Research Microcultures as Socialization Contexts for Underrepresented Science Students

Dustin B. Thoman[1], Gregg A. Muragishi[2], and Jessi L. Smith[3]

[1]Department of Psychology, San Diego State University; [2]Department of Psychology, Stanford University; and [3]Department of Psychology, Montana State University

Abstract
How much does scientific research potentially help people? We tested whether prosocial-affordance beliefs (PABs) about science spread among group members and contribute to individual students' motivation for science. We tested this question within the context of research experience for undergraduates working in faculty-led laboratories, focusing on students who belong to underrepresented minority (URM) groups. Longitudinal survey data were collected from 522 research assistants in 41 labs at six institutions. We used multilevel modeling, and results supported a socialization effect for URM students: The aggregate PABs of their lab mates predicted the students' own initial PABs, as well as their subsequent experiences of interest and their motivation to pursue a career in science, even after controlling for individual-level PABs. Results demonstrate that research labs serve as microcultures of information about the science norms and values that influence motivation. URM students are particularly sensitive to this information. Efforts to broaden participation should be informed by an understanding of the group processes that convey such prosocial values.

Most attention to broadening participation in science and increasing science diversity focuses on high school preparation or foundational undergraduate gateway classes, where much attrition occurs. Yet the loss of diverse talent continues downstream; it is especially devastating when students make it past the foundational levels of science education and then drop out. Thus, we focus on a second gateway for undergraduates: research experiences in faculty-led laboratories. This hands-on, lab-based setting shapes the development of a career in science, especially for students belonging to underrepresented minority (URM) groups (Barlow & Villarejo, 2004; Nagda, Gregerman, Jonides, von Hippel, & Lerner, 1998). Research experience builds academic and professional skills (Strayhorn, 2010), and the lab provides a highly important context for socialization into science (Hunter, Laursen, & Seymour, 2006). In the current study, we focused on the lab as a socialization context and examined whether group differences in prosocial-affordance beliefs (PABs) about science across labs shape the development of interest in science and interest in a future research career, particularly for URM students.

To understand interest in science, it is important to understand how students develop an image of what it means to be a scientist (Cheryan, Master, & Meltzoff, 2015). The research lab is where students often have their first glimpse of learning what it means to become a scientist (Hunter et al., 2006), to think and work like a scientist (Seymour, Hunter, Laursen, & DeAntoni, 2004), and experience doing science day-to-day (Hurtado, Cabrera,

Corresponding Author:
Dustin B. Thoman, Department of Psychology, San Diego State University, 5500 Campanile Dr., San Diego, CA 92182
E-mail: dthoman@mail.sdsu.edu

Lin, Arellano, & Espinosa, 2009). Working closely with lab peers (i.e., their lab mates) is likely to be the first group socialization context in which URM students learn about the behavior and beliefs of others who are doing science. Of course, not all labs are the same. Outcomes of this socialization process should therefore differ across labs. We argue that PABs about science in the research laboratory can be thought of as a microculture that can foster or impede the development of a given student's interest in science.

The research laboratory setting is rich with information about the culture, values, and norms of science. According to goal-congruity theory (e.g., Diekman & Steinberg, 2013), students' career interest depends on how much science meets—or fails to meet—valued work-purpose goals. The two categories of work-purpose goals that receive the most empirical attention are self-oriented, agentic goals (e.g., to have a prestigious job) and other-oriented, prosocial or communal goals (e.g., to help other people). Converging evidence suggests that for URM students, the extent to which science careers are seen to fulfill goals that have a prosocial purpose or communal utility predicts the extent of interest in science (Diekman, Clark, Johnston, Brown, & Steinberg, 2011; Gibbs & Griffin, 2013; Thoman, Brown, Mason, Harmsen, & Smith, 2015). For example, the less that Native American freshmen feel that science affords opportunities to give back and help other people, the lower their experience of interest in their science classes (Smith, Cech, Metz, Huntoon, & Moyer, 2014). Many URM students' cultural backgrounds and identities lead them to place greater significance on the value of helping other people and contributing to one's community through work, compared with non-URM students (Fryberg & Markus, 2007; Villarruel et al., 2009). For students whose cultural backgrounds lead them to highly value other-focused prosocial work goals, science careers are often seen as lacking in opportunities to fulfill these goals, which creates the potential for a mismatch—real or perceived—between students and science careers (Fryberg, Covarrubias, & Burack, 2013; Smith et al., 2014; Stephens, Fryberg, Markus, Johnson, & Covarrubias, 2012).

The prosocial and communal value of science can be conveyed to students with positive results. Students feel more positive toward research and more interested in science careers when more prosocial-purpose messages are included in descriptions of research (Brown, Smith, Thoman, Allen, & Muragishi, 2015) or when they read about the day in the life of a scientist that highlights communal activities (Diekman et al., 2011). When assigned to write about how their biology coursework is relevant to their lives, first-generation URM college students' grades improve. They also tend to write more about prosocial themes than do other students (Harackiewicz, Canning, Tibbetts, Prinisky, & Hyde, 2016). Students in general

benefit from discovering a purpose for their educational pursuits that is beyond the self (Yeager et al., 2014).

Socialization of Beliefs About Science's Affordances for Prosocial Purpose Among Lab Mates

Aschbacher, Li, and Roth (2010) suggest that differences in backgrounds and cultural capital create microclimates that influence whether and how students develop an understanding of what science means and whether they see science as important, interesting, and relevant for their future selves. We use the term *microculture*, rather than microclimate, to highlight students' immediate social context (i.e., lab mates). We theorize that the research lab serves as a microculture of information about the values of science, and we posit that students' interest in science research and careers is shaped by their lab mates' PABs regarding science. Particularly for URM students, who have a stronger cultural orientation toward fulfilling prosocial values through their work and less cultural capital to inform their beliefs about what science is compared with students from well-represented backgrounds (e.g., Cole & Espinoza, 2008), we argue that being in a lab with peers who believe that science provides greater opportunities to fulfill prosocial-purpose goals promotes more interest in the research experience and greater future interest in science compared with being in a lab with peers who perceive science as less likely to fulfill prosocial-purpose goals.

We built on prior research on peer groups as a socialization context for school motivation. During adolescence, peers influence a wide range of academic-engagement behaviors and motivations (Fredricks, Blumenfeld, & Paris, 2004; Juvonen, Espinoza, & Knifsend, 2012; Rodkin & Ryan, 2012), including the intrinsic value of school (Shin & Ryan, 2014) and interest in science, technology, engineering, and mathematics (STEM) careers (Robnett & Leaper, 2013). Ryan's (2000) peer-group-socialization model suggests that experiences with peers influence an adolescent's motivation, engagement, and achievement through modeling, information exchange, and reinforcement of peer norms and values. Experimental research has isolated each mechanism, but during authentic peer-group interactions that occur over time, these socialization mechanisms unfold in concert and become mutually reinforcing (Rodkin & Ryan, 2012; Ryan, 2000).

The study we report here is unique in that it focused on PABs regarding the purpose of science (which are generally missing from the peer-socialization literature) and on a later developmental stage that is more proximal to career choices. Models of career interest typically assume that interests at this stage of development are driven by individual experiences and values and are much less influenced by other people than in earlier stages (i.e.,

adolescence; Renninger, Nieswandt, & Hidi, 2015). We argue that PABs regarding science that are shared within the social-group context of the research lab provide a particularly powerful socialization context for URM students who make it to this stage of science education.

We collected longitudinal data from students working in more than 40 faculty labs at six institutions. Multilevel modeling allowed us to separate student-level and lab-level socialization effects of PABs regarding science to test the prediction that lab mates' PABs would predict subsequent interest in science research and sciences careers for URM students. Further, we conducted a series of analyses to rule out several alternative explanations related to between-lab differences in belonging, other science beliefs, and lab composition.

Method

Participants and data-selection criteria

Participants consisted of 522 undergraduate research assistants (59.4% female; 53.6% White, 20.5% Asian, 11.5% Latino or Hispanic, 7.9% Native American, 2.6% African American, and 5.1% multiple races or other race; 31.1% first-generation college students; median age = 21 years). They worked in biomedical research labs at one California university, two Montana universities, and three tribal colleges in Montana and were recruited to participate in a longitudinal study. The size of the lab groups ranged from 2 to 38 (median = 8, 25th percentile = 4, 75th percentile = 12). URM students were classified on the basis of self-reported ethnicities (or at least one of their ethnicities, in the case of people who reported multiple ethnicities) of Latino, Native American, or African American. Although African Americans are included in this category, the small number in our sample means that conclusions about URM students primarily reflect data from Latinos and Native Americans. Data collection for this study was stopped after new participants were no longer added to the 4-year longitudinal study, which was originally planned for a total sample of 600. Findings from a preliminary subset of this sample (*n* = 337), when recruitment was still ongoing, were reported by Thoman et al. (2015). That article's analysis examined how students' personal work goals and PABs regarding science predicted motivation. That analysis included only student-level data at only two time points and did not consider or test for any lab-level variables.

Procedure

Biomedical faculty (*N* = 41) at each institution who were eligible for funding from the National Institutes of Health were randomly selected to have their student research assistants participate in the study. Student participants were then recruited approximately 4 to 6 weeks into the academic term using contact information provided by the faculty (Time 1). The Time 1 survey included demographic information, student reports of their own work values, and the measure of PABs regarding science. Participants were given a follow-up survey at the end of that academic term (Time 2) and at the end of every subsequent term for up to 2 years (or seven survey waves, each approximately 4 months apart). All follow-up surveys (Time 2 through Time 7) were identical and included measures of beliefs about their lab's research in terms of prosocial, intrinsic, and extrinsic affordances; experience of interest in their research lab; sense of belonging in the lab; and interest in a science career. Participants were compensated with a $35 gift card for each survey they completed. Institutional review boards at every institution at which data were collected approved all procedures and materials.

Measures

Each of the measures described here was included in all Time 1 through Time 7 surveys. A table of reliability coefficients (Cronbach's α) for each measure at each time point is provided in Table S7 of the Supplemental Material available online. Mean αs across measurement times are reported later in the text.

PABs and work values. Students' PABs regarding their lab's research were measured using three items adapted from Johnson (2002). Participants rated each item on a Likert scale from 1 (*not at all*) to 5 (*very much*). Students rated the extent to which their research work "is worthwhile to society," "gives me an opportunity to be directly helpful to others," and "allows me to give back to my community." Participants' scores for the three items (α = .76) were averaged so that higher scores represented higher PABs regarding science. In addition, at Time 1 only, participants' personal values for work were measured with versions of the last two items reframed to ask about the extent to which it was personally important to fulfill that value through their work.

Beliefs about intrinsic and extrinsic affordances. As in the previous measure, items were adapted from Johnson (2002) to measure students' beliefs about intrinsic and extrinsic affordances provided by their lab's research. Participants rated each item on a Likert scale from 1 (*not at all*) to 5 (*very much*). Beliefs about intrinsic affordances were measured with 6 items (e.g., "The research work I do in this lab gives me the chance to be creative," α = .80) and were averaged together. Beliefs about extrinsic affordances were measured with four items (e.g., "Through my work as a research assistant in my lab, I have the chance to earn a good deal of money,"

α = .72) and were also averaged. In all cases, higher scores represent greater affordance beliefs.[1]

Interest in the research being conducted by the lab. Interest in the research being conducted by the lab was measured using six items (e.g., "I enjoy doing work in my research lab very much," α = .90) adapted from Smith, Sansone, and White (2007). Participants rated each item on a Likert scale from 1 (*strongly disagree*) to 7 (*strongly agree*). Scores were averaged so that higher scores represented higher interest in the research being conducted by the lab.

Sense of belonging in the lab. Sense of belonging in the lab was measured using 18 items (e.g., "People in my lab accept me") adapted from Walton and Cohen (2007). Participants rated each item on a Likert scale from 1 (*strongly disagree*) to 5 (*strongly agree*). Scores were averaged (α = .90) so that higher scores represented a higher sense of belonging in the lab.

Interest in pursuing a future career in science research. Interest in a science-research career was measured using six items (e.g., "Could you see yourself building a career as a science researcher?") adapted from Carroll, Shepperd, and Arkin (2009). Participants rated each item on a Likert scale from 1 (*not at all*) to 7 (*extremely*). Scores were averaged (α = .96) so that higher scores represented higher interest in a science career.

Results

Preliminary analyses

Testing for group differences in work values. A univariate analysis of variance was first conducted to examine whether group differences emerge as a function of participant ethnicity in reports of the extent to which participants value prosocial work goals. On the basis of the sizes of groups represented in the sample, ethnicity was coded into three groups: White, URM, and Asian. Results demonstrated a significant effect of ethnicity, $F(2, 497) = 5.98$, $p = .003$. Post hoc comparisons suggested that significantly lower prosocial work values were reported by White students ($M = 3.84$, $SD = .76$), $p = .002$, compared with URM students ($M = 4.09$, $SD = .77$), $p = .016$, or Asian students ($M = 4.05$, $SD = 4.05$); prosocial work values reported by URM and Asian students did not differ significantly ($p = .692$). This pattern of data suggests that URM and Asian participants held similarly high prosocial values for their work, which may indicate that they should have been grouped together in analyses. However, because underrepresented minorities face stigma in STEM fields, and Asians are often positively stereotyped in STEM fields,[2] it is plausible that perceptions of other people's beliefs may have different effects on the research experiences and motivations of URM and Asian students. Therefore, in all analyses, we maintain the three-group categorization for URM, Asian, and White participants.

Intraclass correlations. Multilevel analysis was required to separate variance across the individual-student and lab levels. Study predictions focused on the key lab-level variable representing lab mates' PABs regarding science, so it was important to determine the proportion of variance in each outcome that could be accounted for by differences at the lab level. We therefore calculated an intraclass correlation coefficient (ICC) for all study outcomes. The largest ICCs were for PABs (.12) and career interest (.16). The ICCs for interest in the lab's research (.05) and feeling a sense of belonging in the lab (.08) were smaller.

Multilevel-analysis overview

Study recruitment and data collection occurred over multiple years, so new students joined participating research labs each term on a rolling basis, and each lab was composed of different students each term (including summers; almost all research assistants worked throughout the year). Therefore, we used an autoregressive time-lag data structure for the multilevel model, which allowed us to predict outcomes measured at a given term (time *t*) from predictors measured at the previous term (time *t* − 1), as detailed in the equations that appear later in the text. This analysis strategy allowed for estimation of individual- and lab-level effects for all participants across successive terms, regardless of how long they stayed in the lab, and accounted for nesting of measures within individuals and research labs.

Study hypotheses were tested with a two-level model. All analyses were conducted in HLM (Version 7; Scientific Software International, Inc., Lincolnwood, IL; Raudenbush & Bryk, 2002) using maximum likelihood estimation with robust standard error estimates for fixed effects. Residual assumptions were verified for each model. The equations presented later specify all fixed and random effects estimated in the models. For the lab-level (Level 2) effects, we created an aggregate score for PABs regarding science for all students in the lab for each academic term of the study. Each term's aggregate score was composed of the mean of the ratings from only the students who participated in the lab (and our study) during that given term. For the individual-level (Level 1) effects, we computed individual scores for each participant for each term for which the student provided data. Thus, each PABs model included the lab-level score and the individual score for

each participant in each term. By always including the individual scores for PABs in all models that tested the lab-level PABs effect, we ensured that the lab-level (Level 2) aggregate scores were interpreted with individual scores covaried out (Raudenbush & Bryk, 2002) and therefore represented lab-level microculture scores from participants working contemporaneously in the lab at each point in time. Data at Level 1 were therefore missing for terms before the student was recruited or after the student completed participation (participants were tracked for up to 2 years each). HLM is flexible in handling missing data at Level 1, but it cannot estimate models with missing values at Level 2. Because Level 2 data (lab-level prosocial-purpose scores) were computed from aggregates of Level 1 scores, there were no missing data at Level 2.

Study hypotheses predicted that the aggregated lab-level PAB scores should more strongly predict subsequent research and career interest for URM students than for White or Asian students. Therefore, in the multilevel models, we tested for moderation by ethnicity through the inclusion of two dummy codes for ethnicity at Level 1: one comparing underrepresented minorities with Whites (0 = underrepresented minority, 1 = White) and the other comparing underrepresented minorities with Asians (0 = underrepresented minority, 1 = Asian). The URM group was assigned as the base group in this code scheme because it was the focal group for theoretical prediction regarding effects for lab-level PABs regarding science.

Although the study hypotheses focused on ethnicity, we also tested for moderation by looking at intersectional effects among participants' ethnicity, gender, and social class (i.e., whether students were first-generation college students or continuing generation). However, no significant effects were found for either gender or social class (or their interactions with ethnicity), and controlling for these variables did not change the results for effects of student ethnicity (reported later). Failure to find intersectional effects in the current data does not necessarily mean that such effects are not present in the population; other researchers have found intersectional effects in the context of science education (e.g., Harackiewicz et al., 2016). Intersectional tests were statistically underpowered in the present study. For example, among the URM students who also reported valid data on social class, 78 (54.5%) were first-generation college students and 65 (45.5%) were continuing-generation students. By comparison, White and Asian students were more likely to be continuing-generation students (84.5% and 64.5%, respectively). Thus, statistical tests for whether these intersectional identities moderate effects of lab-level PABs regarding science represent three-way cross-level interactions with relatively small values for *n* in several cells. All data and analyses are available on request.

To test for effects of lab mates' PABs regarding science on focal study outcomes, we separately regressed each individual's outcome (at time *t*) on the predictor variables in a multilevel model that included, at Level 1, the individual student's rating of their PABs at time $t - 1$ and the two ethnicity codes and, at Level 2, the lab-level PABs score at time $t - 1$. Specifically, we modeled the following equations:

Level 1 $\left(\text{individual}\right)$

$$\text{outcome}_{it} = \beta_{0j} + \beta_{1j} \left(\text{individual-level PABs}_{t-1}\right)$$
$$+ \beta_{2j}\left(\text{White}\right) + \beta_{3j}\left(\text{Asian}\right) + \varepsilon_{ij}$$

Level 2 $\left(\text{lab}\right)$

$$\beta_{0j} = \gamma_{00} + \gamma_{01}\left(\text{lab-level PABs}_{t-1}\right) + U_{0j}$$
$$\beta_{1j} = \gamma_{10} + U_{1j}$$
$$\beta_{2j} = \gamma_{20} + \gamma_{21}\left(\text{lab-level PABs}_{t-1}\right) + U_{2j}$$
$$\beta_{3j} = \gamma_{30} + \gamma_{31}\left(\text{lab-level PABs}_{t-1}\right) + U_{3j}.$$

In the Level 1 equations, *i* represents the individual, *j* represents the lab group, and ε represents the model residual variance. In the Level 2 equations, β_{0j} is the random intercept; β_{1j}, β_{2j}, and β_{3j} are the random slopes; γ_{00}, γ_{10}, γ_{20}, and γ_{30} are the fixed intercepts; γ_{01}, γ_{21}, and γ_{31} are the fixed slopes; and U_{0j}, U_{1j}, U_{2j}, and U_{3j} are the associated variances in the intercept and slopes. The continuous Level 1 predictor was centered on the group mean, and the Level 2 predictor was centered at the grand mean. Cross-level interactions between each dummy code and lab-level PABs regarding science were modeled as fixed slopes by entering the lab-level prosocial score to the corresponding Level 2 equations.

Results for all multilevel models are presented in two formats. First, we report outcomes from a model-building technique using likelihood ratio tests to compare differences in model deviance across sequential steps of nested models. An empty (or null) model, with only an intercept and no predictors, served as the baseline for initial comparison. The second model included only covariates that were not of theoretical interest. For example, in the equations presented earlier, this covariate-only model included individual PAB scores, the Level 1 predictor, at time $t - 1$, but no other Level 1 or Level 2 predictors. The third model added only the lab-level aggregate score (i.e., lab PAB score) to Level 2. The comparison between Models 2 and 3 represented the main effect of the research microculture. Finally, the fourth model added the two ethnicity dummy codes to Level 1, as well as the corresponding cross-level interaction terms that tested for

Table 1. Model Comparisons of the Multilevel Models Predicting Key Outcomes

Outcome variable and statistic	Model 1: null model	Model 2: covariates only	Model 3: lab-level PABs regarding science added	Model 4: participant's ethnicity added
Individual-level PABs about science				
Model deviance	1,634.32	855.9	848.31	832.27
Likelihood ratio test	—	$\chi^2(3) = 778.09$, $p < .001$	$\chi^2(1) = 7.58$, $p = .006$	$\chi^2(7) = 16.03$, $p = .025$
Experience of interest in research				
Model deviance	1,828.53	1,015.97	1,009.54	987.8
Likelihood ratio test	—	$\chi^2(3) = 813.53$, $p < .001$	$\chi^2(1) = 6.42$, $p = .011$	$\chi^2(11) = 21.65$, $p = .003$
Interest in a science career				
Model deviance	2,574.32	1,311.93	1,308.06	1,250.61
Likelihood ratio test	—	$\chi^2(7) = 1,262.39$, $p < .001$	$\chi^2(1) = 3.87$, $p = .046$	$\chi^2(13) = 57.44$, $p < .001$

Note: The table presents results of likelihood ratio tests comparing Models 2, 3, and 4 with the immediately preceding models (i.e., thereby testing the efficacy of adding new parameters). Model 1 included 3 parameters for predicting each outcome. Models 2, 3, and 4 included 6, 7, and 14 parameters, respectively, for predicting individual-level prosocial-affordance beliefs (PABs) about science and experience of interest in research. Models 2, 3, and 4 included 10, 11, and 24 parameters, respectively, for predicting interest in a science career.

whether ethnicity moderated the effects of PABs regarding science. Table 1 provides the model deviance and likelihood ratio tests for our three focal outcomes.

Second, to highlight the effects of lab-level PABs regarding science on outcomes for each group, we present tests of simple slopes for each group, calculated by recoding the ethnicity dummy codes for each analysis to make the focal group the reference group (i.e., giving a code of 0 to that group). With this strategy, γ_{01} represents the simple slope for the effect of the lab's aggregate prosocial score on the outcome for the reference group. Further, we provide a complete table of parameter estimates and significance tests for each parameter in each model (for analyses ruling out alternative explanations, see the Supplemental Material).

Testing whether lab mates' PABs regarding science predict individuals' PABs

To examine whether lab mates' PABs regarding science predicted students' own subsequent PABs, after controlling for their prior beliefs, we regressed individual students' ratings for PABs (individual PABs scores) at time t on the predictor variables in the multilevel model described previously. As reported in Table 1, likelihood ratio tests for each model-comparison step demonstrated that the addition of the lab-level scores for PABs (Model 3) and ethnicity codes (Model 4) significantly improved the model fit over the fit of the previous nested models. As shown in Tables 2 and 3, lab mates' PABs at time $t - 1$

significantly predicted PABs for URM participants at time t (because URM students were the reference group, effects for γ_{01} can be interpreted as the simple-slopes effect of lab scores for PABs among URM students), even after controlling for individuals' own PABs at time $t - 1$. Further, results presented in Table 2 suggest that the effect of lab mates' PABs on individuals' PABs did not differ between URM and Whites students or between URM and Asian students (see parameters γ_{21} and γ_{31}, respectively). Simple-slopes analyses suggested that the relationship between lab mates' PABs and individuals' PABs was significant for both URM students, $b = 0.29$, 95% confidence interval (CI) = [0.15, 0.43], $t(33) = 3.74$, $p < .001$, and Asian students, $b = 0.53$, 95% CI = [0.25, 0.81], $t(33) = 3.67$, $p < .001$, but not White students, $b = 0.25$, 95% CI = [−0.25, 0.75], $t(33) = 1.00$, $p = .322$.

Testing whether lab mates' PABs regarding science affects individuals' interest in research over time

To examine whether lab mates' PABs regarding science predicted students' scores for experience of interest in their research over time, we estimated the same model described in the equations; this time, however, research interest at time t was the outcome. As shown in Table 1, likelihood ratio tests for each model-comparison step demonstrated that the addition of the lab-level scores for PABs (Model 3) and ethnicity codes (Model 4) significantly improved the model's fit. The significance of Model 3, which added only the lab-level scores for PABs, is

Table 2. Results From the Multilevel Model Using Lab Mates' Prosocial-Affordance Beliefs (PABs) Regarding Science to Predict Individuals' PABs: Fixed Effects

Fixed effect	Unstandardized regression coefficient	95% confidence interval	t	p
Individual-level PABs regarding science (t)				
URM mean, γ_{00}	4.00	[3.94, 4.06]	$t(33) = 118.29$	< .001
URM lab-level PABs regarding science, γ_{01}	0.29	[0.15, 0.43]	$t(33) = 3.74$	< .001
Individual-level PABs regarding science ($t - 1$): mean, γ_{10}	0.48	[0.34, 0.62]	$t(34) = 7.16$	< .001
White: mean, γ_{20}	−0.35	[−0.15, −0.05]	$t(33) = −3.28$	.002
Lab-level PABs regarding science, γ_{21}	−0.04	[−0.57, 0.43]	$t(33) = −0.16$	.874
Asian: mean, γ_{30}	−0.05	[−0.21, 0.11]	$t(33) = −0.58$	.565
Lab-level PABs regarding science, γ_{31}	0.24	[−0.13, 0.55]	$t(33) = 1.46$	.163

Note: Ethnicity was dummy-coded (0 = underrepresented-minority student, and 1 = White or Asian, depending on the variable). URM = underrepresented-minority student.

important in this analysis because it demonstrated that individuals' PABs (which was included in Model 2) did not account for the effects of lab mates' PABs on individuals' interest in research: Lab mates' PABs predicted scores for research interest even when we controlled for individuals' PABs. Examining single coefficients (see Tables 4 and 5) suggests that both individuals' and lab mates' PABs significantly predicted subsequent research-interest scores for URM students.

The lab-level effect of PABs regarding science was greater for URM students than for White students, but there was no difference between Asian students and White students (see Table 4). Simple-slopes analyses suggested that the slope of the lab mates' PABs effect was significantly greater than zero for both URM students, $b = 0.55$, 95% CI = [0.27, 0.83], $t(33) = 3.86$, $p < .001$, and Asian students, $b = 0.45$, 95% CI = [0.11, 0.79], $t(33) = 2.56$, $p = .015$, but not for White students, $b = −0.01$, 95% CI = [−0.35, 0.33], $t(34) = −0.08$, $p = .935$ (see Fig. 1). As with the model predicting individual-level scores for PABs, lab mates' PABs seem to similarly predict subsequent

research interest for both URM and Asian students, but not White students, although the slope estimate was greatest for URM students.

Testing whether lab mates' PABs regarding science affect interest in a science career over time

Next, we examined the potential effects of lab mates' PABs regarding science on students' interest in a science career over time. We repeated the model above, but this time we also included students' experience of interest in research (at time t) to isolate unique effects on career interest uncontaminated by the students' immediate experience of interest in the lab they were working in. Given that the experience of task interest is a strong predictor of related career interest (Su, Rounds, & Armstrong, 2009), this analysis allowed us to isolate effects on career interest that theoretically should be directly affected by socialization processes within research microcultures.

Table 3. Results From the Multilevel Model Using Lab Mates' Prosocial-Affordance Beliefs (PABs) Regarding Science to Predict Individuals' PABs: Random Effects

Random effect	Standard deviation	Variance component	χ^2	p
Base experience of interest in research, U_{0j}	0.05	0.002	$\chi^2(6) = 1.67$	> .500
Individual-level PABs regarding science, U_{1j}	0.23	0.05	$\chi^2(7) = 10.64$	.025
White, U_{2j}	0.41	0.17	$\chi^2(6) = 2.98$	> .500
Asian, U_{3j}	0.10	0.01	$\chi^2(6) = 4.50$	> .500
Level 1 effect, ε_{ij}	0.64	0.41	—	—

Note: Ethnicity was dummy-coded (0 = underrepresented-minority student, and 1 = White or Asian, depending on the variable).

Table 4. Results From the Multilevel Model Using Lab Mates' Prosocial-Affordance Beliefs (PABs) Regarding Science to Predict Experience of Interest in Research: Fixed Effects

Fixed effect	Unstandardized regression coefficient	95% confidence interval	t	p
Experience of interest in research				
URM mean, γ_{00}	6.07	[5.92, 6.20]	$t(33) = 81.23$	< .001
URM lab-level PABs regarding science, γ_{01}	0.55	[0.27, 0.83]	$t(33) = 3.86$	< .001
Individual-level PABs regarding science: mean, γ_{10}	0.42	[0.26, 0.58]	$t(34) = 5.21$	< .001
White: mean, γ_{20}	−0.30	[−0.58, −0.02]	$t(33) = −2.07$	.036
White: lab-level PABs regarding science, γ_{21}	−0.56	[−1.06, −0.06]	$t(33) = −2.19$	.041
Asian: mean, γ_{30}	−0.27	[−0.49, −0.05]	$t(33) = −2.33$	.029
Asian: lab-level PABs regarding science, γ_{31}	−0.10	[−0.50, 0.30]	$t(33) = −0.48$	.539

Note: Ethnicity was dummy-coded (0 = underrepresented-minority student, and 1 = White or Asian, depending on the variable). URM = underrepresented-minority student.

As shown in Table 1, likelihood ratio tests for each model-comparison step demonstrated that the addition of the lab-level scores for PABs regarding science (Model 3) and ethnicity codes (Model 4) significantly improved the model fit over the fit of the previous nested models. For career interest, simple-slopes analyses demonstrated that lab-level PAB scores predicted greater interest in a science career only for URM students, $b = 0.81$, 95% CI = [−0.04, 1.64], $t(31) = 1.92$, $p = .064$, but not White students, $b = 0.22$, 95% CI = [−0.40, 0.84], $t(31) = 0.72$, $p = .473$, or Asian students, $b = 0.56$, 95% CI = [−0.68, 1.80], $t(31) = 0.90$, $p = .376$ (see Fig. 2). Unlike the model for research interest, however, these slopes did not statistically differ from one another because of the greater variability in point estimates (see Tables 6 and 7).

Testing alternative explanations

The multilevel approach to the data analysis allowed us to separate lab-level and individual-level effects, but a key limitation to drawing strong conclusions was that the data were correlational. Thus, it was important to test for potential alternative explanations by identifying variables that might correlate with between-lab differences in PABs regarding science and our key outcomes of research interest and career interest. We identified and tested three alternative explanations for results. We describe each analysis and central result in the text, and we provide detail in Tables S1 to S6 of complete results in the Supplemental Material.

Belonging. To test whether lab-level differences in PABs regarding science simply indicated more positive or

Table 5. Results From the Multilevel Model Using Lab Mates' Prosocial-Affordance Beliefs (PABs) Regarding Science to Predict Experience of Interest in Research: Random Effects

Random effect	Standard deviation	Variance component	χ^2	p
Base experience of interest in research, U_{0j}	0.15	0.02	$\chi^2(6) = 2.05$	> .500
Individual-level PABs regarding science, U_{1j}	0.29	0.09	$\chi^2(7) = 9.07$	.246
White, U_{2j}	0.53	0.28	$\chi^2(6) = 15.35$	.018
Asian, U_{3j}	0.31	0.09	$\chi^2(6) = 14.60$	.023
Level 1 effect, ε_{ij}	0.76	0.58	—	—

Note: Ethnicity was dummy-coded (0 = underrepresented-minority student, and 1 = White or Asian, depending on the variable).
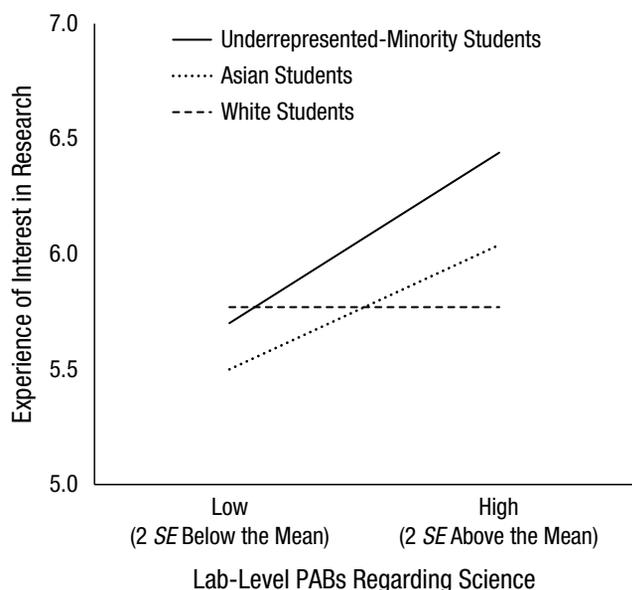
Fig. 1. Results of the simple-slopes analysis predicting students' experience of interest in research as a function of their ethnicity and their lab mates' prosocial-affordance beliefs (PABs) regarding science. The predicted research-interest values were computed from the multilevel model equation for the effect of the cross-level interaction between student ethnicity codes and lab-level PABs regarding science (low = 2 *SE* below the mean, high = 2 *SE* above the mean), controlling for individuals' PABs.

less positive feelings about the lab experience, we tested whether students' lab peers' aggregated scores on sense of belonging in the lab predicted students' scores for research interest and career interest. At the individual level, feelings of belonging in the lab was often positively correlated with research interest (Anderman & Kaplan, 2008; Thoman, Arizaga, Smith, Story, & Soncuya, 2014; Thoman, Smith, Brown, Chase, & Lee, 2013), and we reasoned that a microculture of more or less feelings of belonging in a lab should reflect between-labs differences in general experience, separately from specific PABs regarding science. We tested for an effect of lab mates' sense of belonging in the lab on individual students' feelings of belonging in the lab. We first tested the belonging effect separately from the effects of PABs regarding science and then included both in a model together.

The model equations in our first analysis were identical to those used to test for effects of PABs regarding science, except that we included individual-level and lab-level belonging scores at Levels 1 and 2, respectively, instead of scores for PABs. When predicting research interest, model-comparison results demonstrated that, compared with the covariates model that included only individual-level feelings of belonging as a predictor, the addition of lab-level feelings of belonging did not improve the model, $\chi^2(1) = 0.53$, $p > .500$. Adding the

ethnicity variables and cross-level interactions also failed to improve the model, $\chi^2(13) = 18.59$, $p = .136$. When we examined individual parameters, neither the lab-level feelings-of-belonging term nor any of the cross-level interactions associated with lab-level feelings of belonging approached significance. Simple-slopes analyses further demonstrated that lab-level feelings-of-belonging scores did not significantly predict research interest for URM students, $b = -0.37$, 95% CI = [-1.01, 0.27], $t(30) = -1.16$, $p = .254$; Asian students, $b = 0.06$, 95% CI = [-0.74, 0.86], $t(30) = 0.15$, $p = .844$; or White students, $b = -0.13$, 95% CI = [-0.51, 0.45], $t(30) = -0.71$, $p = .480$.

This same pattern was found in models predicting career interest. Adding lab-level feelings of belonging to the covariates model did not improve the model, $\chi^2(1) = 1.41$, $p = .232$, and although adding the ethnicity terms and cross-level interactions did improve the model, $\chi^2(15) = 30.60$, $p = .010$, the improvement was unrelated to the lab-level feelings of belonging, which suggests that model improvement resulted from differences in group means of career interest. Simple-slopes analyses further demonstrated that lab-level feelings of belonging did not significantly predict career interest for URM students, $b = -0.71$, 95% CI = [-2.53, 1.11], $t(30) = -0.62$, $p = .539$;
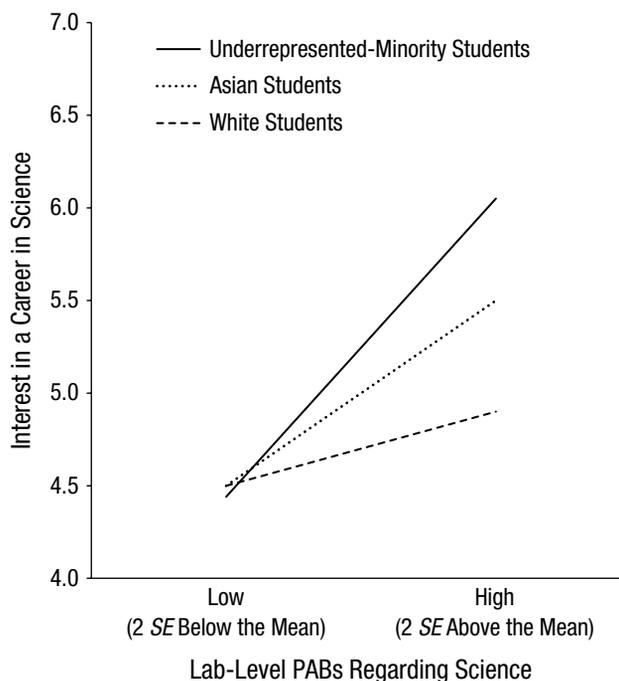
Fig. 2. Results of the simple-slopes analysis predicting students' interest in a science career as a function of their ethnicity and their lab mates' prosocial-affordance beliefs (PABs) regarding science. The predicted values for interest in a science career were computed from the multilevel model equation for the effect of the cross-level interaction between student ethnicity codes and lab-level PABs regarding science (low = 2 *SE* below the mean, high = 2 *SE* above the mean), controlling for individuals' PABs and individuals' experience of interest in research.

Table 6. Results From the Multilevel Model Using Lab Mates' Prosocial-Affordance Beliefs (PABs) Regarding Science to Predict Interest in a Science Career: Fixed Effects

Fixed effect	Unstandardized regression coefficient	95% CI	t	p
Interest in a science career				
URM mean, γ_{00}	5.35	[4.95, 5.75]	$t(31) = 27.01$	< .001
URM lab-level PABs regarding science, γ_{01}	0.81	[−0.04, 1.64]	$t(31) = 1.92$	.064
Individual-level PABs regarding science: mean, γ_{10}	0.003	[−0.18, 0.18]	$t(32) = 0.03$	.974
White: mean, γ_{20}	−0.60	[−1.14, −0.06]	$t(31) = −2.19$	.036
White: lab-level PABs regarding science, γ_{21}	−0.57	[−1.63, 0.49]	$t(31) = −1.06$	.297
Asian: mean, γ_{30}	−0.23	[−1.08, 0.72]	$t(31) = −0.49$	.623
Asian: lab-level PABs regarding science, γ_{31}	−0.25	[−2.12, 1.60]	$t(31) = −0.26$	.798
Experience of interest in research: mean, γ_{40}	0.66	[0.38, 0.94]	$t(32) = 4.52$	< .001

Note: Ethnicity was dummy-coded (0 = underrepresented-minority student, and 1 = White or Asian, depending on the variable). URM = underrepresented-minority student.

Asian students, $b = −0.96$, 95% CI = [−2.78, 0.86], $t(30) = −1.05$, $p = .301$; or White students, $b = −0.51$, 95% CI = [−1.47, 0.45], $t(30) = −1.05$, $p = .300$.

Finally, when we added individual-level and lab-level feelings-of-belonging scores to the original PABs-regarding-science model (separately for predicting research interest and career interest, respectively), the findings already reported for lab-level PABs were virtually unchanged (see Tables S1 and S2 in the Supplemental Material). Thus, differences across students in research interest or career interest could not be explained by between-labs differences in feelings of belonging, and controlling for between-labs differences in feelings of belonging did not change the effects of PABs on research or science-career interest.

Accounting for other affordance beliefs about science. To test whether other fundamental beliefs about science better accounted for effects on research interest and career interest, we considered two additional general affordance beliefs. The first, intrinsic-affordance beliefs regarding science, refers to beliefs that science provides opportunities to fulfill important intrinsic goals of passion for one's work, curiosity, and achievement. At the individual level, past research has shown that such intrinsic-purpose beliefs about science are stronger predictors of interest than PABs regarding science, but even when these intrinsic beliefs are accounted for, PABs still significantly predict interest for URM students but not White students (Thoman et al., 2015).

Table 7. Results From the Multilevel Model Using Lab Mates' Prosocial-Affordance Beliefs (PABs) Regarding Science to Predict Interest in a Science Career: Random Effects

Random effect	Standard deviation	Variance component	χ^2	p
Base interest in science career, U_{0j}	0.83	0.68	$\chi^2(6) = 26.52$	< .001
Individual-level PABs regarding science, U_{1j}	0.19	0.04	$\chi^2(7) = 5.23$	> .500
White, U_{2j}	1.10	1.22	$\chi^2(6) = 19.71$	.003
Asian, U_{3j}	1.99	3.96	$\chi^2(6) = 34.80$	< .001
Experience of interest in research, U_{4j}	0.53	0.28	$\chi^2(7) = 8.12$	.321
Level 1 effect, ε_{ij}	1.23	1.50	—	—

Note: Ethnicity was dummy-coded (0 = underrepresented-minority student, and 1 = White or Asian, depending on the variable).

The second, extrinsic-affordance beliefs regarding science, refers to the degree to which students believe science affords the opportunity to earn money, have prestige, and garner accolades. Particularly for URM students, who are also disproportionately likely to come from families with fewer financial resources, science-career aspirations tend to be more strongly influenced by extrinsic motivations (Jackson, Galvez, Landa, Buonora, & Thoman, 2016).

Replicating the steps from the main analysis, we created lab-level aggregate scores for intrinsic and extrinsic-affordance beliefs. We added to the PABs-regarding-science moderation model the individual students' scores for intrinsic- and extrinsic-affordance beliefs about science at Level 1 and lab-level scores at Level 2. The model included the same dummy codes for ethnicity at Level 1 and the cross-level interactions for the effects of all three lab-level variables (PABs regarding science, intrinsic-affordance beliefs regarding science, and extrinsic-affordance beliefs regarding science) on research interest.

Model-comparison results demonstrated that adding lab-level intrinsic and extrinsic scores to a model that included all other individual variables (i.e., individual-level scores for PABs regarding science, intrinsic-affordance beliefs regarding science, and extrinsic-affordance beliefs regarding science) did not improve the model, $\chi^2(2) = 1.88$, $p > .500$. However, adding lab-level PABs scores to this model (which already included the other individual-level and lab-level variables) resulted in a significant improvement, $\chi^2(1) = 7.25$, $p = .007$. Although adding ethnicity and all of the related cross-level interactions did not improve the model, $\chi^2(19) = 21.67$, $p = .300$, results for the key individual terms of theoretical interest remained consistent with results from previous analyses. That is, even after we controlled for individual-level and lab-level differences in intrinsic- and extrinsic-affordance beliefs, results involving lab-level PABs were replicated (see Table S3 in the Supplemental Material). Simple-slopes analyses again showed that lab mates' scores for PABs significantly predicted research interest for URM students, $b = 0.59$, 95% CI = [0.35, 0.83], $t(29) = 4.71$, $p < .001$. This effect was much smaller for Asian students, $b = 0.35$, 95% CI = [0.01, 0.69], $t(29) = 2.08$, $p = .046$, and lab mates' scores for PABs had no relationship to research interest for White students, $b = 0.06$, 95% CI = [−0.22, 0.34], $t(29) = 0.41$, $p = .685$. Further, for all students, individual-level intrinsic-affordance beliefs and individual-level PABs regarding science predicted research interest. At the lab level, there were no effects of intrinsic or extrinsic beliefs for any group.

We created an analogous model predicting career interest, again controlling for individual differences in career interest. Model-comparison results again demonstrated that adding lab-level intrinsic and extrinsic scores to a model that included all other individual variables did not improve model fit, $\chi^2(2) = 0.69$, $p > .50$. Although adding the lab-level score for PABs regarding science to this model that already included the other individual-level and lab-level variables this time did not produce a significant improvement, $\chi^2(1) = 3.15$, $p = .072$, adding ethnicity and all of the related cross-level interactions dramatically improved the model, $\chi^2(21) = 52.78$, $p < .001$. As found for the model predicting research interest, results for the key individual terms remained consistent with results of previous analyses of career interest. Our results replicated all the findings for PABs and URM students (for individual variables, see Table S4 in the Supplemental Material). Lab-level PABs were more strongly related to career interest for URM students, $b = 0.75$, 95% CI = [−0.09, 1.63], $t(29) = 1.68$, $p = .103$, than for Asian students, $b = 0.72$, 95% CI = [−0.62, 2.06], $t(29) = 1.08$, $p = .287$, and White students, $b = 0.28$, 95% CI = [−0.16, 0.72], $t(29) = 1.26$, $p = .216$.

Surprisingly, within this full model, individual-level extrinsic beliefs, but not intrinsic beliefs, predicted increases in career interest for all students (see Table S4 in the Supplemental Material).

Lab-group composition. Finally, because URM students tend to more highly value prosocial opportunities in science than non-URM students (e.g., Smith et al., 2014), we reasoned that the number of URM students in a lab during a given semester might correlate with the lab's score for PABs regarding science that semester. Therefore, effects of PABs might be explained by the composition (or diversity) of the lab. We computed three versions of the lab-composition score for each lab each semester. First, we computed the percentage of URM students in the lab (ethnicity composition). Second, we computed the percentage of students in the lab who identified as women (gender composition). Third, we computed the percentage of students in the lab who identified as first-generation college students (social-class composition). There was much overlap in these variables. In separate models, we entered each composition variable into the PABs model at Level 2, in each equation that included lab-level PABs. A model with all three lab-diversity variables and their cross-level interactions could not be tested because the number of parameters estimated via maximum likelihood would exceed the degrees of freedom. We report effects for the ethnicity-composition model in the next paragraph, but all models demonstrated the same pattern: Composition did not predict experience of interest in research or career interest, and effects related to lab-level PABs replicated results reported earlier.

For each outcome variable, we used the model-comparison approach to determine whether adding the

percentage of URM students in the lab during a given semester would improve the model compared with the covariates model. Adding lab's ethnicity composition to the covariates model did not improve its performance in predicting experience of interest in research, $\chi^2(1) = 0.86$, $p > .500$, or interest in a science career, $\chi^2(1) = 0.76$, $p > .50$. As shown by the individual parameters presented in Tables S5 and S6 in the Supplemental Material, effects related to lab-level PABs regarding science were the same as reported earlier.

Discussion

Group processes are a necessary but understudied aspect of development of interest in science in undergraduate research labs, which are critical gateways into science careers. To our knowledge, this study is the first to analyze group-level PABs regarding science among lab mates. Even after ruling out several alternative explanations, our results supported the socialization prediction: What students' lab mates believed about the prosocial nature of their research predicted not only the students' own PABs but also, particularly for URM students, their subsequent research and career motivation, over and above the effects of student's own initial beliefs. These findings extend psychological work on peers as a socialization context by demonstrating that (a) peers shape student motivation even during later stages of development; (b) peers' PABs, in addition to their values and engagement behaviors, matter for science motivation; and (c) theory-driven predictions can be used to identify when peer groups differentially affect URM students.

In contrast to the pattern of results for URM students, results for Asian students were inconsistent across outcomes. Effect estimates were positive, but the variability was greater than for other students (even though the number of Asian students in the sample was larger than that of URM students). Asian students are not a homogeneous group, and there are vast differences in lived experience between Southeast Asian students and East Asian students in the United States (e.g., Le & Gardner, 2010). The university from which most Asian students were recruited has a large population of South Asian and Southeast Asian students, but demographic data allowing for disaggregation among Asian subgroups was unavailable. The variability in our findings suggests that a nuanced understanding is needed for racial- or ethnic-minority students who may or may not be underrepresented in science but face unique challenges nonetheless.

Effects of lab mates' PABs regarding science were moderated only by ethnicity, not by gender or social class. Previous research has highlighted the role of communal goals and cultural mismatches for women (Diekman et al., 2011) and first-generation college students (Stephens et al., 2012). It is unclear whether our focus on lab mates' PABs among advanced undergraduate students accounts for why we found effects only of race, or whether other factors (e.g., the particular diversity of our sample or institutional contexts or relatively low statistical power for intersectional analyses) explain these differences across studies. Future research is needed on the social processes influencing motivational experiences of students from all types of intersecting social identities (Else-Quest & Hyde, 2016).

What is clear from these findings is that the lab setting in which students work is a powerful microculture shaping URM students' interest in science. The more that an URM student's lab mates believed that science has prosocial value, the more that student was interested in that lab's research and in a science career. This research ties together several theoretical frameworks, including Ryan's (2000) model of peer group socialization, goal-congruity theory (Diekman & Steinberg, 2013), and expectancy-value theory (specifically utility value; Eccles, 2005; Harackiewicz et al., 2016). Our findings support theoretical assertions about the importance of one's social context and social identity for interest development (Thoman, Sansone, Fraughton, & Pasupathi, 2012; Thoman et al., 2013; Thoman, Sansone, & Geerling, in press). Further work is needed to detail how, psychologically and behaviorally, lab mates' beliefs affect student motivation; this research should be informed by the socialization mechanisms identified in the educational peer-influence literature (Rodkin & Ryan, 2012).

Conclusion

Knowledge about science and socialization into science may be affected by many sources, including the beliefs and values of one's family, portrayals in the media, and experiences in school classrooms. Our findings demonstrate that research labs serve as microcultures of information about science norms and values that influence motivation. Lab mates' PABs about science influence their peers' motivation and career interests over time, particularly for URM students. Evidence of this prosocial-purpose socialization among lab mates suggests that efforts to broaden participation in science need to incorporate the study of group processes during this critical science gateway.

Action Editor

Ayse K. Uskul served as action editor for this article.

Author Contributions

D. B. Thoman developed the study concept. All the authors designed the study and collected data. G. A. Muragishi performed the data analysis under the supervision of D. B. Thoman. All the authors interpreted the data. D. B. Thoman and J. L. Smith drafted the manuscript, and G. A. Muragishi provided critical revisions. All the authors approved the final version of the manuscript for submission.

Supplemental Material

Additional supporting information can be found at http://journals.sagepub.com/doi/suppl/10.1177/0956797617694865

Open Practices

All materials have been made publicly available via the Open Science Framework and can be accessed at https://osf.io/gtv89/. The complete Open Practices Disclosure for this article can be found at http://journals.sagepub.com/doi/suppl/10.1177/0956797617694865. This article has received the badge for Open Materials. More information about the Open Practices badges can be found at http://www.psychologicalscience.org/publications/badges.

Notes

1. For this scale, we had complete data for only 9 participants at Time 7. The results were unchanged when we reran analyses after removing these participants.
2. However, different subgroups of Asians perceive and experience science stereotypes about their subgroups differently (e.g., Le & Gardner, 2010); we return to this point in the Discussion section.

References

Anderman, L. H., & Kaplan, A. (2008). The role of interpersonal relationships in student motivation: Introduction to the special issue. *The Journal of Experimental Education*, *76*, 115–119. doi:10.3200/JEXE.76.2.115-120

Aschbacher, P. R., Li, E., & Roth, E. J. (2010). Is science me? High school students' identities, participation, and aspirations in science, engineering, and medicine. *Journal of Research in Science Teaching*, *47*, 564–582. doi:10.1002/tea.20353

Barlow, A. E. L., & Villarejo, M. (2004). Making a difference for minorities: Evaluation of an educational enrichment program. *Journal of Research in Science Teaching*, *41*, 861–881. doi:10.1002/tea.20029

Brown, E. R., Smith, J. L., Thoman, D. B., Allen, J. M., & Muragishi, G. A. (2015). From bench to bedside: A communal utility value intervention to enhance students' biomedical science motivation. *Journal of Educational Psychology*, *107*, 1116–1135. doi:10.1037/edu0000033

Carroll, P. J., Shepperd, J. A., & Arkin, R. M. (2009). Downward self-revision: Erasing possible selves. *Social Cognition*, *27*, 550–578. doi:10.1521/soco.2009.27.4.550

Cheryan, S., Master, A., & Meltzoff, A. N. (2015). Cultural stereotypes as gatekeepers: Increasing girls' interest in male-dominated STEM fields by diversifying stereotypes. *Frontiers in Psychology, 6*, Article 49. doi:10.3389/fpsyg.2015.00049

Cole, D., & Espinoza, A. (2008). Examining the academic success of Latino students in science technology engineering and mathematics (STEM) majors. *Journal of College Student Development*, *49*, 285–300.

Diekman, A. B., Clark, E. K., Johnston, A. M., Brown, E. R., & Steinberg, M. (2011). Malleability in communal goals and beliefs influences attraction to STEM careers: Evidence for a goal congruity perspective. *Journal of Personality and Social Psychology*, *101*, 902–918. doi:10.1037/a0025199

Diekman, A. B., & Steinberg, M. (2013). Navigating social roles in pursuit of important goals: A communal goal congruity account of STEM pursuits. *Social & Personality Psychology Compass*, *7*, 487–501. doi:10.1111/spc3.12042

Eccles, J. S. (2005). Subjective task value and the Eccles et al. model of achievement-related choices. In A. J. Elliot & C. S. Dweck (Eds.), *Handbook of competence and motivation* (pp. 105–121). New York, NY: Guilford Press.

Else-Quest, N. M., & Hyde, J. S. (2016). Intersectionality in quantitative psychological research: I. Theoretical and epistemological issues. *Psychology of Women Quarterly*, *40*, 155–170. doi:10.1177/0361684316629797

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research*, *74*, 59–109.

Fryberg, S. A., Covarrubias, R., & Burack, J. A. (2013). Cultural models of education and academic performance for Native American and European American students. *School Psychology International*, *34*, 439–452. doi:10.1177/0143034312446892

Fryberg, S. A., & Markus, H. R. (2007). Cultural models of education in American Indian, Asian American and European contexts. *Social Psychology of Education*, *10*, 213–246. doi:10.1007/s11218-007-9017-z

Gibbs, K. D., & Griffin, K. A. (2013). What do I want to be with my PhD? The roles of personal values and structural dynamics in shaping the career interests of recent biomedical science PhD graduates. *CBE Life Sciences Education*, *12*, 711–723. doi:10.1187/cbe.13-02-0021

Harackiewicz, J. M., Canning, E. A., Tibbetts, Y., Prinisky, S. J., & Hyde, J. S. (2016). Closing achievement gaps with a utility-value intervention: Disentangling race and social class. *Journal of Personality and Social Psychology, 111,* 745–765. doi:10.1037/pspp0000075

Hunter, A. B., Laursen, S. L., & Seymour, E. (2006). Becoming a scientist: The role of undergraduate research in students' cognitive, personal, and professional development. *Science Education, 91,* 36–74. doi:10.1002/sce.20173

Hurtado, S., Cabrera, N. L., Lin, M. H., Arellano, L., & Espinosa, L. L. (2009). Diversifying science: Underrepresented student experiences in structured research programs. *Research in Higher Education, 50,* 189–214. doi:10.1007/s11162-008-9114-7

Jackson, M. C., Galvez, G., Landa, I., Buonora, P., & Thoman, D. B. (2016). Science that matters: The importance of a cultural connection in underrepresented students' science pursuit. *CBE Life Sciences Education, 15*(3), ar42. doi:10.1187/cbe.16-01-0067

Johnson, M. K. (2002). Social origins, adolescent experiences, and work value trajectories during the transition to adulthood. *Social Forces, 80,* 1307–1341. doi:10.1353/sof.2002.0028

Juvonen, J., Espinoza, G., & Knifsend, C. A. (2012). The role of peer relationships on academic and extracurricular engagement in school. In S. L. Christenson, A. L. Reschly, & C. Wylie (Eds.), *Handbook of research on student engagement* (pp. 397–401). London, England: Springer.

Le, T., & Gardner, S. K. (2010). Understanding the doctoral experience of Asian international students in the science, technology, engineering, and mathematics (STEM) fields: An exploration of one institutional context. *Journal of College Student Development, 51,* 252–264. doi:10.1353/csd.0.0127

Nagda, B. A., Gregerman, S. R., Jonides, J., von Hippel, W., & Lerner, J. S. (1998). Undergraduate student-faculty research partnerships affect student retention. *The Review of Higher Education, 22,* 55–72.

Raudenbush, S. W., & Bryk, A. S. (2002). *Hierarchical linear models: Applications and data analysis methods* (2nd ed.). Newbury Park, CA: Sage.

Renninger, K. A., Nieswandt, M., & Hidi, S. (2015). *Interest in mathematics and science learning.* Washington, DC: American Education Research Association.

Robnett, R. D., & Leaper, C. (2013). Friendship groups, personal motivation, and gender in relation to high school students' STEM career interest. *Journal of Research on Adolescence, 23,* 652–664. doi:10.1111/jora.12013

Rodkin, P., & Ryan, A. M. (2012). Child and adolescent peer relations in an educational context. In K. Harris, S. Graham, & T. Urdan (Eds.), *APA educational psychology handbook* (Vol. 2, pp. 363–389). Washington, DC: American Psychological Association.

Ryan, A. M. (2000). Peer groups as a context for the socialization of adolescents' motivation, engagement, and achievement in school. *Educational Psychologist, 35,* 101–111. doi:10.1207/S15326985EP3502_4

Seymour, E., Hunter, A. B., Laursen, S. L., & DeAntoni, T. (2004). Establishing the benefits of research experiences for undergraduates in the sciences: First findings from a three-year study. *Science Education, 88,* 493–534. doi:10.1002/sce.10131

Shin, H., & Ryan, A. M. (2014). Early adolescent friendships and academic adjustment: Examining selection and influence processes with longitudinal social network analysis. *Developmental Psychology, 50,* 2462–2472. doi:10.1037/a0037922

Smith, J. L., Cech, E., Metz, A., Huntoon, M., & Moyer, C. (2014). Giving back or giving up: Native American student experiences in science and engineering. *Cultural Diversity & Ethnic Minority Psychology, 20,* 413–429. doi:10.1037/a0036945

Smith, J. L., Sansone, C., & White, P. H. (2007). The stereotyped task engagement process: The role of interest and achievement in motivation. *Journal of Educational Psychology, 99,* 99–114. doi:10.1037/0022-0663.99.1.99

Stephens, N. M., Fryberg, S. A., Markus, H. R., Johnson, C. S., & Covarrubias, R. (2012). Unseen disadvantage: How American universities' focus on independence undermines the academic performance of first-generation college students. *Journal of Personality and Social Psychology, 102,* 1178–1197. doi:10/1037/a0027143

Strayhorn, T. L. (2010). Undergraduate research participation and STEM graduate degree aspirations among students of color. *New Directions for Institutional Research, 2010*(148), 85–93. doi:10.1002/ir.364

Su, R., Rounds, J., & Armstrong, P. I. (2009). Men and things, women and people: A meta-analysis of sex differences in interests. *Psychological Bulletin, 135,* 859–884. doi:10.1037/a0017364

Thoman, D. B., Arizaga, J. A., Smith, J. L., Story, T. S., & Soncuya, G. (2014). The grass is greener in non-science, technology, engineering, and math classes: Examining the role of competing belonging to undergraduate women's vulnerability to being pulled away from science. *Psychology of Women Quarterly, 38,* 246–258. doi:10.1177/0361684313499899

Thoman, D. B., Brown, E. R., Mason, A. Z., Harmsen, A. G., & Smith, J. L. (2015). The role of altruistic values in motivating underrepresented minority students for biomedicine. *BioScience, 65,* 183–188. doi:10.1093/biosci/biu199

Thoman, D. B., Sansone, C., Fraughton, T., & Pasupathi, M. (2012). How students socially evaluate interest: Peer responsiveness influences evaluation and maintenance of interest. *Contemporary Educational Psychology, 37,* 254–265. doi:10.1016/j.cedpsych.2012.04.001

Thoman, D. B., Sansone, C., & Geerling, D. (in press). The dynamic nature of interest. In P. A. O'Keefe & J. M. Harackiewicz (Eds.), *The science of interest.* New York, NY: Springer.

Thoman, D. B., Smith, J. L., Brown, E. R., Chase, J. P., & Lee, J. K. (2013). Beyond performance: The motivational experience model of stereotype threat. *Educational Psychology Review, 25,* 211–243. doi:10.1007/s10648-013-9219-1

Villarruel, F. A., Carol, G., Grau, J. M., Azmitia, M., Cabrera, N. J., & Chahin, T. J. (Eds.). (2009). *Handbook of U.S. Latino psychology: Developmental and community-based perspectives.* Thousand Oaks, CA: Sage.

Walton, G. M., & Cohen, G. L. (2007). A question of belonging: Race, social fit, and achievement. *Journal of Personality and Social Psychology, 92,* 82–96. doi:10.1037/0022-3514.92.1.82

Yeager, D. S., Henderson, M. D., Paunesku, D., Walton, G. M., D'Mello, S., Spitzer, B. J., & Duckworth, A. L. (2014). Boring but important: A self-transcendent purpose for learning fosters academic self-regulation. *Journal of Personality and Social Psychology, 107,* 559–580. doi:10.1037/a0037637