Women's Adaptation to STEM Domains Promotes Resilience and a Lesser Reliance on Heuristic Thinking

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Abstract

Experiences that compel people to challenge social stereotypes can promote enhanced cognitive flexibility on a range of judgmental domains. Women in STEM (Science, Technology, Engineering, and Math) fields are chronically exposed to such experiences and may therefore also demonstrate these benefits. Two studies examined the differential effects of counter-stereotypical experiences on women from STEM and non-STEM fields. Results showed that imagining or recollecting these experiences led women from STEM fields to exhibit a lesser reliance on heuristic thinking compared to women from non-STEM fields, and this difference was mediated by self-perceived resilience to the negative impact of gender stereotyping. Implications for psychologists' and educators' understanding of the relationship between counter-stereotypical experiences and heuristic thinking are discussed.

Keywords: STEM, adaptation, gender, counter-stereotypes

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Chronic exposure to experiences that challenge social stereotypes and conventions can elicit a process of cognitive adaptation which has been associated with enhanced performances on a range of outcomes that benefit from cognitive flexibility, i.e. the ability to switch from such heuristic to systematic modes of thinking (Cheng, Sanchez-Burks, & Lee, 2008; Gocłowska, Crisp, & Labuschagne, 2012; Hutter & Crisp, 2006; for a review see Crisp & Turner, 2011). In this paper, we propose that women's experiences of entering gender atypical domains can elicit a similar process of cognitive adaptation. Women in STEM (Science, Technology, Engineering, and Math) fields experience environments where they need both to perform academically and to devote cognitive resources to inhibit the detrimental impact of biased gender stereotypes. We tested the hypothesis that such experiences develop resilience in the face of negative stereotypes, which in turn stimulates and protects performance for women in STEM domains, even on tasks not directly related to their academic field.

Women in STEM

Despite making almost two thirds of the undergraduate student population, women are still underrepresented in all of the STEM fields, with the exception of the life sciences and medical allied subjects (US data, National Science Foundation, 2013; UK data, Kirkup, Zalevski, Maruyama, & Batool, 2010). Moreover, there is a loss of women at every stage of the STEM careers advancement. Indeed, women represent only 45% of postgraduate and 41% of STEM doctorate students in the US (NSF, 2013), and 34.0 % of postgraduate students in the UK. Numbers get even smaller when looking at the percentage of women working in a STEM occupation, which is 27% in the US (NSF, 2013), and only 12.3% in the UK (Kirkup et al., 2010). Women that could, but do not enter the STEM fields represent an unexpressed potential contribution to the STEM workforce (Blickenstaff, 2005). This will have important consequences for countries' global competitiveness, as a shortage of skilled and trained workers is expected to occur in at least some of the STEM fields such as physics and engineering, and preparedness in science and innovation plays a key role in current knowledge-based economy (HM Treasury, 2004).

The underrepresentation of women in STEM is a recognized social issue, and several campaigns are in place to encourage social change. For example, the UK Resource Centre for Women in STEM[1], and the projects ran by the US Committee on Women in Science, Engineering, and Medicine (CWSEM)[2], are stimulating the industry and academia to challenge their traditional approaches to education and recruitment in STEM. The issue has also been investigated increasingly from a scientific perspective, and several explanations for the phenomenon have been suggested, including a lack of female role models (Stout, Dasgupta, Husinger, & McManus, 2011), cultural pressures (Eccles, 1994), stereotype threat (Steele, 1997; Smith & Hung, 2008), and lack of gender equity (Else-Quest, Hyde, & Linn, 2010).

Challenging Stereotypes in STEM Fields

The literature on women in STEM fields consistently shows how women in these fields are faced with a particular set of challenges. For example, it has been shown that women in STEM fields are exposed to a higher extent to stereotype threat, negative attitudes and discriminations (Seymour, 1995; Steele et al., 2002), and to negative implicit biases (e.g. Knobloch-Westerwick, Glynn & Huge, 2013; Moss-Racusin, Dovidio, Brescoll, Graham, & Handelsman, 2012). The accounts noted above tend to focus on the obstacles and attritions that prevent women from remaining in STEM fields. However, there is also evidence that women in such fields, despite the challenges they are continuously exposed to, can develop resilience and react differently to threating cues. For example, Crisp, Bache, and Maitner

[1] http://www.ukrc4setwomen.org.uk/
[2] http://sites.nationalacademies.org/PGA/cwsem/PGA_045036

(2009) found female engineering students to be unaffected by the typical stereotype threat manipulation, and in fact to display enhanced performance on a math test following a gender-specific threat. Similarly, Richman, vanDellen and Wood (2011) found female academics from engineering fields to be unaffected by an identity threating context. These examples are consistent with the hypothesis that women in male-dominated fields may adapt in beneficial ways to their stereotypically challenging context.

Inspired by the alternative framing that these experiments suggest, we hereby take a different perspective on the problem of women in STEM fields. In contrast to countering the barriers to women entering these fields, we explore the *benefits* to women from entering (and staying in) a STEM field. While we believe that analyzing - and removing – the obstacles that keep women away from science is essential, we hope to provide a perhaps missing piece of the gender diversity debate: the importance of not only identifying the negative outcomes associated with being a woman in a male-dominated field, but of focusing also on the potential positive outcomes (i.e. benefits) that can occur to women who challenge stereotypes and conventions.

Counter-stereotypical Experiences

Women in STEM fields are required to tackle self-relevant stereotypes on a daily basis. We know from the impression-formation literature that exposure to counter-stereotypes can compel people to switch from heuristic to systematic modes of thinking (Fiske & Neuberg, 1990; Hutter & Crisp, 2006). This alternative mindset stimulates complex reasoning, and encourages the perceiver to engage in a process of inconsistency resolution (i.e. inconsistency between the stereotypes associated with the two categories) (Hutter & Crisp, 2006; Hutter, Crisp, Humphreys, Waters, & Moffitt, 2009; Kunda, Miller, & Claire, 1990). Potentially, this mindset can generalize and promote heuristic switching in other domains and tasks that can similarly benefit from less reliance on heuristic thinking. For example, Vasiljevic and Crisp

(2013) asked participants in an experimental condition to generate five counter-stereotypical category combinations (e.g. woman fire-fighter), as opposed to stereotypical combinations (e.g. woman midwife). Doing so promoted lower need for cognitive closure, greater cognitive control (ability to inhibit a dominant response), and greater later thinking (ability to disregard habitual and traditional ways of thinking). Moreover, priming such a mindset promoted the tendency to think of outgroups in non-heuristic or stereotypical terms, and it ultimately promoted generalized tolerance (Vasiljevic & Crisp, 2013). Similarly, tasks that require solving stereotypical inconsistencies between categories (e.g. a woman mechanic target) have been shown to inhibit stereotypical responses and promote generative thinking in impression formation contexts (Hutter & Crisp, 2005), and they have *also* been shown to stimulate creativity and flexibility (Gocłowska & Crisp, 2012; Gocłowska et al., 2013), in a spillover fashion. These beneficial effects on creativity have also been observed in individuals who have counter-stereotypical experiences. Indeed, Cheng and colleagues (2008) found that Asian Americans and female engineering students who are conformable with their potentially inconsistent identities (i.e. they are high on identity integration) display superior creativity skills on tasks relevant to their dual identities.

This is relevant to women in STEM fields. Women studying in male-dominated academic fields are required on a daily basis to solve the stereotypical inconsistency between their gender and their academic field. As mentioned previously, the process of solving stereotypical inconsistencies has been shown to promote generative thought, but it has also been shown to be resource consuming (Hutter & Crisp, 2006; Hutter et al. 2009). This suggests that exposure to such experiences may need to be extended, in order to be cognitively beneficial. Consequently, as women in STEM are exposed to a self-relevant counter-stereotypical combination on a daily basis, they will have gained experience in this psychological process, i.e. they will have automated suppression responses to the stereotypic information associated with women and science. We suggest that women studying in male-dominated academic fields engage in a cognitive process of adaptation to these stereotypically challenging experiences, similar to those explored in the cross-cultural literature (Crisp & Turner, 2011), where multicultural individuals display benefits associated with their multiple identities only following chronic exposure (e.g. Leung, Maddux, Galinsky, & Chiu, 2008; Maddux & Galinsky, 2009).

We hypothesized that thinking about counter-stereotypical experiences would have differential effects on women from STEM and non-STEM fields. We would expect exposure to counter-stereotypical experiences to elicit in women in STEM the same mindset they developed to offset the negative impacts of stereotyping on their academic performance. In contrast, women from disciplines that are not counter-stereotypical would not have experience of such environments, and should not experience the predicted performance boost for women in STEM. What we explore here is whether exposure to counter-stereotypical experiences will additionally enable individuals to abandon heuristic thinking in other domains. The idea is that the ability to suppress heuristic-based ways of thinking and processing will have spillover effects in other judgmental domains tat can similarly benefit from more systematic ways of reasoning (Chen & Chaiken, 1999; Evans, 2008). We predicted that making counter-stereotypical experiences cognitively accessible would boost performances for participants in STEM fields, but not for those in non-STEM fields. In Experiments 1 the counter-stereotypical experiences were made accessible through a mental simulation task, while in Experiment 2 this was achieved by asking participants to recall their own personal experience of being a woman in their field.

Experiment 1

Experiment 1 investigated the effects of exposure to counter-stereotypical experience priming on judgment skills in women from STEM and non-STEM fields. Specifically, the mental simulation task asked participants to imagine themselves on a stereotypical or counter-stereotypical career path. The rationale for choosing a mental simulation task originates from the literature on mental stimulation, which consistently suggests that a mental experience of a social situation can elicit the same behavioral and attitudinal responses as the actual experience (see Crisp & Turner, 2009; Crisp, Birtel, & Meleady, 2011).

Furthermore, we also included a measure of stigma consciousness for women. Stigma Consciousness (SCQ-W, Pinel, 1999) is an individual differences measure that assesses the extent to which a member of a stereotyped group perceives and is affected by the stereotype. Steele, Aronson and Spencer (2002) suggest that this construct may also capture differences in perceived stereotype threat. We thus hypothesized that the counter-stereotypical experience prime might enhance stigma consciousness in women from non-STEM fields as compared to women from STEM fields, as the male-dominated background primed with the manipulation would be more unusual and potentially threatening to them, whereas women from STEM fields would be accustomed to such a challenge.

Method

Participants and design

Participants were recruited by contacting via email STEM and non-STEM departments' administrators, asking them if they could invite their female students to participate in the study. Participants were given the opportunity to opt in for a prize raffle and win one of two Amazon vouchers of the value of £30 and £20, respectively. In total, 133 female students completed the study. Asian students were excluded from the analyses, as previous research has shown this population to be unaffected by the negative stereotypes about women in science (Shih, Pittinsky, & Ambady, 1999). One participant admitted to have used help during the judgment task, and was therefore excluded, reducing the sample to N = 127 (77 non-STEM, 50 STEM students).

Participants were allocated to a 2 (academic field: STEM vs. non-STEM) x 2 (experience prime: counter-stereotypical vs. stereotypical) between-subjects design, with random allocation on the second factor. Participants were aged between 18 and 41 (M = 21.95; SD = 4.11). The non-STEM group included students pursuing degrees in Psychology, Social Sciences/Sociology, Economics/Business, Law, Philosophy, English, American Studies, and Foreign Languages. The STEM group included students pursuing degrees in Physics, Engineering, Mathematics/Statistics, Forensic Science, and Chemistry. The overall majority of participants identified themselves as Caucasian (78.3%), and British (87.6%).

Procedure

The study was conducted online using Qualtrics (Qualtrics Labs Inc., Provo, UT) and took 15-20 minutes to complete. After reading the participant information sheet and filling out the informed consent, participants in the counter-stereotypical experience prime condition were presented with the following instructions:

> Please try to imagine that you are a Computer Science student. Imagine what you think it would be like, in particular, to be a woman studying Computer Science (i.e., what would be your everyday experiences interacting with other students) and describe it briefly[3].

In the stereotypical experience prime condition participants imagined they were Nursing students. Participants were then asked to complete a battery of measures, and upon completion of the study were debriefed and thanked.

Dependent Measures[4]

Heuristic thinking. The key dependent measure comprised tests of judgment that have typically been used to assess heuristic thinking. Ten items were taken from Tversky and

[3] As the prime asked participants to imagine they were Computer Science students, we intentionally did not recruit participants from Computer Science.

[4] The battery of questionnaires also included a Remote Association Task (RAT; Mednick, 1962). Please contact the authors for further information about this outcome variable.

Kahneman (1971, 1973, 1974), Kahneman and Tversy (1973), and West, Toplak, and Stanovich (2008). Heuristics are judgment tools that provide rule-of-thumbs for everyday decision-making (Tversky & Kahneman, 1974), and although they are generally adaptive, in some situations they lead to poor decisions. The ability to suppress the 'impulsive' response and override such heuristic is crucial for successful decision-making (West et al., 2008). As an example, consider the following item: “In a lake there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half the lake?” The first idea that comes to mind is 24, however the correct answer is 47 (if the patch doubles its size every day, it will get at half the lake the day before day 48). Recognizing that the immediate response is fallacious is necessary to the correct solution of the puzzle, thus participants that are accustomed to suppressing the dominant response should display superior performances. A maximum of 10 minutes was allocated to solve the heuristic items. Performance on the task was analyzed using the number of correct answers divided by the number of attempted answers (i.e. accuracy, as in Inzlicht & Ben-Zeev, 2000; Johns, Schmader, & Martens, 2005; Marx & Roman, 2002).

Stigma Consciousness Questionnaire. The Stigma Consciousness Questionnaire for women (SCQ-W; Pinel, 1999) is an individual differences measure that assesses the extent to which a member of a stereotyped group is affected by the stereotype. The questionnaire is a 10-item scale, measured on a 7-point Likert scale (1 = *strongly disagree*, 7 = *strongly agree*). The following are sample items from the measure: ‘When interacting with men, I always feel as though they interpret my behavior in terms of the fact that I am a woman’, ‘I almost never think about the fact that I am female when I interact with men’ (reverse scored). The scale obtained an α of. 756.

Results and Discussion

Means and standard deviations for all DVs are reported in Table 1.

Heuristic thinking

A 2 (academic field: STEM vs. non-STEM) X 2 (experience prime: counter-stereotypical vs. stereotypical) ANOVA revealed no main effect of experience prime, $F(1, 123) = 1.52$, $p = .219$, $\omega^2 = .004$ and a main effect of academic field, $F(1, 123) = 17.55$, $p < .001$, $\omega^2 = .109$, indicating that participants from STEM field obtained superior performances ($M = .485$, $SD = .124$) as compared to participants from non-STEM fields ($M = .365$, $SD = .167$). In line with the hypothesis, a significant academic field x experience prime interaction was also observed, $F(1, 123) = 7.06$, $p = .009$, $\omega^2 = .040$ (see Figure 1). Pairwise comparisons revealed that in the stereotypical experience prime condition there were no differences between STEM and non-STEM participants, $F(1, 123) = 1.06$, $p = .304$, $r = .084$. However, in the counter-stereotypical experience prime condition STEM participants performed better ($M = .536$, $SD = .104$) than non-STEM participants ($M = .349$, $SD = .171$), $F(1, 123) = 26.11$, $p < .001$, $r = .378$. Pairwise comparison also revealed that STEM participants performed better in the counter-stereotypical experience prime condition ($M = .536$, $SD = .104$) as compared to the stereotypical experience prime condition ($M = .430$, $SD = .123$), $F(1, 123) = 6.34$, $p = .013$, $r = .218$; Whereas non-STEM participants performed similarly across the two conditions, $F(1, 123) = 1.26$, $p = .264$, $r = .138$[5].

Stigma Consciousness Questionnaire

A 2 (academic field: STEM vs. non-STEM) X 2 (experience prime: counter-stereotypical vs. stereotypical) ANOVA revealed no main effect of experience prime, $F(1,$

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[5] Including Asian participants in the analysis produced similar results. The main effect of field of study was $F(1, 128) = 14.68$, $p < .001$, $\omega^2 = .090$, the main effect of condition prime was $F(1, 128) = 1.05$, $p = .308$, $\omega^2 = .001$, and the interaction effect was $F(1, 128) = 6.28$, $p = .013$, $\omega^2 = .035$. Pairwise comparisons revealed that in the counter-stereotypical experience prime condition STEM participants performed better ($M = .518$, $SD = .118$) than non-STEM participants ($M = .348$, $SD = .170$), $F(1, 128) = 22.50$ $p < .001$, $r = .378$. Pairwise comparisons also revealed that participants from STEM fields perform better in the counter-stereotypical experience prime condition ($M = .518$, $SD = .118$) as compared to the stereotypical prime condition ($M = .424$, $SD = .128$), $F(1, 128) = 5.37$ $p = .022$, $r = .199$. All other comparisons were non-significant (all ps >.254).

118) = 0.54, p = .463, ω^2 = .000 and a main effect of academic field, F(1, 118) = 6.06, p = .015, ω^2 = .040, indicating that participants from STEM field obtained lower SCQ scores (M = 3.92, SD = 0.85) as compared to participants from non-STEM fields (M = 4.29, SD = 0.78). Finally, the analysis revealed no interaction, F(1, 118) = 0.00, p = .981, ω^2 = .000[6].

As predicted, following exposure to the counter-stereotypical experience prime STEM participants displayed superior quantitative judgment skills compared to non-STEM participants. Given the main effect of field of study, where women from STEM fields achieved superior performances as compared to women from non-STEM fields, it is possible to interpret exposure to the stereotypical scenario as detrimental to women in STEM fields. While a control condition could have ruled out this alternative explanation, the main focus in this experiment was the differential impact of thinking of counter-stereotypical experiences on individuals with and without prior counter-stereotypical experience, and this hypothesis was supported. Results from the Stigma Consciousness Questionnaire are harder to interpret. We expected a similar differential effect of the counter-stereotypical prime condition on this outcome, whereas women from STEM fields were generally less sigma conscious than women from non-STEM fields. This difference might reflect a threatening element involved with the study material i.e. the quantitative nature of the heuristic task, which might be more threatening to women from non-STEM fields. Alternatively, women from STEM fields might be more resilient and accustomed to stereotypically challenging environments, and this is reflected in their stigma consciousness scores.

[6] We also ran a moderated mediation analysis, to test whether the effect of the manipulation on heuristic thinking was mediated by differences in stigma consciousness. We ran the analysis in PROCESS (Hayes, 2013), using model 8. The independent variable was the experimental condition (stereotypical vs. counter-stereotypical), the moderator was the academic field of study (STEM vs. non-STEM), the mediator was Stigma Consciousness, and the outcome variable was Heuristic Accuracy. Bootstrap estimates were based on 5,000 bootstrap samples. Bootstrap analysis revealed that the indirect effect of the highest order was -.0001, SE = .0060, 95% CI = -.0131 +.0095, thus revealing no significant moderated mediation. In line with the analyses previously reported in paper, the interaction between experimental condition and field of study on stigma consciousness was not significant (b = -.007, p = .981), while the interaction between academic field of study and experimental condition on heuristic thinking performance was significant (b =.141, p = .008).

Experiment 2

A possible limitation in Experiment 1 lies in the priming method employed. The mental stimulation task asked participants to imagine they were either a computer science or a nursing student. However, the counter-stereotypical career path (computing) could be perceived as more similar to the STEM students' actual path than the stereotypical career path (nursing) is for the non-STEM students' real path. Therefore, familiarity may be a plausible confound, such that STEM students find the counter-stereotypical priming more familiar and less cognitively taxing, which then leaves them with more resources when taking the heuristics tasks. It is also possible that the manipulation contained a status confound, i.e., computer science may be regarded a high-status profession, while nursing a lower status profession. This might account for STEM (high-status academic fields) students’ lower performances in the stereotypic experience prime condition, as imagining themselves in a lower status field might have impeded their cognitive performance. However, non-STEM students’ performance would be harder to interpret according to this perspective. To avoid these confounds, in Experiment 2 participants were asked to *recollect* their experiences as women in their own academic field. This task directed STEM participants to access their own counter-stereotypical experiences.

Also, in Experiment 2 we explored the role of resilience as a mediator in the relationship between field of study and heuristic thinking. The women in STEM literature provides us with some examples of how women can be accustomed to stereotype exposure, and indeed they might even benefit from the challenge (Crisp et al., 2009; Richman et al., 2011). In order to be successful, women in male-dominated fields must learn to deflect the stereotypes about their gender and career choice. Resisting and suppressing the stereotypical dominant response when exposed to a self-relevant stereotype is a mental operation that, if trained continuously, might lead to develop resilience to such stereotypes, and also the ability to abandon heuristic responses in other domains. As discussed in the introduction, exposure to counter-stereotypes stimulates suppression of heuristic thinking, in favor of more systematic and flexible modes of thinking (Fiske & Neuberg, 1990; Hutter & Crisp, 2005), and this mental process has been found to have carry-over effect in other domains that can similarly benefit from abandoning heuristic thinking (e.g. Gocłowska & Crisp, 2012; Gocłowska et al., 2012). As such, the idea that in order to be successful in STEM fields women need to develop resilience to stereotyping is of interest to this investigation.

Resilience to stereotyping is of interest also from another point of view. Indeed, resilience is believed to play an important role in determining whether women scientists will pursue or abandon their scientific careers (Kidd & Green, 2006), and there are programs such as the CareerWISE[7] project that specifically offer online resilience training for women in STEM. As mentioned in the introduction, there is also empirical evidence supporting the argument that women in STEM must develop resilience to stereotypes in order to thrive in their challenging context.

Methods

Participants and Design

In total 46 female students were recruited. Participants that identified themselves as Asian participants were excluded, and due to a computer error leading to the loss of one participant's data the final sample was reduced to N = 42 (24 non-STEM, 18 STEM students). Participants were recruited on an opportunity basis from the subject pool at a British University, and they received either course credit or a small payment (£3) for their participation.

Participants were allocated to a 2 (academic field: STEM vs. non-STEM) x 2 (condition: control vs. experimental) between-subjects design, with random allocation on the second factor. They were aged between 17 and 31 (M = 21.33; SD = 3.51). The non-STEM

[7] http://careerwise.asu.edu/

participants were pursuing degrees in Psychology, Sociology, Drama, Criminology, and Business. The STEM group participants were pursuing degrees in Physics, Mathematics, Engineering, and Actuarial Science. The majority of participants identified themselves as Caucasian (83.7%), and British (69.8%).

Procedure

The study was conducted in the laboratory using Qualtrics (Qualtrics Labs Inc., Provo, UT) and took 20 minutes to complete. After reading the participant information sheet and filling out the informed consent, participants were presented with the manipulation:

> In this next section we are interested in student experiences in different academic fields. Please describe briefly what is your experience as a woman in your academic discipline.

In the control condition participants skipped the task. After completing a battery of measures, participants were debriefed and thanked.

Measures[8]

Two measures assessed our outcomes of interest: a self-generated description of academic experience, and a 7-items version of the heuristics task used in Experiment 1. Two independent raters rated the academic experience descriptions on the following two scales: exposure to stereotypes, and resilience to stereotyping. The first scale was measured with two items, 'To what extent do participants describe their experience with reference to stereotypes/stereotyping (either implicitly or explicitly)?', and 'To what extent do participants describe their experience with reference to the impact of specifically negative stereotypes (either implicitly or explicitly)?'. As an example, the following participant was rated as high on the exposure to stereotypes scale:

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[8] The battery also included other non-focal variables that are not of interest to this investigation. These measures were: Money Illusion Task (Shafir, Diamond, & Tversky. 1997), Unusual Uses Test (Guilford, 1967), Inadvertent Plagiarism Task (Marsh, Ward, & Landau, 1999), Stroop test (Stroop, 1935). Please contact the authors for more information about these outcome variables.

> "My subject is very 'female' which means that the overwhelming majority of females study it. For that reason, I am sometimes considered as a typical female as I seem to be interested in social science which is not quite true" (non-STEM participant).

The second scale was measured with the item 'To what extent do participants describe their experience in terms of developing resilience and/or overcoming a stereotype?'. As an example, the following participant was rated as high on the resilience to stereotyping scale:

> "As a woman in the male dominated field of engineering, I have found that although I tend to stand out, most people at degree level will treat me with respect. Some will show signs of wanting you to "prove yourself" but after that, there does not tend to be any problem" (STEM participant).

Items were scored on a 7-point Likert scale (1 = *not at all*, 7 = *very much*). The exposure to stereotypes scale produced a Cronbach's α of .777 and .765 for rater 1 and 2 respectively. Aggregations across raters were used as dependent variables, thus, average measures Intraclass Correlation Coefficient (ICC) using a consistency definition are considered (McGraw & Wong, 1996). The exposure to stereotype scale obtained an ICC (2, 2) of .778, and the resilience scale obtained an ICC (2, 2) of .766, indicating substantial agreement between raters (Landis & Koch, 1977).

Heuristics thinking was measured with a shortened 7-items version of the task from Experiment 1.

Results and Discussion

Mean and standard deviations for all DVs are reported in Table 2.

Academic experience

An independent samples t-test showed no differences between STEM and non-STEM participants on the extent of exposure to stereotypes, $t(18) = -0.47$, $p = .654$. However, there was a significant difference in resilience to those stereotypes, $t(8.71) = -2.88$, $p = .019$, indicating that STEM participants reported developing greater resilience to stereotyping (M = 4.31, SD = 2.37) than non-STEM participants (M = 1.75, SD = 1.01). The two measures were not correlated (r = .372, p = .106, two-tailed), indicating that exposure to stereotypes and resilience to stereotyping were independent of one other.

Heuristic thinking

A 2 (academic field: non-STEM vs. STEM) X 2 (condition: control vs. experimental) ANOVA revealed no main effect of academic field, F (1, 38) = 1.62, p = .211, ω^2 = .013, nor of condition, F (1, 38 = 1.30, p = .261, ω^2 = .007. A significant academic field x condition interaction was observed, F (1, 38) = 5.16, p = .029, ω^2 = .088 (see Figure 2). Pairwise comparisons revealed no differences in the control condition, F (1, 38) = 0.53, p = .472, r = .138; however, as predicted, in the experimental condition STEM participants performed better (M = .702, SD = .187) than non-STEM participants (M = .492, SD = .183), F(1, 38) = 5.97, p = .019, r = .388. Pairwise comparisons also revealed that STEM students performed similarly across conditions, F (1, 38) = 0.47, p = .469, r = .107; however, non-STEM participants performed worse in the experimental condition (M = .635, SD = .172) as compared to the control condition (M = .702, SD = .187), F(1, 38) = 7.20, p = .011, r = .388.[9]

Mediational analysis

Mediational analysis was computed to assess whether the effect of participants' academic field on judgment skills was mediated by variations in *resilience to stereotyping*. The mediation analysis was performed on participants in the experimental group only, as resilience to stereotypes could only be measured in this condition. Bootstrapping analyses were conducted using the SPSS macro ‘Indirect’ (Preacher & Hayes, 2008). Bootstrap

[9] Including Asian participants in the analysis produced similar trend. The main effect of field of study was F(1, 41) = 1.35, p = .195, ω^2 = .008, the main effect of condition prime was F(1, 41) = 1.73, p = .252, ω^2 = .015, and the interaction effect was F(1, 41) = 2.33, p = .135, ω^2 = .028. Pairwise comparisons revealed a marginally significant effect indicating that STEM students perform better (M = .656, SD = .223) than non-STEM students in the experimental condition (M = .492, SD = .183), F(1, 41) = 3.40, p = .078, r = .311; pairwise comparisons also revealed that non-STEM participants perform worse (M = .492, SD = .183) in the experimental condition as compared to the control condition (M = .665, SD = .199), F(1, 41) = 4.78, p = .035, r = .291. All other comparisons were non-significant (ps > .792).

estimates that follow are based on 5,000 bootstrap samples. The total effect of academic field on the heuristics task was significant, $B = .210$, $SE = .084$, $p = .023$, whereas the effect of academic field when resilience was controlled was not, $B = .074$, $SE = .097$, $p = .456$. Bootstrap analysis revealed that the total indirect effect through the mediator was .1358, $SE = .0668$, 95% CI = +.0401 +.2773, thus revealing a significant mediation effect (see Figure 3 for the full mediational model). This indicated that resilience mediated the association between recollection of experience as a woman in one's academic field and performance on the heuristics test: STEM participants were better able to override heuristic thinking thanks to resilience to stereotyping elicited while recollecting their academic experiences of being women in a male-dominated field.

We also tested an alternative mediational model. Potentially, women who are more resilient to stereotyping may be more likely to embark on a STEM-related career, or in other male-dominated fields. As such, it is crucial to rule out the alternative mediation model, where resilience to stereotyping might lead to superior performances on the heuristic task via field of study belonging. Analyses revealed that the total effect of resilience to stereotyping on the heuristics task was significant, $B = .064$, $SE = .018$, $p = .002$, and so was the effect of resilience to stereotyping when academic field was controlled for, $B = .053$, $SE = .023$, $p = .037$. Bootstrap analysis revealed that the total indirect effect through the mediator was .0111, $SE = .0204$, 95% CI = -.0069 +.0747, thus indicating that there is no significant mediation effect of academic field on heuristic performance (see Figure 4 for the full mediational model).

General Discussion

We hypothesized that exposure to counter-stereotypical experiences would have differential effects on women from STEM and non-STEM fields. In Experiment 1 the exposure was achieved with a mental simulation task, and results revealed that STEM participants exhibited reduced reliance on heuristic thinking compared to non-STEM women following exposure to the counter-stereotypical prime. In Experiment 2 experience exposure was achieved with a recollection task, such that STEM women would be more likely to recollect counter-stereotypical experiences. This recollection task resulted in non-STEM participants exhibiting increased reliance on heuristic thinking as compared to STEM participants. In addition, results showed that despite reporting being similarly exposed to stereotypes, STEM students reported developing resilience to such stereotypes to a higher extent, and this resilience mediated the difference between groups on the heuristic thinking task. Finally, in Experiment 1 results also revealed a main effect of field of study, whereas Experiment 2 revealed only an interaction effect that was qualified by non-STEM students performing worse in the experimental condition. This difference is likely due to a difference in sample sizes, where Experiment 1 was indeed better powered.

As hypothesized, in Experiment 1 women from STEM fields displayed superior performance when exposed to the counter-stereotypical experience prime. However, the absence of a control condition means that it could have been that the stereotypical experience prime ("Imagine you are a Nursing student") depressed performance (rather than counter-stereotypical primes increasing it). In order to avoid this issue in Experiment 2, we used a control condition where participants did not complete the initial task. Results showed that exposure to the experimental condition lead women from STEM fields to perform better than women from non-STEM fields, while women from non-STEM fields displayed depressed performance compared to the control condition. It is possible, therefore, that continuous exposure to fields that are gender stereotypical or that do not challenge stereotypes might lead to rigidity in thinking, and that women in STEM fields are protected from this by their resilience to the impact of stereotypes.

So women in non-STEM fields' performance were not negatively impacted when accessing other stereotypical experiences in Experiment 1 (i.e. “Imagine you are a Nursing student”), the lack of control condition makes it harder to read the results according to this line of theorising. Indeed, both the stereotypical and counter-stereotypical experience prime condition might lead to increased rigidity in thinking in non-STEM field students, because they may not develop the tools to effectively deal with the relevant stereotypes, regardless of whether they were going unchallenged or not. While the main focus in this investigation was to explore the impact of counter-stereotypical experiences on women from STEM fields, further investigations into this topic should employ neutral control conditions. For example, we could direct participants to describe their academic experiences without making the gender-dimension salient. Doing so would also address another potential limitation, which is the implicit relationship between the two measured dimensions. Indeed, discussing resistance to stereotypes inevitably requires discussing exposure to and existence of stereotypes, and this implicit relationship should be disentangled in future explorations.

Results also revealed that women from STEM fields were less stigma-conscious when taking part in Experiment 1, and that they also report being exposed to stereotypes to the same extent as women from non-STEM fields. One could have reasonably expected women from STEM fields to perceive stereotypes to a greater extent, however it is possible that women in STEM fields might have become accustomed to such stereotypes, in line with the hypothesis that they adapt to their stereotype-challenging environment.

Theoretical Implications

The work hereby presented provides initial support to the argument that women in STEM may adapt in positive ways to their stereotypically challenging experiences, with beneficial effects on cognitive domains unrelated to their academic expertise. The idea is that exposure to stereotypically challenging experiences facilitates the abandonment of heuristic ways of thinking, and encourages a more flexible mindsets (Hutter & Crisp, 2005), in line with dual-process models of reasoning (Chen & Chaiken, 1999; Fiske & Neuberg, 1990; Evans, 2008). This line of reasoning is supported by the evidence showing that thinking about counter-stereotypes stimulates, for example, cognitive skills such as flexibility (Gocłowska & Crisp, 2012), creativity (Gocłowska et al., 2013), and lateral thinking (Vasiljevic & Crisp, 2011). Our results suggest that individuals who are themselves counter-stereotypical might be cognitively stimulated in a similar way. Indeed, these findings are also consistent with Cheng et al. (2008), who demonstrated that under certain circumstances female engineering students display enhanced creativity on tasks relevant to their dual-identities (women and engineers). Our results show that enhanced performances can be elicited by simply priming counter-stereotypical experiences, and that the cognitive task can be unrelated to participants' identities. As such, this line of research brings further support to the diversity hypothesis (Crisp & Turner, 2011), which argues that *any* type of diversity experience that challenges stereotypes and conventions, thus including ethnic or social diversities, can stimulate tangible benefits on a range of cognitive outcomes (for a review, see Crisp & Turner, 2011). Women in STEM fields fit this definition of social diversity, as their counter-stereotypical status requires them to challenge conventions on a chronic basis.

This research also has implications for the women in STEM literature. The challenges that women in science must face include, but are not limited to, stereotype-threatening cues (Steele et al., 2002), negative attitudes and discriminations (Seymour, 1995; Steele et al., 2002), and negative implicit biases (Knobloch-Westerwick et al., 2013; Moss-Racusin et al., 2012). More specifically, research on stereotype threat has highlighted how making the stereotype salient to women can negatively impact their immediate subsequent performance. For example, math-identified female students (Keller, 2007; Lesko & Corpus, 2006; Steinberg, Okun, & Aiken, 2012), and more generally in women undertaking high-level science and math classes (Good, Aronson, & Harder, 2008; Appel, Kronberger, & Aronson,

2011) have been found to be negatively affected by stereotype threat. At the same time, however, some research has found women in STEM to be resistant to such challenges, as explored in Crisp et al. (2009), and Richman et al. (2011). Our idea is that chronic exposure to such experiences *can* stimulate the ability to deflect such stereotypes, and our results indeed suggest that women from STEM fields develop superior resilience to the impact of negative stereotypes as compared to women from non-STEM fields. It is this resilience that mediates the diversity-driven boosting effect, such that women in STEM develop resilience to the negative impact of stereotyping, which in turn supports enhanced performances of unrelated cognitive tasks. This is in line with empirical results showing that women from engineering fields react differently when prompted with an identity threat cue, but only when they scored high on factors related to resilience e.g. family support or positive experiences with role models (Richman et al., 2011). The role of resilience is underexplored in the women in STEM literature, and further investigations into the processes that facilitate or inhibit women's development of resilience are required. It is conceptually possible that continuous exposure to stereotype-threat cues one might learn to deflect the threat element of the situation, and respond to the challenge in an advantageous way. This hypothesis should be further explored in order to identify the challenges and threats that women in STEM can more easily adapt to, and also to identity potential ways to support them in the adaptation process.

Limitations and Future Research

A few limitations to the present set of studies can be identified. First, in order to avoid other stereotype-related confounds, in this investigation we opted to exclude Asian participants, who have been found to react differently under stereotype threat scenarios (Cheryan & Bodenhausen, 2000; Shih et al., 1999), due to the stereotype that Asians are academically more skilled (Lee, 2006). Thus, it is reasonable to speculate that Asian women's experiences in STEM fields might entail different stereotypes and challenges, which would then shape different counter-stereotypical experiences. As such, these participants might respond differently to our manipulation, and for this reason they were excluded by the analysis. However, in future research we believe these potential differences should be by recruiting a larger sample of Asian women studying in STEM fields.

Secondly, our experiments did not examine several potential moderators of the differential impact to counter-stereotypical experiences, and a few candidates can be identified from the literature. Follow up investigations might focus on the role of gender identity, where the most beneficial effects of exposure to counter-stereotypical experiences might occur only for women low in gender identification. This idea is suggested by evidence showing that the impact that stereotype threat manipulations have on women's math performance can be moderated by their gender identity (Schmader, 2002). Another potential candidate is the level of external support that women have when entering a male-dominated field. Indeed, women with more resources (e.g. family support over the career choice) have been found to be protected against the negative impact of identity threats (Richman et al., 2011). Finally, Personal Need for Structure (Neuberg & Newsom, 1993) could also be explored as a moderator. PNS reflects the tendency to rely on abstract representations such as stereotypes, and it has been found to impact reactions to counter-stereotypical stimuli. For example, when exposed to counter-stereotypes individuals low in PNS display lower cognitive flexibility, while individuals high in PNS display superior flexibility (Gocłowska & Crisp, 2012). Thus, it is possible that individual differences in PNS might affect how successfully women can adapt to stereotype-challenging environments.

The heuristic thinking task used in these studies could be thought of as a test of response inhibition, as successful performances require the ability to suppress the immediate dominant response (West et al., 2008). Thus, the measures employed in these experiments differs from those usually measured in the stereotype threat literature, the most common being a math tests (e.g. Keller, 2007; Lesko & Corpus, 2006; Steinberg et al., 2012). They do, however, resemble measures typically examined in research on financial decision-making (e.g., temporal discounting). Future research should try and establish whether such abilities in successfully suppressing the immediate response can also extend to other measures more applicable to real-life settings. For example, Busenitz and Barney (1997) investigated the use of heuristic thinking in managers and entrepreneurs employing real-to-life strategic decisions, and Samuelson and Zeckhauser (1988) investigated decision-making concerning retirement programs. In order to further improve the ecological validity of our experiments, other relevant outcomes that could be explored in future research include drop-out rates of women from STEM fields, and more generally measures of academic success. The idea is that women who can adapt more easily to the challenges and the counter-stereotypical experiences, will also display successful academic adaptation to their environment.

Finally, longitudinal or a cross-sectional data of groups of STEM students in different years of their studies would further support the claim that women in STEM go through an adaptation process. If women in STEM were to display enhanced cognitive flexibility only after one or two terms into their studies, this would offer further support to the hypothesis that women cognitively adapt to challenging experiences when entering a STEM field at university. Moreover, this would rule out the alternative hypothesis that only women who are more resilient enrol in these fields in the first place.

Applied Implications

Instead of focusing on the attritions that prevent women from remaining in STEM fields, our aim was to explore the beneficial effects that women can experience when entering such environments. As such, we adopted a “promotion” rather than “prevention” focus (Higgins, 1998) in our investigation. Exploring the issue from both foci is crucial as promotion and prevention are overlapping and complementary, as the former emphasizes positive outcomes – that is, the beneficial effects that entering STEM can bring to women – and the latter emphasizes negative outcomes – that is, the need to remove barriers and discriminations that keep women away from STEM fields. Policy makers and universities should try to attract more women to STEM by highlighting that such a choice has further benefits other than those associated with having a STEM degree, such as resilience to negative stereotypes and resistant cognitive flexibility, which can be valuable also outside their academic experience.

Conclusions

Our findings provide initial evidence that exposure to counter-stereotypical experiences protects and stimulates women in STEM fields' flexibility. This research can provide policy makers and universities with important information in their attempts to attract more women to STEM fields. The idea is that we should promote gender equality as a moral imperative, but also because doing so may provide tangible benefits for nations' human capital arising from a generalized uplift in innovation, creativity and cognitive skills. By tackling gender inequality in the STEM from a new perspective – that is, focusing on the benefits to the individual entering the domain, rather than only reducing the barriers to entry – we hope this, and continuing research, can make a valuable contribution to scholarly, public and political efforts to create a more equitable society.

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Table 1

Means and SDs across experimental conditions (Study 1)

	Non- STEM		STEM	
	Stereotypical prime	Counter-stereotypical prime	Stereotypical prime	Counter-stereotypical prime
Heuristics performance	0.39 (0.16)	0.35 (0.17)	0.43 (0.12)	0.54 (0.10)
SCQ-W	4.35 (0.70)	4.24 (0.84)	3.99 (0.94)	3.86 (0.77)

Table 2

Means and SDs across experimental conditions (Study 2)

	Non- STEM		STEM	
	Control	Experimental	Control	Experimental
Heuristics performance	0.69 (0.17)	0.49 (0.18)	0.63 (0.22)	0.70 (0.19)
Exposure to stereotypes		4.60 (2.14)		5.06 (2.30)
Resilience to stereotypes		1.75 (1.01)		4.31 (2.37)

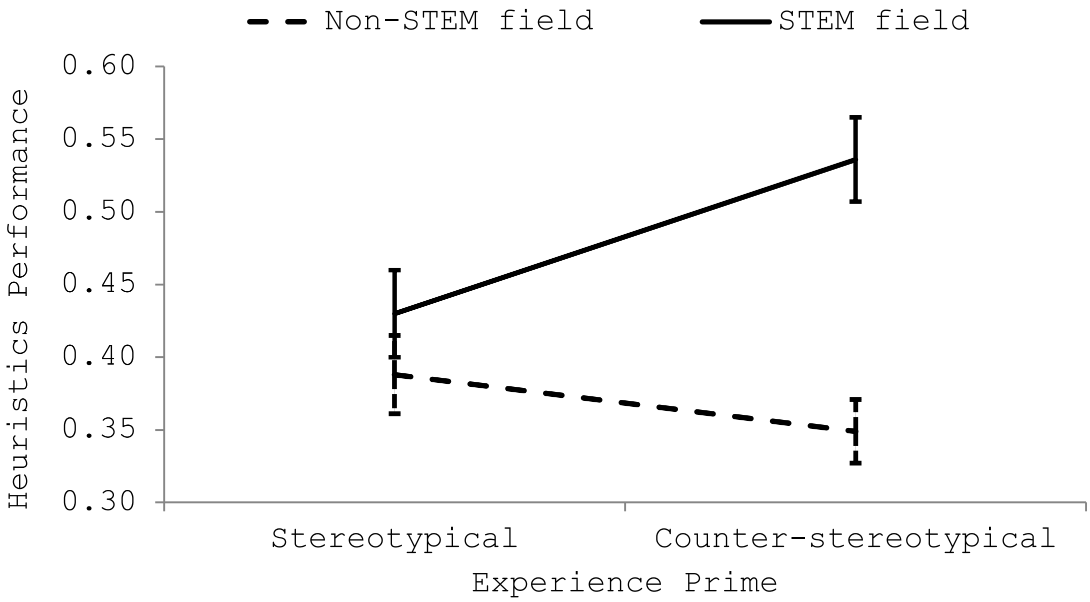

Figure 1. Mean values representing heuristics accuracy in each condition for STEM and non-STEM participants. Standard errors are represented in the figure by the error bars attached to each column (Experiment 1).

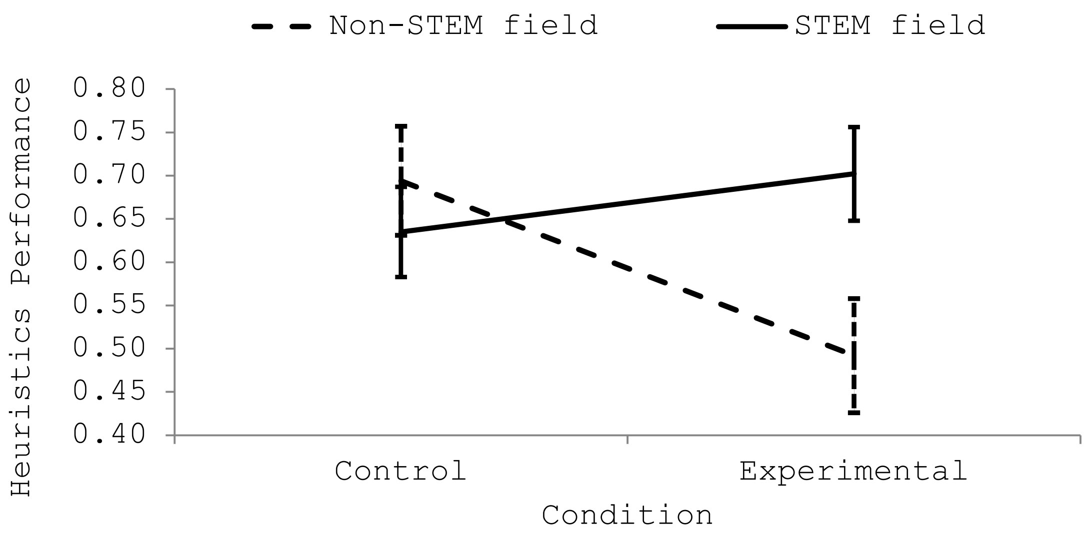

Figure 2. Mean values representing heuristics accuracy in each condition for STEM and non-STEM participants. Standard errors are represented in the figure by the error bars attached to each column (Experiment 2).

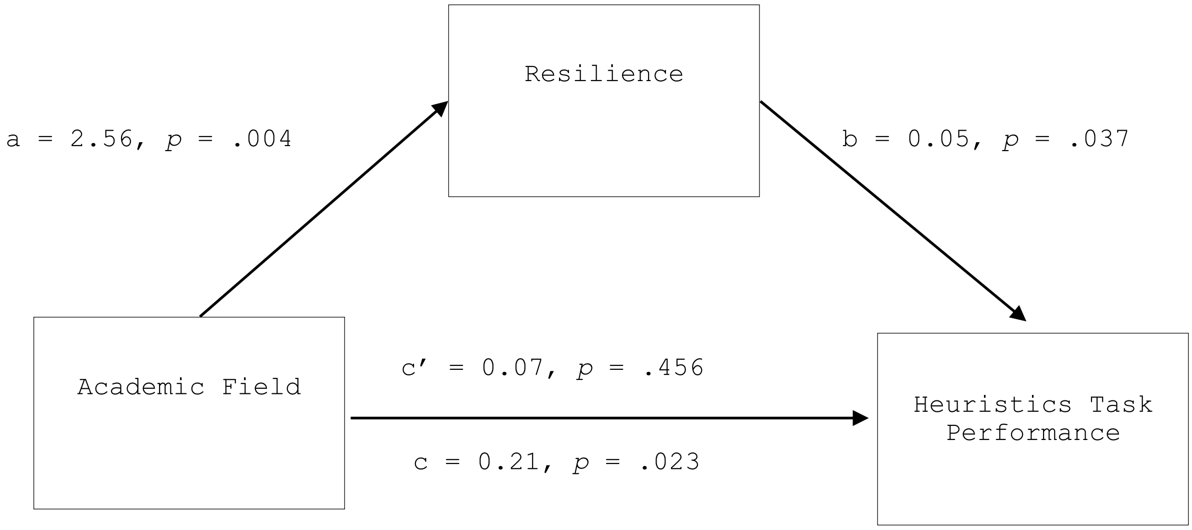

Figure 3. Resilience as mediator of the relationship between academic field and performance on the heuristics task (Experiment 2).

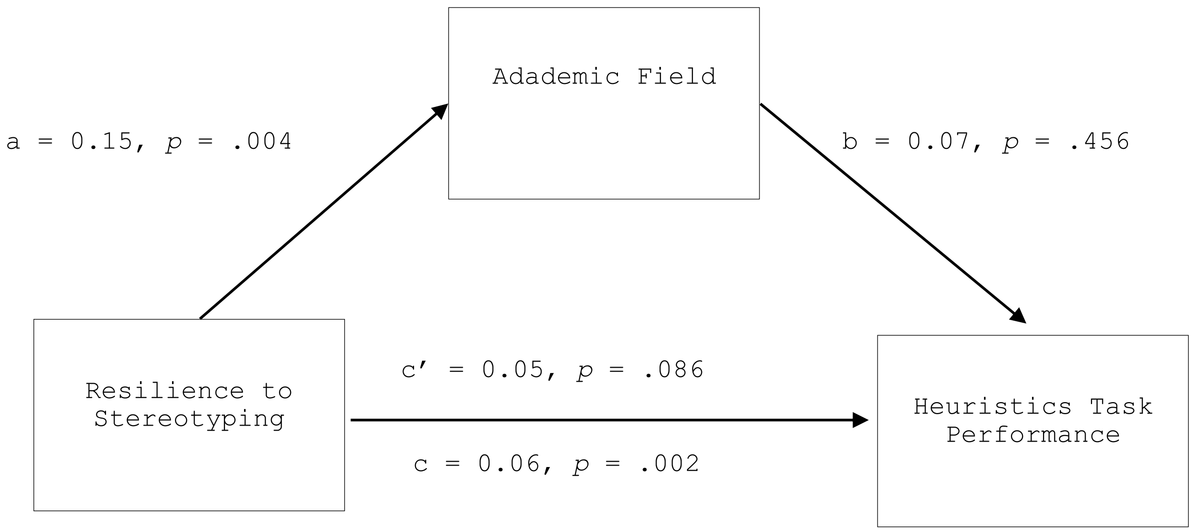

Figure 4. Academic field as mediator of the relationship between academic field and performance on the heuristics task (Experiment 2).