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ORIGINAL RESEARCH

Do adolescents' self-concepts moderate the relationship between STEM stereotypes and motivation?

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Abstract

Professionals in science, technology, engineering, and math (STEM) are often stereotyped as geniuses and nerds (e.g., socially awkward). These stereotypes may demotivate some individuals from pursuing or remaining in STEM. However, these beliefs may enhance motivation among individuals who feel that they fit in with the stereotype. Guided by balanced identity theory and expectancy-value theory, our study investigated the effect of trait-based stereotypes about people in STEM among a sample of 256 U.S. high school students ($M_{age} = 16$, 59% girls, 65% Asian, 15% Latinx, 10% White). We assessed students' trait-based nerd and genius stereotypes about STEM and related self-concepts as well as their STEM motivation (competence and value beliefs). Consistent with balanced identity theory, the effect and direction of endorsing nerd-genius stereotypes was moderated by a student's own self-concepts. Endorsing stereotypes was negatively related to motivation—but only among those low in the related self-concept. Among those high in related self-concepts (e.g., high in nerd-genius self-concept), endorsing STEM stereotypes (e.g., STEM is for geniuses) was unrelated to STEM motivation. Girls, underrepresented students of color, and potential first-generation college students may especially be negatively affected by the stereotypes due to a greater likelihood that these stereotypes will be incongruent with their self-concepts. Thus, trait-based stereotypes about people in STEM may perpetuate current gaps in STEM.

Keywords Achievement motivation · Science · Math · Self-concept · Stereotyping · Belonging

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1 Introduction

Over the course of the last few decades, researchers and policymakers have sought to increase students' interest in science, technology, engineering, and mathematics (STEM) fields given their importance in society (Zakaria 2011). Adolescence is an important developmental period to investigate STEM motivation because many youth are exploring their identities (Lauermann et al. 2017; Wang et al. 2017). As a result, self-concepts, stereotypes, and social roles become especially salient during this time. Among the obstacles to getting youth interested and persisting in STEM are the negative cultural stereotypes about people in STEM occupations.

When people think of an individual who is in STEM, they often think of a nerdy male who is a genius (i.e., the nerd-genius stereotype). For example, this was documented in two recent studies that asked undergraduates to describe a computer scientist (Cheryan et al. 2013b; Ehrlinger et al. 2018). Participants commonly stereotyped computer scientists as male, intelligent, unattractive, lacking social skills, technology oriented, and obsessed with computers. In another investigation, a factor analysis of nerd-genius stereotypes revealed two primary factors: one centered around nerdiness (socially awkward, unattractive, and romantically unsuccessful) and the other centered around intelligence or genius (Starr 2018). The same study found that nerd-genius stereotypes predicted undergraduate women's STEM motivation and identity, independent of either implicit and explicit gender stereotypes. These stereotypes may be especially consequential when they are incongruent with individuals' idealized self-concepts (e.g., Ferguson et al. 2010). For example, students who stereotype people in STEM as nerdy geniuses may be more prone to steer away from STEM when they do not view themselves as nerdy or naturally gifted in math.

In the present study, we assessed high school students' nerd-genius stereotyped beliefs about people in STEM. At the same time, we evaluated students' own self-concepts in these two domains. We thereby sought to better understand why many talented students are not motivated to enroll in advanced courses, pursue majors, or aspire for occupations in STEM. Understanding these processes may more broadly illuminate why women and some minority groups are underrepresented in many STEM fields (National Science Foundation 2017). Guided by the expectancy-value theory of achievement motivation (Eccles and Wigfield 2002) as well as balanced identity and similar models (Greenwald et al. 2002; Niedenthal et al. 1985; Setterlund and Niedenthal 1993), we explored self-concepts as a moderator of the relationship between STEM stereotypes and STEM motivation in a sample of high school students enrolled in summer science internships.

Targeting a high school sample further extends research in this area as most prior studies on STEM stereotyping were conducted with college students (see Hannover and Kessels 2004; Kessels 2005, for pertinent studies in Germany with adolescents). During high school, many students decide whether to take advanced courses in math and science that can affect their subsequent pursuit of STEM majors in college (e.g., Watt 2006). Furthermore, adolescence can be a period of identity exploration regarding possible careers and gender roles (e.g., Grotevant et al. 1986). It is also a time when many youth are keenly concerned with popularity and appearing attractive. These concerns may shape the kinds of goals they pursue, including possible career options (e.g., Farkas and Leaper 2016; Grotevant et al. 1986). Accordingly, the present study investigated STEM-related stereotypes and self-concepts in relation to high school students' STEM motivation.

1.1 Theoretical background

According to expectancy-value theory (e.g., Eccles and Wigfield 2002), achievement motivation is comprised of expectancy (i.e., competence) beliefs and value beliefs regarding a particular achievement domain. Competence beliefs reflect confidence in one's abilities and expectations to succeed in a domain, whereas value beliefs include one's intrinsic interest and perceived utility regarding a domain. Students are more likely to pursue and persist in a subject if their competence and value beliefs are high (Eccles and Wigfield 2002). Several cross-national and longitudinal studies have found that math competence and value beliefs predicted later choices and aspirations (e.g., enrolling in advanced math courses, having math-related career aspirations) even after controlling for initial performance (e.g., Guo et al. 2015; Schoon and Eccles 2014; Watt 2006). According to the expectancy-value model, competence and value beliefs are partly shaped by individuals' stereotypes and self-concepts. As reviewed next, we tested students' STEM-related stereotypes and self-concepts as possible predictors in the present research.

Individuals often seek to match their self-concepts to the idealized person whom they aspire to become. When one is deciding whether to pursue a particular identity, such as a STEM student or professional, individuals may evaluate how well their self-concept (personal goals, values, and beliefs) matches the attributes that they associate with the possible identity (i.e., stereotypes). This premise is highlighted in various psychological theories, including self-categorization theory (Turner et al. 1987; Turner and Reynolds 2012), role-congruity theory (Diekman and Eagly 2008), the self-to-prototype matching approach (e.g., Hannover and Kessels 2004; McPherson et al. 2018; Niedenthal et al. 1985; Setterlund and Niedenthal 1993), the stereotype threat model (Steele 2010), and balanced identity theory (Cvencek et al. 2015; Greenwald et al. 2002; Tobin et al. 2010). In the present paper, we use the latter model to frame our research, although we acknowledge a great deal of overlap across these theoretical approaches.

When there is imbalance or a mismatch between one's self-concept and stereotypes about an identity, individuals are apt to distance themselves from that identity. For example, persons who value being popular may become uninterested in STEM if they stereotype STEM students or professionals as socially awkward. This is akin the phenomenon of stereotype threat (Steele 2010). Conversely, if the stereotypes are compatible with the individuals' self-concepts, their interest in the identity may be enhanced. For instance, if persons identify as naturally gifted and also stereotype people in STEM in a similar way, they may feel like they would belong in the field. This is similar to the phenomenon of stereotype boost (Steele 2010).

Hence, stereotypes may help the STEM motivation of some students while hindering the motivation of others because people are motivated to enter situations that match their self-concepts (Cvencek et al. 2015; Greenwald et al. 2002; Hannover and Kessels 2004; Niedenthal et al. 1985). In support of this premise, a survey of adults in the U.S. found when respondents stereotyped math as a male domain that there tended to be different correlates for men and women: Men were more motivated toward math while women were less motivated (Nosek and Smyth 2011). Another study with U.S. undergraduates found that feeling dissimilar to prototypical computer scientists may help explain the gender gap in computer science interest (Ehrlinger et al. 2018). Participants were asked to describe the "average computer scientist" and then rated how similar the description they provided was to them. This perception of similarity mediated the positive relationship between gender and interest in computer science. That is, men were more likely than women to perceive similarity to the stereotype. Although the interaction of gender and gender stereotypes about STEM has been previously explored, studies have yet to explore a similar interaction effect for stereotypes about people in STEM and individuals' corresponding self-concepts.

1.2 Stereotypes about STEM people

Building upon prior research (Cheryan et al. 2013b; Starr 2018), we considered stereotypes about STEM people and corresponding self-concepts in two domains. As reviewed next, we investigated the stereotype that people who work in STEM are geniuses as well as the expectation that people in STEM are nerdy in relation to individuals' self-concepts in each of these areas.

1.2.1 STEM = nerdy

A stereotype frequently associated with people who work in STEM fields is that they are "nerds"—that is, they are socially awkward, unattractive, and unable to find romantic partners. This STEM = nerd stereotype was commonly endorsed among participants in studies with U.S. undergraduates (Cheryan et al. 2013b; Starr 2018), U.S. high school students (Garriott et al. 2017), as well as German middle-school students (Hannover and Kessels 2004). Based on prior research, the nerd stereotype may undermine some people's interest in STEM. Experimental studies found that portrayals of computer scientists as stereotypically nerdy or geeky led to lower interest in science among women (e.g., Cheryan et al. 2011, 2013a, b). Additionally, one study in the U.S. found that women reported more negative attitudes towards STEM when romantic goals were activated (Park et al. 2011). Some males also may view females who excel in STEM as less romantically attractive. A study among German middle-school students (Kessels 2005) found that girls who excelled in physics felt unpopular with boys; indeed, boys tended to report disliking girls who excelled in physics (also see Yoder and Schleicher 1996 for similar findings with U.S. adults).

In sum, the STEM = nerd stereotype may tend to undermine some individuals interest in STEM.

Based on balanced identity theory, stereotyping persons in STEM as nerds may be especially likely to have a negative impact on STEM motivation among those for whom the stereotype contradicts their self-concepts. Moreover, endorsing the stereotype may actually bolster some individuals' STEM interest when it is compatible with their self-concept. We thus hypothesized that endorsing the stereotype that people in STEM are nerdy would be negatively related to STEM motivation among high school students who do not view themselves as nerdy. Conversely, endorsing the same stereotype would be positively related to STEM motivation among those who do view themselves as nerdy (Hypothesis 1).

1.2.2 STEM = genius

Professionals in STEM fields are often stereotyped as geniuses or naturally gifted in the discipline (Cheryan et al. 2013b; Ehrlinger et al. 2018; Hannover and Kessels 2004; McPherson et al. 2018; Storage et al. 2016). Alternatively, one may view success as something that can be attained through effort and growth (Dweck 2007). Prior studies indicate that people were more likely to attribute success in STEM fields to genius or innate intelligence compared to success in many other fields (Storage et al. 2016). To the extent that students believe that STEM success requires being a genius but do not see themselves as highly intelligent, they may become less motivated to pursue these fields to avoid the risk of appearing unintelligent (Dweck 2007). In support of the balanced identity model, a recent study with undergraduates found that the concordance between views of scientists as highly intelligent and students' intelligence self-concepts predicted their science career interest (McPherson et al. 2018). By extension, we expected to observe a similar pattern in our sample of high school students. We hypothesized that believing people in STEM are geniuses would be negatively related to STEM motivation among adolescents who did not view themselves as naturally gifted in math. Conversely, holding this belief would be positively related to STEM motivation among those who also view themselves as gifted in math (Hypothesis 2).

1.3 Present study and hypotheses

In the present study, we examined whether stereotype-related self-concepts moderated the relationship between stereotypes about STEM people and STEM motivation (i.e., competence and value beliefs). We hypothesized that self-concepts would significantly moderate this relationship. Specifically, we predicted that people who endorse STEM stereotypes but do not feel they fit the stereotype would have lower STEM motivation; conversely, those who endorse STEM stereotypes but hold self-concepts that fit the stereotype would have relatively higher motivation. To test these hypotheses in a regression analysis, we predicted the interaction term would be significant and that simple slopes would reveal that the effects of stereotypes would differ for people low versus high in the related self-concept. We separately tested the balanced identity model for both the nerd stereotype and self-concept (Hypothesis 1) and for the genius stereotype and self-concept (Hypothesis 2).

In our analyses, we controlled for students' math grades, gender, underrepresented-minority status, and potential first-generation college status (i.e., whether or not mother had graduated from college). Math grade was taken into account to infer whether the balanced identity model predicted STEM motivation beyond their recent achievement. In addition, the proposed model was presumed to apply similarly regardless of gender, ethnicity, and potential first-generation college status. That is, if the stereotype was congruent or incongruent with a student's self-concept, then it should have similar effects on motivation. However, average differences in self-concepts, endorsing particular stereotypes, or STEM motivation based on the students' gender, underrepresented-minority status, or potential first-generation college status may occur (see Leaper 2015), which we explored in preliminary analyses.

The current study adds to previous literature in three ways. First, we tested the congruence (vs. incongruence) of stereotypes and self-concepts among high school students, whereas most of the prior studies looked at undergraduates. Second, we examined the stereotypes and self-concepts in relation to STEM competence beliefs and STEM value using the expectancy-value framework, whereas other studies focused primarily on STEM career or course interest. Finally, we investigated the nerd and genius stereotypes separately rather than combined (cf. Starr 2018).

2 Method

2.1 Participants

Students from two summers (2017 and 2018) of a high school summer science program ($N = 256$) participated in the current study. (Our number of participants exceeded the minimum sample size of 186 recommended in a power analysis.) Three-fifths of participating students were adolescent girls (59%, $n = 151$) who were on average 16 years old ($SD = .89$, range 14–18). Half of students (50%) were entering their senior year of high school in the subsequent fall term, while 36% were entering their junior year and 13% were entering their sophomore year. Most participants identified either as Asian (65%, $n = 167$), Latinx (15%, $n = 39$) or White (10%, $n = 26$). Additionally, 17 students identified as multiethnic, most commonly Asian and White ($n = 7$) or Latinx and White ($n = 3$). Finally, seven students identified as Middle Eastern and five as Black. We categorized participants as being an underrepresented minority (URM) in STEM if they identified as Latinx, Black, or multiethnic with Latinx or Black as one of their ethnic categories. By this definition, 20% of participants ($n = 51$) were designated as URM. Finally, three-quarters (76%, $n = 194$) of the sample had a mother who had at least finished college, while 13% ($n = 34$) had a mother who had finished high school but did not complete a four-year degree and 8% ($n = 21$) had a mother who had not finished high school. Potential first-generation students, defined as those not having a mother who had graduated from a four-year college, made up 20% of the sample ($n=50$).

2.2 Procedure

Students attending the summer internship were sent an email invitation to participate in the survey at the beginning of the summer. Following informed consent, participants completed the survey online from their own computer. Survey completion took about 25 min on average. Participants did not receive compensation for their time.

2.3 Measures

2.3.1 Demographic variables

Students were asked to report their gender, age, year in school, and maternal education level. Additionally, they were asked to indicate their ethnic or racial background. Finally, they were asked to report their most recent math grade.

2.3.2 STEM competence and value beliefs

Seven questions based on the expectancy-value framework (e.g., Eccles and Wigfield 1995) were used to measure participants' competence (i.e., expectancy) beliefs and value beliefs in science, technology, engineering, and mathematics (STEM). Three questions asked about STEM *competence beliefs* ($\alpha=.86$). For example, one item asked, "In general, how confident are you in your ability to do well in STEM courses?" (1 = *not at all confident* to 5 = *extremely confident*). Four questions asked about *value beliefs* ($\alpha=.80$). For instance, one question asked, "In general, how interesting or fun do you find working on assignments in STEM?" (1 = *very boring* to 5 = *very interesting*). Scores were averaged for each scale.

2.3.3 Stereotypes about STEM people

Based on prior research studies (e.g., Cheryan et al. 2013b), the Nerd-Genius STEM Stereotypes Scale (Starr 2018) assessed participants' endorsement of stereotypes about people in STEM people. Initially, the scale was designed to assess four domains: genius, socially awkward, unattractive, and romantically unsuccessful. However, a factor analysis revealed a two-factor model was the best fit with the latter three subscales loading together (see Starr 2018). Thus, two subscales were analyzed in the present study: The genius subscale included two items ("People who succeed in STEM careers are geniuses," "People who succeed in STEM careers are naturally gifted," $\alpha = .68$). The nerd subscale included six items ("People who work in STEM are socially awkward," People who work in STEM lack a social life," "People who work in STEM are 'nerdy' in appearance," "People who work in STEM don't spend a lot of time on their physical appearance," "People who work in STEM find dating difficult," "People who work in STEM are not romantically attractive," $\alpha = .90$). Items rated on a 6-point scale (1 = *strongly disagree* to 6 = *strongly agree*). Also, scores were averaged for each subscale.

2.3.4 Self-concepts

Student self-concepts were measured using one question for the nerd self-concept and one question for genius self-concept. For the nerd self-concept, the item was "I consider myself a geek or a nerd". For the *genius self-concept*, the item was "I am naturally gifted in STEM subjects." Students answered on a 5-point scale from 1 (*not at all like me)* to 5 (*very much like me*).

3 Results

3.1 Preliminary analyses and demographic comparisons

Descriptive statistics and bivariate correlations among the variables are presented in Table 1. We also include students' self-identified gender, URM status, and potential first-generation status (i.e., mother had not attained college degree) in these analyses. Boys were significantly more likely than girls to endorse the stereotype that people in STEM are nerdy and marginally more likely to endorse the genius stereotype. Also, when compared to girls, boys held significantly higher competence and value beliefs in STEM. Non-URM students were significantly more likely to believe that people who work in STEM are nerdy when compared to URM students, and non-URM students had significantly higher competence and value beliefs in STEM. Finally, students whose mother had attained a college degree held significantly higher STEM competence beliefs when compared to those who had not. Given these differences, we controlled for students' gender, URM status, and potential first-generation status in the later analyses.

As expected, those who identified as girls (vs. boys), URM (vs. non-URM), and/or potential first-generation college students (vs. with mothers with college degrees) were significantly less likely to hold the genius self-concept (see Table 1). There were no significant differences based on demographics for holding the nerd self-concept.

3.2 Regression analysis plan

We hypothesized that there would be a significant interaction between both STEM stereotypes and the related self-concept for both STEM competence beliefs and

Table 1 Descriptive statistics and bivariate correlations (N = 256)

	1	2	3	4	5	6	7	8	9	10
1. STEM competence beliefs	–	.508***	.264***	−.244***	−.175**	−.157*	.064	.047	.278***	.594***
2. STEM value beliefs		–	.188**	−.192**	−.195**	−.091	−.084	−.004	.225***	.321***
3. Math grade			–	−.203**	−.398***	−.401***	.136*	.069	.016	.351***
4. Gender				–	.098	.088	−.241***	−.116	.037	−.264***
5. URM					–	.560***	−.169**	−.007	−.010	−.177**
6. Potential first-generation						–	−.095	.011	−.036	−.212**
7. Nerd stereotype							–	.445***	.068	.074
8. Genius stereotype								–	.053	.163**
9. Nerd self-concept									–	.222***
10. Genius self-concept										–
Scale range	1–5	1–5	1–10	0–1	0–1	0–1	1–6	1–6	1–5	1–5
Mean	3.75	4.32	8.82	N/A	N/A	N/A	2.71	3.50	3.08	3.41
SD	.73	.58	1.33	N/A	N/A	N/A	1.00	1.12	1.22	.99

Gender (1 = girl, $n = 151$; 0 = boy, $n = 105$). URM = Underrepresented Minority Status (1 = URM, $n = 51$; 0 = non URM, $n = 205$). Potential first-generation (1 = mother has not graduated from 4-year college [$n = 50$]; 0 = mother has graduated from 4-year college [$n = 201$])

*$p < .05$; **$p < .01$; ***$p < .001$

STEM value beliefs. We conducted separate regression analyses with each of these two outcome variables.

For each STEM stereotype and self-concept, we first centered the variables by subtracting the mean from each score. Then for each regression, a three-step hierarchical regression was employed to test our hypotheses. In the first step we controlled for students' math grade, gender, URM status, and potential first-generation status. (Initially, we also included students' age in the first step, but it was not significant in any of the analyses; therefore, the regressions were repeated without this variable to increase statistical power.) In the second step, we entered the STEM stereotype and related self-concept. In the third step, we tested the STEM stereotype × self-concept interaction.

For any regressions with a significant STEM stereotype × self-concept interaction, the simple slope was calculated for each dependent variable at high self-concept (+ 1SD), moderate self-concept (at the mean), and low self-concept (− 1SD), while still controlling for math grade, gender, URM status, and first-generation status.

The results of the four hierarchical regressions and simple slopes are summarized below. These include separate regressions with STEM competence beliefs and STEM value for both of the STEM stereotypes and related self-concepts.

3.3 Hypothesis 1: Nerd stereotype and self-concept

3.3.1 STEM competence beliefs

Both the first step and second step significantly added to the model. However, the interaction between nerd stereotype endorsement and self-concept was not significant, $F_{change}(1, 243) = 2.37$, $p = .125$. In the first step, both female gender (negative relation) and math grade (positive relation) significantly contributed to STEM competence beliefs. In the second step, nerd self-concept significantly positively contributed to STEM competence beliefs, $\beta = .29$, $t(243) = 5.02$, $p < .001$; but nerd stereotype endorsement did not, $\beta = -.05$, $t(243) = -.80$, $p = .428$.

3.3.2 STEM value beliefs

The first step, the second step, and the final step (stereotype × self-concept interaction) each significantly added to the model (see Table 2). In the first step, female gender and URM status were both negatively related to STEM value beliefs. In the second step, endorsing the STEM = nerd stereotype was negatively related to STEM value beliefs, while the nerd self-concept was positively related to STEM value. In the third step of the regression analysis when the stereotype × self-concept interaction was entered, there was a significant increase in accounted variance of STEM value beliefs, $\Delta R^2 = .02$, $F_{change}(1, 243) = 4.46$, $p = .04$.

Probing the interaction revealed that the hypothesis was correct. After controlling for math grade, gender, URM status, and potential first-generation status, the simple slope between nerd stereotype and self-concept was significant for students who reported either (a) low nerd self-concept, $\beta = -.29$, $t(243) = -3.77$, $p = < .001$;

Table 2 Hierarchical regression analysis with STEM value beliefs in relation to nerd stereotype and self-concept (N = 256)

Variable	Model 1			Model 2			Model 3		
	B	*SE B*	*β*	*B*	*SE B*	*β*	*B*	*SE B*	*β*
Math grade	.055	.031	.122+	.059	.030	.131**	.063	.030	.139*
Female gender	−.178	.074	−.150*	−.238	.072	−.201**	−.238	.072	−.201*
Underrepresented minority	−.260	.111	−.177*	−.310	.106	−.211**	−.305	.105	−.208*
Potential first-generation	.102	.111	.070	.129	.106	.088	.139	.105	.095
Nerd stereotype				−.112	.036	−.190**	−.109	.036	−.186*
Nerd self-concept				.124	.028	.257***	.130	.028	.270***
Stereotype × self-concept							.062	.029	.123*
R^2_{change}	.080			.093			.015		
F_{change}	5.34**			13.64***			4.46*		

Potential first-generation: 1 = mother has not graduated from 4-year college. 0 = mother has graduated from 4-year college

$^{+}p < .10$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

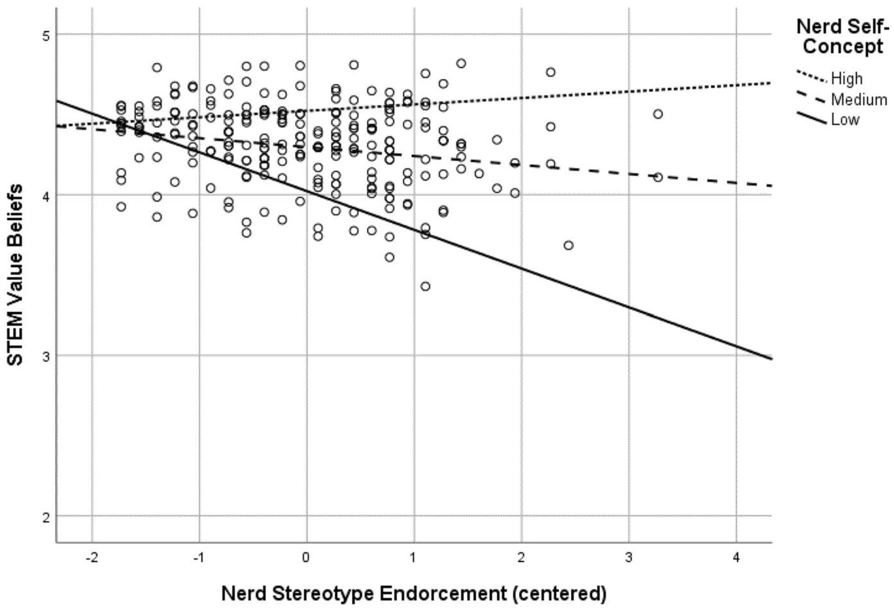

Fig. 1 STEM value beliefs: nerd stereotype by nerd self-concept
Note Stereotype is significant at medium and low self-concept. Controlling for math grade, gender, underrepresented minority status, and potential first-generation status

Table 3 Hierarchical regression analysis with STEM competence beliefs in relation to genius stereotype and self-concept (N = 256)

Variable	Model 1			Model 2			Model 3		
	B	*SE B*	*β*	*B*	*SE B*	*β*	*B*	*SE B*	*β*
Math grade	.114	.038	.201**	.036	.033	.063	.032	.033	.057
Gender	−.299	.091	−.201**	−.139	.078	$-.093^{+}$	−.149	.077	$-.100^{+}$
Underrepresented minority	−.144	.136	−.078	−.156	.114	−.085	−.149	.113	−.080
Potential first-generation	−.027	.136	−.015	.080	.115	.044	.054	.114	.030
Genius stereotype				−.033	.033	−.051	−.040	.033	−.061
Genius self-concept				.417	.041	.562***	.419	.040	.564***
Stereotype × self-concept							.089	.034	.132**
R^2_{change}	.122			.263			.017		
F_{change}	8.57***			52.23**			6.94		

Potential first-generation: 1 = mother has not graduated from 4-year college. 0 = mother has graduated from 4-year college

$^{+}p < .10$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

or (b) medium nerd self-concept, β = −.19, $t(243) = -3.07$, $p = .002$. Thus, among students who did not strongly view themselves as a nerd, endorsing the stereotype that people in STEM are nerdy was negatively related to STEM value beliefs. Conversely, among students who had high nerd self-concept, stereotype endorsement was not significantly related to value beliefs. Furthermore, among people who did not endorse the stereotype, there was no significant difference between STEM value beliefs based on high, medium, or low nerd self-concept. However, this difference became significant at medium nerd stereotype endorsement and widened at high nerd stereotype endorsement. See Fig. 1 for a display of this interaction effect.

3.4 Hypothesis 2: Genius stereotype and mathematically gifted self-concept

3.4.1 STEM competence beliefs

When testing predictors of STEM competence beliefs, each of the three steps in the hierarchical regression added significantly to the model (see Table 3). In the first step, math grade (positive) and female gender (negative) were both significantly related to STEM competence beliefs. In the second step, gifted self-concept was significantly related. In the third step, the interaction between genius stereotype and self-concept explained a significant increase in variance in STEM competence beliefs, $\Delta R^2 = .02$, $F_{change}(1, 243) = 6.94$, $p = .009$. Additionally, genius self-concept remained significant.

The interaction supported our hypothesis. After controlling for math grade, female gender, URM status, and potential first-generation status, the simple slope

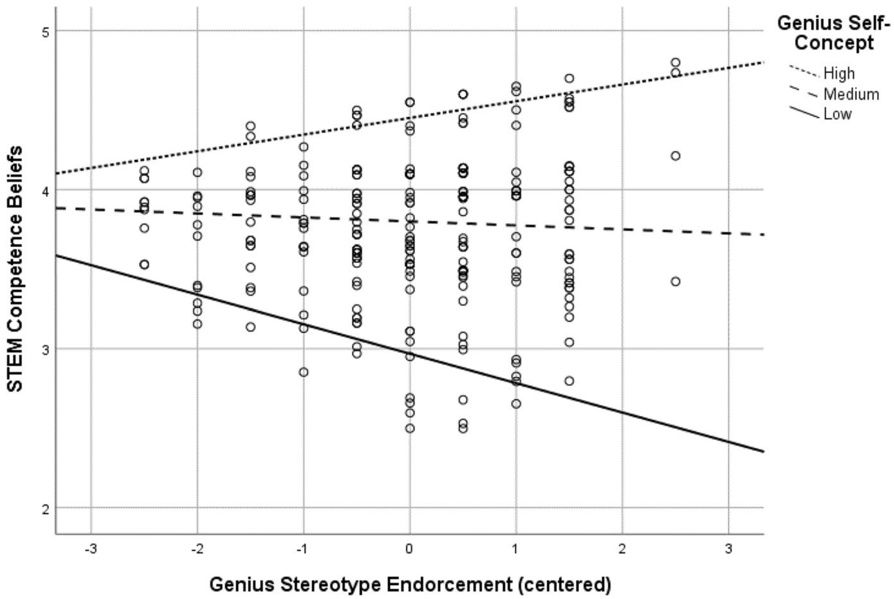

Fig. 2 STEM competence beliefs: genius stereotype by genius self-concept
Note Stereotype significant at low levels of self-concept. Controlling for math grade, gender, underrepresented minority status, and potential first-generation status

between the genius stereotype and STEM competence beliefs was significant for students who reported low on the STEM genius self-concept, $\beta = -.20$, $t(243) = -2.63$, $p = .009$. In contrast, the genius stereotype was unrelated to STEM competence beliefs for students who reported high on the STEM genius self-concept, $\beta = .08$, $t(243) = 1.09$, $p = .28$. Furthermore, among people who did not endorse the stereotype, there was no significant difference between STEM competence beliefs based on high, medium, or low genius self-concept. However, this difference became significant at medium genius stereotype endorsement and widened at high genius stereotype endorsement. The interaction effect is displayed in Fig. 2.

3.4.2 STEM value beliefs

In the regression with STEM value beliefs, only the first and second steps were significant. STEM value was positively associated with genius self-concept, $\beta = .28$, $t(243) = 4.27$, $p = < .001$, and it was unrelated to genius stereotyping, $\beta = -.07$, $t(243) = -1.13$, $p = .260$. Contrary to our hypotheses, genius self-concept was not a significant moderator.

4 Discussion

Our study explored whether self-concepts moderated the relationship between STEM stereotypes and STEM motivation among U.S. high school students. Stereotypes related to STEM may diminish some students' STEM motivation when they are incongruous with their personal self-concepts. Conversely, endorsing stereotypes may enhance motivation when the stereotype is concordant with students' self-concepts. We examined both nerd and genius trait-based stereotypes about STEM and their related self-concepts. The results partially supported the hypothesized balanced identity model for both trait stereotypes. For both stereotypes, those who believed in the stereotype but did not hold the congruent self-concept reported significantly less motivation in STEM. Contrary to expectations, we did not find strong evidence that holding stereotype-congruent self-concepts positively predicted STEM motivation of high school students in our sample. Instead, endorsing nerd-genius stereotypes was not significantly related to the motivation of those who saw their self-concepts as congruent. Thus, we found support for a stereotype-threat effect but not for a stereotype-boost effect.

4.1 Nerd-genius STEM stereotypes may hinder STEM motivation, depending on your self-concepts

The present study suggests that some trait-based stereotypes about STEM people may be an influential factor in students' STEM motivation. However, the impact of these stereotypes may depend on the relevance of the stereotype to students' own self-concepts. Stereotypes may hinder STEM motivation when they threaten individuals' self-concepts or goals, but they may positively affect motivation when they are congruent with them. This premise is advanced in balanced identity theory (e.g., Cvencek et al. 2015; Greenwald et al. 2002), role-congruity theory (e.g., Diekman and Eagly 2008), the self-to-prototype matching approach (e.g., Hannover and Kessels 2004; Niedenthal et al. 1985), the stereotype threat model (Steele 2010), and self-categorization theory (e.g., Turner et al. 1987). That is, each of these models posits that motivation in a domain is shaped by an individuals' perceived similarity or dissimilarity to representative members of a group. As discussed below, the present results lent support to the balanced identity model for those with incongruent self-concepts and stereotyped beliefs (stereotype threat)—but not for those with congruent self-concepts and stereotyped beliefs (stereotype boost).

First, the hypothesized balanced identity model was partially supported for the STEM = nerd stereotype. Among students who did not see themselves as nerdy, endorsing this stereotype was negatively related to STEM value beliefs. This finding is congruent with research that many people view people in STEM as unattractive, socially awkward, and unable to find romantic partners, and that this may be negatively related to STEM motivation (Cheryan et al. 2013b; Ehrlinger et al. 2018; Starr 2018). Thus, the STEM = nerd stereotype appeared to have a stereotype threat effect for this group. In contrast, among people who expressed strong belief that they were nerdy, holding the STEM = nerd stereotype was unrelated to STEM value-beliefs.

This suggests that endorsing the stereotype did not boost STEM motivation—but at least it did not appear to undermine it.

In addition, the hypothesized balanced identity model was similarly affirmed regarding the nerd-genius stereotypes and self-concepts. When students did not believe they were math geniuses, endorsing the STEM = genius stereotype was negatively associated with STEM motivation. Once again, however, the obverse was not indicated; among students who viewed themselves as gifted in math, endorsing the STEM = genius stereotype was unrelated to STEM motivation.

In addition to being consistent with balanced identity theory, the result regarding the STEM = genius stereotype complements research on mindsets. The latter work has found that people may be less motivated to pursue a domain that is viewed as requiring a fixed or innate talent (e.g., "genius") due to fear of failure (Dweck 2007). The present results suggest that having a fixed mindset about a domain such math or other STEM fields may undermine motivation when students do not see themselves as highly gifted. At the same time, having a positive self-concept may not necessarily boost one's motivation.

It is notable that congruence regarding the nerd stereotype and self-concept predicted STEM value beliefs, while congruence regarding the genius stereotype and self-concept predicted STEM competence beliefs. Endorsing STEM = nerd stereotypes may lead individuals to devalue STEM, while endorsing STEM = genius stereotypes may result in lowering individuals' competence beliefs (discussed below). In Starr's (2018) recent study of undergraduates, the nerd and genius facets were combined in a composite measure of STEM stereotyping. The present study suggests it may be helpful to consider them separately as they may affect STEM motivation in somewhat different ways.

The negative association between endorsing the STEM = nerd stereotype and STEM value was strongest among those who did not self-identify as nerdy. Given the importance of popularity and sexual attractiveness to many teens (see Furman and Rose 2015), stereotyping STEM as nerdy may lead some students to see these fields as incompatible with attaining their interpersonal goals; hence, some adolescents may consider STEM as personally undesirable and thereby devalue these subjects. In contrast, the negative association between endorsing the STEM = genius stereotype and STEM competence beliefs was specific to those who did not see themselves as gifted in math. Rather than threaten their perceived social standing (as suggested for the STEM = nerd stereotype), the genius stereotype may affect some students' sense of confidence (or competence) in STEM. In this regard, there may have been something akin to a stereotype threat effect whereby the thought of having to be a genius to succeed in a field leads to lowered confidence (e.g., Dweck 2007; Pronin et al. 2004; Steele 2010). Finally, it is notable that the attributes associated with the nerd stereotype (e.g., socially awkward) are generally characteristics that people wish to avoid, while the genius stereotype is a positive stereotype involving an attribute that many persons may desire. This may additionally account for why the nerd stereotype significantly related to lower value beliefs while the genius stereotype significantly related to lower competence beliefs.

4.2 Implications for understanding disparities in STEM achievement

When stereotypes about members of a particular professional group are incongruent with one's self-concept, then it may be less likely that a person would be motivated to belong to that group (Greenwald et al. 2002). However, gender, ethnicity/race, potential first-generation college status, and other background characteristics may moderate these associations because they may affect the likelihood that individuals endorse particular stereotypes or self-concepts (see Leaper 2015). In the present study, boys (vs. girls) and non-URM (vs. URM) students were on average more likely to endorse the STEM stereotypes regarding being nerdy. Also, girls (vs. boys), URM (vs. non-URM) students, and potential first-generation students (vs. those with a mother who graduated from college) on average scored lower on the math-genius self-concept.

Among those who belonged to one or more groups with lower average math self-concepts, perhaps their motivation was more adversely affected by the STEM-genius stereotype. Girls may be less likely to think of themselves as gifted in math because girls and women are less likely to be considered geniuses in U.S. culture (e.g., Storage et al. 2016; Szymanowicz and Furnham 2013) or to consider themselves as highly intelligent (Bian et al. 2017). As a result, they may be more threatened by fields stereotyped as requiring brilliance (Bian et al. 2018). Similarly, Black individuals are less likely to be considered highly intelligent in U.S. society (Steele 2010), and similar stereotypes may exist for Latinx individuals.

4.3 Limitations, future directions, and practice implications

Overall, our study helps to advance balanced identity theory, the self-to-prototype matching model, and other similar theories of motivation. The present research highlights how the incongruence between endorsed stereotypes and self-concepts in a given domain, such as STEM, may affect the motivation of adolescents. At the same time, as reviewed below, there are areas in which future work can build and improve upon our investigation.

First, the present study focused on a sample of high school students attending a summer science internship program at a university. Students enrolled in a summer science internship in comparison to other students at their schools may hold fewer negative STEM stereotypes as well as higher competence and value beliefs. As a result, it is possible that these stereotypes may be more likely to negatively affect students from a general adolescent sample. Therefore, we recommend conducting similar research among students in a high school setting.

Second, it would be interesting to test the balanced identity model among a cross section of developmental periods. Stereotypes that are incongruent with student self-concepts may be less likely to affect elementary school students due to limited transitive logical thinking skills (Patterson and Bigler 2018). However, some research using implicit measures of stereotyping suggest that the balanced identity model may still extend to younger ages (Cvencek et al. 2015).

Third, when evaluating the balanced identity model, we recommend utilizing more extensive measures of self-concepts and stereotypes. Our study used only one question to measure each self-concept. Also, it may be helpful to consider other kinds of stereotypes about people in STEM. For example, these fields are often viewed as low in satisfying communal goals (e.g., Diekman et al. 2010).

A fourth direction for future research is to investigate possible mechanisms that explain how stereotypes affect motivation. Prior studies suggest STEM identity may partly mediate associations between stereotypes and STEM motivation (Cundiff et al. 2013). Thus, it is possible that STEM identity or feelings of belongingness mediate the relationship between self-concepts and stereotypes to STEM motivation.

Fifth, we recommend considering the relative contributions of different STEM Stereotypes × Self-Concept interactions to students' STEM motivation in studies with larger samples sizes. That is, it could be helpful to determine whether incongruence with one stereotype is more pernicious than another. Relatedly, there are other negative stereotypes about STEM to consider, such as STEM not being a helping profession (e.g., Diekman et al. 2010) or being only for men (e.g., Cvencek et al. 2015; Nosek and Smyth 2011).

Finally, if stereotypes about people in STEM are undermining some students' motivation, then we hope that teachers, families, and media outlets will seek ways to counteract them. For example, teachers can directly challenge some STEM stereotypes in classrooms, such as the view that scientists are "brilliant geniuses" or lack an active social life (e.g., Danbold and Huo 2017). Teachers might also showcase diverse kinds of individuals who work in STEM as exemplars. To do so, teachers might use examples from the This is What a Scientist Looks Like project (Wilkinson 2014). More generally, it is important to expose students to STEM representatives from diverse backgrounds that dispel common stereotypes. In doing so, teachers should be careful not to use representatives who simply reinforce White male nerd-genius stereotypes as this may demotivate students (e.g., Bamberger 2014). Hyper-feminine examples may be similarly discouraging as they may not be believable and may alienate some girls (Betz and Sekaquaptewa 2012). Relatedly, it would be helpful if positive images of scientists were more pervasive in popular media (e.g., Luong and Knobloch-Westerwick 2017).

4.4 Conclusions

The present study extends prior research on the associations between STEM stereotypes and students' STEM motivation. Although a few studies have noted how endorsing stereotypes about people in STEM may predict high school or college students' STEM interest (Cheryan et al. 2013b; Ehrlinger et al. 2018; Garriott et al. 2017; Master et al. 2016; Starr 2018), we considered the combined effects of nerd-genius STEM stereotypes and self-concepts in relation to high school students' STEM motivation. Notably, we found evidence to partially support a balanced identity or self-to-prototype matching model (as well as other similar approaches) whereby the impact of stereotypes on motivation may depend on the extent they are congruent or incongruent with individuals' self-concepts (e.g., Ferguson et al.

2010; Greenwald et al. 2002; Hannover and Kessels 2004; Niedenthal et al. 1985). Trait-based stereotypes about STEM, such as that people in STEM are geniuses or socially incompetent, may steer some individuals away from STEM if these views are incongruent with their self-concepts. At the same time, some trait-based stereotypes about STEM may not affect the interest of some individuals who find the stereotype matches their self-concept. Finally, to the extent that there may be average gender, ethnic, and parental educational differences in relevant self-concepts, STEM stereotypes may contribute to current gaps in STEM.

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Compliance with ethical standards

Conflict of interest Neither author has any conflicts of interest.

Ethical approval The study was approved by the University of California Santa Cruz Institutional Review Board.

Informed consent Informed consent was obtained from all participants. Additionally, parents were sent an informational letter with the option to opt their child out of the study.

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