 1995), Latinos (Aronson & Salinas, 1997), and students of low socioeconomic status (Croizet & Claire, 1998).

To elicit stereotype threat, there may be no need to either directly present people with the stereotype (Spencer et al., 1999) or remind them of their membership in a stereotyped group (Steele & Aronson, 1995, Study 4). Instead, we contend that stereotype threat may be evoked by any factor that increases the saliency of group stereotypes. Deaux and Major's (1987) interactive model of gender-related behavior suggests that the situation or environment can serve as a causal factor (in addition to attributes associated with the perceiver and the target) in determining whether gender stereotypes will be activated. We predicted that one such environmental factor, being outnumbered by members of the opposite sex, would suffice to cause females to experience the detrimental effects of negative stereotypes about their mathematical ability. We refer to any such environment that can activate the threatening effects of gender stereotypes as a *threatening intellectual environment*.

That this particular situation constitutes a threatening intellectual environment for females is consistent with distinctiveness theory (Abrams, Thomas, & Hogg, 1990; McGuire, McGuire, Child, & Fujioka, 1978; McGuire, McGuire, & Winton, 1979; McGuire & Padawer-Singer, 1976). This theory suggests that a minority status can evoke a sense of group identity, which is then incorporated into the working self-concept. For example, after manipulating the sex composition of 3-person groups, Cota and Dion (1986) found that whereas 34% of participants in the minority conditions became aware of their own gender, only 16% of those in the same-sex condition did the same. Furthermore, McGuire et al. (1979) found that as the relative number of opposite-sex individuals increased, the spontaneous mention of gender increased proportionately. This last finding raises the possibility that as females are increasingly outnumbered by males, a situation that is common to many advanced-level quantitative high school classes, university courses, and workplace environments, females may become more aware of their gender. We predicted that the

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increased awareness of one's group, and the negative stereotypes that are associated with this group, would cause poorer performance.

According to the theory of stereotype threat, a minority status should disrupt cognitive functioning only on a stereotyped task. However, according to tokenism theory (Lord & Saenz, 1985; Saenz, 1994; Saenz & Lord, 1989), a minority or token status—being a token minority in an otherwise homogeneous group—should elicit cognitive deficits in all domains. Saenz (1994) argued that a token status invokes the feeling of being responsible for representing one's minority group favorably in any given domain. Saenz suggested that the feeling of responsibility or self-consciousness diverts the token's attention from the cognitive task at hand and therefore can result in deficits in problem solving and memory.

The theories of tokenism and stereotype threat make different predictions regarding the effects of a minority status on cognitive performance (Steele & Aronson, 1995). Stereotype threat posits that it is the stereotype itself that causes evaluation apprehension. When people are placed in the minority and are asked to perform in a stereotyped domain, they are reminded of the stereotype that detracts from their group's reputation. It is the cognizance of the stereotype that then leads to performance deficits. In contrast, tokenism posits that the token status itself causes self-consciousness, and individuals therefore feel the pressure of being responsible for representing other members of their group in a positive light, regardless of whether they are asked to perform in stereotyped or nonstereotyped domains. Thus, both theories predict that females would experience performance deficits when they are a numerical minority. According to the theory of stereotype threat, however, a deficit would occur only in a negatively stereotyped domain, such as mathematics.

GOALS AND THE EXPERIMENTAL PARADIGM

The main goals of the current study were to test whether (a) placing females in the minority, or in an environment in which they are outnumbered by males, is sufficient to create a threatening intellectual environment that causes deficits in their intellectual performance and (b) whether minority-induced performance deficits, if any, are specific to a stereotyped domain or generalize to stereotyped and nonstereotyped domains just the same. The experimental paradigm consisted of asking participants to take a test with either 2 people of the same sex (same-sex condition) or 2 people of the opposite sex (minority condition). The test comprised items from either a stereotyped (math) or a nonstereotyped (verbal) domain. If being in the minority affects females' performance negatively, then females in the minority condition would experience decrements relative to females in the same-sex condition. Males, however, would perform similarly in both conditions because math is not a stereotyped domain for them. In addition, if performance decrements that occurred were mediated by stereotype threat, then they would occur only in the stereotyped domain (stereotype-threat hypothesis). In contrast, if performance deficits occurred as a result of being a token in a group, then they would occur in both stereotyped and nonstereotyped domains (tokenism hypothesis).

Experiment 1 was designed to examine these hypotheses with female participants. Experiment 2 was crafted to control for the performance of male participants, as well as to examine whether females' math performance would decrease in proportion to the relative number of males who were present in their environment.

EXPERIMENT 1

This experiment was designed to examine whether females who are outnumbered by males (the minority condition) experience performance decrements relative to females who are placed in a gender-homogeneous environment (the same-sex condition) and to test the stereotype-threat and tokenism hypotheses.

Method

Participants

Seventy-two female undergraduate students at Brown University participated in this study in exchange for credit toward a course requirement. They were randomly assigned to one of four conditions in a Sex Composition (minority condition vs. same-sex condition) × Test Type (math test vs. verbal test) between-subjects factorial design.

Materials

The math and verbal tests were composed of 20 and 25 items, respectively. The two tests consisted of equally difficult multiple-choice items taken from the Graduate Record Examination (GRE) test guide (Educational Testing Service, 1994). In earlier samples, only 36.6% and 32.5% of examinees answered all of the math and verbal items correctly, respectively (Educational Testing Service, 1994).

Procedure

Female participants were randomly assigned to either the same-sex or the minority condition. In the same-sex condition, the experiment started once all 3 female participants arrived. In the minority condition, 2 out of 8 male confederates were randomly assigned to each session, and the experiment started once the 2 male confederates and the female participant arrived. All participants received the same cover story. They were told that the goal of the study was to create an educational training program for enhancing performance on standardized achievement tests. Furthermore, they were informed that their performance on the test would be reported orally to the other group members. Participants were then given 15 min to complete either a math or a verbal test. Finally, they were asked to complete a demographic sheet, which asked them to report their mathematical and verbal SAT scores.

So that any effects due to an experimenter's presence would be minimized, the experimenter was present in the room only when it was absolutely necessary (e.g., to pass out the tests). The experimenter's sex was counterbalanced over participants. That is, half of the participants were greeted by a male experimenter, whereas the other half were greeted by a female experimenter.

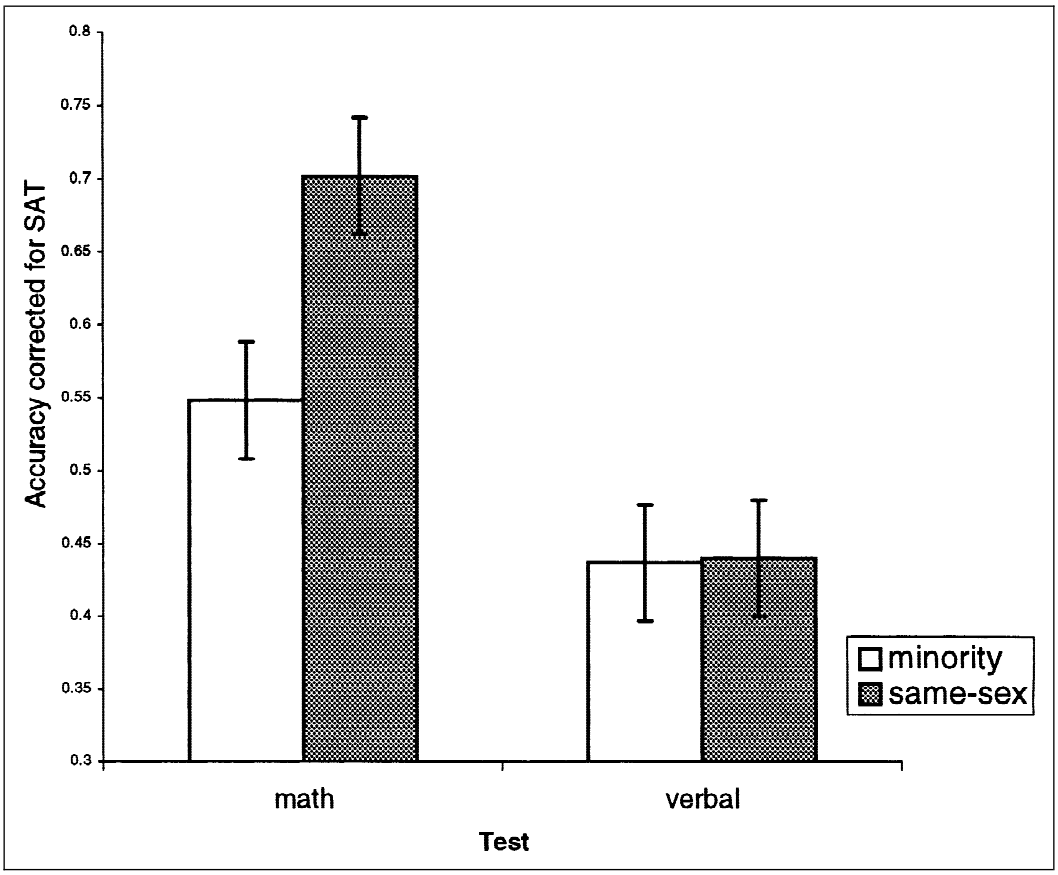

Fig. 1. Accuracy of test performance, corrected for Scholastic Assessment Test (SAT) score, as a function of sex composition of group and test type. Error bars represent standard errors.

Results and Discussion

For each participant, we computed an accuracy score based on the number of correct items divided by the total number of items attempted. To take into account participants' previous performance, we then adjusted these accuracy scores by participants' self-reported SAT scores (Steele & Aronson, 1995). Figure 1 shows that the group means support the stereotype-threat over the tokenism hypothesis. Females in the minority condition demonstrated a decrease in performance on the math test only (and not the verbal test) when compared with females in the same-sex condition.

We ran a 2 × 2 analysis of covariance (ANCOVA) on accuracy, with SAT scores as the covariate. This analysis resulted in a significant interaction between sex composition and test type, $F(1, 67) = 3.80$, $p < .05$. An analysis of simple effects revealed that, as predicted by stereotype threat, females in the minority condition attained significantly less accurate scores on the math test ($M = .55$, $SE = .05$) than did females in the same-sex condition ($M = .70$, $SE = .05$), $F(1, 67) = 6.98$, $p < .01$. This result constitutes a medium effect size, Cohen's $d = .73$. Conversely, when taking the verbal test, females in the minority condition ($M = .44$, $SE = .03$) did not attain significantly worse scores than females in the same-sex condition ($M = .44$, $SE = .03$). Thus, females in the minority condition scored less accurately than did females in the same-sex condition, but only in the stereotyped domain.[1] The main effect for test type was not significant.[2]

These findings showed that when females were placed in a threatening intellectual environment (when they were outnumbered by males), they tended to demonstrate deficits in their mathematical performance, even without an explicit reminder of the ability-impinging

1. When we considered only the number of questions answered correctly (number correct), we found the same pattern of results, though some were less significant. The 2 × 2 ANCOVA using self-reported SAT as the covariate resulted in a significant interaction between sex composition and test type, $F(1, 67) = 4.14$, $p < .05$. Relative to participants in the same-sex condition, females in the minority condition showed a trend for producing lower scores on the math test ($M = 4.57$, $SE = 0.37$ vs. $M = 5.44$, $SE = 0.35$), $F(1, 67) = 2.01$, $p < .19$, a result that constitutes a medium effect size, Cohen's $d = .56$, but attained similar scores on the verbal test ($M = 0.23$, $SE = 0.03$ vs. $M = 0.21$, $SE = 0.03$). It is important to note, however, that accuracy is a more meaningful performance measure than number correct because it takes into account both the number of questions answered and the number of questions attempted (for a similar argument, see Shih, Pittinsky, & Ambady, 1999).

2. To test whether there was a main effect for test type, we had to adjust the dependent measure to be the percentage score (number completed correctly out of all items completed), because there were more verbal than math items (25 and 20, respectively). We thus ran a 2 × 2 ANCOVA on the percentage score, using participants' SAT scores as the covariate. The results were the same as previous ones, and there were no main effects for test type.

stereotype. In contrast to the predictions of tokenism theory, however, being in the minority did not appear to be sufficient for inducing cognitive deficits. Instead, deficits were specific to the negatively stereotyped task (the mathematics test, but not the verbal test).

There were two important unresolved questions, however, that we addressed in Experiment 2. First, would males show the same pattern of decrements as females? That is, would males experience a threatening intellectual environment as a result of taking a math test while being in the minority? We predicted that males in the minority condition would not show decrements in math performance compared with males in the same-sex condition because math is not a stereotyped domain for males.

Second, would females experience deficits only when they were in the minority, or would any intersex contact be deleterious to their performance? To answer this question, we ran an additional mixed-sex condition in which females were in the majority (2 females and a single male). According to distinctiveness theory, group saliency increases with an increase in the relative number of out-group members (McGuire et al., 1979). Thus, we predicted that females' performance would decrease with an increase in the relative number of males in their environment. That is, females in the mixed-sex majority condition would perform worse than females in the same-sex condition, because the environment would still elicit stereotype threat, but would perform better than females in the minority condition. A threatening intellectual environment may encompass situations in which females are in the majority but, because of the presence of even a single male, are still reminded of and suffer decrements from a negative stereotype in the stereotyped domain.

EXPERIMENT 2

The procedure of Experiment 2 was almost identical to that of Experiment 1, except that (a) participants were both male and female, (b) participants completed a math test only, and (c) we included an additional condition in which females were in a mixed-sex majority (2 females and 1 male).

Method

Participants

Ninety-two male and female undergraduate students at Brown University participated in this study in exchange for either credit toward a course requirement or a payment of $6.00. Seventy-four participants were assigned to one of four conditions in a Sex Composition (minority condition vs. same-sex condition) × Sex (male vs. female) between-subjects factorial design. Additionally, 18 female participants were assigned to a mixed-sex majority condition.

Materials and procedure

The procedure was the same as in Experiment 1, with two exceptions: All participants were asked to take the math test, and they were given 20 (rather than 15) min to complete the test because participants in Experiment 1 answered an average of only 8.32 math items. After participants completed this test, they were asked to fill out a demographic sheet, which asked them to report their math SAT score.

Results and Discussion

Test performance: Minority versus same-sex conditions

The groups' accuracy means, adjusted for participants' self-reported SAT scores, support the conclusion that there was a threatening intellectual environment for females (see Fig. 2). The 2 × 2 ANCOVA on accuracy, using participants' self-reported SAT scores as the covariate, revealed a marginally significant interaction between sex and sex composition, $F(1, 67) = 3.12$, $p = .08$.[3] No other effects were significant or close to being significant.

An analysis of simple effects showed that females in the minority condition ($M = .58$, $SE = .03$) scored significantly less accurately than females in the same-sex condition ($M = .70$, $SE = .04$), $F(1, 67) = 5.64$, $p < .02$. This result constitutes a large effect size, Cohen's $d = .80$. In contrast, males in the minority condition ($M = .67$, $SE = .04$) did not score significantly less accurately than males in the same-sex condition ($M = .66$, $SE = .04$). Thus, these results replicated the previous accuracy findings from Experiment 1. Females who were placed in the minority condition showed a deficit in accuracy vis-à-vis females who were placed in the same-sex condition. In contrast, male participants were not affected by the sex-composition manipulation.[4]

Females' test performance as a function of number of males

In accordance with distinctiveness theory, we predicted that females' math performance would decrease as a function of the relative number of males in their environment. We conducted a linear contrast analysis, adjusting for self-reported SAT, testing the prediction that female participants in the minority condition scored the lowest ($M = .58$, $SE = .03$), female participants in the mixed-sex majority condition scored in the middle ($M = .64$, $SE = .03$), and female participants in the same-sex condition scored the highest ($M = .70$, $SE = .04$). This analysis revealed a significant pattern, $t(51) = 2.42$, $p < .02$, $r = -.32$. Thus, females' math performance decreased as the relative number of males in the room increased.

This experiment provided additional evidence for three ideas. First, minority status can cause intellectual deficits in stereotyped domains. When placed in the minority, females, but not males, experienced math performance deficits. Second, stereotype threat can be evoked by environmental cues, such as simple changes in the sex composition of the environment, even without an explicit reminder of the negative stereotype. These environmental cues thus create a threatening intellectual environment. Third, females show increasing decrements in math performance with an increase in the relative number

3. As suggested by Neter, Kutner, Nachtsheim, and Wasserman (1996), two cases were excluded from this analysis because their absolute difference between fits (DFFITS) value exceeded 1, and because their Cook's Distance values were greater than the 50th percentile of the F distribution.

4. Data for the number correct, however, do not support our predictions. The 2 × 2 ANCOVA, using SAT scores as the covariate, failed to reveal significant interactions, $F < 1$, or significant differences between females in the minority and same-sex conditions ($M = 7.25$, $SE = 0.93$ vs. $M = 7.96$, $SE = 0.93$) or between males in the minority and same-sex conditions ($M = 10.44$, $SE = 0.86$ vs. $M = 10.85$, $SE = 0.86$). As we stated earlier, however, accuracy is a more telling index of performance as it takes into account both raw scores and the number of items attempted.

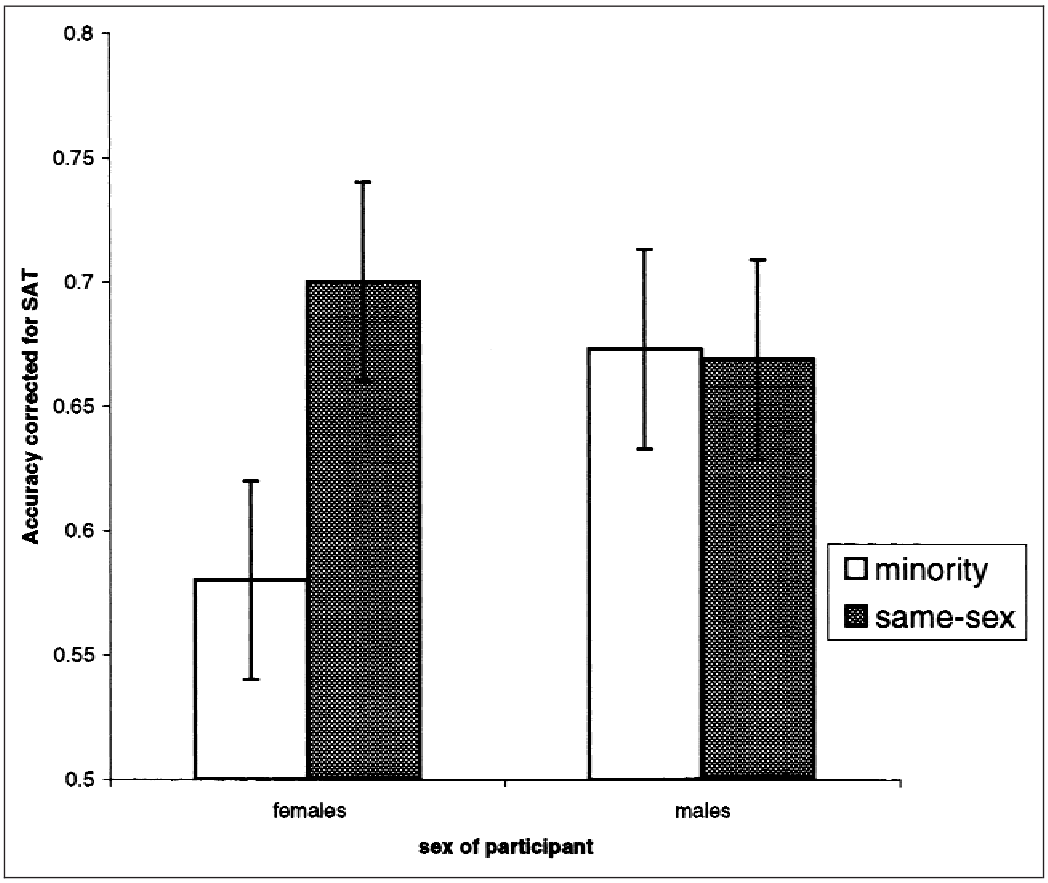

Fig. 2. Accuracy of test performance, corrected for Scholastic Assessment Test (SAT) score, as a function of sex composition of group and sex of participant. Error bars represent standard errors.

of males in their environment; their performance declines the more the environment departs from an all-female environment. This finding is consistent with distinctiveness theory's assertion that group salience increases with an increase in the relative number of out-group members in the immediate social environment (McGuire et al., 1979).

CONCLUSION

Simply placing high-achieving women in an environment in which men outnumber them can cause them to experience performance deficits in a stereotyped problem-solving domain, such as mathematics. Furthermore, in this threatening intellectual environment, performance deficits tend to increase as the relative number of males increases. It seems that sex composition, therefore, may act as a causal situational factor in determining whether gender stereotypes, such as negative stereotypes about females' mathematical ability, will be activated (also see Deaux & Major, 1987). This activation, in turn, may cause high-achieving females to experience performance deficits.

In the current study, these decrements in performance were specific to the stereotyped domain (math but not verbal). The findings are therefore consistent with the predictions of stereotype threat, but contrary to those of tokenism. Thus, being in the presence of males appears to be a necessary but not a sufficient condition for deficits in females' math performance. These results contribute to a growing body of research showing that the effects of a minority status are mediated by variables such as sex and domain of performance (Yoder, 1994; Yoder, Aniakudo, & Berendsen, 1996).

Even though the stereotype-threat hypothesis explains the data better than does tokenism theory, a few words of caution are in order. First, the predictions of tokenism theory may not have been supported because of the relative size of the majority and minority groups in the current study. The majority members outnumbered minority members by only one person. Thus, it is possible that the minority group did not feel as "tokenized" as they would have felt in a larger group. Second, the dependent measure, performance on a written test, may have been too private to elicit a tokenism effect. It is possible that if participants were required to take an oral test, instead of a written test, they would have experienced greater self-consciousness in both the stereotyped and the nonstereotyped domains.

The present study also has several implications for educational practice. One concerns the controversy surrounding the merits of single-sex over coed education. Advocates of single-sex education argue that separating the sexes can minimize the deleterious effects of gender stereotypes and bolster females' attitudes toward more "masculine" subject matters such as math and science (American Association of University Women Educational Foundation, 1992, 1998; Riordan, 1990). Although the current study was not designed to assess whether females would benefit from single-sex education, the finding that their math performance tended to decrease as the number of males

in their environment increased suggests that females may in fact benefit from being placed in single-sex math classrooms.

Although a person need not be chronically targeted by stereotypes to be impaired by them (Aronson et al, 1999), a person who is highly identified with a given domain and is continuously in the minority may be more likely to be impaired by stereotypes than a person who is not continuously in the minority. Women who are placed in advanced math courses in high school and those who take undergraduate and graduate courses in mathematics are often exposed to an everyday reality of being in the minority. These women are especially vulnerable to the negative consequences of stereotype threat because they tend to be highly identified with the math domain. Steele (1997) suggested that groups that suffer from stereotype threat might embrace an adaptive response of "disidentification." That is, they may reconceptualize their values and identity so as to remove the stereotyped domain as a basis for self-evaluation. Females who are highly identified with mathematics, however, do not have such recourse, and are therefore more vulnerable to the effects of negative stereotypes than are females who are not strongly identified with mathematics. It may not be surprising, then, that the gap between males' and females' scores on the math SATs is largest in the gifted population (Benbow & Stanley, 1980, 1983; Hyde, Fennema, & Lamon, 1990).

The data from the current study support the conclusion that the presence of males constitutes a threatening intellectual environment for females performing a math task, and specifically that women experience a greater deficit in their math performance the more males there are in the environment. However, this study still leaves a number of important questions unanswered. First, what is the nature of the mechanism that mediates these performance deficits? Although Steele and Aronson (1995) suggested that evaluation apprehension may be the underlying causal mechanism, it is possible that performance expectations (e.g., Stangor, Carr, & Kiang, 1998) and stereotype activation (e.g., Dijksterhuis & van Knippenberg, 1998) play important roles as well. Second, although males usually find themselves in advantaged social groups, they are considered less able than females in some domains, such as performance on verbal tasks (Skaalvik & Rankin, 1994; Smedler & Torestad, 1996). Would a male who is asked to perform a verbal task experience deficits in the presence of females? If not, minority effects may be confined to chronically stereotyped groups (Yoder, 1994).

In sum, merely placing high-achieving females in a stereotyped setting, in which they are in contact with males, causes a decrease in their performance. This phenomenon highlights the indirect environmental effects of negative stereotypes on the targets of these stereotypes (e.g., Stangor et al., 1998; Steele & Aronson, 1995) and adds to the growing literature on the social and cognitive effects of belonging to a stigmatized group (e.g., Crocker & Major, 1989; Major, Spencer, Schmader, Wolfe, & Crocker, 1998). For females who pursue quantitative-related vocations, this phenomenon has real-world implications. The gender makeup of an environment alone, be it in a classroom or on the job, can create a threatening intellectual environment for females. This environment, in turn, can have an adverse impact on females' intellectual performance.

Acknowledgments—We thank the following individuals (in alphabetical order) for their invaluable insights: Naomi Sarah Ball, Nikki Cockrell, Steve Fein, Lori Goldstein, Laurie Heatherington, Saul Kassin, Joachim Krueger, Brian Nosek, Scott Pion, Jandira Ramos, and Jack Wright.

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(RECEIVED 11/20/99; ACCEPTED 1/31/00)