

The Influence of Microaffirmations on Undergraduate Persistence in Science Career Pathways

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ABSTRACT

The present studies aimed to advance the measurement and understanding of microaffirmation kindness cues and assessed how they related to historically underrepresented (HU) and historically overrepresented (HO) undergraduate student persistence in science-related career pathways. Study 1 developed and tested the dimensionality of a new Microaffirmations Scale. Study 2 confirmed the two-factor structure of the Microaffirmations Scale and demonstrated that the scale possessed measurement invariance across HU and HO students. Further, the scale was administered as part of a longitudinal design spanning 9 months, with results showing that students' reported microaffirmations did not directly predict higher intentions to persist in science-related career pathways 9 months later. However, scientific self-efficacy and identity, measures of student integration into the science community, mediated this relationship. Overall, our results demonstrated that microaffirmations can be measured in an academic context and that these experiences have predictive value when they increase students' integration into their science communities, ultimately resulting in greater intentions to persist 9 months later. Researchers and practitioners can use the Microaffirmations Scale for future investigations to increase understanding of the positive contextual factors that can ultimately help reduce persistence gaps in science, technology, engineering, and mathematics degree attainment.

INTRODUCTION

Advances in science, technology, engineering, and mathematics (STEM) are crucial for the future prosperity of the United States (President's Council of Advisors on Science and Technology [PCAST], 2012; National Academy of Sciences, 2016). At this time, however, significant shifts in the demographic makeup of the U.S. population are posing a challenge to the United States' ability to support STEM workforce needs, resulting in a call to identify evidence-based practices to broaden participation (Valantine and Collins, 2015). Similarly, diversifying the representation of students is recognized as essential for the United States to maintain its productivity and economic strength in a global marketplace and solve current challenges (George *et al.*, 2001; PCAST, 2012). Indeed, some argue that diversity directly impacts how problems are represented and solved, with research demonstrating that diverse groups of high-ability problem solvers typically outperform homogeneous groups of the very best problem solvers in computational simulations (Hong and Page, 2004). Despite knowing the benefits of having a diverse workforce, historically underrepresented (HU; i.e., African American, Hispanic or Latino/Latina, American Indian, Hawaiian/Pacific Islander, and Alaska Native) people have been pursuing STEM career pathways at significantly lower rates

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than their historically overrepresented (HO; i.e., white, Asian) counterparts, with the representation disparity increasing at each higher degree level (National Academies of Sciences, Engineering, and Medicine [NASEM], 2017).

The research described in this paper seeks to extend understanding about why undergraduate students persist in navigating science-related career pathways and to identify the similarities and differences among HU and HO students studying in the same academic context. Specifically, we explored how perceived positive social environmental cues contribute toward increasing student integration into the scientific community by elevating students' scientific self-efficacy and scientific identity levels, resulting in increased student intentions to persist in STEM.

Many theoretical models have advanced understanding on the circumstances of academic persistence among students in general (Wigfield and Eccles, 2000; Hidi and Renninger, 2006; Eccles, 2007; Deci and Ryan, 2008). Less research has focused specifically on predicting academic persistence among HU students in STEM. An example of the latter is social cognitive career theory (SCCT; Lent *et al.*, 1994), which hypothesizes that greater social support and fewer social barriers foster students' self-efficacy, that is, *their confidence that they can engage in specific behaviors or actions associated with their chosen discipline*. Crucially, SCCT predicts that the development of one's self-efficacy leads to STEM success, because self-efficacy facilitates interest in academic careers via positive outcome expectations (Lent *et al.*, 2005). Various studies by Lent and his colleagues have shown that self-efficacy related to a student's academic field is a helpful causal mechanism, or mediator, of STEM success (e.g., Lent *et al.*, 2011, 2013; Brown and Lent, 2016). SCCT explains the chronic underrepresentation of HU students as stemming from students' confidence deficiency, but others have shown that, for measuring longer-term career choices, contextual factors that foster social integration into discipline communities is strongly predictive of persistence (NASEM, 2017).

Integration into the Science Community Promotes Intentions to Pursue Research Careers

An additional theoretical model that predicts academic persistence among HU students in STEM is the tripartite integration model of social influence (TIMSI; Kelman, 2006). This model explains persistence 1 and 4 years after graduation as a function of three levels of integration into the scientific community. Estrada *et al.* (2011, 2018b) operationalized level 1 as scientific self-efficacy, building on previous work by Lent and colleagues (1994) and Chemers and colleagues (2011) in this area. Level 2 was operationalized as scientific identification with the discipline community, and level 3 as internalizing the values of the scientific community's objectives. Longitudinal results showed that each of these orientations were related to intentions to persist in science-related career pathways. Specifically, findings indicated that scientific self-efficacy and scientific identity individually predicted HU student persistence in STEM careers among undergraduates and graduate and postdoctoral students (Chemers *et al.*, 2001, 2011) and were predictive even up to 4 years after baccalaureate degree attainment (Estrada *et al.*, 2018b). The current research builds on this previous work to examine how perceived positive social environmental cues

contribute toward increasing student integration into the scientific community. The previous research in this area, however, was composed only of HU student participants. The current study aimed to advance this research by examining scientific self-efficacy and scientific identity in both HU and HO students and as resulting from the kindness cues of microaffirmations.

Kindness Cues Promote Integration into the Science Community

A recent review article on the subject of the social influence of kindness and community on student persistence in STEM suggests that, while student self-efficacy and identity matter, social contexts also contribute to promoting persistence in a meaningful way (Estrada *et al.*, 2018a). Research on stereotype threat, for example, describes the different ways in which academic settings explicitly and implicitly signal threat, inferiority, and noninclusion for HU students (Steele and Aronson, 1995; Steele, 1998). Chronically experiencing these adversities heightens distress and can result in de-identification with the science community (Aronson *et al.*, 1999; Stone, 2002). Critical race theory suggests that prejudice and racism are imbedded in higher education in ways that are extremely difficult to alter (Kozol, 1991; Ladson-Billings, 1998). From this literature emerged the concept of microaggressions, which Ellis and colleagues (2019) define as "forms of everyday discrimination that describes innocuous and explicit discriminatory communications to racially and socioeconomically marginalized groups" (p. 1). Sue and colleagues (2007) further define microaggressions as occurring through overt and covert microassaults, microinvalidation, and microinsults. These obvious and subtle communications of racism and prejudice are prevalent in higher education, sometimes imbedded in curricula, mentorship interactions, and science training programs, and have negative impacts on student emotional well-being and academic persistence (Solórzano, 1998; Solórzano *et al.*, 2000). Overall, these areas of research suggest that HU students encounter barriers as they navigate science-related career pathways that HO (noneconomically challenged) students face at lower rates. The conclusion is that academic institutions are not providing equitable experiences for those pursuing science-related degrees (Hurtado and Carter, 1997). However, elimination of microaggressions may not be sufficient to increase persistence among all students. Students also need to be provided with kindness cues that communicate inclusion and belonging, which may or may not be antithetical to the experience of microaggressions (Estrada *et al.*, 2018a).

Drawing from research that humans innately seek affiliation and attachment (Coon, 1946; Bowlby, 1969; Bakermans-Kranenburg *et al.*, 1973), Estrada *et al.* (2018a) proposed that kindness cues that affirm social inclusion within the science community contribute toward students' integration into their professional communities. As with aggression, affirmations can be communicated through macro- (i.e., larger obvious and easy to perceive) and microcommunication (i.e., subtle) channels. *Macroaffirmations* are obvious forms of communicating kindness (conveying respect for the dignity of another person) and inclusion, which may include sharing, helping, obvious facial expressions, politeness, and other readily recognized prosocial actions. *Microaffirmations*, on the other hand, are subtle or ambiguous kindness cues that can include tone of voice, space

left between people when interacting, subtle mimicry, and actions that convey vulnerability. This definition is broader than Ellis and colleagues' (2019) definition introducing the conception of microaffirmations to include microcompliments, microsupports, and microvalidations—all of which are measured through verbal communication (which extends work on microaggressions by Sue *et al.*, 2007). In this paper, microaffirmations can include subtle verbal and often nonverbal microcommunications that typically are considered more authentic than macrocommunications, because the communicator is less aware and able to control how he or she “leaks” communications to the perceiver (Koenig and Eagly, 2005).

When the macro- and microcommunications are not in alignment, HU students may experience an ambiguous, mixed-message environment that is confusing and even stressful (Estrada *et al.*, 2018a). For example, ambiguity can exist when university posters highlight African-American and Latino students (a macro level of communication), yet white and Asian students are more often called on in classes and used as examples of excellence. This type of “attributional ambiguity” is inherent to environments that elicit stereotype threat (Steele, 1997). That is, when HU students experience a lack of belonging, but do not know whether it arises from system injustice (an external attribution) or from internal “failure” (an internal attribution), the resultant process is increased rumination and self-monitoring that coconspire to deplete working memory and result in early exit (see Schmader *et al.*, 2008). In these ways, microaffirmations can be communicated in a variety of academic settings, including in the context of mentorship (Powell *et al.*, 2013), curriculum content, and training programs.

Differential Experiences of Affirmation in Higher Education

A review of the relevant literature suggests that kindness cues conveyed through microaffirmations that affirm inclusion are likely important to both HU and HO students' integration into the science community but may not be experienced at the same rate, or even in the same context, and may be differently emphasized. Experiencing a campus or discipline culture as unkind—including experiencing stereotype threat, prejudice, racism, or hostility—leads to an array of negative outcomes, including academic and social withdrawal, isolation, stress, cognitive fatigue, and exiting (see *Barriers and Opportunities for 2-Year and 4-Year STEM Degrees* report for full list of consequences and references to this body of literature; NASEM, 2016). Further, the Higher Education Research Institute's national study provided strong evidence that college culture influenced STEM student performance, engagement, and persistence, even when the influences of socioeconomic and academic preparation were controlled (Chang *et al.*, 2011).

Although less emphasized, positive student social experiences and interactions are critical to understanding academic persistence and are potentially orthogonal to aggression. Specifically, research on self-affirmation theory (Cohen and Sherman, 2007, 2014; Sherman *et al.*, 2013), communal goal affirmation (Diekmann *et al.*, 2010, 2011), and expectancy-value theory (Harackiewicz *et al.*, 2002, 2008; Durik *et al.*, 2006; Hulleman *et al.*, 2008) build off the stereotype threat literature to explicitly test how social contexts that better affirm students and connect to their values within the existing institutional

environment result in academic benefits. Robust research programs have demonstrated efficacy in reducing achievement gaps and promoting persistence in STEM fields among majority students with some evidence of efficacy among HU students (Harackiewicz *et al.*, 2014). These interventions of affirming a student or his or her values (i.e., cuing acceptance and affirmation of a person's identity, values, skill set) strongly suggest that perceiving affirmations may be important to persistence for science students. Further research is needed, however, to better understand the nuances of how HU and majority students are alike and differ with regard to these relationships.

In addition to there being contextual differences in affirmation experiences, differences in what is perceived as affirming may not be the same for all people. For example, research on culture and self shows that European Americans more consistently emphasize individualism, with greater value placed on individual and independent accomplishments (Oyserman *et al.*, 2002). In contrast, HU students are more likely to value community and cooperation over individualism and competition (Brown, 2008; Valenzuela, 2010), which can conflict with academic institutional values (Stephens *et al.*, 2012; Chang, 2018). Student emphasis can make a difference, with people who seek connection as a source of self-worth being less willing to persist in an environment that is competitive, nonwelcoming, rejecting, and even “cutthroat.” An emphasis on individualistic values can become highly problematic to the collectivistic sense of self. Some research is showing that HU scholars show benefits from connecting to communities (such as STEM-related clubs and organizations; Espinosa, 2011). These contexts provide opportunities to experience macro and microaffirmation kindness cues, which include respect for dignity and experiencing belonging to community, and may significantly increase a sense of social safety that is optimal for learning and persistence. These predictions align with theorizing and empirical findings on how affirming one's social belonging leads to a higher grade point average, in Black, but not in white seventh-grade students (Shnabel *et al.*, 2013) and that adopting approaches to science education that are more culturally aligned with learners has benefits (Mutegi, 2011; Cobern, 2012; Atwater *et al.*, 2013; Parsons and Carlone, 2013).

Summary of the Present Studies

The present studies aimed to advance the measurement and understanding of microaffirmation kindness cues and assessed how they related to HU and HO undergraduate student persistence toward science-related career pathways. In study 1, the Microaffirmations Scale was developed to assess the extent to which students experience microaffirmations, and exploratory factor analysis was used to investigate the dimensionality of the scale. After having observed the dimensionality of the Microaffirmations Scale across HU and HO students in study 1, in study 2, we sought to 1) confirm the observed dimensionality in a separate sample of students, 2) determine the extent to which the Microaffirmations Scale was similarly understood and interpreted across HU and HO students, and 3) answer two key research questions. First, does the experience of kindness cues that affirm inclusion, measured as microaffirmations, predict higher intentions to persist in science-related career pathways for HU and HO students? Second, do scientific self-efficacy and identity, measures of student integration into the science community,

mediate the relationship between microaffirmations and intentions to persist, such that those students who report higher microaffirmations show higher indices of integration and, ultimately, stronger intentions to persist approximately 9 months later? To answer these research questions, we used a longitudinal design in study 2 to test whether scientific self-efficacy and scientific identity at the end of Fall semester (time 2) mediated (in separate models) the relation between the frequency of experiencing microaffirmations at the beginning of Fall semester (time 1) and intentions to persist in science-related career pathways at the end of the following Spring semester approximately 9 months later (time 3).

STUDY 1

Study 1 sought to develop a measure of microaffirmations among HU and HO students at a diverse urban university.

Participants

Four hundred ninety-eight undergraduate students across four different lower-division chemistry courses completed the Microaffirmations Scale as part of a larger survey that was administered online during the end of Fall 2015 semester at a large urban university in northern California. Of the 498 students, 480 provided a response for each of the seven microaffirmation items and comprised the sample that was used to examine the dimensionality of the Microaffirmations Scale. This sample was 65% female and 32% male, with 3% not reporting gender; 38% HU and 58% HO, with 4% not reporting race or reporting races that were not HU or HO (e.g., from an African nation). In line with the National Institutes of Health's (NIH) categorizations, HU students were defined as those who were African American, Latino/Hispanic, American Indian, Alaskan Native, Native Hawaiian, or Pacific Islander, and HO students were defined as those who were white or of Asian descent (e.g., Asian American, East Asian) and did not identify as Hispanic. The demographic distribution of the sample somewhat reflected the undergraduate demographic makeup of the academic institution, which was 32% HU, 48% HO, and 20% mixed or

unknown in the year of the study (Data USA, 2016). The course enrollments predominantly consisted of second- and third-year students.

Measures: The Microaffirmations Scale

We developed the Microaffirmations Scale for use in this study. Students were provided with a definition of microaffirmations that built upon the definition introduced in a "think piece" by economist Mary P. Rowe (2008), which read, "apparently small acts, which are often hard-to-see, events that are public and private, often unconscious but very effective, which occur whenever people wish to help others to succeed." They then were given instructions to "think about the concept of microaffirmations, especially as you experience them as a student at your university. With this in mind, please estimate how often you have experienced the following microaffirmations over the past month." Students reported the frequency at which they experienced seven described microaffirmations over the past month using the following scale (0 = never, 2 = weekly, 4 = daily, 6 = always), with higher ratings representing more frequent experiences. In total, the scale had seven response options (0–6), with 1, 3, and 5 remaining intermittent (unlabeled) options. The seven items of the Microaffirmations Scale are shown in Table 1.

The items of the Microaffirmations Scale were predicted to comprise two factors. Specifically, items 1, 2, and 3 were predicted to form one factor, because these items were affirmations related to the individual (e.g., "Affirmations that you..."), whereas items 4, 5, 6, and 7 were predicted to form the second factor, because these items were affirmations related to social identity groups (e.g., "Affirmations that people of your culture..."). Further, because a microaffirmation received by a student could theoretically affirm any and all domains captured by our seven items, nonorthogonal factors were hypothesized to comprise the Microaffirmations Scale. For example, a microaffirmation received from a professor may affirm that one can complete one's degree (item 1), but it might also affirm that individuals from one's

TABLE 1. The Microaffirmations Scale: results of the factor analyses among HU and HO students in study 1^a

Microaffirmations Scale item	HU (n = 181)		HO (n = 281)	
	Factor 1 Group Identity affirmation	Factor 2 Individual affirmation	Factor 1 Group Identity affirmation	Factor 2 Individual affirmation
6. Affirmations that people of your culture are important contributors to advancing knowledge	0.98	−0.04	0.96	−0.04
5. Affirmations that people of your ethnicity are important contributors to advancing knowledge ^b	0.95	−0.01	0.97	−0.05
7. Affirmations that people of your sexual orientation are important contributors to advancing knowledge	0.56	0.18	0.80	0.06
4. Affirmations that people of your gender are important contributors to advancing knowledge	0.52	0.32	0.76	0.19
2. Affirmations that you belong in the institution	−0.02	0.92	0.10	0.80
3. Affirmations that you are a scientist	−0.02	0.81	0.05	0.67
1. Affirmations that you can complete your degree	0.07	0.79	−0.06	0.92
Total variance accounted for:	35%	32%	44%	28%

Bolded values refer to factor loadings on the hypothesized factors.

^aWe termed factor 1 Group Identity microaffirmations and factor 2 Individual microaffirmations.

^bRemoved from scale due to redundancy with item 6.

cultural group are important contributors to advancing knowledge as well (items 6).

Procedure

During the end of Fall 2015 semester, students were given the opportunity to participate in an online survey for course credit. The survey included the Microaffirmations Scale and various other measures that were unrelated to the current study. The survey took approximately 15 minutes to complete on Qualtrics (www.qualtrics.com).

Data Analysis Plan: Assessing the Dimensionality of the Microaffirmations Scale

Using the statistical software R, we examined the dimensionality of the Microaffirmations Scale for both HU ($n = 181$) and HO ($n = 281$) students. Specifically, for each group, the number of factors of the Microaffirmations Scale was determined by examining its scree plot, counting the number of eigenvalues that were greater than 1 (Kaiser, 1960), and considering results of a parallel analysis. A parallel analysis is another way of identifying the number of factors retained in an exploratory factor analysis and produces eigenvalues that are adjusted for sampling error (Williams *et al.*, 2010). If more than one factor was identified in either group, we then conducted, using maximum-likelihood estimation, an exploratory factor analysis with direct oblimin rotation on the seven items for the number of factors that were identified. We used maximum-likelihood estimation as our extraction method because it is preferred when multivariate normality is not severely violated (Fabrigar *et al.*, 1999; Costello and Osborne, 2005). In line with the suggestions of Fabrigar *et al.* (1999), we examined the skew and kurtosis of each item to determine whether multivariate normality was severely violated. Specifically, if the skew of each item was not greater than 2 and the kurtosis of each item was not greater than 7 (West *et al.*, 1995), we concluded that maximum-likelihood estimation was an appropriate estimator to use. Direct oblimin rotation was chosen because such rotations are used when factors are predicted to be nonorthogonal (Costello and Osborne, 2005). We considered items with factor loadings above 0.50 as being “significant” with respect to whether they loaded onto any one factor (Costello and Osborne, 2005). In the case of multiple factors being identified, items needed to possess cross-loadings below $|0.40|$ to be retained (Ferguson and Cox, 1993). Finally, we examined the internal consistency of the derived factor(s) via Cronbach’s alpha. An alpha above 0.70 was deemed acceptable (Nunnally and Bernstein, 1994).

Results

The item means, standard deviations, skew, kurtosis, and interitem correlations for the HU and HO samples are reported in Supplemental Tables S1 and S2.

For the HU sample, the first factor had an eigenvalue of 4.50, the second factor had an eigenvalue of 1.04, and the scree plot for these data suggested that the slope of the scree plot curve began to level off beginning at factor 3 (which possessed an eigenvalue of 0.44). Each of these indicated a two-factor structure. Further, the interitem correlations also generally supported a two-factor structure insofar as the items that were predicted to comprise each factor correlated more strongly with one another compared with the items that were predicted to

comprise the other factor. Our parallel analysis, however, suggested the retention of one factor. Because each item did not have a skew that was greater than 2 or kurtosis greater than 7, we then conducted an exploratory factor analysis with maximum-likelihood estimation and direct oblimin rotation to examine the ways in which the items loaded onto two factors. Results of this analysis (see Table 1) indicated that each of the seven items significantly loaded onto their respective factors (all loadings > 0.52) and possessed cross-loadings that were below our set cutoff (no cross-loadings > 0.33). Thus, despite the parallel analysis suggesting a one-factor solution, we elected to move forward with a two-factor solution, because the eigenvalues, scree plot, and interitem correlations suggested two factors, and each item clearly loaded onto its predicted factors. The first factor comprised four items and accounted for 35% of the variance, and the second factor comprised three items and accounted for 32% of the variance, indicating that 67% of the variance was accounted for by the two factors.

We next examined whether a similar factor structure would emerge among the HO sample. The first factor had an eigenvalue of 4.83, whereas the second factor had an eigenvalue of 0.95, just below our 1.0 cutoff. The scree plot looked similar to the one observed for the HU sample, in that slope of the scree plot curve began to level off beginning at factor 3 (which possessed an eigenvalue of 0.48), and the interitem correlations also suggested two factors. The parallel analysis suggested retaining one factor. Given the eigenvalue of the second factor falling just below 1.0 and the scree plot and interitem correlations suggesting a two-factor structure, we elected to conduct an exploratory factor analysis with direct oblimin rotation based on two factors despite the results of the parallel analysis. Maximum-likelihood estimation was used because each item had a skew that was not greater than 2 or kurtosis greater than 7. Results indicated (see Table 1) that the first factor comprised four items and accounted for 44% of the variance, and the second factor comprised three items and accounted for 28% of the variance, totaling 72% of the variance accounted for by the two factors. The items that loaded onto each of these factors were the same as those observed in the HU sample, and each significantly loaded onto its respective factors (all loadings > 0.67) and possessed cross-loadings that were below our set cutoff (no cross loadings > 0.20). These results suggested a two-factor structure.

Examining the interitem correlations for both the HU and HO sample indicated that item 5 (“Affirmations that people of your ethnicity are important contributors to advancing knowledge”) and item 6 (“Affirmations that people of your culture are important contributors to advancing knowledge”) were redundant (HU $r = 0.90$; HO $r = 0.89$). This suggested that HU and HO students were generally interpreting ethnicity and culture as the same thing. Each of these items essentially had the same factor loadings and item-total correlations (i.e., correlation between the item and the total score of the factor without the item) across the groups. Thus, we randomly dropped item 5 from factor 1.¹ Both factor 1 (after removing item 5) and factor 2 were internally consistent in both groups (HU factor 1

¹We reran our analyses for both HU and HO students after dropping item 5. While the eigenvalues and parallel analyses suggested the retention of one factor for both groups, the scree plot suggested a two-factor structure. Further, for both groups, the factor loadings derived from the exploratory factor analyses were generally similar to the loadings that were obtained when item 5 was included.

$\alpha = 0.85$, HU factor 2 $\alpha = 0.89$; HO factor 1 $\alpha = 0.92$, HO factor 2 $\alpha = 0.86$). Further, the two factors were correlated within each group (HU $r = 0.61$; HO $r = 0.67$).

Taken together, the factor structure and item loadings were largely similar across both HU and HO students and each of the two factors was correlated, providing justification for using direct oblimin rotation. The two-factor structure of the Microaffirmations Scale led us to term the first factor Group Identity microaffirmations, because these items refer to the student's social identity groups (e.g., "people of your gender," "people of your culture"). We termed the second factor Individual microaffirmations, because these items were specific to the individual (e.g., "affirmations that you..."). Based on mean item scores, means and standard deviations of the Group Identity microaffirmations factor (which excluded item 5) were as follows: HU $M = 3.27$, $SD = 1.88$; HO $M = 3.51$, $SD = 1.93$. Means and standard deviations for the Individual microaffirmations factor were as follows: HU $M = 3.37$, $SD = 1.74$; HO $M = 3.52$, $SD = 1.63$. As indicated by independent-samples t tests, each of these means was not significantly different across groups (p values > 0.199).

Discussion

The results of study 1 suggested that the Microaffirmations Scale comprises two factors across both HU and HO students: Group Identity microaffirmations and Individual microaffirmations. These factors possessed good internal consistency and a comparable factor structure for both HU and HO students. As indicated by the substantial correlation between item 5 and item 6, students appeared to interpret culture and ethnicity as the same thing, leading us to drop item 5 from the Group Identity factor. Further, no significant differences were found between HU and HO students in their self-report of these measures. However, the parallel analysis in both groups suggested a one-factor structure, and the eigenvalue of the second factor was just below 1.0 within the HU sample, also suggesting a one-factor structure. Therefore, in study 2, via confirmatory factor analyses, we examined whether a one- or two-factor structure best fit the Microaffirmations Scale using a different sample of students and whether there was any difference in model fit if item 5 or item 6 was omitted.

STUDY 2

Building on study 1, in study 2 we administered the Microaffirmations Scale, in addition to measures of integration into the science community (i.e., scientific self-efficacy and identity) and intentions to persist in science-related career pathways, to a separate sample of students across three time points. This longitudinal design allowed us to answer the proposed research questions. Specifically, does the experience of kindness cues that affirm inclusion, measured as microaffirmations, predict higher intentions to persist in science-related career pathways? Second, do scientific self-efficacy and identity mediate the relation between microaffirmations and intentions to persist, such that those who report higher microaffirmations show higher indices of integration and, ultimately, stronger intentions to persist 9 months later? We conducted separate analyses for each of the Microaffirmations Scale factors to determine whether each factor provided similar or different answers to our research questions. Before testing our main hypotheses, however, we used confirmatory factor analyses to examine whether we could empirically support

our decision to drop item 5 versus item 6 from the Group Identity factor and whether a one- or two-factor structure best fit the Microaffirmations Scale among both HU and HO students. We also conducted measurement invariant analyses to examine the extent to which the Microaffirmations Scale was being interpreted and responded to similarly across these groups.

Participants

Eighty-one undergraduate students across six lower-division chemistry courses completed the study at all three time points (time 1: beginning of Fall 2016 semester; time 2: end of Fall 2016 semester, approximately 3.5 months after time 1; time 3: end of Spring 2017 semester, approximately 9 months after time 1). The sample was 73% female and 23% male, with 4% not reporting gender; 51% HU and 43% HO (NIH definition of race/ethnicity), with 6% not reporting race or reporting races that were not HU or HO (e.g., African). The demographic composition in this study comprised more HU students than the larger university demographic composition at the time of the study, which was 34% HU, 45% HO, and 21% mixed or unknown (Data USA, 2016). As in study 1, most students were either second- or third-year students.

The original sample size of students at time 1 and the attrition rates for each time point are described in the *Procedure* section below.

Measures

The internal consistencies reported below were derived from the students who completed our survey at all three time points ($N = 81$). Mean scores were calculated and used for each measure. Participants received the same survey, with all of the following items, at each time point.

Micro Affirmations: Indicator of Inclusivity. The Microaffirmations Scale developed and described in study 1 was used in study 2 (including item 5). The measure was again internally consistent (Group Identity $\alpha = 0.89$; Individual $\alpha = 0.82$).

Scientific Self-Efficacy: Indicator of Integration into the Science Community. Students' confidence in operating as a scientist across various tasks was assessed with a previously validated six-item scale (Estrada et al., 2011, 2018b; Hernandez et al., 2017). Students reported level of confidence for each item on a scale of 1 (not at all confident) to 5 (absolutely confident). Items included "use technical science skills (use of tools, instruments, and/or techniques of your field of study)" and "use academic literature and/or reports to guide your research." The measure was internally consistent ($\alpha = 0.89$).

Scientific Identity: Indicator of Integration into the Science Community. Scientific identity was assessed with a previously validated five-item scale (Estrada et al., 2011, 2018b). Students indicated the extent to which each item was true of them on a scale of 1 (strongly disagree) to 7 (strongly agree). Items included "I have a strong sense of belonging to the community of scientists" and "I feel like I belong in the field of science." The measure was internally consistent ($\alpha = 0.94$).

Intentions to Persist in Science Career Pathways. Students' intentions to persist was captured with the item, "To what

extent do you intend to pursue a science-related research career?" Intentions were reported on a scale from 0 (definitely will not) to 10 (definitely will). This one-item measure has been shown to predict application to and enrollment in STEM degree graduate programs 1 year after baccalaureate degree completion (Estrada *et al.*, 2011).

Procedure

During the beginning weeks of the Fall 2016 semester (time 1), undergraduate chemistry students were given the opportunity to participate in an online survey for extra credit. This survey, used at all three time points, included the Microaffirmations Scale, measures for scientific self-efficacy, scientific identity, and intentions to persist in science career pathways, and other measures that were unrelated to the current study. Two hundred and seventy-nine students completed the survey at time 1. The survey took approximately 15 minutes to complete on Qualtrics. The same students who were invited to participate at time 1 were invited to participate in the same online survey during the last 2 weeks of the Fall 2016 semester (time 2) for extra credit. Three hundred and five students completed the survey at time 2. There were more completions at time 2 because the survey was sent to the entire class and more students opted to complete in time 2. However, only the 206 students who participated at both time 1 and time 2 were contacted via email and invited to complete the same survey shortly after the end of the Spring 2017 semester (time 3). Students were given a \$5 Amazon e-gift card for completing the survey at time 3. Eighty-one (39%) of the students who completed the survey at both time 1 and time 2 completed the survey at time 3. Importantly, as assessed via chi-square analyses, the distribution of HU and HO students and males and females who completed time 1 and 2 did not significantly differ from those who completed all three time points.

Data Analysis Plan

Confirming the Factor Structure of the Microaffirmations Scale. The exploratory factor analyses conducted in study 1 indicated that the Microaffirmations Scale included two factors common to both HU and HO students (a Group Identity factor and an Individual factor) and that items 5 and 6 were statistically indiscriminate of each other. In study 2, using the data obtained at time 1, we confirmed this factor structure by conducting separate confirmatory factor analyses for HU and HO students via the *cfa* function found within the lavaan package in R (Rosseel, 2012). We used data only from students who provided a response for each Microaffirmations Scale item (HU $n = 106$, HO $n = 127$). Parameters were estimated with maximum likelihood. We evaluated model fit via the model chi-square test, the root-mean-square error of approximation (RMSEA), the standardized root-mean-square residual (SRMR), and the comparative fit index (CFI). For the RMSEA and SRMR, very good fit was indicated by values less than 0.05, reasonable fit was indicated by values between 0.05 and 0.10, and poor fit was denoted by values greater than 0.10 (Browne and Cudeck, 1992; Hu and Bentler, 1999). For the CFI, values of 0.95 or higher suggested good fit (Hu and Bentler, 1999).

Next, with respect to the Microaffirmations Scale, we established measurement invariance across HU and HO students to justify our decision to examine the scale across groups. Scale measurement invariance indicates that participants across groups

with equivalent levels of the latent construct have identical expected raw scores on that measure (Drasgow and Kanfer, 1985; Hirschfeld and Von Brachel, 2014). In other words, measurement invariance indicates that the two groups are similarly interpreting and responding to the scale (Drasgow and Kanfer, 1985).

As described by Hirschfeld and Von Brachel (2014), there are different levels in the extent to which a scale has measurement invariance across groups. Configural invariance denotes that both the number of latent variables and the loadings of the indicators are similar across groups. Metric invariance indicates that the magnitude of the loadings is equivalent across groups, allowing one to meaningfully compare the relations between the latent variables across groups. Scalar invariance denotes that the item loadings *and* item intercepts are equivalent across groups, allowing one to meaningfully compare the latent variable means across groups (Chen, 2008). To determine the level of measurement invariance, we used nested model comparisons (for a more thorough description of these nested model comparisons, see Hirschfeld and Von Brachel, 2014) in which we evaluated each level of invariance via the $\Delta\chi^2$ test (Kline, 2005), the fit indices (with their set cutoffs) described earlier, and by examining the Δ CFI. Specifically, measurement invariance was established when the change in chi-square was not significant, the fit indices indicated good to excellent fit, and the Δ CFI was <0.01 (Cheung and Rensvold, 2002; Hirschfeld and Von Brachel, 2014).

Approach to Testing Hypotheses. Upon establishment of measurement invariance, separate simple mediation models were conducted to answer our research questions (see Figure 1 for hypothesized models). Specifically, we tested whether scientific self-efficacy and scientific identity at time 2 mediated the relation between microaffirmations (for each of the two factors) at time 1 and intentions to persist in science-related career pathways at time 3 across *all students* who completed the survey at each of the three time points. Therefore, to increase our power for testing our main hypotheses, we elected to use the entire sample of students rather than examining our hypotheses within each group; we also conducted separate mediation analyses with smaller group samples for HU ($n = 41$) and HO ($n = 35$) students as exploratory analyses, which are reported in Supplemental Table S3.

The approach to mediation used Preacher and Hayes's (2008) bootstrapping method with 5000 resamples. Specifically, we used the *mediate* function found within the psych package in R (Revelle, 2018) to obtain a bias-corrected 95% confidence interval for the mean indirect effect for which significant mediation has occurred if the confidence interval does not include 0 (Hayes, 2009). Confidence intervals that are derived from bias-corrected bootstrap methods are more accurate and possess more power than other resampling methods (MacKinnon *et al.*, 2004).

Resampling procedures such as bootstrapping have the advantage of possessing fewer assumptions pertaining to the distribution of the indirect effect compared with the Sobel test, which requires the indirect effect to be normally distributed (MacKinnon *et al.*, 2004; Hayes, 2009). Unlike Baron and Kenny's (1986) causal mediation procedures, resampling procedures do not require the independent variable (X) to be significantly associated with the dependent variable (Y) (c path) for

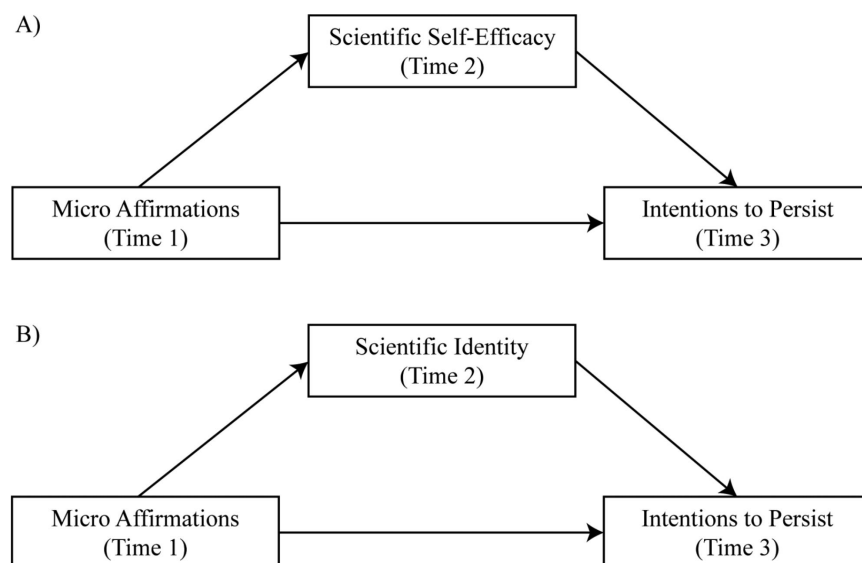


FIGURE 1. Models pertaining to our research questions. We tested whether scientific self-efficacy (A) and scientific identity (B) at time 2 mediated the relation between microaffirmations (for each of the two factors) at time 1 and intentions to persist in science-related career pathways at time 3.

mediation to occur, because the total effect between X and Y comprises both direct and indirect effects (Hayes, 2009). In other words, the association between X and Y could theoretically completely exist through the indirect effects of one or more mediators, rendering a nonsignificant direct effect in the process.

A listwise deletion method (i.e., only included those who provided responses for each measure) was used before conducting each simple mediation model, and sample sizes are provided for all analyses. All reported statistics obtained from the simple mediation analyses are standardized.

Results: Confirming the Factor Structure of the Microaffirmations Scale

Before using the Microaffirmations Scale in study 2, we confirmed the factor structure of the scale via confirmatory factor analyses. Specifically, using the data from those who completed the Microaffirmations Scale at time 1, we conducted separate confirmatory factor analyses for HU ($n = 106$) and HO ($n = 127$) students. We allowed the two factors to covary.

The Microaffirmations Scale administered in study 2 included item 5 and item 6, which were again substantially correlated for both HU and HO students at time 1 in study 2 (HU $r = 0.92$, HO $r = 0.92$), providing further evidence that students were interpreting ethnicity and culture as the same thing. We next examined fit for the two-factor structure observed in study 1 by dropping item 5 and again after dropping item 6 for both groups. With respect to HU students, while model fit was excellent for a model in which item 5 was dropped ($\chi^2(8) = 8.20$, $p = 0.415$, RMSEA = 0.02, SRMR = 0.03, CFI = 1.00), model fit was somewhat better for a model in which item 6 was dropped ($\chi^2(8) = 6.58$, $p = 0.585$, RMSEA = 0.00, SRMR = 0.02, CFI = 1.00). For HO students, the reverse was true. Whereas a model in which item 5 was dropped indicated good fit ($\chi^2(8) = 13.38$, $p = 0.099$, RMSEA = 0.07, SRMR = 0.06, CFI = 0.99), a model in which

item 6 was dropped indicated poorer fit, particularly as denoted by the significant model chi-square test ($\chi^2(8) = 18.44$, $p < 0.001$, RMSEA = 0.10, SRMR = 0.06, CFI = 0.98). Although removing item 6 versus item 5 indicated superior fit for HU students, fit was excellent in both cases. However, good fit for HO students was only obtained after removing item 5 (e.g., the chi-square test was significant when item 6 was dropped, denoting poor fit, whereas the chi-square test was not significant when item 5 was dropped). Because we tested our study 2 hypotheses on the entire sample and not HU and HO students separately (although this was done as exploratory analysis), we concluded that our decision in study 1 to remove item 5 was empirically supported. Going forward, all reported analyses pertaining to the Group Identity factor excluded item 5.

The fit statistics for each of the following confirmatory factor analyses among HU and HO students at time 1 are shown in Table 2. For HU students, we first examined fit for a one-factor model. The model chi-square test and fit indices indicated very poor fit ($\chi^2(9) = 63.44$, $p < 0.001$, RMSEA = 0.24, SRMR = 0.09, CFI = 0.84). As reported earlier, when we examined fit for the two-factor model observed in study 1 (omitting item 5), the model chi-square test was not significant, and each of fit indices suggested excellent fit (see Table 2). Additionally, each of the items from the Microaffirmations Scale loaded strongly and positively on their respective factors (all loadings > 0.66 , all p values < 0.001 ; see Supplemental Table S4 for all loadings). As in study 1, the two factors were correlated ($r = 0.61$).

With respect to HO students, we also began by fitting a one-factor model to the data, for which very poor fit was indicated ($\chi^2(9) = 138.77$, $p < 0.001$, RMSEA = 0.34, SRMR = 0.16, CFI = 0.70). Also as reported earlier, results of fitting the two-factor model observed in study 1 (omitting item 5) to the HO data revealed good fit (see Table 2). Each of the items loaded strongly and positively on its respective factors (all loadings > 0.60 , all p values < 0.001 ; see Supplemental Table S4 for all loadings), and the two factors were correlated as they were in study 1 ($r = 0.47$).

Taken together, despite the parallel analyses in study 1 indicating a one-factor structure for HU and HO students, a two-factor model provided superior fit in both groups. We next conducted measurement invariance analyses on two-factor models in which item 5 was removed. As reported in Table 2, for all levels of measurement invariance, change in chi-square tests was not significant, model fit was good to excellent, and the Δ CFI was not larger than 0.01.² These results indicated that the

²An additional nested model (in which the scalar invariance model was nested within it) was tested to determine whether the latent means of the factors differed across HU and HO students. Results indicated that not only were the intercepts and factor loadings statistically equivalent across groups (i.e., scalar invariance), but the latent means of the factors were as well. $\chi^2(26) = 32.33$, $p (\Delta\chi^2) = 0.475$, RMSEA = 0.05, SRMR = 0.06, CFI = 0.99.

TABLE 2. Microaffirmations Scale: goodness of fit for single-group confirmatory factor analyses and measurement invariance confirmatory factor analyses among students at time 1^a

Group	χ^2 (df)	p (χ^2)	RMSEA	SRMR	CFI
Microaffirmations Scale (omitting item 5) single-group solutions ^b					
HU ($n = 106$)					
One-factor model	63.44 (9)	<0.001	0.24	0.09	0.84
Two-factor model	8.20 (8)	0.415	0.02	0.03	1.00
HO ($n = 127$)					
One-factor model	138.77 (9)	<0.001	0.34	0.16	0.70
Two-factor model	13.38 (8)	0.099	0.07	0.06	0.99
	χ^2 (df)	p ($\Delta\chi^2$)	RMSEA	SRMR	CFI
Microaffirmations Scale (omitting item 5) measurement invariance ^b					
Configural invariance	21.57 (16)	—	0.06	0.04	0.99
Metric invariance	24.77 (20)	0.525	0.05	0.05	0.99
Scalar invariance	30.84 (24)	0.195	0.05	0.05	0.99

^aRMSEA, root-mean-square error of approximation; SRMR, standardized root-mean-square residual; CFI, comparative fit index; configural invariance, indicator intercepts and factor loadings allowed to vary; metric invariance, factor loadings constrained to be equal; scalar invariance, indicator intercepts and factor loadings constrained to be equal.

^bItem 5 was not included in the confirmatory factor analyses reported here.

Microaffirmations Scale was being similarly understood by HU and HO students, justifying our decision to combine the groups to test our hypotheses pertaining to the Microaffirmations Scale.

Descriptive Statistics and Zero-Order Correlations of the Psychosocial Measures

The descriptive statistics of the psychosocial measures, which were derived from all participants who provided responses for each particular measure, are provided in Table 3. There were no significant differences between HU and HO students on any of these variables, which were tested via independent-samples t tests (all p values > 0.666). Zero-order correlations among these measures are displayed in Table 4.

Microaffirmations and Intentions to Persist

The initial analysis aimed to answer our first research question: Does the experience of kindness cues that affirm inclusion,

measured as microaffirmations, predict higher intentions to persist in science-related career pathways? Zero-order correlation analyses were conducted to assess this direct relationship. Interestingly, as shown in Tables 4 and 5, microaffirmations at time 1 (regardless of the specific factor) were not directly predictive of intentions to persist in science-related career pathways at time 3 when all students were considered. However, when we examined the relation between microaffirmations and intentions to persist in science-related career pathways closer in time (i.e., at time 1 and time 2), each of the two microaffirmations factors was significantly and moderately associated with greater intentions to persist among the full sample (Table 5).

We also examined these relations among HU and HO students separately as exploratory analyses. As noted earlier, the cell sizes for HU and HO students were small, indicating that these within-group correlations should be interpreted with caution. As was observed for the entire sample, microaffirmations

TABLE 3. Descriptive statistics of the key psychosocial measures in study 2 among students who completed the study across each of the 3 time points

Group	Time 1		Time 2		Time 3
	Group Identity microaffirmations	Individual microaffirmations	Scientific self-efficacy	Scientific identity	Intentions to persist ^a
	M (SD) α	M (SD) α	M (SD) α	M (SD) α	M (SD) α
Full sample ($n = 81$)	3.38 (1.93) 0.89	3.62 (1.58) 0.82	3.74 (0.75) 0.89	5.18 (1.37) 0.94	8.24 (2.80) —
HU ($n = 41$)	3.56 (2.12) 0.87	3.56 (1.84) 0.90	3.74 (0.78) 0.90	5.19 (1.53) 0.96	8.20 (2.67) —
HO ($n = 35$)	3.29 (1.76) 0.90	3.64 (1.31) 0.74	3.73 (0.75) 0.89	5.24 (1.27) 0.93	8.49 (3.00) —

^aAlphas pertaining to intentions to persist are not provided, because this was measured with a single item.

TABLE 4. Zero-order correlations across the psychosocial measures in study 2 among students who completed the study across each of the 3 time points

Psychosocial variable ^a	Full sample (n = 81)					HU students (n = 41)					HO students (n = 35)				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1. Group Identity microaffirmations (T1)	—					—					—				
2. Individual microaffirmations (T1)	0.56*	—				0.76*	—				0.18	—			
3. Scientific self-efficacy (T2)	0.24*	0.38*	—			0.21	0.37*	—			0.36*	0.49*	—		
4. Scientific identity (T2)	0.30*	0.48*	0.55*	—		0.38*	0.57*	0.39*	—		0.18	0.37*	0.78*	—	
5. Intentions to persist (T3)	0.14	0.16	0.38*	0.39*	—	0.04	0.08	0.27	0.14	—	0.23	0.27	0.51*	0.69*	—

^aT1 = time 1; T2 = time 2; T3 = time 3.* $p < 0.05$.

at time 1 were not significantly associated with intentions to persist in science-related career pathways at time 3 for both HU and HO students (Table 5), though these correlations were noticeably smaller among HU compared with HO students ($r = 0.04$ and $r = 0.08$ for the Group Identity and Individual microaffirmations factors, respectively, among HU students vs. $r = 0.23$ and 0.27 for the Group Identity and Individual microaffirmations factors, respectively, among HO students). Examining the relation between microaffirmations and intentions to persist in science-related career pathways closer in time revealed that each of the two Microaffirmations Scale factors were associated with greater intentions to persist among HU students at time 1 and time 2 (Table 5). In contrast, only one significant correlation was observed for HO students: the Individual microaffirmations factor was significantly associated with greater intentions to persist at time 1 (see Supplemental Tables S5, S6, and S7 for correlation matrices of all of the measures across each time point for all students, HU students, and HO students, respectively).

Taken together, while reported microaffirmations at time 1 were not associated with intentions to persist at time 3 (roughly 9 months later) across all students, and both HU and HO students, microaffirmations (both factors) were strongly related to HU intentions to persist at time 1 and time 2 (roughly 3.5 months later). Although each of these same correlations was modest and positive among HO students (all r values > 0.18), low power may have led these associations to not be significant. These analyses suggested that microaffirmations (both factors) may be more strongly related to intentions to persist for HU students, compared with HO students, even though they did not directly predict longer-term persistence (i.e., at time 3).

Measures of Integration as Mediators

Using the entire sample, simple mediation analyses were conducted to answer the second research question: Do scientific self-efficacy and identity mediate the relation between microaf-

firmations and intentions to persist in science-related career pathways among all students, such that those who report higher microaffirmations show higher indices of integration, and ultimately stronger intentions to persist roughly 9 months later?

Table 6 reports the bootstrapped bias-corrected 95% confidence intervals for the standardized indirect effect (BC CI_{95%}) of all simple mediation tests that were conducted in addition to the respective standardized path coefficients for each mediation model. Figure 2 provides an illustration of the hypothesized simple mediation models (Figure 2, A and B, for scientific self-efficacy and scientific identity as mediators, respectively) with their respective BC CI_{95%} and standardized path coefficients.

Mediator: Scientific Self-Efficacy. The first mediation analyses examined whether scientific self-efficacy at time 2 mediated the relation between microaffirmations (for each of the two factors) at time 1 and intentions to persist at time 3 across all students (Table 6 and Figure 2A). With regard to the Group Identity factor, significant mediation occurred, because the BC CI_{95%}, [0.01, 0.22], did not include 0. With respect to the Individual factor, the results were similar. Specifically, the relation between reported Individual microaffirmations at time 1 and intentions to persist at time 3 was mediated by scientific self-efficacy at time 2, because the BC CI_{95%} did not include zero, [0.03, 0.28].

Mediator: Scientific Identity. A second set of mediation analyses were conducted that examined whether scientific identity at time 2 mediated the relation between microaffirmations (for each of the two factors) at time 1 and intentions to persist at time 3 across all students (Table 6 and Figure 2B). For the Group Identity factor, the BC CI_{95%} was [0.02, 0.27] and did not include 0. This indicated that scientific identity at time 2 mediated the relation between Group Identity microaffirmations at time 1 and intentions to persist at time 3. Similarly, the results showed that scientific identity at time 2 mediated the relation

TABLE 5. Bivariate correlations among microaffirmations at time 1 and intentions to persist in science-related career pathways at each time point in study 2

	Full sample (n = 81)		HU students (n = 41)		HO students (n = 35)	
	Group Identity microaffirmations	Individual microaffirmations	Group Identity microaffirmations	Individual microaffirmations	Group Identity microaffirmations	Individual microaffirmations
Intentions						
Time 1	0.32*	0.47*	0.43*	0.63*	0.23	0.36*
Time 2	0.25	0.35*	0.34*	0.46*	0.27	0.19
Time 3	0.14	0.16	0.04	0.08	0.23	0.27

* $p < 0.05$.

TABLE 6. Models showing scientific self-efficacy and scientific identity mediated the relation between microaffirmations and intentions to persist in science-related career pathways^a

Mediator (sample size)	<i>c</i>	<i>a</i>	<i>b</i>	<i>c'</i>	Indirect effect	
	β	β	β	β	β	BC CI _{95%}
Group Identity microaffirmations						
Scientific self-efficacy (77)	0.13	0.26*	0.37**	0.03	0.09	[0.01, 0.22] [^]
Scientific identity (78)	0.14	0.30**	0.38***	0.03	0.11	[0.02, 0.27] [^]
Individual microaffirmations						
Scientific self-efficacy (78)	0.14	0.37***	0.37**	0.00	0.14	[0.03, 0.28] [^]
Scientific identity (79)	0.16	0.48***	0.40**	-0.03	0.19	[0.05, 0.38] [^]

^a*c* = direct effect of microaffirmations on intentions to persist in science-related career pathways; *a* = effect of microaffirmations on the mediator; *b* = effect of the mediator on intentions to persist in science-related career pathways controlling for microaffirmations; *c'* = effect of microaffirmations on intentions to persist in science-related career pathways controlling for the mediator; BC CI_{95%} = bootstrapped bias-corrected 95% confidence interval for the standardized indirect effect. In each case, the independent variable was microaffirmations at time 1 and the dependent variable was intentions to persist in science-related career pathways at time 3. All reported statistics are standardized.

**p* < 0.05.

***p* < 0.01.

****p* < 0.001.

[^] Significantly different from 0.

between Individual microaffirmations at time 1 and intentions to persist at time 3, because the BC CI_{95%} [0.05, 0.38], did not include zero.

DISCUSSION

These studies were conducted to advance knowledge and measurement regarding microaffirmations and how microaffirma-

tions influence undergraduate student persistence in science-related career pathways. The results of our studies showed that microaffirmations positively influenced students' intentions to persist in science-related career pathways when these experiences contributed to their integration into scientific communities. The following is a more detailed discussion of how the results contribute to measurement and advance theory and evidence-based practices regarding microaffirmations, student integration, and persistence in science career pathways.

Results of the Simple Mediation Models Examining Research Question #2

Top Underlined Row = Group Identity Factor

Bottom Row = Individual Factor

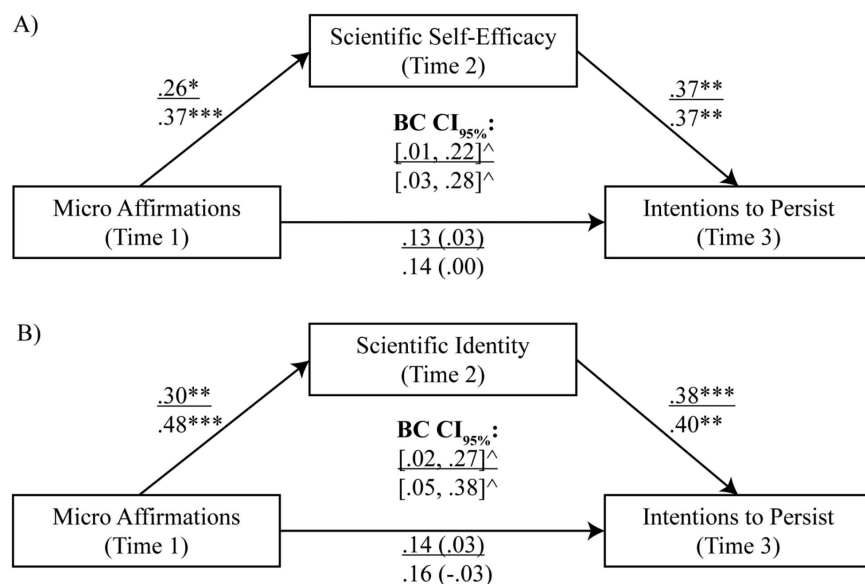


FIGURE 2. Results obtained with the Group Identity microaffirmations factor are denoted in the underlined top row, and the results obtained with the Individual microaffirmations factor are denoted in the bottom row. The numbers in parentheses represent the coefficients between microaffirmations and intentions to persist while controlling for the mediator (i.e., *c'*). All reported statistics are standardized. BC CI_{95%} = bootstrapped bias-corrected 95% confidence interval for the standardized indirect effect. *, *p* < 0.05; **, *p* < 0.01; *, *p* < 0.001; [^], significantly different from 0.**

Measuring Microaffirmations

Before this study, no self-report measure of microaffirmations was available. Studies 1 and 2 addressed this gap by providing evidence for a new measure of the kindness cues of microaffirmations via the Microaffirmations Scale. Specifically, study 1 suggested that the Microaffirmations Scale comprised two factors: one factor focused on social identity groups and the other focused on the individual. These two factors mirror the work on stereotype threat, which also establishes that threats can occur related to social identity groups (e.g., ethnic or religious group) or that threats can be more individualized (Steele *et al.*, 2002). Further, our results showed that these factors were comparable for both HU and HO students. In study 2, we confirmed the two-factor structure observed in study 1 (after dropping item 5) for both HU and HO students on a separate sample of undergraduates. Further, we established that the Microaffirmations Scale possessed measurement invariance across HU and HO students.

An interesting finding was that, among our samples, HU and HO students did not

significantly differ from each other in their self-reported experiences of Group Identity or Individual microaffirmations in either study 1 or study 2. Also, in both studies, item 5 (“Affirmations that people of your ethnicity are important contributors to advancing knowledge”) and item 6 (“Affirmations that people of your culture are important contributors to advancing knowledge”) were redundant items as denoted by substantial bivariate correlations, indicating that students were largely interpreting ethnicity and culture as the same thing. Study 2 results showing excellent model fit for HU students was observed for models in which item 5 and item 6 were dropped, whereas good model fit was only obtained after dropping item 5 among HO students. Studies with larger sample sizes and more questions regarding students’ understanding of their ethnicity and culture for both HU and HO students could provide additional insights into understanding this finding and build upon previous research in this area of study (Parsons, 2014). Relatedly, future studies should be conducted to demonstrate that the Microaffirmations Scale is best fit by a two-factor structure using larger samples than those used in the current studies.

Given the results of our studies, the Microaffirmations Scale can be used for tracking positive student experiences. A potential benefit of being able to measure microaffirmations is that training and interventions can be created to increase subtle, authentically affirmative environments, and the impacts can be tracked. Thus, the measure can be a useful tool for researchers and practitioners alike.

Microaffirmations’ Relation to Intentions to Persist

Previous research on attachment and belonging suggests that, if a student experiences kindness cues, such as subtle affirmations, this will lead to greater intentions to persist and that the absence of these cues may contribute toward HU students exiting from STEM career pathways (Baumeister and Leary, 1995; Hurtado and Carter, 1997; Locks *et al.*, 2008). However, the results from our studies showed that there is nuance in this relationship. Kindness cues, measured as Group Identity and Individual microaffirmations, were not directly associated with students’ intentions to persist in science-related career pathways 9 months later. Specifically, across all students, the reported frequency at which kindness cues were experienced at the beginning of Fall semester (time 1) were not related to reported intentions to persist in science-related career pathways at the end of the following Spring semester (time 3). Our exploratory analyses indicated that this was also the case for HU and HO students when considered separately (see Table 5). Interestingly, however, among HU students, experiencing both Group Identity and Individual microaffirmations was directly related to intentions at time 1 and time 2, 3 months later. The sizes of these associations were moderate to large. Although potentially a result of low power, there was only one significant, but moderate, relation among these variables for HO students. Overall, within shorter time frames, the results showed more direct relationships between these kindness cues and intentions for HU students than HO students.

Regarding the initial research questions, however, the results of study 2 clearly showed there was no direct predictive relationship between microaffirmations at time 1 and intentions to persist in a science-related career at time 3, 9 months later, across all students. These findings suggest that microaffirma-

tions alone do not directly predict longer-term intentions to persist in a science-related career. The full story is more evident when combined with the results related to our second research question.

The Impact of Integrating Students into Their Professional Communities

To answer the second research question, we conducted mediation analyses to assess the extent to which microaffirmations that increase student integration (measured as increasing scientific self-efficacy and identity) result in longer-term intentions to persist in science-related career pathways. This type of analysis increases understanding about “when” an experience, context, or intervention results in desired outcomes. The results of our mediation analyses were consistent with previous literature suggesting that kind, affirming environments can lead to greater integration into a community, which in turn results in greater persistence to engage with the norms of that community (Estrada *et al.*, 2018b). In this case, the results of the mediation analyses showed that, when students experienced microaffirmations that increased integration, measured as scientific self-efficacy (i.e., confidence one can do science) or identification as a scientist, they were more likely to intend to persist in science-related careers. Importantly, data for these mediators were obtained in a temporal sequence (i.e., microaffirmations at time 1, scientific self-efficacy and identity at time 2, intentions at time 3), allowing us to draw inferences about the directions of the relations among these variables. Despite the effects of the indirect effects being small (i.e., the 95% CI was just above 0 in some cases), these findings provide initial evidence that experiencing microaffirmations is important to the students’ professional socialization process.

One interesting note concerns the exploratory mediation analyses that were conducted (i.e., separate mediation models for HU and HO students; see Supplemental Table S3). Although our cell sizes were small and indicate caution in interpreting our results, these analyses suggested that HO students were driving most of the significant indirect effects observed in study 2 for the full sample of students. Future studies should examine these mediation models in larger samples of HU and HO students to determine whether these exploratory results can be replicated.

What Was Learned about HU and HO Students in a Multicultural University?

Among this student population attending a highly diverse urban university, there were more similarities than differences among HU and HO students. The results showed that HU and HO students reported similar levels of microaffirmations in both study 1 and study 2, and there were no differences among our other psychosocial measures in study 2 (i.e., scientific self-efficacy and identity at time 2, intentions to persist at time 3). Further, while there were some apparent differences between HU and HO students in terms of the raw correlations between our measures in study 2 (Table 4) and in the exploratory mediation analyses we conducted, we are cautious in drawing firm conclusions on whether these results are artifacts of small HU and HO cell sizes or accurate reflections of group differences. Further research with larger sample sizes will provide better discernment regarding the presence of significant differences. Still, the

many similarities of the groups are particularly surprising given national data showing HU students are less likely to persist than HO students (PCAST, 2010; Valentine *et al.*, 2016). As mentioned earlier, HU and HO students in study 2 did not show significant differences in intentions. These results suggest that there is something unique about this university, which has a high first-generation college student population and a student population that was 34% HU during the time of study (Data USA, 2016) and in which 50% of the classes in study 2 were taught by an HU faculty member.

Caveats

The present study was not without caveats. First, our outcome measure—intentions to persist in science-related career pathways—was self-reported and may not reflect actual persistence. Previous research has shown that this one-item measure is significantly related to applications and admission into STEM-related degree programs, which provides some assurance of the efficacy of the measure (Estrada *et al.*, 2011). Future studies that use behavioral outcome measures that reflect persistence such as grades, course progression, and/or graduation would advance the research by testing whether the found mediation results replicate across different types of outcomes.

Another caveat concerns the length of time across which our measures were assessed. Specifically, our measures were all roughly administered within a single school year. While this time frame was useful for testing mediation models, future research using longer time frames would enable additional research questions to be asked regarding duration of impact of all variables measured across the undergraduate science career pathway. Additionally, the design of study 2 resulted in somewhat low completion rates at time 3, when participation was rewarded with a \$5 gift card rather than the extra credit given at time 1 and 2. While the proportion of students (with respect to HU vs. HO status and gender) who completed the study across all 3 time points did not differ from those who completed both time 1 and time 2, we cannot know for sure how the attrition rate impacted our results. For example, it was interesting that, whereas the two factors of the Microaffirmations Scales were significantly correlated among HU ($r = 0.61$) and HO ($r = 0.47$) students at time 1 in study 2, the two were not significantly correlated among our HO students who completed *all 3 time points* ($r = 0.18$). This result could be related to our high attrition. Further, while speculative, monetary rewards may select for certain types of students rather than those motivated by extra course credit. Conducting future studies with common reward structures would be helpful to better understand these results.

Additionally, the present data were obtained at only one urban university in northern California, which may contribute to limiting the generalizability of the conclusions provided. Indeed, as mentioned previously, the university students surveyed in the present study are extremely diverse, and no particular group is the true majority at the institution, even across some STEM majors. Relatedly, the Chemistry Department at the university has several faculty and lecturers who are from HU groups, which may have contributed to the current pattern of findings. Context may matter, and demographic distributions may be an area of future study in need of great research.

CONCLUSIONS AND FUTURE DIRECTIONS

In summary, our results showed that students' experiences of the kindness cue of microaffirmations can contribute toward their integration into their discipline communities, ultimately impacting their persistence in science career pathways. Further, the results showed that kindness cues that affirm inclusion, measured as microaffirmations, can be reliably measured in an academic context and that this experience has predictive value when it increases students' integration into their science communities. These findings potentially provide new tools for advancing knowledge about why curricular changes, science training program interventions, or mentorship work, particularly when using research designs that allow researchers to claim causal impacts. This line of research contributes to the growing understanding of how positive contextual factors can help reduce the persistence gaps in science-related degree attainment and contribute positively toward the diversification of the STEM workforce.

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