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Do gender–science stereotypes predict science identification and science career aspirations among undergraduate science majors?

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Abstract The present research examined whether gender–science stereotypes were associated with science identification and, in turn, science career aspirations among women and men undergraduate science majors. More than 1,700 students enrolled in introductory science courses completed measures of gender–science stereotypes (implicit associations and endorsement of male superiority in science), science identification, and science career aspirations. Results were consistent with theoretically based predictions. Among women, stronger gender–science stereotypes were associated with *weaker* science identification and, in turn, *weaker* science career aspirations. By contrast, among men stronger gender–science stereotypes were associated with *stronger* science identification and, in turn, *stronger* science career aspirations, particularly among men who were highly gender identified. These two sets of modest but significant findings can accumulate over large populations and across critical time points within a leaky pipeline to meaningfully contribute to gender disparities in STEM domains.

Keywords Implicit attitudes · Gender · Stereotypes · Identity · Science

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1 Introduction

Women traditionally have been and continue to be underrepresented in the physical sciences, technology, engineering, and math (STEM) domains (NSF 2012). Compared to men, women are less likely to enter STEM domains and, at each critical decision-making point, more likely to drop out of STEM domains (Lubinski and Benbow 2006). The gender gap in STEM persists despite the fact that gender differences in math performance—a crucial domain of relevance for science, technology, and engineering—are trivial and, in many cases, non-existent (Hyde et al. 2008; Lindberg et al. 2010). Although many factors contribute to the gender gap in STEM engagement (for reviews, see Ceci et al. 2009; Halpern et al. 2007), gender differences in choice have received much recent attention.

Social commentators and social scientists recently have suggested that a primary reason women are underrepresented in STEM is because highly qualified women are not interested in STEM domains and choose to pursue careers in other domains (Ceci and Williams 2010; Ferriman et al. 2009; McArdle 2008). Interestingly, the focus on personal choice has directed attention toward gender differences in interest, preferences, and values that have consequences for career choices and away from factors in the social context, such as salient gender stereotypes. Personal choices are, however, made in particular contexts, often being influenced by situational factors.

The goal of the current work is to examine whether stereotypes about the gendered nature of science differentially relate to women's and men's choices to pursue science careers. The current work extends prior theory and research in four ways. First, the inclusion of both women and men in our analyses permits an examination of whether stereotypes contribute to the gender gap in STEM domains through simultaneous processes that both discourage science career aspirations among women *and* encourage aspirations among men. Second, we assess stereotypes at both the self-report and implicit levels, because stereotypes that are consciously rejected may nonetheless operate at the implicit level to subtly influence women's and men's career aspirations (Nosek and Smyth 2011). Third, we examine whether science identification mediates the relation between stereotyping and science career aspirations among women and men. Finally, adopting a Person × Situation approach (Lewin 1951) in which we assume that situational forces have greater impacts on some individuals than others, we examine whether the proposed mediated effect is moderated by the strength of identification with one's gender. To consider these possibilities, we review relevant theory and research on stereotype threat and lift effects, which provide a general framework for thinking about the mechanisms by which gender–science associations may influence women's and men's choices to pursue science.

1.1 Theoretical background

The need to belong is a fundamental human need (Baumeister and Leary 1995) and stereotypes signal thoughts about who does and who does not belong in particular settings. Consistent with this notion, when stereotypes suggest that members of one's own group are underrepresented in a domain, belonging uncertainty is aroused and domain disidentification may occur (Steele 1997; Walton and Cohen 2007), which may undermine one's desire to persist in the domain. Indeed, a growing body of literature indicates that stereotypes linking gender to achievement domains differentially influence women's and men's desire to pursue those domains (e.g., Cheryan et al. 2009; Correll 2004; Davies et al. 2002). For example, women who associate math with men are less likely to major in quantitative fields than are women who do not hold those associations (Nosek and Smyth 2011). In addition, among women who are STEM majors, stronger math-male associations predict less desire to pursue graduate study in STEM fields (Kiefer and Sekaquaptewa 2007; Schmader et al. 2004). By contrast, among men, stronger math-male associations predict greater likelihood to major in quantitative fields (Nosek and Smyth 2011).

Theoretically, domain identification should mediate the link between stereotypes and the desire to pursue a domain. For instance, social identity and stereotype threat theorists (Inzlicht and Schmader 2012; Steele 1997; Steele et al. 2002) have suggested that negative stereotypes about one's group in a domain should contribute to disidentification with that domain. Notably, disidentification can occur even among those who are initially identified with the domain, such as women majoring in science. As stated by Steele (1997, p. 614): "When this threat [of being judged or treated stereotypically] becomes chronic in a situation….it can pressure disidentification". For women majoring in science fields that are male-dominated, chronic exposure to stereotypic math-male associations in the environment may weaken their sense of belonging and identification with science. Weaker science identification, in turn, may weaken intentions to continue in science. For men, however, chronic exposure to math-male associations may strengthen their sense of belonging and identification with science, consistent with research on stereotype lift and stereotype boost (Shih et al. 1999; Walton and Cohen 2003). Stronger science identification, in turn, may strengthen intentions to continue in science.

Although consistent with prior theorizing, to the best of our knowledge no prior research has empirically tested whether the link between stereotypes and career aspirations is mediated by domain identification. In addition, no prior work has simultaneously examined the predictions of stereotype threat theory and stereotype lift theory in a single context to examine whether domain identification mediates the association between gendered notions of the domain and domain career aspirations for both women and men. In the present work we examine these links within the domain of science. Consistent with stereotype threat theory, and as shown in Fig. 1 (path a), we predicted that stronger science-male associations should predict weaker science identification among women. By contrast, consistent with stereotype lift theory (Walton and Cohen 2003), stronger science-male associations should predict stronger science identification among men. Common across gender, however, we expected science

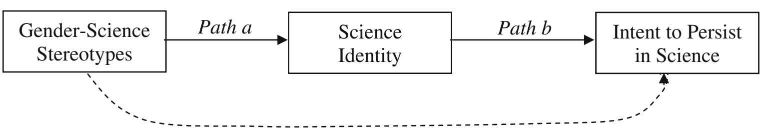

Fig. 1 Path model of the predicted mediated effect among women and men

identification to positively predict intent to persist in science (path b). Although no prior work has examined whether domain identification mediates the link between stereotypes and career aspirations, as shown in Fig. 1, prior work has examined the link between stereotyping and domain identification (e.g., Nosek et al. 2002) and the link between domain identification and intent to persist in the domain (e.g., Stout et al. 2011). Thus, the present work extends prior theory and research by examining how stereotypes and domain identification work together to predict career aspirations among women and men in a single context.

1.2 Implicit versus self-reported stereotyping

There is reason to suspect that the relation between gender–science stereotyping and intent to persist in science may be stronger for implicit stereotyping than self-reported stereotyping. Implicit measures of gender–science stereotypes, as measured in the present study by the Implicit Association Test (IAT; Greenwald et al. 1998), reflect exposure to the repeated pairing of science and male in the environment. As such, implicit science-male associations indicate the extent to which stereotypic associations are "in the air", or chronically activated, for the individual (Steele 1997). Importantly, these automatic associations can be present and can negatively affect performance, motivation, and domain identification without being endorsed and consciously internalized by members of negatively stereotyped groups (Steele 1997; Vescio et al. 2006). Self-report measures of gender–science stereotypes, by contrast, reflect personal endorsement of the stereotype that may be inconsistent with implicit stereotypic associations. Because people can be reluctant to report personal endorsement of stereotypes, and because they may not even be aware of holding such stereotypes (Nosek and Smyth 2011), we expected implicit stereotyping to play a stronger role than self-reported stereotyping in predicting science career aspirations.

1.3 Gender identity as a moderator

Finally, if gender stereotypes are particularly self-relevant for those who are highly gender identified (Greenwald et al. 2002; Kiefer and Sekaquaptewa 2007; Nosek et al. 2002; Schmader 2002), then the mediated effect shown in Fig. 1 (i.e., the effect of stereotyping on intent to persist in science via science identity) should be stronger among those high (vs. low) in gender identity. Moderated mediation of this sort is consistent with prior work; for example, gender stereotypes negatively predict intent to pursue graduate study in math among women high (but not low) in gender identity (Kiefer and Sekaquaptewa 2007). Extending prior work, we would expect similar patterns among women in science. Additionally, among men in science who are high (but not low) in gender identity, we would expect gender stereotypes to positively predict science identity and intent to pursue future science careers.

To test these hypotheses, we analyzed relevant data from a large study of women and men enrolled in introductory biology, chemistry, and physics courses. These courses serve as prerequisites for science majors, thus providing a pool of skilled women and men who have the potential to pursue careers in science.

2 Methods

2.1 Participants and procedure

During the final week of fall semester classes, 1,799 participants were recruited from introductory biology, chemistry, and physics courses designed for science majors at The Pennsylvania State University. In return for course credit, participants completed an online series of Implicit Association Tests (IATs; Greenwald et al. 1998), self-report measures, and demographic questions. To test predictions, we selected relevant measures from this larger dataset. More specifically, analyses were performed on implicit gender–science stereotypes and explicit measures of gender–science stereotypes, science identification, gender identification, and intent to persist in science.

Following standard procedures for analyzing IAT data, participants were eliminated from the working data set if they responded too quickly to have attended to the stimuli (<300 ms) on more than 10 % of the trials in the critical blocks of the IATs (5.4 % of participants, n = 97; Greenwald et al. 2003). This resulted in a working data set comprised of responses from 876 women and 826 men ranging in age from 18 to 46 (M = 19.05, SD = 1.70). The ethnic composition of participants reflected the ethnic composition of the university: 78.4 % identified themselves as White, 6.6 % as East Asian, 4.6 % as Black or African American, 3.5 % as South Asian, 2.8 % as bi- or multi-racial-ethnic, 0.3 % as Native Hawaiian or Pacific Islander, 0.2 % as American Indian or Alaska Native, and 3.6 % did not report their race-ethnicity. In addition, 4.9 % identified themselves as Hispanic or Latina(o).

2.2 Measures

2.2.1 Gender–science stereotypes

Gender–science stereotypes were assessed in two ways. First, implicit gender–science stereotypes were assessed using the IAT. The IAT is a response-latency categorization task that assesses the strength of associations between concepts, such as science and gender. It is based on the principle that it is easier to pair concepts that, through learned experience or chronic rumination, have come to be associated with each other (e.g., science and male; humanities and female) than to pair concepts that are not associated with each other (e.g., science and female; humanities and male). The stimulus words used for each category are listed in Table 1. The key assignments used for each category were randomly assigned. IAT scores were created using the procedures described by Greenwald et al. (2003), such that higher IAT scores indicated stronger stereotypic associations (i.e., science = male and humanities = female) than counter-stereotypic associations (i.e., science = female and humanities = male).

Second, self-reported gender–science stereotypes were measured with the following two items from Schmader et al. (2004): (1) “It is possible that men have more ability in science than do women” and (2) “In general, men may be better than women at science”. Participants indicated their agreement with each item using a six-point scale ranging from Strongly Disagree (−2.5) to Strongly Agree (2.5). We averaged across

Table 1 Words used as stimuli for the implicit association tests

Category			
Science	Humanities	Female	Male
Experiment	Literature	Female	Male
Hypothesis	Essay	Her	Him
Science	Poetry	She	He
Scientific	Art	Woman	Man
Quantify	Language	Hers	His

the two items to create a stereotype score ($\alpha = 0.93$), with higher scores indicating greater endorsement of gender–science stereotypes.

2.2.2 Gender identity

After reporting their gender, and also using a scale from Strongly Disagree (-2.5) to Strongly Agree (2.5), participants completed the four items of the *Importance of Identity* subscale of Luhtanen and Crocker (1992) Collective Self-Esteem Scale (e.g., "In general, being a woman/man is an important part of my self-image"). After reverse scoring appropriate items, we averaged across items to create a gender identity score for women ($\alpha = 0.69$) and men ($\alpha = 0.74$). Higher scores indicate stronger identification with one's gender.

2.2.3 Science identity

Using the same scale described above, participants indicated their agreement with four items designed to measure identification with science (e.g., "Science is important to me"; Stout et al. 2011). We averaged across items to create a science identity score ($\alpha = 0.81$), with higher scores indicating stronger identification with science.

2.2.4 Intent to persist in science

Using four-point scales ranging from Very Unlikely (-1.5) to Very Likely (1.5), participants indicated (a) how likely it would be for them to major in science, (b) how likely it would be for them to pursue graduate study in science, and (c) how likely it would be for their eventual career to directly pertain to science. We averaged across ratings to create an intent to persist in science variable ($\alpha = 0.83$), with higher scores indicating greater intent to persist in science in the future.

3 Results

We analyzed the data in two steps. First, we performed mediation analyses to test the hypothesis that the relation between gender–science stereotyping and intent to persist in science is mediated by science identity. Because opposite patterns of associations were expected for women and men, we tested mediation separately by gender. Second,

Table 2 Univariate and bivariate statistics among women and men

	Implicit gender–science stereotyping	Self-reported gender–science stereotyping	Science identity	Gender identity	Intent to persist in science
Women					
M	0.17	−0.77	1.95	1.22	0.88
SD	0.40	1.31	0.67	0.82	0.83
Men					
M	0.35	0.18	2.00	1.08	0.89
SD	0.38	1.36	0.60	0.88	0.74
Correlations					
Implicit stereotyping	–	0.04	0.11**	0.04	0.05
Self-reported stereotyping	0.07*	–	0.08*	0.24**	−0.01
Science identity	−0.17**	−0.13**	–	0.03	0.45**
Gender Identity	0.01	0.06	−0.14**	–	−0.03
Intent to persist in science	−0.09**	−0.06	0.59**	0.03	–

Correlations for women appear below the diagonal; correlations for men appear above the diagonal
$^{*}p < .05$; $^{**}p < .01$

we tested the hypothesis that the mediated effect is stronger among those high (vs. low) in gender identity.

3.1 Descriptive statistics

Table 2 presents the means, standard deviations, and correlations for each variable separately for women and men. Based on prior theory and research, we predicted that the relation between intent to persist in science and stereotyping would be (a) stronger on implicit stereotyping than self-report stereotyping and (b) negative among women but positive among men. Consistent with predictions, among women, intent to persist in science was negatively related to implicit stereotyping but not self-reported stereotyping. Among men, however, intent to persist in science was not significantly related to either implicit or self-reported stereotyping.

3.2 Mediation analyses

A statistically significant total effect of stereotyping on intent to persist in science only emerged for implicit stereotyping among women. We next tested whether this relation was mediated by science identity using the SPSS macro created by Preacher and Hayes (2004). Implicit gender–science stereotyping was the predictor, science identity the mediator, and intent to persist in science the outcome. The top row of Table 3 displays the total, direct, and indirect effects of the tested model, as well as the

Table 3 Unstandardized regression coefficients for the constitutive paths, as well as point estimates and confidence intervals for the indirect effects, of the hypothesized path model

	Total effect	Direct effect	Path *a*	Path *b*	Indirect effect [a]	Percentile-based 95 % C.I.'s for indirect effect		R^2 for Overall model[b]
						Lower bound	Upper bound	
Women								
Implicit stereotyping	−0.19**	0.02	−0.28**	0.73**	−0.207**	−0.289	−0.127	0.34**
Self-reported stereotyping	−0.04	0.01	−0.07**	0.74**	−0.051**	−0.078	−0.024	0.35**
Men								
Implicit stereotyping	0.10	0.00	0.18**	0.56**	0.101**	0.039	0.166	0.20**
Self-reported stereotyping	−0.01	−0.03	0.04*	0.56**	0.020*	0.002	0.039	0.21**

Path *a* refers to the least squares regression coefficient predicting science identity from stereotyping. Path *b* refers to the least squares regression coefficient predicting intent to persist in science from science identity, controlling for stereotyping. * $p < .05$; ** $p < .01$

[a] Significance based on Sobel test

[b] R^2 represents the proportion of variance in intent to persist in science that is explained by gender–science stereotyping and science identity

unstandardized regression coefficients of the constitutive paths. Specifically, the path from implicit stereotyping to science identity (i.e., path a) and the path from science identity to intent to persist in science controlling for implicit stereotyping (i.e., path b) were both significantly different from zero based on ordinary least squares regression estimates. In addition, the indirect effect of implicit stereotyping on intent to persist in science via science identity (i.e., the product of path a and path b) was significantly different from zero as indicated by both a Sobel test and a 95 % percentile-based bootstrap confidence interval based on 5,000 bootstrap samples (Preacher and Hayes 2004). Importantly, the effect of implicit stereotyping on intent to persist in science became non-significant when science identity was included in the model (see total vs. direct effect in top row of Table 3). Together these results suggest that science identity completely mediated the relation between implicit stereotyping and intent to persist in science among women.

Although establishing mediation typically requires the demonstration of a significant total effect of the predictor variable on the outcome (Baron and Kenny 1986), some scholars argue that meaningful indirect effects may exist in the absence of total effects (e.g., MacKinnon et al. 2000; Shrout and Bolger 2002). Therefore, using the same procedure as above, we tested whether self-reported stereotyping among women, and self-reported and implicit stereotyping among men, had an indirect (rather than a mediated) effect on intent to persist in science through science identity. As shown in the bottom three rows of Table 3, the indirect effects for women and men on self-reported stereotyping and for men on implicit stereotyping significantly differed from zero as indicated by both a Sobel test and a 95 % percentile-based bootstrap confidence interval based on 5,000 bootstrap samples.

3.3 Are the indirect effects moderated by gender identity?

We next tested whether gender identity moderated the mediated and/or indirect effects reported in Table 3. Specifically, we examined whether the regression coefficient predicting science identity from stereotyping (i.e., path a) was moderated by gender identity. Toward that end, we estimated regression equations separately by gender for the implicit and self-reported stereotyping measures. In each equation, we regressed science identity on stereotyping, gender identity, and their interaction (Preacher et al. 2007). As shown by the unstandardized regression coefficients in Table 4, the stereotyping × gender identity interaction was significant in only one equation—among men on self-reported (but not implicit) stereotyping. Among women, there was no evidence that gender identity moderated the mediated or indirect effects of stereotyping on intent to pursue science.

We used the SPSS macro provided by Preacher et al. (2007) to examine the conditional indirect effects indicated by the significant self-reported stereotyping × gender identity interaction among men. Specifically, we examined the conditional indirect effects of self-reported stereotyping on intent to persist in science via science identity at one standard deviation above and below the mean for gender identity (see Aiken and West 1991). The direction of the moderated effect was consistent with predictions; the indirect effect was significant among men high in gender identity,

Table 4 Unstandardized regression coefficients for stereotyping × gender identity interaction predicting science identity

	b	SE	t	R^2	ΔR^2
Women					
Implicit stereotyping × gender identity	0.01	0.07	0.13	0.05	0.000
Self-reported stereotyping × gender identity	0.02	0.02	0.90	0.04	0.001
Men					
Implicit stereotyping × gender identity	−0.07	0.06	−1.05	0.01	0.001
Self-reported stereotyping × gender identity	0.03	0.02	1.98*	0.01	0.005*

* $p < .05$; ** $p < .01$.

$ab = 0.03$, $SE = 0.01$, $Z = 2.68$, $p < .01$, but not among men low in gender identity, $ab = 0.001$, $SE = 0.01$, $Z = 0.10$, $p = .92$.

4 Discussion

This research was designed to examine whether gender–science stereotypes were associated with science identification and science career aspirations among undergraduate science majors. As predicted, among women, stronger gender–science stereotypes were associated with *weaker* science identification and, in turn, *weaker* science career aspirations. By contrast, among men, stronger gender–science stereotypes were associated with *stronger* science identification and, in turn, *stronger* science career aspirations. These two sets of findings, though small in magnitude, can together contribute to gender disparities in STEM engagement when accumulated across large populations and across critical time points within a leaky pipeline (Abelson 1985; Prentice and Miller 1992). Notably, gender–science stereotyping and science identity together accounted for approximately 35 % of the variance in intent to persist in science among women and approximately 20 % of the variance among men.

In addition, we examined whether gender–science stereotypes would be particularly relevant for those who were strongly identified with their gender. Toward this end, we tested whether the link between gender–science stereotypes and science identification would be moderated by one's gender identification. We found only limited support for this hypothesis among male participants; specifically, gender identification moderated the effects of self-reported (but not implicit) stereotypes among men. The lack of parallel findings among female science majors differs from prior findings showing that women's implicit gender-math stereotyping interacted with gender identification to influence math career aspirations (e.g., Kiefer and Sekaquaptewa 2007). Thus, questions about the potential interactive effects of gender identity and implicit stereotypes on career aspirations in different contexts and with varied populations should remain a focus of future research.

Future research should also examine the generalizability of our broader findings to other samples or contexts. The data in the present research were generated by undergraduate science majors who have already made an initial commitment to studying the field of science. As a result, the present findings point to gender stereotypes and science identity as factors of potential importance to the retention of college-aged women and men in science. What remains an open question is whether gender stereotypes and/or science identity are of similar import to decisions related to the initial recruitment of women and men into science. In other words, future research should examine whether strong gender–science stereotypes may contribute to gender gaps in recruitment to STEM fields, as others have suggested (see Nosek et al. 2002; Nosek and Smyth 2011).

There are two other limiting factors that should be considered in the evaluation of the present work and the planning of subsequent research. First, the present data are correlational, prohibiting strong conclusions regarding causality. Thus, as would be expected given the strong pattern of correlations, the mediated and indirect effects associated with the reverse path model (career aspirations → science identity → gender–science stereotypes) were also significantly different from zero for women and men on both stereotyping measures. We gave priority to a model in which gender–science stereotypes predicted science identity that, in turn, predicted intent to persist science only because such a model is consistent with the dominant theoretical lens. Thus, future work could examine various causal models as well as variables unmeasured in the current data, but which may account for some of the effects reported. Second, our results suggest that stereotypes contribute to, but do not completely explain, the gender gap in science. Other factors, such as peer and teacher–student interactions and perceived self-efficacy, for example, may be critical for retaining women in science (for review, see Halpern et al. 2007).

Despite limitations, our work importantly points to possible interventions aimed at reducing the gender gap in STEM engagement. If stereotypes are associated with science identification and, in turn, career aspirations, as our work suggests, then there may be two points at which interventions may be successful. As others have noted, retraining stereotypes among women and men in STEM domains may increase motivation and domain identification (e.g., Forbes and Schmader 2010). However, the retraining of stereotypes may be constrained by the actual gender representation in a particular domain. Instead, it may be more practical to focus on factors that directly affect science identification, since our data suggest that stereotypes may exert their influence on career aspirations via their influence on science identification. Focusing on the factors that buffer women's science identification in the face of negative stereotypic associations (e.g., Stout et al. 2011) may be an important avenue for future research aimed to retain women in STEM fields.

5 Conclusion

In sum, the current work serves as an important reminder that personal choices are made within particular social contexts, and stereotypes are part of that context. Our results point to the importance of gender–science stereotypes in predicting science identification and, in turn, science career aspirations in opposite directions for women and men. Thus, importantly, the very factors (science stereotypes) that are associated with weaker science identification and weaker career aspirations among women are associated with stronger science identification and stronger career aspirations among men. Together, the small dissuading influence of stereotypes among women and the small enhancing influence of stereotypes among men can accumulate over time and at critical junctures to contribute to meaningful gender disparities in STEM domains.

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