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Losing its expected communal value: how stereotype threat undermines women's identity as research scientists

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Abstract The worry or concern over confirming negative gender group stereotypes, called stereotype threat, is one explanation for women's worldwide underrepresentation in undergraduate science classes and majors. But how does stereotype threat translate into fewer women motivated for science? In this quantitative study with a sample from the US, we use Expectancy Value Theory to examine whether and how stereotype threat concerns might influence women's science identification. To do this, we collected survey data from 388 women enrolled in introductory physics (male-dominated) and biology (female-dominated) undergraduate laboratory classes at three universities. We examined multiple indirect effect paths through which stereotype threat could be associated with science identity and the associated future motivation to engage in scientific research. In addition to replicating established expectancy-value theory motivational findings, results support the novel prediction that one route through which stereotype threat negatively impacts women's science identity is via effects on perceptions about the communal utility value of science. Especially among women in physics who

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expressed greater stereotype threat concerns than women in biology, science identification was lower to the extent that stereotype threat reduced how useful science was seen for helping other people and society. Implications for ways to create an inclusive learning context that combats stereotype threat concerns and broadens undergraduate women's participation in science are discussed.

Keywords Gender · Science identification · Science education · Expectancy value · Stereotype threat · Motivation

> I've always felt that in physics you must have total commitment…it's not a job; it's my whole life.
>
> —Dr. Chien-Shiung Wu
>
> First woman elected as president of the American Physical Society, 1975

1 Introduction

As Dr. Wu, a Chinese-American woman nuclear physicist, illustrates in this opening quotation, "scientist" can be a personal identity; a fundamental aspect of the self-concept (Smith and White 2001; Markus 1977). To the extent that such identification with science (or any field) predicts achievement and perseverance (e.g., Chemers et al. 2011; Woodcock et al. 2012) it is important to understand the ways in which science identity is developed, undermined, or lays latent as a function of particular social educational structures. Dr. Wu broke many gender (and ethnic) barriers, where the zeitgeist was blatant racism and sanctioned sexism in US society (see Hammond 2009).

Worldwide, women are still rare among physicists. For example, women receive as few as 19 % of undergraduate physics degrees in the United States (National Science Board 2012) with similar patterns emerging in tertiary and doctoral degrees worldwide (European Commission 2012). Scandinavian countries graduate the fewest percentage of women physics undergraduates whereas Iran and Italy yield higher percentages (Urry 2000). As the International Union of Pure and Applied Physics Working Group on Women in Physics (2000) reports "despite cultural differences, the overall situation for women in physics in India, Egypt, Brazil, Latin America, Uruguay, Bolivia and Argentina is much the same. Fewer women than men are receiving degrees in physics." Such underrepresentation renders women who are in physics as "tokens"; such solo status can trigger worry or concern about fulfilling gender stereotypes (e.g., Sekaquaptewa and Thompson 2003). The current study examines the extent to which women in undergraduate physics laboratory classes experience these gender stereotype concerns and whether and how such concerns contribute to women's identification with science and the associated motivation to engage in scientific research.

Social identities are comprised of "people's knowledge of their memberships in social groups and the emotional significance that they attach to these memberships" (p. 611, Swann and Bosson 2010). When a situation (e.g., a science classroom) signals that an aspect of one's social identity (e.g., gender) may be viewed or judged

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through the lens of a negative stereotype, this type of social identity threat is termed "stereotype threat" (Steele et al.). Because being outnumbered by men implicitly activates feelings of stereotype threat (e.g., Inzlicht and Ben-Zeev 2000; Smith and White 2002) when women work or learn in male-dominated fields, they often experience feelings of stereotype threat (Schmader 2002; Schmader et al. 2004; Steele et al. 2002a).

Nearly 20 years of research on stereotype threat has established that when gender stereotypes are activated in a high stakes testing situation, women's math and science performance suffers (for a review see Nguyen and Ryan 2008). Yet, even high ability women who perform well are more likely to opt out of science, technology, engineering, and mathematics (STEM) domains at a greater proportion than their male counterparts, indicating a motivational explanation (e.g., Good et al. 2012; Jacobs et al. 2005; Seymour and Hewitt 1995; Smith et al. 2013; Stout et al. 2011; Xie and Shauman 2003). Performance, skills, and confidence are important to be sure, but scholars and educators must consider more than just ability to understand science identity (McGee et al. 2012). Indeed, the development of a strong identity as a scientist is shaped by a number of additional motivational factors unrelated to performance (Schmader et al. 2004; Shapiro and Williams 2012; Thoman et al. 2013) and we focus here on the impact of stereotype threat on undergraduate women's perceptions about the values of science that may be associated with women's overall science identity.

1.1 Science identification

Developing and maintaining a stable academic domain identity is paramount to positive educational and career outcomes (e.g., Ahlqvist et al. 2013). There are multiple inputs, pathways, and consequences associated with a student's identification with an academic domain (for a review see Osborne and Jones 2011), and cultural norms often exert a strong influence (Swann and Bosson 2010). Yet, few studies have examined *whether* women's academic domain identification is associated with stereotype threat specifically (as reviewed by Thoman et al. 2013), and no studies that we are aware examine *how* stereotype threat contributes to women's science identification.

A handful of studies have shown a negative relationship between awareness of (and sensitivity to) stereotypes and domain identity (Ahlqvist et al. 2013; Nosek et al. 2002; Karpinski and Hilton 2001). For example, among undergraduate women living in a dormitory for "women in science and engineering" (WISE), awareness of explicit gender stereotypes about STEM was negatively correlated to identification with science (Ramsey et al. 2013). Moreover, in situations where stereotype threat is likely to be low (e.g., in the presence of counter-stereotypic role models and experts), science identity is stronger (Stout et al. 2011; Young et al. 2013). One of the few studies that examined the connection between stereotype threat specifically and overall domain identification showed greater levels of stereotype threat among Latino undergraduate students was associated with lower levels of science identity which in turn, predicted a decreased desire to pursue a scientific career after college (Woodcock et al. 2012).

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We build on this work examining the relationship between stereotypes and science identity and ask whether *and* how the degree to which even slight variations in naturally occurring stereotype threat concerns contribute to undergraduate women's identification with science specifically, and the relationship between science identity and associated future intention to pursue scientific research with faculty. Given the dearth of literature on this specific association, we draw from established motivational theories, specifically expectancy-value theory, to inform our hypotheses.

1.2 Expectancy value theory

People feeling vulnerable to stereotype threat not only underperform on high stakes exams such as the Graduate Record Exam (see Nguyen and Ryan 2008 for review), but also suffer decrements in confidence, elevated anxiety, and an overall reduction in expectancies for academic success (e.g., Cadinu et al. 2003, 2005; Stangor et al. 1998; for a review see Smith 2004). The role of such performance expectancies in women and girls' motivation for STEM has a long history within the Expectancy-Value Theory literature (e.g., Eccles 1989, 2009; Eccles and Wigfield 2002; see Wang and Degol 2013 for a review). Expectancy-Value Theory is a multiplicative function used to predict performance and motivation, and it is assumed that expectancy and value are positively related to each other (e.g., Eccles and Wigfield 2002). According to the theory, individuals choose, persist, and succeed in career fields/educational domains to the extent they believe that they will do well in the field (expectancies) and the field is relatively valuable (value perceptions).

Among children, expectancies for success predict achievement performance (e.g., grades) and perceiving relatively high value, in mathematics or sports for example, predicts motivation (e.g., greater course enrollment and involvement, see Eccles and Wigfield 2002 for a review). Over time, expectancies and value become positively related to each other as children develop into adults and begin to see more and more value in tasks they perform well. Results hold true whether those expectancies or values come about directly from close others (e.g., a mother's beliefs about her daughter's math ability, Jacobs and Eccles 1992) or broader socio-cultural norms (e.g., stereotypes, Wang and Degol 2013; Eccles 2005).

Thus, Expectancy-Value Theory predicts if stereotype threat is associated with a decline in expectancies for success (operationalized as confidence and anxiety), women's motivation and identification with science should similarly suffer (Eccles 2009). As past work has confirmed the deleterious effects of stereotype threat on confidence (e.g., Cadinu et al. 2003) and anxiety (albeit evidence for anxiety is mixed, see Smith 2004 for a review), we expect to replicate these expectancy findings among undergraduate women in physics lab classes, compared to those enrolled in biology, as a function of increased stereotype threat concerns. We also test whether women's expectancies for success in their science lab classes (and the contribution of each expectancy aspect in particular) is associated with women's identification with science and future motivation to engage in scientific research.

For the most part, the focus of expectancy-value research on women in science has centered predominantly on the "expectancy" side of the theory (and has

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extended into other theories such as social-cognitive career theory, Lent et al. 1996) with an emphasis on polices and practices aimed at supporting students' feelings of competence and confidence (Eccles and Wigfield 2002). The role of "value" in the Expectancy-Value Theory equation, has received considerably less empirical attention in the literature. Eccles herself has suggested that understanding value, particularly in terms of how it relates to students' perceptions of their own identities and social roles, is key to understanding motivated action (Eccles et al. 1999). Indeed, when a student says to herself "I can, but I don't want to" such a choice likely reflects the relative perceived (low) value of the option (Jacobs et al. 2005).

To be sure, there are many different types of values that an academic major, a career or task can afford that will motivate students (i.e., attainment value, intrinsic value, utility value, perceived cost; Eccles 2005). We focus here on "utility value." A discipline or task has utility value if a person perceives the task as affording a means for reaching either a short- or long-term goal, for example, helping other people. Students who are guided to self-generate the "utility" of a task or are provided information about a task's utility during instruction show more interest in the task, especially those who are low in confidence (e.g., Hulleman and Harackiewicz 2009; Hulleman et al. 2010).

Utility value is a broad category; we focus here on two types. communal and agentic utility value (Fiske et al. 2007; Diekman et al. 2011). These two types of utility value are fundamental values embedded within most cultures (e.g., Bakan 1966; Fiske et al. 2007; Helgeson 1994; Pohlmann 2001). Communal value is the extent to which a task is other-oriented (i.e., involves working with or helping others and creates opportunity for intimate bonds) whereas agentic value is the extent to which a task provides autonomy, power, prestige or wealth (Pohlmann 2001). Communion is embedded within female (and typically western) gender norms and agency within male (typically western) gender norms (e.g., Eagly et al. 2000) and as a cause or consequence, there is a large robust finding that men prefer working with "things" and women prefer working with "people" (see the meta analyses by Su et al. 2009).

Although American male and female children as young as 5 on up through adults all equally value agentic utility (e.g., money), women and girls are more likely to value communal utility (e.g., Morgan et al. 2001; Weisgram et al. 2010; Konrad et al. 2000), and seeing such value in a given field is associated with women's career interest and motivation (e.g., Diekman et al. 2010, 2011; McGee and Keller 2007). For example, Weisgram et al. (2010) demonstrated that a novel job described as high in communal utility (defined as having altruistic value) was linked to decreased interest for boys and men, but among girls and women, interest in the novel job was just as high if described as affording altruistic utility (communal) or money utility (agentic). Science jobs are generally perceived as low in communal utility value; science is seen as providing few opportunities to connect with and benefit other people; especially compared to other formerly male-dominated disciplines (medical doctor, lawyer) and female-dominated disciplines (e.g., nursing, education) (Diekman et al. 2010). This perception of science as non-communal is problematic and deters undergraduate American women from a science, career (Diekman et al. 2010, 2011). In short (mis)perceptions that science professions are low in communal

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values conveys information that is at odds with what many women value in a career (e.g., Good et al. 2012; Morgan et al. 2001; Smith et al. 2013) and such low communal value is likely an impediment to women's science identity (Wang and Degol 2013).

When stereotype threat is triggered, women become vigilant to cues that they do not belong (e.g., Cheryan et al. 2009; Good et al. 2012). As such, we predicted that women may be particularly likely to perceive science as low in communal value utility when experiencing stereotype threat in their science classroom, which would be a novel finding. This prediction is based in research on "stereotype threat spillover" (Carr and Steele 2010) such that coping with stereotype threat can lead women to be loss-averse (Carr and Steele 2010), cause women to downplay the importance of their own feminine characteristics (Pronin et al. 2003) result in a deflated sense of women's communal "we" sense of self (Keller and Sekaquaptewa 2008), and make salient the majority group's values (in this case, the majority group is white men who do not highly value the communal utility of science, Smith et al. 2014a, b). It is therefore important to ask if certain science classroom contexts (those more likely to trigger stereotype threat) undermine undergraduate women's ability to see science disciplines as affording communal utility value, and if so, such low communal utility value should negatively influence women's willingness to identify with science.

1.3 Study overview

The goal of the study was to examine whether and how stereotype threat impacts women's science identity using an Expectancy-Value Theory formulation with a specific focus on communal utility value. We also examined the relationship between science identity and women's intention to engage in future scientific research (versus motivation for science more generally). Understanding women's intention to pursue and engage in scientific research as part of their future college studies is especially important considering the need to diversify the scientific workforce to improve discovery, innovation, and remain competitive to meet global scientific needs (McGee et al. 2012; STEMconnector 2012; President's Council of Advisors on Science and Technology 2012). Women are highly underrepresented in science jobs in general, but are even more likely than men to opt out of *research intensive* science majors and careers (e.g., Martinez et al. 2007) especially in highly male-dominated science research fields such as physics (NSF 2011).

We surveyed undergraduate women at three US universities enrolled in either highly male-dominated physics laboratory classes or female-dominated biology laboratory classes. It was predicted that women in physics lab classes would report greater experiences of stereotype threat than women in biology lab classes because the male-dominated nature of the classes should trigger stereotype threat (Inzlicht and Ben-Zeev 2000; Smith and White 2002). Moreover, it was expected that greater gender stereotype threat concerns would reduce expectancies for success (in line with past research findings). Our novel prediction was that greater stereotype threat concerns would be associated with a reduction in the perceived communal utility value of science that would be related to less willingness to identify with science. We further expected that lower levels of science identity would be associated with

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women's decreased intention to engage in scientific research with faculty. We also explored the contributing role of an alternative type of utility value (agency). Although less central to the study aim, it was possible that stereotype threat would be linked to greater agentic value perceptions. Recall, agentic utility values are characterized by a self-oriented focus and involves seeking new experiences with a focus on power, competition and/or achievement (Pohlmann 2001). Given science is a "masculine" field that is (or at least is stereotyped as) highly competitive and agentic (Diekman et al. 2010; see also Smith et al. 2013) it is possible that women who have greater gender stereotype threat concerns would be more likely to associate agentic values with science. Alternatively, because agency is already central to the culture of science, it is possible that perceptions of the agentic value of science will be unaffected by stereotype threat concerns. We test both possibilities.

2 Method

2.1 Participants and procedure

A total of 388 women enrolled in introductory biology (n = 198) and physics (n = 190) courses (61.6 % Caucasian; ages 18–39; median age = 20.78; 12.4 % Freshman; 27.6 % Sophomores; 24.7 % Juniors; 32.2 % Seniors; 2.5 % "other") at three different universities (located in the South, West Coast, and Mountain West in the United States of America) participated in this survey in exchange for $10 in compensation. More than one-half (61.9 %) of the participants reported majoring in a STEM discipline, 37.4 % reported majoring in some other discipline, and 0.7 % had not yet declared a major. The introductory biology courses we sampled from were populated primarily by women (67.6 %) whereas the introductory physics courses mainly consisted of men (64.3 %). No differences emerged as a function of data collection site, thus this variable is not discussed further.

Course rosters containing student email addresses for students enrolled in biology and physics lower division (100 and 200 level) lab courses were obtained from the registrars' offices. Email messages inviting students to participate in a "research motivation study" to "gain understanding about perceptions of science lab classes" were then distributed to students at the midpoint of the academic term. Participants completed an internet-based survey assessing which lab class they were enrolled in, their feelings of stereotype threat, and measures assessing their confidence in science, anxiety about science, beliefs about the degree to which science fulfills communal and agentic utility values, their future research intentions and, most importantly, their identification with science. Measures were counterbalanced.

2.2 Measures

2.2.1 *Stereotype threat*

Participants rated themselves on three different items adapted from the Impression and Threat Concern Scale (Marx and Goff 2005; see also Keller and Sekaquaptewa

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2008) on scales ranging from 1 (*strongly disagree*) to 7(*strongly agree*). The adapted items were as follows: "I worry that my ability to perform well in my class is affected by my gender;" "I worry that if I perform poorly in my science lab class, others will attribute my poor performance to my gender;" and "I worry that, because I know the negative stereotype about women and science ability, my anxiety about confirming this stereotype will negatively influence how I perform in my science lab class." The three items were summed to form a stereotype threat (ST) index ($\alpha = 0.90$).

2.2.2 *Confidence in science*

As one index of expectancy for success, we assessed science confidence using the confidence in learning science (CLS) subscale of the Science Motivation Questionnaire (SMQ; Glynn and Koballa 2006). Participants respond to five items on Likert scales ranging from 1 (*never*) to 5 (*always*). The five confidence items are as follows: (a) "When I am in a college science course I expect to do as well as or better than other students in the science course"; (b) "When I am in a college science course I am confident I will do well on the science labs and projects"; (c) "When I am in a college science course I believe I can master the knowledge and skills in the science course"; (d) "When I am in a college science course I am confident I will do well on the science tests"; and (e) "When I am in a college science course I believe I can earn a grade of 'A' in the science course." These items were summed to create a confidence in science index ($\alpha = 0.84$).

2.2.3 *Anxiety about science*

As a second index to expectancy for success, we used the 5-item ''anxiety about science assessment" (ASA) subscale of the SMQ (Glynn and Koballa 2006) t o measure science anxiety. ASA items include: (a) "I am nervous about how I will do on the science tests"; (b) "I worry about failing the science tests"; (c) "I become anxious when it is time to take a science test"; (d) "I am concerned that other students are better in science"; and (e) "I hate taking science tests". These items were originally designed to be reversed-scored and summed to contribute to an overall motivation score on the SMQ. However, factor analytic work with the SMQ has shown ASA items to produce strong factor loadings, with standardized coefficients ranging from 0.63 to 0.81 (Glynn, Taasoobshirazi, & Brickman 2009). The ASA is therefore believed to possess sufficient enough construct validity to be used as a stand-alone measure. Responses are scored on a Likert scale ranging from 1 (*never*) t o 5 (*always*). These items were summed to form an anxiety index ($\alpha = 0.83$).

2.2.4 *Perceptions of science utility values*

Participants answered two questions assessing how much they believed that science careers afforded communal and agentic utility values on scales ranging from 1 (*not at all*) to 7 (*extremely*) (taken from Diekman et al. 2010, 2011). The communal item was as follows: "How much do you believe that science affords working with

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people, helping others, and serving the community?" The agentic item was as follows: "How much do you believe that science affords power, achievement, and seeking new experiences or excitement?"

2.2.5 *Future science research intentions*

Participants rated their intention to engage in science research in the future on three items on scales ranging from 1 (*not likely at all*) to 5 (*very likely*) as used in Smith et al. (2014b). The items were as follows: "How likely would you be to pursue undergraduate research opportunities?" How likely would you be to volunteer to work in a faculty research lab?" "How likely would you be to volunteer to work on a faculty member's research team?" "How likely would you be to volunteer to work on a faculty member's research?" These items were summed to form a research intentions index ($\alpha = 0.96$).

2.2.6 *Identification with science*

Items from a group identification measure developed by Doosje et al. (1995) were adapted to assess the extent of participants' identification with science. The original 4-item measure was developed for the purpose of tapping the cognitive and affective dimensions of identification with an academic domain (i.e., "I see myself as a psychology student"). For the purposes of this study, we modified the original measure and added two additional items to provide broader coverage of the above-noted dimensions of identification. Items in the present study were rated on a 1 (*strongly disagree*) to 7 (*strongly agree*) scale as follows: (a) "I see myself as a science student"; (b) "I am pleased to be a science student"; (c) "I feel strong ties with other science students"; (d) "I identify with other science students"; (e) "I feel that being a science student is an important reflection of who I am" (added item from Luhtanen and Crocker 1992; Walsh and Smith 2007); and (f) "I don't act like the typical science student" (reverse-scored; see Walsh and Smith 2007). These items were summed to form an identification with science index ($\alpha = 0.90$).

3 Results

3.1 Analyses overview

Table 1 presents the descriptive statistics and correlations for all of the study variables. Two structural equation models were analyzed using *Mplus* version 7 (Muthen and Muthen 2012) using the maximum likelihood estimation model. Model 1 provides a test for our conceptual model, with a focus on the relationship between stereotype threat effects and science identity occurring through communal utility value (see Fig. 1). In model 2, we add agentic utility as a secondary value process variable alongside communal utility value, in order to test whether potential effects involving communal utility value hold even when accounting for students' agentic values (see Fig. 2). Because the models that we present are not nested, we cannot

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Table 1 Correlations, means, standard deviations, and ranges for model variables

Subscale	1	2	3	4	5	6	7
1 Stereotype threat	–	−0.25***	0.25***	−0.15**	−0.06	−0.03	−0.12*
2 Confidence		–	−0.34***	0.20***	0.26***	0.37***	0.50***
3 Anxiety			–	−0.06	−0.01	−0.07	−0.14**
4 Communal utility value perception				–	0.43***	0.27***	0.38***
5 Agentic utility value perception					–	0.31***	0.38***
6 Future science research intentions						–	0.56***
7 Science identification							–
R^2 values							
Model 1 R^2 values	0.02	0.07	0.06	0.02	–	0.32	0.32
Model 2 R^2 values	0.02	0.07	0.06	0.02	0.004	0.31	0.33
Total mean	5.96	19.25	17.37	5.68	5.98	14.09	31.21
Biology mean	5.36	19.64	17.37	5.69	6.06	14.21	31.14
Physics mean	6.58	18.80	17.38	5.67	5.91	13.95	31.28
Total standard deviation	4.25	3.56	4.38	1.13	1.04	4.81	7.67
Biology mean	3.75	3.49	4.13	1.18	1.00	4.97	8.54
Physics mean	4.64	3.60	4.65	1.07	1.08	4.63	6.65
Range	3–21	5–25	5–25	1–7	1–7	5–20	6–42

** $p < 0.01$; *** $p < 0.001$

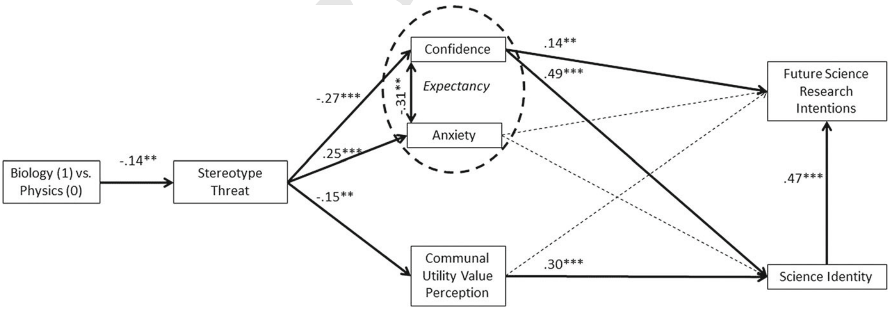

Fig. 1 Model 1: Testing perceived communal utility value of science. Path coefficients represent the statistically significant standardized estimates from the structural equation analysis. *Dashed lines* indicate non-significant paths in the model. R^2 values for the variables ranged from 0.02 (Stereotype Threat; Communal Utility Value Perception) to 0.32 (Science Identity; Future Science Research Intentions). Note: **$p < 0.01$; ***$p < 0.001$

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statistically compare model fit. Instead we indirectly compare the models based on the fit indices for each model (χ^2/df, CFI, RMSEA, and SRMR).

3.2 Testing the role of perceived communal utility value: model 1

Overall, model fit statistics indicate that our conceptual model provides a good fit for the data. Three indices for this model suggest a good fit (CFI = 0.967; RMSEA = 0.062; SMR = 0.04), and one indicator suggests that this is an acceptably fitting model (χ^2/df = 2.513). Because the overall model achieved good fit, we can explore the specific theoretical predictions through direct and indirect paths between variables, as illustrated in Fig. 1.

The first prediction tested in our conceptual model is that women in physics classes would report higher levels of stereotype threat than those in biology classes. As seen in the significant relationship between the two variables at the left side of Fig. 1, this hypothesis was confirmed (means for biology and physics classes are presented in Table 1).

The next relationships tested in the model involved the relationship among stereotype threat and women's expectancy-value motivation variables. Among the expectancy variables, replicating previous findings, greater feelings of stereotype threat significantly predicted lower confidence and higher anxiety. Further, central to the current study's predictions, greater feelings of stereotype threat also significantly predicted lower perceptions of communal utility value of science among these women science students.

Next, the model tests whether the expectancy-value variables were associated with science identity. As seen in Fig. 1, although both confidence and anxiety significantly correlated with science identity in the expected directions (see Table 1), when both variables were accounted for in the model, only confidence,

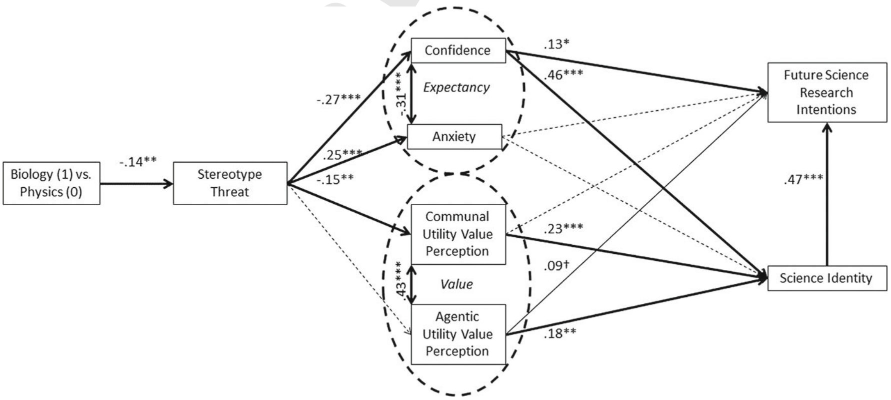

Fig. 2 Model 2: The additional contribution of perceived agentic utility value of science. Path coefficients represent the statistically significant standardized estimates from the structural equation analysis. *Dashed lines* indicate non-significant paths in the model. R^2 values for the variables ranged from 0.02 (Stereotype Threat; Communal Utility Value Perception) to 0.33 (Science Identity). Note: $^{\dagger}p < 0.10$; $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$

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and not anxiety, was significantly related to science identity. More importantly for the current study's predictions, greater perceived science communal utility value was significantly associated with greater science identity.

We next examined indirect effects, which can reveal the influence of a variable that a direct effect test might miss (e.g., Preacher and Hayes 2004). Indeed, the tests of model indirect effects also demonstrate that stereotype threat was significantly indirectly associated with science identification through two paths. Consistent with others' theoretical predictions (e.g., Cadinu et al. 2003), the first significant indirect path suggests that stereotype threat predicts lower science identity through its associated with confidence (bootstrapped, 95 % CI −0.35 to −0.13). In addition, we are the first to predict and provide evidence that even small increases in stereotype threat indirectly relates to a decrease in science identity through its association with perceived communal utility value of science (bootstrapped, 95 % CI −0.14 to −0.02).

Lastly, as seen in Fig. 1, the model demonstrates that future intentions to pursue research are directly predicted both by science identity and confidence. As with science identity, tests of indirect effects suggest that stereotype threat significantly indirectly relates to lower research intentions through multiple paths. First, a significant path through both confidence (bootstrapped, 95 % CI −0.087 to −0.014) and confidence and science identification emerged (bootstrapped, 95 % CI −0.107 to −0.038). More important for the current study hypotheses, a significant path from stereotype threat to science research intentions emerged through perceived communal utility value and science identity (bootstrapped, 95 % CI −0.042 to −0.006). Thus, although perceived communal utility value did not directly influence research intentions (despite their positive correlation, see Table 1), it did play an indirect role along with science identity in explaining how feelings of stereotype threat predict women's lower intentions to engage in science research.

3.3 Testing the possible contribution of perceived agentic utility value: model 2

Although our conceptual model emphasizes the contributions of perceived communal utility value to women's science identity, agentic values (high pay, opportunities for pursuing one's curiosity, and intrinsic science interests) are the values that the majority of people consider as centrally important to science motivation, identity, and success (Dyer and McWhinnie 2011; McGee and Keller 2007; Smith et al. 2014b; Webb et al. 2002). Thus, it is possible that when accounting for agentic values in our model, the role of communal utility value perceptions could diminish. We test this empirical question by estimating Model 2, which is identical to Model 1 but with the addition of perceived agentic utility value as a parallel value alongside communal utility value (see Fig. 2).

As seen in Fig. 2, although greater agentic value perceptions significantly predict greater science identity, agentic value perceptions are not influenced by stereotype threat nor do they play an indirect role in effects of stereotype threat on science identity. More importantly for our theoretical framework, including agentic value perceptions in the model does not change effects of communal utility value perceptions. Both the direct and indirect effects involving communal utility value

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reported in Model 1 remain significant in Model 2. Further, examination of model fit statistics suggests that adding agentic utility value does not improve fit of the empirical model (CFI = 0.944; RMSEA = 0.079; SMR = 0.061; χ^2/df = 3.412). Each of the model fit indices indicate that Model 1 fits the data better than Model 2. Thus, adding perceived agentic utility value to the empirical model does not diminish the importance of communal utility value.

3.4 Testing alternative reverse pathway models

Although we argue that stereotype threat concerns are associated with a reduction in expectancies for success and the perceived communal utility value of science, the correlational nature of our data render it important to test reverse pathways among the variables. We did this in two ways. To start, we tested whether the type of class (physics versus biology) was associated with confidence, anxiety, and communal utility value, and if in turn, these variables were associated with concerns about stereotype threat, with stereotype threat concerns being more proximally associated with science identity and motivation. Model fit statistics show that reversing the relationships in this way resulted in poor fit (CFI = 0.57; RMSEA = 0.20; SRMR = 0.14; χ^2/df = 17.05) suggesting that this pathway was not a significantly supported possibility.

Next, we tested whether the type of class (physics versus biology) was associated with communal utility value first, and if in turn this variable was associated with concerns about stereotype threat, with stereotype threat concerns then being associated with expectancies (confidence and anxiety), science identity, and motivation. Again, the model fit statistics show that reversing the model in this way also resulted in a poor fit (CFI = 0.84; RMSEA = 0.12; SMR = 0.09; χ^2/df = 6.76).

Taken together, we argue that although the causal pathways cannot be confirmed with complete certainty because of the correlational nature of the data, testing these alternative pathway models offer some evidence as to the veracity of the direction of effects as shown in Model 1. We return to this topic in the discussion.

4 Discussion

Understanding factors that influence women's science identity is important to understanding women's pursuit and persistence in male dominated STEM fields (e.g., Osborne and Jones 2011; Ramsey et al. 2013). We set out to examine whether and how women's science identity is associated with feelings of stereotype threat, especially in male-dominated physics classes. Drawing from Expectancy-Value Theory (e.g., Eccles and Wigfield 2002), we focused on the associations among science identity, stereotype threat, and women's perceptions about the communal utility value of science –perceptions about how much science affords the chance to work with and help other people. As predicted, our findings showed that in line with past experimental work on stereotype threat (e.g., Murphy et al. 2007) feelings of stereotype threat were relatively greater in the (male-dominated) physics lab classes versus the (female-dominated) biology lab classes. This is important, as there are clearly essential differences within various types of science disciplines that should not be overlooked, which can happen when "science" fields are merged into one broad category. The relationship between science identity and stereotype threat was significantly associated with beliefs about how much science fulfills communal utility value. The addition of perceived agentic utility value did not add to or change the pattern of results. Science identification was also found to be important in predicting future intentions to engage in science research, which was generally lower among women who reported feeling stereotype threat.

Our findings are among only a handful to date that examine women's science identity as an outcome predicted by stereotype threat, and are one of the first to demonstrate one of the ways in which even small differences in stereotype threat experiences in a naturalistic setting contribute to women's science identity. Women's science identity was associated indirectly with stereotype threat via perceptions in how much science can and does involve working with and helping other people. When women reported fewer stereotype threat concerns, they were more likely to see that science has communal utility value, and in turn greater perceived communal utility value was associated with elevated science identity. In contrast, when women reported greater stereotype threat concerns, which was more often the case in male-dominated physics classes compared to biology classes, they also viewed science as affording fewer communal utility opportunities; lower communal utility value was associated with lower science identity. These findings, we hope, have both theoretical and applied implications.

Theoretically, our model merged together three different literatures to test predictions about influences on undergraduate women's science identity: stereotype threat (e.g., Steele 1997), Expectancy-Value Theory (e.g., Eccles and Wigfield 2002), and research on communal goals and interpersonal values (e.g., Diekman et al. 2011; Maddux and Brewer 2005). Specifically, our findings contribute to the literature on what is known about the ways in which stereotype threat, women's science identification, and motivation are related. What we do know from the relatively little existing past research is that stereotype threat reduces women's motivation for a stereotype-relevant domain. To be sure, motivation is related to domain identification (e.g., Smith and White 2001). Much of this evidence however is indirect; for example, when considering an upcoming engineering conference, women who see that the overwhelming majority of conference attendees are men (versus gender equal) report less motivation to participate in the conference (Murphy et al. 2007). Indeed, women's motivation to consider a novel science field of study declines when that field is presented as male-dominated versus gender equal (Smith et al. 2013). Even when women are not confronted directly with their token status, just sitting in a classroom that is decorated with male-stereotypic items activates stereotype threat and results in women reporting less interest in pursuing (computer) science (Cheryan et al. 2009). These studies assume, but do not measure or manipulate, stereotype threat. Actual direct assessment of stereotype threat and motivation is relatively rare (cf., Davies, Spencer, Quinn, and Gerhardstein 2002; Schmader et al. 2004; Thoman et al. 2008) and although domain identification and motivation are typically positively related (Osborne and Walker 2006), rarer still is

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the inclusion of domain identification as the specific variable under study. Thus, one contribution of the current study was determining that undergraduate women in US physics laboratory classes (which were male-dominated) experience stereotype threat to a greater extent than women in more gender equal or female-dominated science classes (e.g., biology); such stereotype threat concerns were associated with women's depleted identification with science.

It is well documented within the stereotype threat literature that domain identification moderates the effect of stereotype threat on performance (e.g., Aronson et al. 1999; Cadinu et al. 2003) and as such, domain identification is typically used as a participant selection criterion (e.g., Spencer et al. 1999), as a predictor variable (e.g., Forbes et al. 2008; Lawrence and Crocker 2009; Osborne and Walker 2006), or as a covariate (e.g., Smith and White 2002) to isolate the effects of stereotype threat on other outcomes. Little research exists on the stereotype threat-identification-motivation relationship (see Thoman et al. for review). Understanding that stereotype threat decreases interest in pursuing or persisting in science is important, as measures of interest are indicative of actual degree selection, degree completion, and career pursuit (for a review see Nye et al. 2012). Yet, for women, science is a ''leaky pipeline'' (Blickenstaff 2005; Wickware 1997) whereby even momentary gains in interest or career intentions do not ensure persevering in science. What is also needed is for women to develop strong feelings of a personal connection to science, whereby much of her sense of self is defined by her participation in science. Our results suggest that one important pathway through which science identification was influenced by stereotype threat was via expectancy-value differences, in particular in perceptions about the communal utility value of science.

Indeed, our findings extend past work on Expectancy-Value Theory by focusing on the association between stereotype threat concerns and a specific type of (gender conflated) utility value: communal values. Women as a group are generally more likely to perform better and enjoy working on tasks that are perceived as purposefully serving society and involve other people (see Su et al. 2009 for a review). Yet, science is often stereotyped as not affording such communal goals (e.g., Diekman et al. 2010, 2011). Add to this that stereotype threat triggers vigilance to cues that women do not belong in male-dominated domains (e.g., Kaiser et al. 2006; Murphy et al. 2007; Steele et al. 2002b). Putting this all together, we predicted and found that this unique merging of literatures was useful for informing contributing factors to women's science identity. Certainly it is possible that our combined theoretical framework is only applicable to science identity in women. Moreover, we only examined two different types of utility value and there are many other values worthy of investigation. Our hope is that other domain identities and other types of values might also be served by considering these theoretical perspectives together.

Our findings also have practical implications for designing empirically based interventions aimed at reducing stereotype threat and enhancing women's science identity (e.g., Smith and Hung 2008). In line with recent work showing that helping parents see the personal utility of math and science improves their high-school sons and daughters' motivation for the fields (Harackiewicz et al. 2012) our findings go

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one step further and suggest that not all "utility" values are equal when considering improving women's science identity. Instead, communal utility in particular (compared to agentic utility for example) may be important for educators and scholars to consider when designing and delivering classroom interventions aimed at broadening the participation of women in science (and other underrepresented minority groups, see Smith et al. 2014a). Our results imply that women's identification with science may be enhanced when the communal utility value of physics is made salient, which remains to be tested in future research.

Additionally, our focus on the relationship between science identity and science research intentions adds to the emerging literature on broadening women's participation as scientific and biomedical researchers. In the European Union—27, as few as 33 % of all science researchers in 2009 were women (European Commission 2012). And for those women who are science researchers, there remains a worldwide gender disparity in access to resources (Ivie and Tesfaye 2012). For example, women science researchers in the US made up only 25 % of NIH and 23 % of NSF 2007 grant awards (Nature Neuroscience 2010). Such underrepresentation has clear implications not only for social justice and equal access but also for workforce development, economics, discovery, and innovation (e.g., McKinsey and Company 2007). Individuals might embark on the pursuit of careers in scientific research because they are inherently interested in developing their understanding of the laws and phenomena that govern the operation of the natural world. However, such reasons for conducting research often change depending on the people and situations they encounter, leading to more complicated patterns of motivation for conducting research (Smith et al. 2014b). Undergraduate research experience is one way science interest can be captured and sustained especially among underrepresented students (Hurtado et al. 2009). Our findings point to science identity as a pivotal place in the process that may help understand women's research intentions in lower level science classes: research motivation appears to be channeled through science identity development and the perception that science affords fulfillment of important communal values.

4.1 Limitations and future directions

Our research focused specifically on women's science identity, and not men's, largely because of women's underrepresented status in science (National Science Board 2012; European Commission 2012) and because the gender stereotypes regarding science are negative towards women as a group (e.g., Rahm and Charbonneau 1997; see also Nosek et al. 2009). Nevertheless, the world is in dire need of more qualified people participating in science in general and thus it is important for future work to examine how positive gender stereotypes about men, for example, may "boost" versus trigger a "choking under pressure" reaction among majority men that contributes to men's science identity (e.g., Smith and Johnson 2006). It is also the case that some cultures highly value and uphold communal ideals for both men and women, and to the extent that ethnic minority male students (e.g., US Native American men) identify with those cultures they too may experience similar science identity processes as our findings here (Smith et al.

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2014a). Research on the intersectionality of race, gender, and social class based stereotype threat, is key to advancing our understanding of science identity (e.g., Tine and Gotlieb 2013).

Another important limitation is the correlational nature of the data. Although our conceptual model makes causal predictions, conclusions about causality, direct effects, or the direction of causality should not be inferred from correlational data. One benefit of using structural equation modeling is that associations between variables can be decomposed through multiple a priori specified pathways, allowing for comparisons of multiple indirect paths. This strength was evident in the current findings as, for example, both confidence and anxiety were correlated with science identity but only confidence (and not anxiety) served a significant indirect effect role in the association between stereotype threat and science identity. In addition, although agentic and communal utility value were correlated with each other and both correlated with science identity, only communal (and not agentic) utility value played a role in the relationship between stereotype threat and science identity. What is more, we tested two possible alternative models that reversed the direction of effects, and found no support for those models. Thus, although causality and directionality cannot be inferred, our study examined the multiple pathways of correlational decompositions for the variables surveyed.

The stereotype threat literature is rich with excellent experiments establishing its effects and correlates in controlled environments (e.g., Aronson et al. 1999; Croizet et al. 2001; Derks et al. 2008); for example, being outnumbered in a stereotype threatening situation decreases feelings of belonging and connection (e.g., Murphy et al. 2007) and is associated with feelings of a hostile work and learning environment (e.g., Oswald and Harvey 2000. Our examination of multiple paths from stereotype threat to science identity in a naturalistic setting we think complement and extend the existing literature. The next step for research is to consider the overlap and distinctions among the experimentally determined mechanisms involved with stereotype threat effects (e.g., Smith 2004) and communal utility value beliefs. In this way, we can learn more about "third variable" effects that were untested in the current study. For example, perhaps biology classes are more likely than physics classes to have women faculty as instructors. If so, a stereotype inoculation perspective (Dasgupta 2011) would predict that female role models within biology (versus physics), for example, might buttress associated reductions in how much female students think science involves working with and helping other people; this is a key empirical question for future research.

Our project findings are necessarily limited by the measurement instruments we selected, for better or worse. Although we were careful to select measures established in the literature, it is true that self-reported explicit measures of science identity might not always capture the level of importance and value of the domain to the overall self (Osborne and Jones 2011). Some scholars instead have begun to focus on implicit science identity as a more holistic and predictive measure of science outcomes (e.g., Nosek et al. 2002; Ramsey et al. 2013). Future research would benefit from continuing to explore the nuanced differences in implicit versus explicit science identity and the relationship between the two. For example, which

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type of identity is necessary (albeit not sufficient) for the development of the other? Which type of science identity, or combination of the two, might buffer, versus make a group member vulnerable, to stereotype threat effects (e.g., Aronson et al. 1999; Osborne and Jones 2011)? Indeed, we approached science identity from a stereotype threat framework, which has pros and cons. There is a need for empirical data on the link between stereotype threat and science identity, as we reviewed previously—to date most evidence for this link is indirect. Yet it is also true that naturalistic data might not shine a bright light on this link. People may not be especially willing to admit to or even have insight into personal experiences with prejudice and stereotypes (Crosby 1984) and as such, overall mean scale levels might be low in field studies of science identity and stereotype threat. This was indeed the case in our own study. Yet, our findings suggest that even small differences in stereotype threat concerns have meaningful associations with science identification, and modest differences in science identity are associated with important differences in future research intentions.

What is the ideal level of science identity for women working in male-dominated science fields such as physics? This is an empirical question. As Osborne and Jones (2011) point out, for example, the very type of self-identity educators are interested in fostering is often the very same identity that makes someone vulnerable to stereotype threat effects (Aronson et al. 1999; Schmader 2002; Steele 1997). The discovery of some optimal amount of science identity among underrepresented students is a critical question to consider in future research. The answer likely involves a motivational experiences feedback loop (Thoman et al. 2013) whereby science identity becomes tied to belonging, interest, and activity engagement in ways that stereotype threat concerns both undermine the experience (via performance avoidance goals) and enhance the experience (by cueing an unsafe and adverse negative environment that should be exited).

5 Conclusion

As was illustrated by Dr. Wu at the outset of our paper, for some science can define one's life, and this identification with science can drive persistence and commitment to the field. Our study is among the first to examine how stereotype threat concerns shape science identification and how science identification is associated with the motivation to engage in scientific research for an underrepresented group of people. Combining three different literatures (Stereotype Threat, Expectancy-Value, and Communal Goals and Values), this study provides evidence that women's science identity is shaped by their experience of stereotype threat, with the relationship between stereotype threat and science identification being explained by the perceived communal utility value of science. Implications for our results are twofold: (1) the importance of removing stereotype threat cues and triggers and (2) emphasizing the ways in which science contributes to and helps others as a means to enhancing women's identification with science. Both implications are in the service of ultimately broadening the participation of women in male-dominated science research fields.

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