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Toward a Model of Social Influence That Explains Minority Student Integration into the Scientific Community

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Students from several ethnic minority groups are underrepresented in the sciences, indicating that minority students more frequently drop out of the scientific career path than nonminority students. Viewed from a perspective of social influence, this pattern suggests that minority students do not integrate into the scientific community at the same rate as nonminority students. Kelman (1958, 2006) described a tripartite integration model of social influence by which a person orients to a social system. To test whether this model predicts integration into the scientific community, we conducted analyses of data from a national panel of minority science students. A structural equation model framework showed that self-efficacy (operationalized to be consistent with Kelman's rule orientation) predicted student intentions to pursue a scientific career. However, when identification as a scientist and internalization of values were added to the model, self-efficacy became a poorer predictor of intention. Additional mediation analyses supported the conclusion that while having scientific self-efficacy is important, identifying with and endorsing the values of the social system reflect a deeper integration and more durable motivation to persist as a scientist.

Keywords: social influence, self-efficacy, identity, values, integration

A Leaky Pipeline?

Policy makers and administrators refer to the journey from college through a professional academic career as the "academic pipeline." The prototypical student begins his or her academic college career after high school, continues through a master's and/or doctoral program, and ultimately assumes a professional appointment. Historically, members of different ethnic groups have moved through this pipeline at different rates, and U.S. national education data consistently show that this pipeline is "leakier" for minority than for nonminority students (DePass & Chubin, 2009; U.S. Department of Education, National Center for Education Statistics, 2005). These leaks occur at each stage of the academic process, with Black, Hispanic, and Native American students consistently less likely to proceed than White or Asian students. This is particularly true of students who are in a scientific discipline such as biological, behavioral, or physical sciences (Cook & Córdova, 2006). The end result is underrepresentation of members of these groups in scientific research careers. While the educational disparity has attracted considerable commentary, there have been few attempts by social psychologists to apply theoretical models to understand and address this issue.

To encourage underrepresented minority students to stay in the sciences, an array of programs have been set up to offer opportunity, support, and training experiences. These programs are administered through formal local and national minority training programs, as well as more informal mentorship and ad hoc endeavors. While the efficacy of these programs has attracted national scrutiny in recent years, emerging evidence shows that these programs make a difference (National Research Council, 2005; Schultz, Estrada-Hollenbeck, & Woodcock, 2008). Our goal in this article is not to ask whether these programs work (see Schultz, Woodcock, Estrada-Hollenbeck, Hernandez, & Chance, 2010) but rather to propose a model of social influence to describe factors relevant to when minority students are more likely to continue to pursue a scientific career and when they are not.

Self-Efficacy and Academic Perseverance

One of the most widely studied psychological predictors of academic perseverance is self-efficacy. This line of research emerges from the work of Bandura (1997) who described self-efficacy as "the belief in one's capabilities to organize and execute courses of action required to produce given attainments" (p. 3).

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Bandura contended that an individual's self-appraisal of ability is a strong predictor of the person's likelihood to perform those actions in the future. In a series of large-scale meta-analyses of both field and laboratory studies conducted across diverse contexts and behavioral domains, self-efficacy has been shown to consistently predict behavioral outcomes and changes in individual functioning over time (see Bandura & Locke, 2003). Thus, the finding that self-efficacy enhances motivation and performance in a variety of situations—ranging from academic (Chemers, Hu, & Garcia, 2001) and athletic performance (Moritz, Feltz, Fahrbach, & Mack, 2000), to children and adolescent psychosocial functioning (Holden, Moncher, Schinke, & Barker, 1990), to minority students pursuing engineering careers (Lent et al., 2005)—appears to be robust.

In an extension of Bandura's general theory, Lent and colleagues have argued for the importance of self-efficacy in understanding academic perseverance. To this end, they have developed and tested the social cognitive career theory (SCCT; Lent, Brown, & Hackett, 1994) in a variety of academic settings. A central feature of SCCT is that higher social support and lower social barriers contribute to the development of self-efficacy, which in turn increases interest in an academic career choice directly and indirectly through outcome expectations (Lent et al., 2005). These variables contribute to the choice of academic major as well. In a study of underrepresented students, Lent et al. (2005) showed that the SCCT predicted academic interest and goals among engineering students. In addition, studies have shown that self-efficacy consistently predicts students' interest, goals, and persistence to pursue careers in the science, technology, engineering, and mathematics (STEM) disciplines. More recently, studies have shown that this model applies to both minority and nonminority students (Lent et al., 2005). Other theoretical models have been applied to academic perseverance (Deci & Ryan, 2008; Eccles, 2007; Hidi & Renninger, 2006; Wigfield & Eccles, 2000) and career choice (Ceci, Williams, & Barnett, 2009; Holland, 1997). However, to our knowledge, SCCT is the only social psychological theory shown to predict minority college student perseverance in the sciences.

Self-Efficacy and Social Influence

In tests of SCCT, the amount of environmental support (such as receiving financial or social support) has been shown to positively predict self-efficacy (Lent, 2007), and in some cases, barriers in the environment (such as self-reported social, instrumental, and gender barriers) negatively predicted self-efficacy (Lent et al., 2005). While SCCT describes how the environment affects individuals, it puts the onus of change squarely on the student. In essence, the theory hinges on the idea that a person must acquire self-efficacy if he or she is to ultimately persevere. However, viewed from a different perspective, SCCT can be interpreted as a process of social influence. Feedback from the academic community is socializing the individual to either believe he or she can or cannot perform the skills necessary to persevere in this social context. When the feedback is positive, the student builds confidence in his or her skills, develops higher self-efficacy in that domain, and is more likely to pursue the desired behaviors than if negative feedback is given. Lent (2007) described this feedback loop, where success or failure affects self-efficacy and outcome expectations, which are related to interests, intentions or goals, and actions, and these then loop back to success or failure.

From a social influence perspective, this feedback cycle of self-efficacy describes a contended rule of academia: If a student performs as his or her academic community expects, he or she will be given positive feedback from that community, barriers will decrease, and the student will be encouraged to continue. In turn, students who successfully follow the rules of the academic community feel a greater sense of self-efficacy as they perform better and receive encouragement from the academic community members. It is important to note that the academic system has significant reward structures for those who perform well, and these persons are the most likely to have high self-efficacy (Lent, 2007). Viewed from this perspective, self-efficacy is not a desired end but actually evidence of a minority student abiding by a basic rule of academia. The reverse is true as well: If a student cannot meet the academic community's standards, he or she is likely to receive negative feedback, which will result in lower self-efficacy regarding skills associated with a particular career path. In short, science students who are successfully socially influenced are very likely to be people who have high self-efficacy and feel they can do scientific work. Further, in a social influence framework, intention to persevere is actually an index of integration into the social system. That is, the intention to stay in academia is a measure of a person's willingness to continue to be a part of the academic social system into the long term.

The Scientific Community as an Agent of Social Influence

When framed in this way, the process of training new scientists can be described as one involving social influence. According to Kelman and Hamilton (1989), social influence occurs when "a person changes his or her behavior as a result of induction by some other person or group—the influencing agent" (p. 78). Social influence research focuses on the effect of the social context upon the individual and differs from models of socialization that focus upon individual difference measures such as personality types (Holland, 1997) or personality characteristics (Eccles, 2007). The social influence literature is replete with examples of how individuals (in spite of individual differences) are knowingly, or more commonly unknowingly, influenced by others. For members of our Western individualistic culture who embrace the notion that people predominantly determine their own destinies (Markus & Kitayama, 1994), the idea of being influenced can be distasteful. In fact, much of the classic research on social influence has the goal of showing individuals how to resist social influence (Hodges & Geyer, 2006). Often the influencing agents in these studies are seen as a negative force, in some way denying a person the opportunity to exercise independent thought and conduct. Yet, social psychologists have clearly shown that social influence is ubiquitous—occurring all the time and in a wide array of situations (Chartrand & Bargh, 1999; Cialdini & Trost, 1998; Nolan, Schultz, Cialdini, Goldstein & Griskevicius, 2008; Schultz, Nolan, Cialdini, Goldstein, & Griskevicius, 2007). The influential effects of cultural norms are also pervasive—affecting the way in which people construe themselves and their relationships with others (Markus & Kitayama, 1994). The question is not *whether* minority science students are being influenced but rather *how* are minority science students being influenced? Another important question that educators and policy makers may ask is whether this form of influence effectively patches the leaky academic pipeline?

From the social influence perspective, there is an influencing agent and a target of influence (Cialdini & Trost, 1998; Kelman, 1956, 2006). In the academic environment, the influencing agents are representatives or members of the academic scientific community. The targets of influence are potential and current science students. Thus, the socialization and integration of a student into the scientific community fit the classic social influence paradigm. Ideally, the academic scientific community agents influence students to stay in the sciences. Eventually, the student becomes a professional scientist who will influence the scientific community in turn. Similar to the rule-oriented self-efficacy feedback loop, there is a cycle of social influence in which context affects the individual. However, unlike the self-efficacy feedback loop, a social influence framework affords the opportunity for reciprocal influence. Given our framing of scientific training as one of social influence, how does the research literature on social influence inform the understanding of how science students integrate into the scientific community?

The Study of Social Influence

The focus of recent studies of social influence has been on influence tactics (e.g., the foot-in-the door or door-in-the-face techniques) and on when and why tactics do or do not work. Cialdini and Goldstein (2004) provided a thorough review of recent social influence literature and highlighted how different goals mediate or moderate the relationship between a specific tactic and the resulting acts of compliance or conformity by the target of influence. While certainly relevant to many situations, this sort of research clearly does not explain how a complex social system such as the scientific community influences minority students entering college to pursue a scientific research career. First, this situation of influence is not a one-time situation but an ongoing situation in which many incidents of influence are likely to occur. Second, if the student is indeed influenced, it is quite likely that many different goal motivators will be activated—including the goals of accuracy, affiliation, and maintenance of a positive self-concept, as Cialdini and Goldstein described. Finally, evidence of social influence occurring is likely to result in a broad spectrum of behavioral changes, not just a single behavioral outcome. To capture this larger process of social influence, we draw on an early model of social influence.

Looking Back to Go Forward

Fifty years ago, Herbert Kelman proposed a model of social influence that showed how a person's orientation toward a social system predicted the conditions under which a person would conform with the demands of the influencing agent (Kelman, 1958, 1961). Kelman concluded that there were three processes of social influence—compliance, identification, and internalization—which are each defined by unique antecedent and consequent conditions. Experimental tests of the theory were conducted to explore a specific incident of influence, much as the current research on social influence has done. However, several years later, Kelman (1963) expanded upon his initial theory to take into account that social influence often occurs in a larger context. In fact, he described social influence as a linkage between the individual and the larger social system (Kelman, 1974). According to Kelman (2006), most situations of influence can be described as falling into one of two categories. The first comprises *situations of socialization* in which individuals in a developmental sense are prepared for roles within a society, group, or organization. The second, category encompasses *situations of resocialization* when a situation is "designed to move individuals . . . from old to new roles with their accompanying beliefs and values" (Kelman, 2006, p. 8). This may occur in situations of psychotherapy, conversions of various sorts, and acculturation. It is this later type of resocialization that potentially describes minority students' journey through the academic pipeline.

According to Kelman (1956, 2006), each process—compliance, identification, and internalization—is a unique way in which an individual is oriented to a social system. Compliance occurs when an individual adheres to the rules or norms of the system. With compliance, the person ceases to pursue the behaviors the social system desires if the rewards and approval cease (or when penalties and disapproval increase significantly). This is referred to as a *rule orientation*. Identification occurs when an individual's identity is incorporated into his or her activities within that social system. In this case, the social system defines an aspect of the self, and the person feels a sense of belonging. This is a *role orientation*. Finally, internalization "reflects an orientation to system values that the individual personally shares" (Kelman, 2006, p. 11), which Kelman refers to as a *value orientation*. Thus, an individual may be linked to the social system through adopting the rules, roles, and values of the social system, and the social influence process will vary depending on the person's orientation to the social system.

Measuring Rules, Roles, and Values

While Kelman (2006) suggested that there are three levels of influence that are marked by shifts in the target's internal orientation to the influencing agent, regardless of orientation, the same behavior may be exhibited. However, the motivation for conforming to the influencing agent in both the short and the long term vary according to the target's orientation. Thus, discerning the social influence process comes from measurement of the person's orientation toward the influencing agent (in this case, the scientific community) and not from the measurement of behavioral intentions or overt actions. Rule, role, and value orientation in the context of academia has not been measured previously, so we drew on a wide array of research to develop measures and hypotheses for each orientation.

Rule Orientation: Compliance and Self-Efficacy

Compliance occurs when "an individual accepts influence from another person or group in order to attain a favorable reaction from the other—either to gain a specific reward or avoid a specific punishment controlled by the other, or to gain approval or avoid disapproval from the other" (Kelman, 2006, p. 3). The effect of this is elevated rule-oriented (or compliance-based) self-efficacy. In the context of an academic setting, students comply when they learn the material and the skills required for their majors. Both explicit and implicit rules govern this learning process. First, there is the rule that if students pass their courses, they can move forward toward a degree. If students do particularly well, then influencing agents (professors and counselors) may provide extra incentives and encouragement to continue in that discipline. Evidence that science students feel they can and do conform to the rules of the scientific academic community would be reflected in the level of efficacy they feel in performing the tasks and skills of a scientist. Conceivably, their belief that they can perform the tasks and skills indicates that they have complied with the influencing attempts of the academic community and have learned what they needed to learn. It is important to note here that this does not have anything to do with whether or not students identify as scientists or feel they do or do not belong to the community of scientists, nor does it tell us whether they find the skills they have acquired valuable. When students exhibit a rule orientation toward the scientific community, they simply are confirming that they had the opportunity to learn, that they complied with learning the skills required of the scientists, and that they assess themselves as being capable of doing scientific work. In this context then, scientific self-efficacy is an indicator of Kelman's compliance level of social influence. Research, previously reviewed in this article, would predict that this would be positively related to continuing to pursue a scientific career (Lent, 2007). We contend that the development of self-efficacy is just one part of a more complex theoretical framework.

Role Orientation: Identification and Scientific Identity

As Hamilton (2004) wrote, identification is perhaps the most complex social influence process of the three. Identification occurs when "an individual accepts influence from another person or a group in order to establish or maintain a satisfying self-defining relationship to the other" (Kelman, 2006, pp. 3–4). The complex nature of this process can emerge when people are unaware that they are behaving in a manner consistent with the influencing agent's requests because of the roles they have adopted. If asked, a person would not necessarily know that his or her behavior is contingent on maintaining satisfying relations with a social group. Yet, if the person were to shift his or her identity away from the group, behaviors consistent with group norms and expectations would cease. In essence, successful influence is role dependent. As an explanation of why minority students stay or do not stay in the pipeline, this theory would predict that the more a person identifies as a scientist (i.e., feels he or she belongs in the community of scientists, affiliates with those in the community, and perceives science as an important aspect of his or her identity), the more likely the person would be to behave in a manner consistent with the expectations of that role and to pursue a scientific career.

There is some evidence that minority students do not assume academic identity at the same rate as do nonminority students. Stereotype threat research has shown that when there are "signals" or context contingencies that communicate to minority students that they do not belong in the scientific community, students' performances decline while cognitive vigilance increases (Murphy, Steele & Gross, 2007). Ambady, Shih, Kim, and Pittinsky (2001) showed that even among 5- to 7-year-olds and 11- to 13-year-olds, if a stereotyped identity is made salient, performance on cognitive tasks is negatively affected. Steele (1997) argued that stereotype threat prevents or breaks down a person's identification with academics, while heightening his or her ethnic or gender identity. This process can have a detrimental effect on academic identity, perseverance, and performance (Steele, 1997). The result is a process in which the student experiences academic disidentification in order to maintain positive self-esteem. There is empirical support for this theory. Longitudinal data have shown that for African Americans, academic identification declines the longer they are at university (Osborne, 1995; 1997), and this is particularly true for African American men (Cokley, 2002). This research suggests that when the scientific community attempts to influence a minority science student to assume a role in the scientific community, some minority students face unseen barriers to accepting that role; thus, this research partially explains the minority student gap in the sciences. Hypothetically, the more a student is able to overcome these barriers and assume the identity of a scientist, the more likely this student would be to follow the norms of that role and to pursue a career in the sciences. Thus, even when a student has the required skills and abilities (i.e., self-efficacy), he or she might not persist in the academic pipeline if a feeling of belonging is not present. Role orientation builds upon rule orientation and indicates persistence that is driven by a deeper level of integration.

Value Orientation: Internalization of the Values of the Scientific Community

The final social influence process listed by Kelman (2006) is internalization, which occurs when "an individual accepts influence from another in order to maintain the congruency of actions and beliefs with his or her own value system" (p. 4). In the context of the scientific community, people exhibit an internalized social influence process when their authentic valuing of the objectives of the scientific community is the primary motivation for their desire to pursue a scientific career. The internalized values Kelman specified are akin to those that Schwartz, Melech, Lehmann, Burgess, and Harris (2001) characterized as "serv[ing] as guiding principles in people's lives" (p. 521). While Schwartz et al. focused primarily on 10 cross-cultural value constructs, Kelman described a variety of values held by members of any social system toward which targets of influence orient themselves. People who are newly exposed to the social system internalize these values when they authentically endorse the preferences held by the group.

This conception of values differs slightly from that of Eccles and colleagues in their research on subjective task value. First, while Eccles focused upon the value of specific tasks, Schwartz et al. as well as other researchers (cf. Hofstede, 2001) focused on the level of importance people place on a particular cultural belief or a social system. Second, as a part of Eccles' measure of task values, there are questions that assess the intrinsic value of a task (Durik, Vida & Eccles, 2006; Eccles & Wigfield, 2002). In Hofstede's (2001) and Schwartz et al.'s (2001) approach to values, an individual or group measures the importance of a belief or value without consideration of how enjoyable or useful behaviors associated with that belief or value may be. For instance, in Schwartz's Portrait Value Scale, people are asked to rate how much a description of a person who finds a certain belief important is or is not like them (Schwartz et al., 2001). The items on the scale do not ask for ratings of enjoyment level or the usefulness of the value construct under appraisal. A measure of the importance of a belief, rather than intrinsic enjoyment or usefulness, most clearly captures Kelman's conception of internalization. Regardless of its level of enjoyment or usefulness, when the value of a social group is rated by an individual as being important to him or her, this is evidence of internalization of that value.

In a recent study of values and internalization, Taylor and Graham (2007) specifically examined achievement values among African American and Latino students from low socioeconomic backgrounds. To measure the values of second-, fourth- and seventh-grade students, Taylor and Graham asked them to nominate peers whom they admired, respected, and wanted to be like. The value placed on achievement was calculated by the type of persons the students nominated—low, average, or high achievers. They found that African American girls and Latinas increasingly valued high achievement as they got older. However, for both African American boys and Latinos, the value of high achievement declined with age, with Latinos actually giving more value to average academic achievement than to high achievement by the seventh grade. This research suggests that minority student internalization of the value to achieve may be complex. It is likely, however, that those minority students who attend college do come with some broad value of academic achievement. However, the extent to which their value of the objectives of science predicts their intention to pursue a scientific career remains untested.

Summary

While all three social influence processes—operationalized as rule-oriented (or compliance-based) self-efficacy, role identification, and value endorsement—function independently, one or more processes at a time can be linked to academic perseverance in the sciences. For instance, people who feel that they can perform scientific tasks well may not fully self-identify as scientists (i.e., demonstrate identification) nor believe that what they are doing is valuable (i.e., demonstrate internalization). However, it is just as true that students can be influenced at more than one level. For instance, people who feel that they cannot perform scientific tasks well (i.e., demonstrate low self-efficacy) may continue to pursue a scientific career because their parents were both scientists, science is a strong piece of their identity, and they value scientific objectives. Guided by Kelman's (2006) theory, which we refer to hereafter as the tripartite integration model of social influence (TIMSI), we hypothesized that each orientation would be intercorrelated and yet be uniquely predictive of integration in the scientific community. Students' intention to continue to pursue a scientific career, and therefore to be a part of the scientific community in the future, was our measure of integration.

In the study, we also examined how the TIMSI was predictive across the time course of the academic pipeline, specifically for undergraduate minority science students, graduate minority science students, and minority science students who left the academic pipeline. We hypothesized that graduate students would be the most socialized into the scientific community and thus that their social influence process indicators—scientific efficacy, scientific identity, and scientific community value endorsement—would be stronger than for undergraduates and more predictive of their intention to pursue a scientific career. Following this same logic, we hypothesized that those who had left the academic pipeline with a bachelor's degree would have weaker indicators than those still in an academic pipeline and that these same measures would be less predictive of those students' intention to pursue a scientific career since they were most likely to be in competing or minimally science-related professional environments to which they were being socialized.

Method

The data for this article were drawn from a national longitudinal panel of underrepresented minority science students that was first convened in 2005. Our test of the TIMSI model was based on a cross-sectional analysis of data drawn from the second year of the study, when all the variables reported in this article were administered. We begin with a description of the participants, measures, and the data analysis plan relevant to the hypotheses we tested.

Participants

A longitudinal panel of 1,053 minority science students was recruited from 50 universities across the United States. Participants were considered minority students if their ethnic group was deemed underrepresented in U.S. science graduate degree programs and faculty positions in 2005. Participants were screened into the panel if they intended to pursue a scientific career at the time of enrollment. Data collection has occurred through an online survey conducted biannually. The analytic sample reported is a cross-section of students who completed the second year of the survey (71.3% of the full panel), which was the first year in which all variables reported were offered in the protocol (referred to as Year 1 hereafter). Of this subsample, the small number of participants who left their degree programs without a bachelor's degree ($n = 12$) or who did not provide usable data ($n = 20$) were not included in the analysis. The working sample consisted of undergraduate students ($n = 368$), graduate students ($n = 191$), and those who left college with a baccalaureate degree but were not pursuing a graduate degree ($n = 160$). The undergraduates were primarily in their early twenties (median age = 22 years, age range = 18–48) and female (71%); their ethnicity was split between those of African American (42%) or Hispanic/Latino/Latina (43%) descent. The undergraduate sample included those in their freshmen (2%), sophomore (11%), junior (22%), and senior (65%) academic years. The graduate students were slightly older (median age = 25 years, age range = 19–47) and predominantly female (73%); their ethnicity was split between those of African American (40%) or of Hispanic/Latino/Latina (40%) descent. The graduate sample consisted of those currently pursuing a master's (52%) or doctoral (48%) degree. Finally, the sample of those that had left college was primarily in their early twenties (median age = 24 years, age range = 18–40), female (71%), and of African American descent (51%). Among those who had left college, the majority were working either full time (65%) or part time (26%). Of those working, 64% were employed in a science-related position (e.g., research, teaching, or other). The demographic characteristics of the sample reflect the gender and ethnic diversity found in the National Institute of Health's minority science student training programs in 2005 (Schultz, Woodcock, & Butler, 2006), including a very small percentage who self-reported as "White," which is a commonly used race category for Hispanics/Latinos.

Measures

Scientific self-efficacy: Indicator of rule orientation. Participants used a six-item scale, modified from Chemers et al. (2010) original 14-item Scientific Self-Efficacy Scale, to assess their ability to function as a scientist in a variety of tasks, each of which was rated on a scale of 1 (*not at all confident*) to 5 (*absolutely confident*). Items include "use technical science skills (use of tools, instruments, and/or techniques)," "generate a research question to answer," "figure out what data/observations to collect and how to collect them," "create explanations for the results of the study," "use scientific literature and/or reports to guide research," and "develop theories (integrate and coordinate results from multiple studies)." In the current data, the self-efficacy scale was found to have high internal consistency ($\alpha = .91$).

Scientific identity: Indicator of role orientation. We utilized a modified version of the Scientific Identity Scale (Chemers et al., 2010), which included five items. Participants were asked to assess on a scale of 1 (*strongly disagree*) to 5 (*strongly agree*) to what extent each statement was true of them. Items included "I have a strong sense of belonging to the community of scientists," "I derive great personal satisfaction from working on a team that is doing important research," "I have come to think of myself as a 'scientist'," "I feel like I belong in the field of science," and "the daily work of a scientist is appealing to me." The scale had high internal consistency ($\alpha = .86$).

Scientific Community Objectives Value Scale: Indicator of value orientation. Because no existing scale was available to measure scientific value orientation, we developed a new scale for this study to assess the extent to which participants valued the objectives of the scientific community. Items were validated in a pilot study in which professional academic scientists from a prestigious research institute rated the extent to which they endorsed a list of scientific community values. The most highly rated items were then used for this four-item scale, which was based on the question–response structure of the Portrait Value Questionnaire (Schwartz et al., 2001). Participants were asked to rate "how much the person in the description is like you." Response options included *not like me at all*, *not like me*, *a little like me*, *somewhat like me*, *like me*, and *very much like me*. The descriptions that participants assessed included the following: "A person who thinks it is valuable to conduct research that builds the world's scientific knowledge," "a person who feels discovering something new in the sciences is thrilling," "a person who thinks discussing new theories and ideas between scientists is important," and "a person who thinks that scientific research can solve many of today's world challenges." The scale had high internal consistency ($\alpha = .85$).

Intention as an index of scientific integration in Year 1. The level of integration into the scientific community was assessed with the item, "To what extent do you intend to pursue a science-related research career?" The response options ranged from 0 (*definitely will not*) to 10 (*definitely will*). For our initial analyses, the response to this question was our outcome variable. This measure has been found to be significantly correlated with an index of behaviors associated with pursuit of a scientific career (Estrada-Hollenbeck, Aguilar, Woodcock, Hernandez, & Schultz, 2009).

Behavioral indices of scientific integration in Year 2. At Year 2, self-reported behavioral measures were collected from those who had been junior or senior undergraduate students at Year 1. The first measure was *research experience*. Participants were asked whether in the past 6 months they had "personally designed or conducted an original research project?" or "designed or conducted an original research project as part of a research team?" Those participants who responded affirmatively to one of the questions were classified as having participated in research (coded as 0 = no, 1 = yes). Participants were also asked, "In the last six months, have you applied to any graduate schools?" (0 = no; 1 = yes) and whether they were currently attending graduate school (0 = no; 1 = yes).

Plan of Analysis

In order to test our hypotheses, (i.e., to assess whether self-efficacy, identity, and value uniquely predict scientific integration for undergraduates, graduate students, and participants who have left the academic pipeline), we conducted a series of analyses in a structural equation modeling framework. First, we established the measurement invariance of the self-efficacy, identity, and value scales across the three groups through a series of confirmatory factor analyses (Models 1–3). Second, we tested the hypothesized group differences in self-efficacy, identity, and value predicting scientific integration through a series of nested multigroup structural equation analyses (Models 4–8). Full information maximum likelihood estimation in AMOS Version 16 was used to complete the analyses (Arbuckle, 2007).

Evaluation of model fit. In addition to the model chi-square test, the following indices were used to evaluate model fit, as Hu and Bentler (1998) recommended: root-mean-square-error of approximation (RMSEA) and the comparative fit index (CFI). Further, when nested models are compared, the delta chi-square test is used to evaluate misfit (Kline, 2005). The following cutoffs for indications of good fit were adopted a priori: a RMSEA value at or below .05 (or a 90% confidence interval that includes .05 but does not include .10), CFI values at or above .95, and in comparisons of nested models, nonsignificant delta chi-square values.

Exploratory mediation analysis. Finally, we conducted exploratory longitudinal analyses, investigating the relationship of self-efficacy, identity, and value on behavioral indices of integration in Year 2 (i.e., conducting research, applying to graduate school, and entering graduate school). Further, we tested whether scientific integration, measured as intention to pursue a scientific career in Year 1, mediated the relationship between self-efficacy, identity, and value orientations and the Year 2 behavioral indices of scientific integration. Since the mediation models involved dichotomous outcome variables, weighted least squares estimation in Mplus Version 5.21 was used to complete the analyses (Muthén & Muthén, 1998-2009). The statistical significance of the mediated (i.e., indirect) effect of the predictors on the outcome through the intervening variable has traditionally been tested with a product-of-coefficients approach or Sobel test (Sobel, 1982), wherein the statistical significance of the indirect effect is tested by computing the ratio of the product of *ab* to the standard error of *ab* (where *a* is estimate of the effect of the independent variable on the mediating variable, and *b* is the estimate of the mediating variable on the outcome variable). A recent body of research based on computer simulations indicates that the distribution of the product of coefficients is positively skewed, resulting in a lack of power to reject the null hypothesis that the indirect effect is equal to zero (Bollen & Stine, 1990; MacKinnon, Lockwood, Hoffman, West, & Sheets, 2002). An alternative approach for testing the statistical significance of the indirect effects concerns bootstrapping (Bollen & Stine, 1990). Bootstrapping is a nonparametric resampling technique (Effron & Tibshirani, 1993), wherein the hypothesized model is estimated from observations repeatedly sampled from the data set. Over thousands of iterations of resampling and re-estimating the model, an empirical sampling distribution of the indirect effect is constructed and is referenced to define confidence intervals (Preacher & Hayes, 2008). Consistent with current recommendations, a bootstrap procedure (with 5,000 repetitions) was used to estimate bias-corrected confidence intervals for the direct and indirect effects for these models (MacKinnon, Fairchild, & Fritz, 2007; Shrout & Bolger, 2002).

Results

We conducted our analyses to examine how minority science students integrate into the scientific community. Using the TIMSI to guide our analyses, we tested two major hypotheses. First, we hypothesized that measures of rule (scientific self-efficacy), role (scientific identity), and value (value of scientific objectives) orientations would each uniquely predict scientific integration (measured as intention to pursue a scientific career). Second, we hypothesized that these relationships would be strongest for graduate students since they are theoretically more integrated into the scientific community than undergraduates. Those who left the academic pipeline would show the weakest relationship. We report the results of three structural equation models that we constructed to examine the effect of scientific self-efficacy, scientific identity, and values on scientific integration for undergraduates, graduate students, and those students who had left academia with a bachelor's degree.

Confirmatory Factor Analyses

Single group solutions. We performed three separate confirmatory factor analyses to evaluate the fit of the three-factor model of self-efficacy (six indicators), identity (five indicators), and value (four indicators) in the undergraduate, graduate, and left-academia groups. As shown in Table 1 (M1), the hypothesized three-factor model was supported in each of the three groups, with CFI values at or above .95 and RMSEA 90% confidence intervals (CIs) that included .05. As shown in Table 2, all indicators loaded positively and strongly on their respective factors in the undergraduate, graduate, and left-academia groups. Further, the latent interfactor correlations are moderately large, positive, and statistically significant in all groups. There were, however, two interesting differences in the pattern of latent correlation. Self-efficacy and values were noticeably lower for the graduate student group than for the undergraduate and left-academia groups. Also, the relationship between identity and values was lower for the left-academia group than for the undergraduate and graduate groups.

Multiple group solutions. Next, we tested the measurement invariance of the hypothesized three-factor structure. First, we tested the three-factor structure for all groups simultaneously, providing a test of configural invariance. As shown in Table 1 (M2), we found support for the configural invariance of the hypothesized model, indicating that the three-factor form is the same in all groups (i.e., indicators load on the same factors and double loadings are absent). Second, we constrained the magnitude of the unstandardized factor loadings of each indicator to be equal across all groups, providing a test of metric invariance. For example, the unstandardized factor loading for the third indicator of the self-efficacy factor (Se3: "I have come to think of myself as a 'scientist'"), was constrained to be the same in the undergraduate, graduate, and left-academia groups. As shown in Table 1 (M3), imposing the factor loading equality constraints did not signifi-

Table 1
Goodness-of-Fit Indices for Single-Group and Multiple-Group Confirmatory Factor Analyses and Structural Regression Models of Integration into the Scientific Community

Variable	$\chi^2(df)$	$\Delta\chi^2(df)$	CFI	RMSEA	$CI_{90\%}$
Confirmatory factor analyses					
Single-group solutions					
M1. Undergraduates (n = 468)	197.06 (87)***		.97	.05	.04, .06
M1. Graduates (n = 303)	196.94 (87)***		.95	.07	.05, .08
M1. Left-academia (n = 160)	144.16 (87)***		.95	.06	.05, .08
Multiple-group solutions					
M2. Configural invariance	538.40 (261)***	27.31 (24)	.96	.03	.03, .04
M3. Metric invariance	565.71 (285)***	27.31 (24)	.96	.03	.03, .04
Alternative structural regression models					
M4. Baseline	612.03 (321)***		.96	.03	.03, .04
M5. Constrain self-efficacy path (all groups)	615.94 (324)***	3.91 (3)	.96	.03	.03, .04
M6. Constrain identity path (all groups)	616.22 (326)***	0.28 (2)	.96	.03	.03, .04
M7. Constrain value path (left academia)	617.23 (327)***	1.01 (1)	.96	.03	.03, .04
M8. Constrain value path (others)	617.65 (328)***	0.42 (1)	.96	.03	.03, .04

Note. χ^2 = nested chi-square difference test; CFI = comparative fit index; RMSEA = root-mean-square error of approximation; CI = confidence intervals; M = Model.
*** $p < .001$.

Table 2
Correlation Matrix of Latent and Observed Variables, Descriptive Statistics, and Pattern Loading Matrix for Undergraduate, Graduate, and Left-Academia Groups

	Undergraduates				Graduate students				Left-academia group			
Variable	Self-efficacy (rule)	Identity (role)	Values	Scientific integration	Self-efficacy (rule)	Identity (role)	Values	Scientific integration	Self-efficacy (rule)	Identity (role)	Values	Scientific integration
Correlation matrix												
Self-efficacy (rule)	—				—				—			
Identity (role)	.61***	—			.45***	—			.61***	—		
Value	.51***	.53***	—		.40***	.45***	—		.54***	.52***	—	
Scientific integration	.30***	.51***	.41***	—	.19^{+}	.41***	.43***	—	.33**	.51***	.30***	—
Subscale descriptives												
M	3.85	3.78	4.98	7.41	4.12	3.97	5.23	7.62	3.97	3.72	5.10	7.11
SD	0.73	0.88	0.87	2.91	0.67	0.84	0.76	2.68	0.71	0.91	0.78	2.82
Cronbach's alpha	.91	.85	.86	—	.90	.85	.84	—	.90	.87	.82	—
Pattern matrix												
Self-efficiency (Se)	.84				.73				.74			
Se1[a]												
Se2	.84				.84				.79			
Se3	.84				.81				.79			
Se4	.78				.82				.81			
Se5	.76				.76				.77			
Se6	.68				.71				.75			
Identity (Id)												
Id1[a]		.81				.81				.75		
Id2		.64				.65				.71		
Id3		.79				.80				.79		
Id4		.73				.73				.78		
Id5		.70				.68				.72		
Value (Val)												
Val1[a]			.71				.67				.73	
Val2			.86				.84				.77	
Val3			.79				.74				.65	
Val4			.79				.81				.78	

Note. All pattern factor loadings were statistically significant at $p < .001$. Left-academia group = those who left school after receiving a bachelor's degree.
[a] Indicator variable used to identify the measurement model.
* $p < .05$. ** $p < .01$. *** $p < .001$.

cantly worsen the fit of the model, $\Delta\chi^2$ (24, N = 486) = 27.31, p = .29, indicating that the groups are interpreting the items in the same way (Kline, 2005). These results provide initial support for the basic tripartite approach to scientific integration and strong evidence for the distinction among self-efficacy, identity, and value constructs.

Structural Regression Models

In our model, the latent predictor variables are self-efficacy, identity, and value (Year 1) and the observed dependent variable is scientific integration (Year 1). No unmeasured common causes of self-efficacy, identity, value, and scientific integration are assumed. Further, the model assumes that scientific integration does not cause self-efficacy, identity, and value orientations. We hypothesized that self-efficacy, identity, and value would have different predictive value for the groups, with the highest predictive value for the graduate students and the lowest predictive value for participants who had left the academic pipeline. In order to test our model, we conducted a series of multigroup nested structural regression models.

First, we tested the fit of the basic model (M4), wherein self-efficacy, identity, and values predicted scientific integration, and the structural regression coefficients were allowed to vary for each group. As shown in Table 1, the fit indices showed support for the hypothesized structural regression model. We inspected the structural regression coefficients predicting scientific integration for each group and discovered an interesting pattern of results among the regression coefficients. First, we were surprised to find that self-efficacy was not predictive of scientific integration, after controlling for the other variables in the model: undergraduates: $\beta = -.07$, $b = -0.32$ ($CI_{95\%} = -0.90, 0.26$); graduate students: $\beta = -.11$, $b = -0.53$ ($CI_{95\%} = -1.11, 0.05$); and those who had left academia: $\beta = .01$, $b = 0.03$ ($CI_{95\%} = -1.01, 1.07$). While self-efficacy was predictive in the simple bivariate analysis (see Table 2), it was not uniquely predictive over and above the contributions of identity and values. Further, we found that identity was a strong predictor of scientific integration for all groups: undergraduates: $\beta = .43$, $b = 1.36$ ($CI_{95\%} = 0.95, 1.78$); graduate students: $\beta = .45$, $b = 1.38$ ($CI_{95\%} = 0.95, 1.81$); and those who had left academia: $\beta = .47$, $b = 1.40$ ($CI_{95\%} = 0.77, 2.03$). Finally, we found the hypothesized group differences for the value orientation, such that values were predictive of scientific integration for undergraduate and graduate groups: undergraduates: $\beta = .22$, $b = 0.81$ ($CI_{95\%} = 0.39, 1.22$), and graduate students: $\beta = .16$, $b = 0.63$ ($CI_{95\%} = 0.12, 1.15$), but were not predictive of scientific integration for those who had left academia: $\beta = .05$, $b = 0.23$ ($CI_{95\%} = -0.60, 1.06$). Additional analyses indicted that collinearity effects were not responsible for the findings reported here.[1]

We proceeded to formally test the hypothesized group differences with a series of nested models. First, since the individual paths were nonsignificant, we constrained the unstandardized structural equation coefficients for self-efficacy predicting scientific integration to be equal to zero for all groups. As shown in Table 1 (M5), constraining the self-efficacy path to zero did not significantly worsen model fit. Second, since all of the paths were statistically significant and positive, we constrained the unstandardized structural regression coefficient for identity predicting scientific integration to be equivalent across all groups. As shown in Table 1 (M6), constraining the identity path to be equivalent across all groups did not significantly worsen the fit of the model. Third, since the path for the left-academia group was nonsignificant, we constrained the unstandardized structural regression coefficient for the value orientation predicting scientific integration to zero for the left-academia group. As shown in Table 1 (M7), constraining the value path to be equal to zero for the left-academia group did not significantly worsen the fit of the model. Finally, since the paths were both positive and statistically significant, we constrained the unstandardized structural regression coefficient for the value orientation predicting scientific integration for the undergraduate and graduate student groups to be equal. As shown in Table 1 (M8), constraining the value paths of the undergraduate and graduate student groups to be equal did not significantly worsen the fit of the model. The model, depicted in Figure 1, provided excellent fit to the data and exhibited partial support for our hypothesis. In addition, we examined if gender and ethnicity predicted integration over and above our model. We found no effect of these demographic variables.

Supplemental Analysis of Left-Academia Group

For our sample group of predominantly African American and Latino students, exit from the academic pipeline commonly occurs between degree programs. For this reason, we wanted to examine further the left-academia group, composed of individuals who had

[1] Multicollinearity among the predictors (see Figure 1) is potentially a serious problem in both regression and structural equation modeling frameworks, as severe collinearity can inflate standard errors and increase the probability of Type-II error (Kenny, 1979). In order to gather incremental evidence regarding the collinearity issue, we examined (a) general recommendations from a recent Monte Carlo simulation study, (b) empirical recommendations from our model estimates, and (c) multicollinearity diagnostics in a ordinary least-squares regression framework. First, a recent Monte Carlo simulation study indicates that Type-II error rates become negligible when reliability is high (~.90), sample size is relatively large (i.e., 6:1 ratio of observations to estimated parameters), and collinearity is moderate (<.60), even when the model R^2 is relatively small (Grewal, Cote, & Baumgartner, 2004). Our data and model meet the recommendations we have listed. Second, other empirical indicators of artifactual bias produced from multicollinearity include standardized regression weights that are out of bounds (i.e., β values > 1 or < −1), negative variances for latent variables, and large standard errors of unstandardized regression weights (Garson, 2010). The observed standardized regression weights are within bounds, all variances are positive, and the standard errors are not overly large. We compared the standard errors of scientific self-efficacy as a sole predictor to those found in Model 4. We found that the standard errors of scientific self-efficacy in the sole predictor model (*SE*s = .26, .30, .38) were analogous to those found in Model 4 (*SE*s = .29, .30, .53) for the undergraduates, graduate students, and left-academia group, respectively. Finally, we examined the estimates of tolerance and of the variance inflation factor (VIF) in a standard ordinary least-squares (OLS) regression framework for each group. In regression, tolerance values less than .10 and VIF values greater than 10.0 indicate substantial impact of multicollinearity (Kline, 2005). The multicollinearity diagnostics indicate that collinearity did not exhibit a substantial influence on regression coefficients in the OLS framework, with tolerance values ranging between 0.63 and 0.85 and VIF values ranging between 1.18 and 1.58. On the basis of the convergence of the incremental evidence listed, we are confident that the findings reflect the underlying relationships among the constructs rather than a statistical artifact.

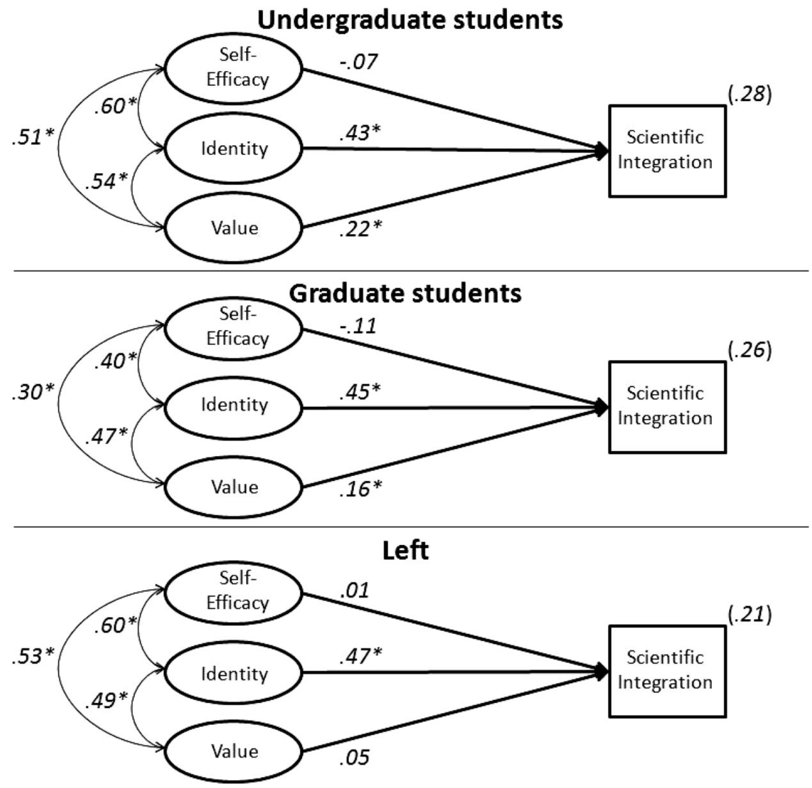

Figure 1. Standardized coefficients for structural regression Model 4. Coefficients inside parentheses are squared multiple correlation coefficients. $^*p < .001$.

exited the academic pipeline after receiving a baccalaureate degree in the sciences. While we treated this group singularly in analysis because they shared a common exit from the academic scientific pipeline, we felt it was important to note that the majority reported they were working in scientific (64%) occupations. In short, they were pursuing a scientific career (although not pursuing scientific academic advancement). As a supplemental analysis, we examined the ability of the TIMSI model to discriminate between those employed in science-related positions and those who were not.

First, we compared the three scale scores for those employed in the sciences with the scores of those with nonscience careers. The descriptive statistics indicated that those employed in science-related positions ($N = 52$) expressed slightly higher levels of scientific self-efficacy ($M = 4.06$, $SD = 0.72$, vs. $M = 3.83$, $SD = 0.73$), scientific identity ($M = 3.91$, $SD = 0.86$, vs. $M = 3.43$, $SD = 0.95$), and scientific values ($M = 5.16$, $SD = 0.78$, vs. $M = 4.90$, $SD = 0.78$) compared with those in the nonscience-related positions ($N = 84$). Next we performed a discriminant function analysis using the three scales (Scientific Self-Efficacy, Scientific Identity, and Scientific Values) to predict group membership (0 = nonscience job, 1 = science job). One discriminant function was calculated, Wilks's lambda = .93, $\chi^2(3) = 9.24$, $p = .02$, canonical $R = .26$. An examination of the standardized discriminant function coefficients, which is used to compare the relative importance of the predictors, indicated that scientific identity was the strongest predictor, followed by scientific values and scientific self-efficacy (coefficients = .89, .16, and .03, respectively). Further, the model correctly classified 74 (88%) of those in the science jobs group and 13 (25%) of those in the nonscience jobs group.[2] This indicates that the factors that predict staying in the sciences may differ from those that predict leaving the sciences. Together, these results indicate that the TIMSI model is sensitive to differences between these two groups.

Exploratory Mediation Models

In a second series of structural regression models, we explored the longitudinal effect of self-efficacy, identity, and value orientations (Year 1) on distal science-relevant behavioral outcomes (Year 2). We were particularly interested in examining whether scientific integration mediated the effects. In the following models, the distal behavioral outcome variables (i.e., conduct research, apply to graduate school, and enter graduate school) are binary. Since these outcome variables were most relevant to college undergraduate students (Year 1), we restricted the analyses to the undergraduate sample previously described who were juniors and seniors in Year 1 of the study ($n = 408$).

[2] This low prediction rate may indicate that the variables that predict choosing a science-related job differ from the factors that predict choosing a nonscience-related job among science students (such as opportunity, family obligation, and level of debt). Thus, while individuals who choose a science-related job are likely to report scientific efficacy, identity, and values, those who do not may (or may not) report these orientations.

An examination of the correlation matrix of the latent and observed variables indicated that there were statistically significant positive bivariate relationships among the predictors (self-efficacy, identity, and value), the mediator (scientific integration), and the distal outcome of conducting research (see Table 3). Although we observed a less consistent pattern of statistically significant relationships between the predictors and other distal outcome measures (Year 2 applications to graduate school and enrollment in graduate school), we proceeded with modeling all potential mediated effects (Shrout & Bolger, 2002).

Conducting research. As depicted in Figure 2, in our first structural regression model, the latent TIMSI variables (Year 1, self-efficacy, identity, and values) were predictors of the scientific integration (Year 1, proximal outcome) and conducting research (Year 2, distal outcome), when the effects of prior research experience (Year 1) were controlled on both proximal and distal outcomes. As highlighted in Figure 2 by the bold paths, there were marginally or statistically significant direct effects of the latent predictors identity and values on the mediator (scientific integration), and a statistically significant direct effect of the mediator on the distal outcome (conduct research). Next we turned our attention to tests of indirect effects.

As summarized in Table 4, self-efficacy did not exhibit a unique total effect on the distal outcome (c: $\beta = .07$) or a unique direct effect on the mediator scientific integration (a: $\beta = .05$), over and above the other predictors and the covariate (prior research experience: $\beta = .27$), obviating the potential for a unique indirect effect (a $\times$ b: $\beta = .01$) on conducting research in Year 2. Unlike self-efficacy, the identity variable exhibited a marginally significant unique direct effect on scientific integration (a: $\beta = .20$), which in turn exhibited a statistically significant unique direct effect on research in Year 2 (b: $\beta = .21$). The model indicates that identity exhibited a small but statistically significant indirect effect on research in Year 2 (a $\times$ b: $\beta = .04$) through scientific integration. Value orientation also exhibited a statistically significant unique direct effect on scientific integration (a: $\beta = .27$). Thus, the model indicates that value orientation exhibited a small but statistically significant indirect effect on research in Year 2 (a $\times$ b: $\beta = .06$) through scientific integration.

Application to graduate school. As shown in Figure 2, an identical model was tested with applications to graduate school as the distal Year 2 outcome and prior applications as the covariate (not depicted in Figure 2). There were statistically significant direct effects from the latent predictors identity and value on the mediator scientific integration; a significant direct effect of the mediator on the distal outcome (apply to graduate school) and a significant direct effect from the latent predictor (value) on the distal outcome.

Similar to the previous models, self-efficacy was not uniquely predictive of scientific integration or the distal outcome applications over and above the other predictors and the covariate (prior applications: $\beta = .34$), hindering the potential for a unique indirect effect (a $\times$ b: $\beta = .01$). Identity, however, exhibited a statistically significant unique direct effect on scientific integration (a: $\beta = .21$), and scientific integration, in turn, exhibited a significant unique direct effect on application to graduate school Year 2 (b: $\beta = .18$). The model indicates that identity exhibited a small but significant indirect effect on application to graduate school (a $\times$ b:

Table 3
Correlation Matrix of Latent and Observed Variables and Descriptive Statistics of Predictors, Covariates, and Outcomes for Undergraduate Group

	Year 1						Year 2		
Variable	Self-efficacy	Identity	Value	Scientific integration	Research	Applications	Research	Applications	Graduate school
Year 1									
Self-efficacy (rule)	—								
Identity (role)	$.47^{***}$	—							
Value	$.50^{***}$	$.53^{***}$	—						
Scientific integration	$.31^{***}$	$.39^{***}$	$.42^{***}$	—					
Research[a] (n = 401)	$.23^{***}$	$.22^{**}$	$.21^{***}$	$.22^{***}$	—				
Applications[a] (n = 403)	$-.10^{*}$	.05	−.05	−.03	−.01	—			
Year 2									
Research[a] (n = 298)	$.21^{***}$	$.18^{**}$	$.23^{***}$	$.27^{***}$	$.31^{***}$	.00	—		
Applications[a] (n = 312)	.01	$.12^{\dagger}$	$.15^{**}$	$.17^{***}$	$.23^{***}$	$.28^{*}$	$.10^{\dagger}$	—	
Graduate school[a] (n = 162)	.03	$.22^{**}$	.09	$.14^{*}$	$.27^{***}$	$.23^{\dagger}$	.06	$.77^{***}$	—
Mean	0.00	0.00	0.00	7.21					
Percentage					38.0	5.00	38.00	30.00	22.00
SD	0.58	0.74	0.77	2.90	0.49	0.21	0.49	0.46	0.47

Note. Self-efficacy, identity, and value are latent variables. Research (Years 1 & 2), applications (Years 1 & 2), and graduate school enrollment are observed variables. All latent variables have means fixed to 0 and *SD* is square root(latent variance).
[a] Dichotomous variable reported as percentage. The number of responses to dichotomous variables varied within the undergraduate group. Research coded as 0 (*have never conducted research by self or as part of a team*) or 1 (*conducted research coded as follows:* research coded as 0 = *have not conducted research alone or as part of a team in the past 6 months* or 1 = *have conducted research alone or as part of a team in the past 6 months*). Applications coded as 0 (*have not applied to any graduate schools in the past 6 months*) or 1 (*have applied to one or more graduate schools in the past 6 months*). Graduate school enrollment coded as 0 (*left college with bachelor's degree*) or 1 (*currently attending graduate school*).
$^{\dagger} p < .10$. $^{*} p < .05$. $^{**} p < .01$. $^{***} p < .001$.

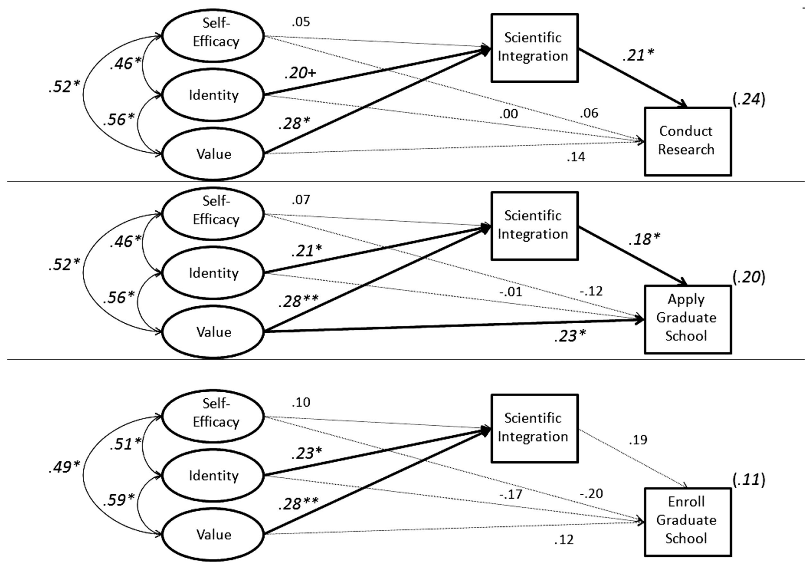

Figure 2. Mediation effect of self-efficacy, identity, and value orientations on distal educational outcomes (conducting research, applying to graduate school, & enrolling in graduate school) through intention to pursue a career in the sciences, with prior research experience and prior applications controlled. All estimates are standardized. Values in parentheses signify R^2 values. Covariates are prior research and prior applications to graduate school.

β = .04) through the scientific integration. Value orientation exhibited both a statistically significant unique total effect on application to graduate school (c: β = .28) and a significant unique direct effect on scientific integration (a: β = .28). The model indicates that the effect of value orientation on application to graduate school was partially mediated through scientific integration (c′: β = .23; a × b: β = .05).

Attending graduate school. The final model was identical to the previous model with the distal outcome of attending graduate school in Year 2 (see Figure 2). Contrary to the previous two models, scientific integration did not exhibit a statistically significant unique direct effect on graduation school attendance in Year 2 although the standardized loading was .19 (higher than the previous model). The sample size for this model was much smaller (n = 162) than the previous models since not all undergraduates were eligible to attend graduate school in Year 2. While we cannot conclude that a statically significant relationship exists, we can say that the relationships are in the predicted direction and comparable to other models in the size of central regression coefficients.

In summary, we designed these three models to explore how well the TIMSI model predicted future science-related behavior, over and above past behavior. More important, we sought to explore how our proximal outcome variable (i.e., scientific integration) served as a mediator between the TIMSI variables and the outcome. The models indicate that scientific integration is a significant predictor of future behavior (over and above the powerful effect of prior behavior) for the behaviors that involve the most student agency (i.e., involvement in research activities and application to graduate school). Further, the impact of the TIMSI variables identity and values are mediated through scientific integration. The overall models, including prior behavior and the TIMSI variables, explained approximately 24% of the variance in Year 2 research behavior and approximately 20% of the variance in Year 2 applications to graduate school. Finally, while none of the individual predictors were statistically significant, the overall TIMSI model explained approximately 11% of the variance in Year 2 enrollment in graduate school.

Discussion

Our overarching purpose in this article was to explore how a social influence framework can enhance the understanding of how students integrate into the scientific community. While our sample included underrepresented minorities, our objective here has not been to determine whether the process of social influence for minority students is different from the majority, nor do we seek to generalize our findings beyond the scope of the African American and Latino population that participated in this study. Rather, we examined how the TIMSI is predictive across the time course of the academic pipeline, specifically for minority undergraduate science students, graduate science students, and science students who left the academic pipeline with a baccalaureate degree. We hypothesized that graduate students would be the most socialized into the scientific community, and thus their social influence process indicators—scientific efficacy, scientific identity, and scientific community value endorsement—would be stronger than for undergraduates and more predictive of their intention to pursue a scientific career. Following this same logic, we hypothesized that those who had left the academic pipeline with a bachelor's degree would have weaker indicators and that these same measures would be less predictive of their intention to pursue a scientific academic career since they are more likely to be living in competing professional environments to which they are be socialized.

Table 4
Mediators of the Effect of Rule, Role, and Value Orientations on Distal Educational Outcomes Through Intention to Pursue a Career in the Sciences

	Outcomes											
	Research				Applications				Graduate school			
Predictors	b	β	b/*SE*	BC $CI_{95\%}$	b	β	b/*SE*	BC $CI_{95\%}$	b	β	b/*SE*	BC $CI_{95\%}$
c												
Self-efficacy (rule)	0.13	.07	0.78		−0.19	−.11	−1.15		−0.32	−.18	−1.20	
Identity (role)	0.06	.04	0.28		0.04	.03	0.21		0.30	.21	0.94	
Value	0.23	.20	$1.81^{\dagger}$		0.33	.28	2.66^{**}		0.20	.17	0.94	
a												
Self-efficacy (rule)	0.26	.05	0.81		0.34	.07	1.02		0.53	.10	1.46	
Identity (role)	0.83	.20	$1.87^{\dagger}$		0.90	.21	2.02^{*}		0.93	.23	2.05^{*}	
Value	0.90	.27	2.96^{**}		0.93	.28	3.08^{**}		0.94	.28	3.05^{**}	
b												
Scientific integration	0.07	.21	2.80^{**}		0.06	.18	2.12^{*}		0.06	.19	1.38	
c′												
Self-efficacy (rule)	0.11	.06	0.67		−0.21	−.12	−1.29		−0.36	−.20	−1.34	
Identity (role)	0.00	.00	−0.02		−0.01	−.01	−0.06		0.24	.17	0.71	
Value	0.17	.14	1.34		0.27	.23	2.17^{*}		0.14	.12	0.65	
a × b												
Self-efficacy (rule)	0.02	.01		−0.02, 0.09	0.02	.01		−0.01, 0.09	0.03	.02		−0.01, 0.16
Identity (role)	0.06	.04		0.005, 0.17	0.06	.04		0.003, 0.18	0.06	.04		−0.01, 0.24
Value	0.07	.06		0.02, 0.14	0.06	.05		0.01, 0.14	0.06	.05		−0.02, 0.18
Covariate												
Prior research	0.56	.27	4.49^{***}									
Prior applications					1.60	.34	4.82^{***}					
R^2			.24				.20				.11	

Note. Estimates were calculated in weighted least squares regression with 5,000 bootstrap replications; b = unstandardized estimate; β = standardized estimate; b/*SE* = *Z* test for statistical significance of the unstandardized estimate; BC $CI_{95\%}$ = bootstrapped bias-corrected 95% confidence intervals for the indirect effect.
All outcomes were dummy coded as follows: Research coded as 0 (*never conducted research by self or as part of a team*) or 1 (*conducted research by self or as part of a team*); application coded as 0 (*have not applied to any graduate schools*) or 1 (*applied to one or more graduate schools*); graduate school enrollment coded as 0 (*left college with bachelor's degree*) or 1 (*attending graduate school*). Values in parentheses represent lower and upper bounds of the bias corrected bootstrapped confidence interval (lower, upper).
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

The Relationship of Self-Efficacy, Identity, and Value to Integration

Overall, we found evidence that the data were consistent with outcomes predicted by the TIMSI. Each of the measures – scientific self-efficacy, scientific identity, and value of scientific objectives – was significantly correlated with integration into the sciences. These findings are consistent with previous research showing that there is a significant relationship between self-efficacy and intention to pursue a career in science, technology, engineering, and mathematics (Lent, 2007). In addition, our initial results regarding scientific identity are consistent with research that finds a strong relationship between identity and academic persistence (Morella, Serpe, Stryker, & Schultz, 2010; Steele, 1997). Our results add to the body of research on values by showing that internalizing the values of a social system is related to social system integration for those at many stages of the pipeline. Together, the initial results support the first hypothesis that while self-efficacy, identity, and values are intercorrelated, overall they also individually, positively, and significantly relate to integration into the social system—in this case, the intention to continue to pursue a scientific career.

However, our findings did deviate slightly from our hypothesis. While identity and values were predictive for all three sample groups, which included science students who were undergraduates, graduate students, and students who left academia with a degree, self-efficacy was predictive for the undergraduate and the left-academia groups only. Finding that this relationship is attenuated for graduate school students indicates that while graduate students may feel they can do the work, their identification as scientists and their endorsement of scientific community values are more highly related to their continued intention to stay in the sciences.

The TIMSI provides a new theoretical framework with which to account for these relationships. The theory suggests that these variables are predictive because they measure the level and strength of integration into a social system. Using a social influence framework, we can say that long-term integration into a complex social system does not rely solely on an individual feeling that he or she can do the tasks that the social system expects of its members. There are other factors related to integration that involve developing a social identity and internalizing the values of that social system. The preliminary cross-sectional descriptive results and pattern loadings fit the TIMSI framework well.

Self-Efficacy, Identity, and Value Predictors of Intention

Our hypothesis—that each orientation would uniquely predict intention—was not wholly confirmed. Although in the bivariate analysis rule-oriented self-efficacy was significantly associated with intention, the model including identity and value orientations and constraining self-efficacy to zero provided a strong fit. This indicates that self-efficacy does not have unique predictive properties. This is a somewhat surprising finding and appears to be at odds with the SCCT of academic success, which contends that self-efficacy uniquely predicts goals and actions (Lent et al., 2005). However, it is worth noting that the SCCT does not contain any reference to identity or values, and thus these were never a part of the model. While issues of collinearity would mean there was a loss of statistical power to detect unique effects of predictor variables, we found no statistical indication that this was a problem in the analysis conducted. From a theoretical standpoint, it is possible that as students progress in their integration into a complex social system, those who feel they can do the work (and report strong self-efficacy) integrate into the social system more deeply when they identify and internalize the values of the larger social system. From this perspective, identification and internalization of values might mark deeper integration of a person into the social system, resulting in stronger unique relationships with long-term academic perseverance in the sciences. This interpretation of the findings explains why scientific self-efficacy is related to identity and values yet maintains that these are conceptually distinct constructs, which is consistent with both the literature on self-efficacy and social identity.

The exploratory mediation analyses support this interpretation of the data. These analyses showed that for undergraduates, scientific integration mediates the relationship between identity and conducting research and applying to graduate school. Likewise integration mediates the relationship between values and these distal scientific career activities. These results indicate that an undergraduate's identity as a scientist and endorsement of the values of a scientist (mediated by scientific integration) are more predictive of longer term behavioral indices of scientific integration such as participating in research and applying to graduate school than scientific self-efficacy. Combined with the cross-sectional analysis, the results suggest that for this student population progressing through the academic pipeline from undergraduate to graduate school, scientific self-efficacy is less related to integration, while identification and internalization remain strong indicators and predictors of student perseverance in the sciences.

The initial social influence model that Kelman (1958) introduced did not measure the growth or relationship among the three variables of rule, role, and value across time, nor did he ever simultaneously regress these variables onto a measure of social integration. The experimental research he conducted, in fact, focused primarily on attitude change in a laboratory setting as opposed to integration into a social community in a field experiment. Our model is consistent with his theoretical ideas, however, in that all three of our orientation measures were related to a measure of integration as he proposed (Kelman, 1963, 1974). But we must concede that in our operationalization of TIMSI, we have used proximal measures of rule, role, and value and have tested a more elaborate model than Kelman initially researched. In doing so, we have identified that while self-efficacy, identity, and values are related to integration into a complex social system, their relationship changes when the element of time is introduced. Of course, additional longitudinal analysis tracking the real-time development of scientific self-efficacy, scientific identity, and scientific values across time would further clarify how these variables' growth trajectories vary relative to the others.

Similarities and Differences Among Undergraduates, Graduate Students, and Those Who Have Left Academia

Our hypothesis that minority science graduate students would be most integrated into the scientific community and those who had left academia would be least integrated was partially confirmed. Our final structural regression model shows that values were a unique predictor of intentions for the undergraduate and graduate groups but not for the left-academia group. Yet, the demographic description of the left-academia cohort shows that 64% of these students were working in a science-related position. Thus, the majority of this group had not completely abandoned scientific work, yet they had chosen not to continue in the academic scientific pipeline. In a supplemental analysis, we assessed the extent to which TIMSI discriminates between those who were and were not pursuing scientific careers. It is interesting that self-efficacy was the least predictive discriminate factor. These former science students all reported scientific self-efficacy regardless of what career path they had chosen. For underrepresented minorities, this step from undergraduate to graduate degree programs is a point at which the academic pipeline leaks considerably (U.S. Department of Education, National Center for Education Statistics, 2005). This supplemental analysis suggests that the choice to stay in the sciences, whether within or outside the academic pipeline, is not highly related to these students' scientific self-efficacy. The development of a scientific identity does appear to relate to whether individuals stay in the sciences for those in academia and those who leave. Finally, the initial analysis of the entire panel shows that, in general, endorsement of scientific values does appear to more highly relate to intentions to stay in the sciences for those in academia and not for those who have left. What our data do not allow us to examine is if underrepresented minority students integrate into the scientific community differently than majority students. However, we can conclude that for this sample, the TIMSI does discriminate the nonacademic science and nonscience career choice groups.

Caveats

While the results of this study support the utility of the TIMSI as an explanation of how students integrate into the scientific community, there are several limitation that should be noted.

Participants. A first caveat is that our sample was entirely underrepresented minorities. This group of participants may have unique cultural and developmental experiences that are not the same as those from the majority American culture. However, the analysis was a test of a model that was initially developed with a mainstream participant pool in the 1950s and was further refined over the course of the following 50 years (Kelman, 1956, 2006). While the model was not empirically tested, a great deal of field and action research utilizing the model has been conducted with a variety of participants. Further research, however, is necessary to verify that the findings of the study reported here, in which proximal measures of rule, role, and value were used, can be broadly generalized.

Developmental or incidental? The TIMSI suggests that the most integrated students will feel they can do the science, they will self-identify as scientists, and they will value the objectives of a scientist. Yet, throughout the discussion, we have described the possibility that the three orientations described in the TIMSI model—self-efficacy, identity and values—may have different predictive value depending upon the depth of integration into the social system. That conclusion is based upon the cross-sectional analyses of the undergraduate, graduate, and left-academia groups and the supplemental mediation analysis. Because of the nature of the data, we cannot confirm at this time that these results are an artifact of the time in which the data were collected or whether they reveal a developmental trend. Further research utilizing longitudinal data is needed before it can be said that these variables, particularly self-efficacy, develop and then plateau once a person has been involved in a social system for many years. This has interesting implications for how to promote academic perseverance. Perhaps there is a point at which students simply need to maintain self-efficacy rather than increase self-efficacy in order to stay engaged in a social community.

Self-efficacy. When self-efficacy first began to be studied in academic settings, researchers surmised that this variable was consistently related to academic performance ($r = .38$) and persistence ($r = .34$; see the meta-analysis by Multon, Brown, & Lent, 1991). The operationalization of the classic self-efficacy concept entailed a measurement of an individual's belief that he or she has the ability to produce a desired effect (Bandura, 1997, 2003). For instance, in a study of engineering self-efficacy, students were asked how confident they were that they could complete educational requirements and job duties (Lent, Brown, Schmidt, et al., 2003), and in a study of general academic self-efficacy, students were asked to rate their confidence in performing specific skills pertinent to academic achievement (Chemers, Hu, & Garcia, 2001). In our study, following the work of Chemers et al. (2010), we adjusted the self-efficacy measurement to be specific to science-related skills that typically would be mastered by individuals complying with the demands (or rather rules) of the science-career community. Since we did not assess academic performance, nothing in our findings calls into question the findings relating classic academic self-efficacy to academic success. Our research does suggest, however, that variables related to adopting community identity and values may become more powerful unique predictors of long-term integration of science students into an academic scientific career path (what some might interpret as a measure of persistence) than scientific self-efficacy as operationalized through Kelman's rule orientation.

Is intention the same thing as behavior? Kelman's (1956; 2006) original social influence theory suggests that people can orient themselves to a social system through rules, roles, and values. The more integrated they are into the social system, the more likely they are to conform to the behavioral requests and expectations of the social system. In the case of minority science students integrating into the scientific community, we have shown that an individual who feels he or she can do the work of scientist, who identifies as a scientist, and who values the objectives of a scientist is very likely to intend to pursue a scientific career, therefore exhibiting the predominant behavior of a socially integrated person. The analysis of the left-academia cohort also shows that the TIMSI does an effective job of discriminating between those who actually pursue a scientific career and those who do not. These findings are consistent with previous research demonstrating that the leap from intention to actual behavior is not far (Kaiser & Wilson, 2004), particularly when measured with specificity (see also the theory of planned behavior research, which links intentions to behaviors in Armitage & Conner, 2001; Cooke & French, 2008; Ajzen & Fishbein, 1980). Repeatedly, Lent and others have found that goals to enter the science, math, and technology majors predict enrollment and persistence behaviors (Lapan, Shaughnessy, & Boggs, 1996; Lent, Brown, Nota, & Salvatore, 2003) as well as performance in the sciences (Luzzo, Hasper, Albert, Biby, & Martinelli, 1999; Sullivan & Mahalik, 2000). While we concede that intention is not the same as behavior, we contend that it is an effective proximal indicator for individuals who are taking the journey through the academic pipeline and continuing to integrate into the scientific community. Further, the mediation analyses show how identity and values are predictive of intention, which is then predictive of distal science-community-consistent behaviors a year later (i.e., conducting research, applying to graduate school, and attending graduate school). These predictive and mediated relationships were not found for self-efficacy, indicating that long-term unique predictive power may not exist.

In Summary

Sometimes in order to go forward in our understanding of a given phenomenon, it is helpful to look back. Fifty years ago, Herbert C. Kelman (1956; 1958) introduced a tripartite model of social influence that described three qualitatively distinct processes of social influence: compliance, identification, and internalization. Operationalizing these orientations in terms of rule-oriented self-efficacy, identity, and value endorsement, we have demonstrated that this theory still has explanatory value. At the same time, our analysis expands this tripartite model by suggesting that the three orientations may not have equal unique predictive capacity when tracking medium- and longer term integration into a complex social community. The TIMSI suggests an alternative way of thinking about the complex integration process of students into a social community across time. We believe that this article provides a platform upon which future research can be conducted on how students of all ethnic backgrounds integrate into academia as a whole.

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