

When talent goes unrecognized: racial discrimination, community recognition, and STEM postdocs' science identities

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Received 10 December 2020

Revised 3 July 2021

10 December 2021

4 April 2022

Accepted 14 April 2022

Abstract

Purpose – While science, technology, engineering and math (STEM) postdoctoral scholars often enter their positions with strong science identities, racially marginalized scholars are often not treated as scientists, which can weaken their science identities. This study aims to examine how racial discrimination negatively affects their science identities in STEM and the importance of community recognition in mitigating these effects.

Design/methodology/approach – The authors use reflected appraisals and identity theory to theoretically guide this work. The data are based on a survey of 215 postdoctoral scholars in STEM disciplines.

Findings – The authors find that community recognition mediates the negative relationship between perceived discrimination and postdoctoral scholars' science identities.

Research limitations/implications – The study shows the importance of recognizing the achievements and identities of underrepresented STEM scholars to counteract the chronic and cumulative identity nonverification that leaves talent unrecognized and disrupts scholars' science identities.

Originality/value – The authors explore the negative impact of discriminatory experiences on the importance individuals place on their identities as scientists and if this can be affected by the degree to which they feel that other scientists recognize them as competent scientists among a group of scholars who have earned the highest of academic degrees, and who are also relatively understudied: postdocs.

Keywords Race, STEM, Science identity, Racial discrimination, Postdoctoral scholars, Reflected appraisals

Paper type Research paper

Introduction

When students from demographic groups that are underrepresented in the sciences encounter science, technology, engineering and math (STEM) environments, their ability



Studies in Graduate and

Postdoctoral Education

Vol. 13 No. 2, 2022

pp. 221-241

© Emerald Publishing Limited

2398-4686

DOI 10.1108/SGPE-12-2020-0079

Funding: This research is based upon work supported by the National Science Foundation (NSF) Grant No. HRD-1647196.

and capability to succeed are often questioned (Herrera and Hurtado, 2011; Gutiérrez y Muhs *et al.*, 2012). As such, racially minoritized [1] scientists have reported that they feel especially isolated and excluded within STEM (Ong *et al.*, 2011; Robinson *et al.*, 2016). Not only do they face challenges to their roles as students, but these trainees also face stereotypes that position their racial group as incompatible with the STEM environment (Herrera and Hurtado, 2011; Gutiérrez y Muhs *et al.*, 2012) and the manifestations of these stereotypes: discriminatory behaviors (Frost, 2011). These experiences of race-based stigma have been well-documented as negatively impacting students' sense of belonging in the academy (Brockman, 2021; Hurtado *et al.*, 2007; Camacho and Lord, 2011; Chang *et al.*, 2011). The marginalization they experience in unsupportive science environments impacts the centrality – the psychological attachment or importance (Settles, 2004) – of their science identity. Science identity can be broadly defined as the internalized sense of self related to science or how much one believes themselves to be a “science person” (Carlone and Johnson, 2007; Hazari *et al.*, 2013; McDonald *et al.*, 2019).

By the time they enter their appointments, STEM postdoctoral trainees (hereafter “postdocs”) have developed science identities that are central to their sense of themselves (Hudson *et al.*, 2018). Their commitment to science is exhibited in their pursuit and successful completion of baccalaureate, master’s and doctoral degrees in science disciplines. The decision to continue on in a STEM postdoc is further evidence of a strong science identity.

However, even at this advanced level, racially minoritized postdocs often struggle to gain recognition as legitimate scientists (Hudson *et al.*, 2018). Minoritized postdocs of color often experience discrimination and isolation. When they interact with others in their fields, they are not always treated as though they are scientists, either comparable to their status as a trained scientist with a doctorate or relative to how other similarly-situated scientists are treated (McGee, 2016; Miles *et al.*, 2020; Nelson and Rogers, 2003). In addition, they do not see many people like themselves represented among their peers and the faculty, making them feel as though they do not belong in these spaces (Malone and Barabino, 2009). It is vitally important to study this phenomenon because research has shown that chronic stereotype threat and risk of confirming negative stereotypes related to science can lead individuals to dis-identify with the science domain entirely (Steele and Aronson, 1995; Woodcock *et al.*, 2012).

In this article, we examine the relationship between postdocs’ experiences of racial discrimination and the degree to which they consider being a scientist as central to their sense of themselves. Furthermore, we determine if feeling supported by the broader science community mediates this relationship. We ask the following questions:

- Q1. What is the relationship between perceived level of discrimination and science identity centrality?
- Q2. Can it be explained in part by the degree to which postdocs feel that other scientists convey confidence in them *as scientists*?

To answer this question, we draw on a survey of 215 STEM postdocs working in higher education institutions in the USA and conduct mediation analyses centered on racial discrimination. We find that local racial discrimination is linked to a weaker science identity, but that broader scientific-community recognition completely mediates this relationship. These findings show the importance of having one’s science identity valued and recognized by the scientific community, especially for scholars who experience racial discrimination.

Background

Culture and demographics of science, technology, engineering and math fields

Black, Latinx and Indigenous scientists are vastly underrepresented in STEM fields in student and faculty roles both in the USA (Martin, 2009; Nelson and Rogers, 2003) and other countries such as Australia, Canada and New Zealand (Freeman *et al.*, 2019; Marginson *et al.*, 2013). This underrepresentation is also apparent within STEM postdoc roles (National Academy of Sciences, National Academy of Engineering and Institute of Medicine, 2014). The following section will describe the postdoc situation in greater detail. First, however, we will focus on the broad culture of STEM, specifically in the USA which comprises our participants of focus, to provide the context that undergirds our study.

The racialized culture of STEM in the USA is perhaps most apparent in engineering, where only 1.5% of PhDs in engineering and computer sciences are awarded to Black students (Zweben and Bizot, 2016). The number of Black faculty in engineering have remained stagnant at 2.5% for the last 10 years in the USA (Yoder, 2017).

Gender disparities are also present in STEM higher education worldwide (Marginson *et al.*, 2013). However, the share of women in faculty and student roles has substantially increased, especially in recent years internationally (Marginson *et al.*, 2013; UNESCO, 2021). In fact, women have achieved parity or even surpassed the number of men in the life sciences in many countries around the world (UNESCO, 2021; Yoder, 2017). This is also the case in our country of focus, the USA, whereby women now outnumber men (55%) in biological and agricultural sciences and now constitute more than a third of the overall STEM population (Yoder, 2017). However, among STEM graduate students, Black, Latinx and Native American students barely make up 3% of graduate students pursuing STEM degrees (Okahana and Zhou, 2018). Thus, while the STEM gender gap appears to be closing, much less progress has been made for underrepresented racial groups.

Due to the deeply-engrained, prevailing culture that associates science with whiteness, a socially-constructed hierarchy of ability persists (Battey and Leyva, 2016; Joseph *et al.*, 2015; Martin, 2009). This hierarchy foments pervasive stereotypes in STEM (Bobo, 2001; Brockman, 2021; Nosek *et al.*, 2002). Research has shown that Black students in the USA are particularly affected by discrimination as a result of these stereotypes about their perceived ability (Major and O'Brien, 2005).

Minoritized students often encounter STEM PhD environments which are hostile and unsupportive due to competitive, meritocratic and supposedly colorblind cultures which conceal the reality of institutional racism that exists in these spaces (Basile and Lopez, 2015; Bonilla-Silva, 1997; Brunsma *et al.*, 2017). Broadly, this institutional culture ignores the racial identities of scientists through a framework which centers on individuated aptitude (Armstrong and Thompson, 2003; McGee *et al.*, 2021; Seymour *et al.*, 1997). For example, a student participant within a 2017 study conducted by McGee and Bentley (2017) reported that her advisor advised her to not worry about her skin color and just focus on her academic work. This pretense – that STEM academia is colorblind – is belied by decades of evidence to the contrary. This supposed colorblind mentality does not lead to color-neutral outcomes in STEM environments.

Because of the culture of STEM, and stereotypes, discrimination and hostile working environments, minoritized scientists of color often feel isolated and as though they do not belong in STEM spaces (Charleston *et al.*, 2014; Robinson, 2013). This discrimination and isolation can often result in racially-minoritized scientists, particularly Black scientists, completely leaving STEM in favor of other career paths, which they do at higher rates than their white counterparts (Turk-Bicakci and Berger, 2014). Black students experience the lowest degree completion rates in STEM compared with all other groups in the USA

(Sowell *et al.*, 2015). These patterns of discrimination and isolation persist even in faculty appointments, a point at which a doctoral degree should be enough evidence of competence in one's field (Sowell *et al.*, 2015). This issue is especially relevant due to our focus on USA postdocs.

Postdoc experiences patterned by race

We explore the negative impact of discriminatory experiences on the importance individuals place on their identities as scientists among a group of scholars who have earned the highest of academic degrees and who are also relatively understudied (Cantwell and Lee, 2010): postdoc researchers. STEM pathways, particularly those that end in a career as an academic scientist – often extend beyond the doctoral degree and into postdoc appointments.

According to the National Academy of Sciences, National Academy of Engineering and Institute of Medicine (2014), thousands of graduates of doctoral programs move on to postdoctoral training. Similar positions to a postdoc have been in existence for over a century (Garbutt, 2006) and the term “postdoc” appears to have been first used in 1942 (Merriam-Webster, 2022). Continuing from STEM doctoral programs to postdoc positions is prevalent around the world in countries such as Australia (Hardy *et al.*, 2016), China (Wang, 2010; Ahmed *et al.*, 2015), India (Namrata, 2019; Science and Engineering Research Board, 2022), the UK (The UK Grad Programme, 2007; Woolston, 2020) and our country of focus, the USA, which contains the largest share of postdocs in the world (Ahmed *et al.*, 2015; Gülcher and Pérez-Díaz, 2020). Approximately 690,000 postdocs were hired in the USA between 1985 and 2011 (Ahmed *et al.*, 2015). In contrast, China, which is estimated to have the second largest share of postdocs in the world, was estimated to have hired approximately 105,000 postdocs in that timeframe (Ahmed *et al.*, 2015). Within these countries, the number of postdocs hired over time has steadily grown (Ahmed *et al.*, 2015; National Academy of Sciences, National Academy of Engineering and Institute of Medicine, 2014). In fact, in the USA, the number of postdoc positions has more than tripled in the past four decades (National Academy of Sciences, National Academy of Engineering and Institute of Medicine, 2014). These increases have been attributed to increasing pressures on the academic research expectations of universities (Micoli and Wendell, 2018) and the organizational adaptations to the intensification of the research economy (Cantwell and Taylor, 2013). These pressures and organizational adaptations often lead to an overwhelming reliance of institutions and academic principal investigators (PIs) on external grants to fund their laboratories and manage academic research production (Cantwell, 2015).

This vast augmentation of the sheer number of postdoc positions in the USA has happened alongside a stagnation of tenure-track faculty and a 10-fold increase of nontenure track academic positions since 1975 (Micoli and Wendell, 2018). The reliance of institutions on relatively inexpensive postdoctoral scholars instead of tenure-track faculty to meet research demands is a trend that is not likely to change anytime soon (Cantwell and Lee, 2010). This has led to many postdocs to never advance beyond the postdoc position and remain in these roles indefinitely (Cantwell and Lee, 2010). However, due to the various job titles afforded to postdocs, it is difficult to accurately assess the number of scholars serving in the postdoc role (Jaeger and Dinin, 2018).

Most postdocs in the USA (78 %) are in the life and physical sciences; another 14% are in engineering, math and computer science. Like the demographics of STEM graduate students, the demographics of the postdoctoral population have changed as well. In the past 25 years, the percentage of women postdocs in the USA has grown from 25% to nearly 45% in the life sciences and from 10% to about 20% in the physical sciences and engineering (National Academy of Sciences, National Academy of Engineering and Institute of Medicine,

2014). While similar historical data on shifts in the numbers of nonwhite scientists are not available, the [National Academy of Sciences, National Academy of Engineering and Institute of Medicine \(2014\)](#) reports that only 4% of the STEM postdoc population is composed of Black, Latinx and Native American US citizens and permanent residents.

Given this degree of underrepresentation of Black, Latinx and Native American scientists, there is little reason to believe that these scientists have not experienced the kind of discrimination described throughout the STEM literature, yet there is a dearth of research exploring discrimination among the postdoc population. Higher academic rank is not always followed by instant recognition of the skills associated with this position. In fact, research suggests that the relationship between higher status (e.g. education) and improved psychological outcomes (e.g. mental health) is attenuated for racially minoritized groups and that this is attributable to increased perceived discrimination resulting from decreased representation ([Cheng *et al.*, 2015](#); [Feagin and Sikes, 1994](#)). Becoming more underrepresented over time, minoritized postdocs may perceive greater ostracization than they experienced previously, and this may be linked to disparate career interests and outcomes. Research has shown that compared to white and Asian postdocs, Black, Latinx and Native American postdocs were significantly more likely to become interested in nonresearch careers throughout the course of their postdoc appointment ([Gibbs and Griffin, 2013](#)). This can make their experience within and beyond this role difficult since many PIs lack sufficient knowledge of nonresearch careers to be effective mentors in this endeavor ([Hokanson and Goldberg, 2018](#)).

We expect that a key reason for this attrition is racial discrimination resulting from these hostile environments. Attrition is not an outcome we investigate in the current study. However, we are focused on the relationship between perceived discrimination and *science identity centrality*, a significant predictor of long-term academic commitment and persistence in STEM for underrepresented groups, above and beyond other important factors such as self-efficacy ([Estrada *et al.*, 2011](#); [Naphan-Kingery and Elliott, 2018](#)). Because identity centrality is linked to commitment and willingness to persist in research science career pathways long-term, this project uses identity theory to unpack how identity nonverification, like discrimination within a STEM postdoc position and subsequent perceptions of reflected appraisals may diminish science identity centrality.

Identity theory and positive reflected appraisals

This project is centered theoretically on symbolic interactionism ([Blumer, 1969](#); [Mead, 1934](#)) with a particular focus on the reflected appraisal process. [Cooley \(1902/1964\)](#) originally defined reflected appraisals as how individuals make sense of feedback received from others. According to this theory, individuals glean cues about their performance from the way others treat them and compare this with their own personal identity standard. This is established in Cooley's idea of the "looking-glass self," whereby people see themselves reflected in the way that others react to them. People want to see their views about themselves recognized, confirmed and shared by those in their in-group.

Like others, postdocs' self-evaluations are affected by the way others perceive them and, most importantly, how the postdoc perceives others' words and actions directed toward them ([Gecas and Schwalbe, 1983](#); [Pitt *et al.*, 2020](#)). These words and actions provide cues of the appraisals others have of them. Therefore, discrimination would be expected to greatly affect postdocs' self-concepts. The logic follows thusly: if the biology postdoc not only graduates from a doctoral program but also earns a competitive postdoctoral appointment, she would evaluate herself as being a capable – maybe even more than capable – scientist. She would expect others to see her that way and treat her as a capable scientist, both in words and actions. Not only would their positive treatment support her evaluation of herself,

but it would also strengthen her sense of herself as a scientist; she would become more committed to the identity. Conversely, if she receives a negative evaluation from others of her performance of her science identity, she will doubt her evaluation and, in turn, will lessen her sense of herself as a scientist.

This project draws specifically on Burke's conceptualization of identity theory (1991) which espouses the importance of self-identity in the reflected appraisal process. The reflected appraisal process is important to how individuals conceptualize their identity because individuals develop social identities in relation to others who confirm their membership (Stets and Burke, 2014). When congruence between the perceptions of others' appraisals of the actor and the actor's own appraisal of themselves occurs – or, in this case, when the science postdoc feels that their science identity is validated by the science community – this is considered an identity verification (Burke and Stets, 2009). This verification leads to positive feelings of belonging and a strengthening of one's identity as a scientist. When incongruence occurs or the community does not validate the scientific identity of a postdoc, this leads to identity nonverification. This experience elicits negative feelings of belonging and a weakening of one's identity centrality; in this case, the postdoc's identity is borne out of their role as a STEM student and researcher: their *science identity*.

Since postdocs understand their science identity as representing a component of the self in academic situations, a lack of support from others can be detrimental to the meaning of this scientific identity for the postdoc. Therefore, the lack of perceived social support for a postdoc's science identity can decrease commitment to that particular identity. Studies on commitment expand upon work on identity centrality (which focuses on the importance of identities for *self*-definition) by taking into account the relationship between *social* networks and the individual (Stryker, 1987). Burke and Reitzes (1991) argue that high levels of commitment will lead to involvement in organizations, activities and frequent interactions with others who verify and support this person's identity. Thus, on the other hand, if a postdoc feels as though their identity is not supported by their scientific community, they may not only feel isolated but also make concerted efforts to not become involved in activities with others in their scientific community due to the continual devaluation and lack of recognition of their science identities, essentially isolating themselves from their scientific community. It becomes a feedback loop. A continual lack of perceived social support from others in the scientific community can have the effect of decreasing the importance of one's science identity, perhaps explaining the high levels of attrition of women and Black students/workers from STEM fields (Sowell *et al.*, 2015 Turk-Bicakci and Berger, 2014).

The laboratories and other research contexts that postdocs work in are important spaces for them to encounter social support and receive recognition from other scientists, such as the PI and other postdoctoral scholars. These, presumably, positive social environments provide minoritized scientists with opportunities to enact a role (scientist) and be treated as a competent performers of that role. In these spaces, prospective scientists should experience the kind of identity verification – particularly from their scientist peers – that increases both commitment to and centrality of a scientist identity. However, these locations can be primary sources of the discrimination the scientists experience, thereby damaging the importance, they place on being a scientist and being in such an environment.

But these local environments are not the only exposure minoritized scientists have to other scientists. From their reception when they attend conferences in their disciplines to the more formal avenues for recognition of their work (e.g. paper presentations, publications, awards, paid consulting opportunities), there are a host of ways that STEM postdocs who feel unvalidated as scientists in their local context might find that validation among scientists beyond the local environment. This kind of global recognition and verification by

the broader community of scientists may be as important as (or, we suspect, more important than) local verification of the postdocs' science identity in the formation of a stronger sense that they themselves are scientists too.

Current study and hypotheses

In the current study, we examine the relationship between perceived level of racial discrimination and science identity centrality among STEM postdocs and if it can be affected by the degree to which they feel that other scientists recognize them *as competent scientists*. Specifically, we ask: What is the relationship between perceived level of racial discrimination and science identity centrality? and Can this be explained in part by the degree to which postdocs feel that other scientists recognize them as competent scientists? We used perceived discrimination in their local environment as our measure of **identity nonverification** (Burke, 1991) because research has shown minoritized people of color are particularly affected by discrimination as a result of stereotypes of perceived ability (Major and O'Brien, 2005). When discrimination occurs, minoritized people of color are not treated the same as others in the scientific community. This differential treatment would be expected to disconfirm postdocs' science identities because when they are not treated as competent scientists in the same capacity as their nonminoritized counterparts, their science identities are challenged. Because higher levels of discrimination are expected to disconfirm the science identities of postdocs and the centrality of these identities, we hypothesize that for postdoctoral STEM scholars:

- H1. Perceptions of racial discrimination will lead to lower levels of science identity centrality, i.e. postdocs will place less importance on their science identities in constructing their overall sense of self.

We used the respondents' perceptions that the (broad) scientific community recognizes them as competent scientists as our measure of **positive reflected appraisals**. When members of a postdoc's workplace discriminate against them based on their race, it signals they cannot be scientists because they do not resemble prototypical scientists, which is a form of identity non-verification (Burke, 1991). We expect this can, in turn, decrease their science identity centrality. However, we believe that this can be mediated by perceptions of reflected appraisals from the broader scientific community. Thus, with the assumptions centering around our previous hypothesis in mind, we hypothesize:

- H2. The relationship between perceived discrimination and science identity centrality will be mediated by perceived positive appraisals, i.e. postdocs' perceptions that their broader scientific communities recognize them as scientists.

Thus, we tested whether or not and the extent to which this kind of broad science-community recognition mediated the relationship between perceived racial discrimination and science identity, as shown in Figure 1.

Data and methods

We used a Web-based survey to gather information from 215 STEM postdoctoral appointees. We believe that postdoctoral trainees in STEM, particularly those doing postdocs in academic contexts, are a useful population for this investigation because we expect them to be firmer in their sense of themselves as scientists than the undergraduate or graduate students that similar research has been based upon (Pitt *et al.*, 2021). In 2017, staff

members in the Offices of Postdoctoral Affairs at 30 research-intensive doctoral universities forwarded our invitation to participate in the research to their cohorts of postdoctoral trainees. The invitation described the parameters for involvement in the research, specifically that potential respondents be US citizens or permanent residents within the first three years of a STEM postdoc that fell into one of the following categories: agriculture and conservation resources, biological and biomedical sciences, STEM education, engineering and computer science or the physical sciences and math.

More than 750 postdocs showed interest in the initial invitation to participate in our study. However, most of those potential respondents were ineligible to participate because they did not meet the aforementioned recruitment parameters for the study. Ultimately, we ended data collection with a sample of 215 postdoctoral trainees. Of these respondents, 65% are women. We weighted our analyses to account for the oversampling that created this imbalance. We used the proportion of STEM postdoctoral recipients (35%; [NCSES - SDR, 2017](#)) who are women as a target population for this weighting. The racial balance – 77% white, 23% nonwhite – more closely approximates the percentages of white/nonwhite US citizens and permanent residents with STEM doctorates ([NCSES - SDR, 2017](#)). Representation among the disciplines was as follows: agriculture, 6.5%; biological and biomedical sciences, 56.3%; STEM education, 3.3%; engineering, 14.4%; and physical sciences, 19.5%. These percentages differ from the national postdoc population by less than 10% ([NCSES - SDR, 2017](#)).

Key dependent variable [2]

Science identity centrality. To understand the degree to which our respondents considered “being a scientist” as important to their sense of themselves, as articulated in research question and *H1*, we asked them a series of 10 questions developed by [Chemers et al. \(2011\)](#). On a four-point scale ranging from 1 (strongly disagree) to 4 (strongly agree), the participants indicated their agreement with statements such as, “In general, being a scientist is an important part of my self-image,” “I have come to think of myself as a scientist,” and “I feel like I belong in the field of science” ($\bar{x} = 3.18$) which were averaged and treated as a single factor: science identity centrality ($\alpha = 0.84$). See measures for these statements as follows:

- (1) *Science identity centrality* ($\alpha = 0.82$); scale = 1 (Strongly Disagree) to 4 (Strongly Agree):
 - In general, being a scientist is an important part of my self-image.
 - Being a scientist is unimportant to my sense of what kind of person I am.*
 - I have a strong sense of belonging to the community of scientists.

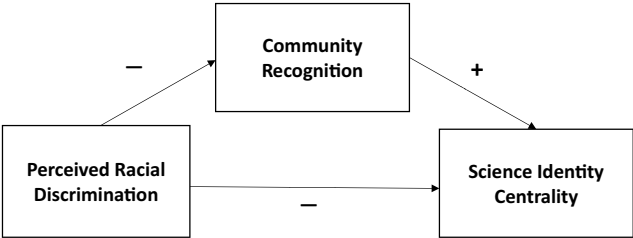


Figure 1.
Mediation model

- I derive a great personal satisfaction from working on a team that is doing important research.
 - Being a scientist is an important reflection of who I am.
 - Being a scientist is not a major factor in my social relationships.*
 - I have come to think of myself as a “scientist.”
 - Thinking of myself as a scientist is compatible with other aspects of my background (ethnicity, gender, social class, etc.)
 - I feel like I belong in the field of science.
 - I am a scientist.
 - My social network includes a lot of scientists and/or science students.
 - I would feel more like a scientist if there were more people of my background (ethnicity, gender, social class, etc.) in my field.*
 - The daily work of a scientist is appealing to me.
 - Overall, being a scientist has very little to do with how I feel about myself.*
- (2) *Perceived community recognition* ($\alpha = 0.89$); scale = 1 (Strongly Disagree) to 6 (Strongly Agree):
- I feel that the scientific community provides me with choices and options.
 - I feel understood by people in the scientific community.
 - People in the scientific community convey confidence in my ability to do well.
 - People in the scientific community encourage me to ask questions.
 - People in the scientific community listen to how I would like to do things.
 - People in the scientific community try to understand how I see things before suggesting a new way to do things.
- (3) *Perceived racial discrimination* ($\alpha = 0.93$); scale = 1 (Strongly Disagree) to 4 (Strongly Agree):
- Some people believe that you have less ability.
 - If you are not better than average, people will assume that you are limited.
 - People expect you to do poorly.
 - People are less likely to encourage you.
 - You are not fully accepted or included.
 - If you ask a simple question, people will think it is because of your ethnicity.
 - If you do poorly on a task, people will assume that it is because of your ethnicity.

*Indicates reverse-scored items.

The mean (on a four-point scale) of 3.18 is only slightly higher than equivalent measures of science identity centrality in samples of undergraduate *and* graduate science trainees (Chemers, 2011; Stets *et al.*, 2017). There were no significant differences between white and underrepresented and minoritized URM postdocs on this variable, $t(187) = 1.27, p = 0.21$.

Key independent variables [3]

Perceived racial discrimination (local identity-nonverification). We measured perceived racial discrimination using a modified version of the seven-item stereotype threat scale

devised by [Steele and Aronson \(1995\)](#). The questions gauge the degree to which respondents *believe* people discriminate against them. On a five-point scale ranging from 1 (never) to 5 (always), participants indicated how often they believe they are treated in certain ways, in their postdoc appointment, because of their race. Possible experiences include “some people believe that you have less ability” and “you are not fully accepted or included.” The responses to the seven items were averaged, producing a scale ranging from 1 to 5 ($\bar{x} = 1.54$) and treated as a single factor: perceived racial discrimination ($\alpha = 0.93$). As suspected, the difference between white ($\bar{x} = 1.34$) and URM ($\bar{x} = 2.35$) postdocs is significant, $t(26) = 7.23$, $p = 0.00$. The majority of white postdocs (89%) said they never or rarely felt discriminated against because of their race. Only 37% of URM postdocs said the same.

Science-community recognition (broad positive reflected appraisals). To address research question and *H2*, we measured our respondents’ perceptions that the broad scientific community trusts them as competent scientists using the six-item work climate scale ([Williams and Deci, 1996](#); [Baard et al., 2004](#)), a scale that has been validated for use across a range of work environments and types of respondents. On a six-point scale ranging from 1 (strongly disagree) to 6 (strongly agree), participants indicated their agreement with statements such as, “People in the scientific community convey confidence in my ability to do well” and “People in the scientific community listen to how I would like to do things.” In the prompt for this question, we explained that people in the scientific community encompassed scientists both in university settings and outside of them. It was not a measure of local support. These items were combined in a scale ranging from 6 to 36 ($\bar{x} = 25.42$) and treated as a single factor: science-community recognition ($\alpha = 0.89$). There were no significant differences between white and URM postdocs on this variable, $t(187) = 0.84$, $p = 0.40$.

Possible covariates

In our analysis, we controlled for whether respondents were in a biological science field (coded “1”) or not (coded “0”). These fields have relatively proportionate levels of representation for women and URM groups. Being in a more diverse STEM field could mean experiencing less discrimination, and therefore their levels of science identity centrality may be higher. The data were unsuitable to account for respondents being nested within institutions [4]; however, we note that all of the institutions are predominantly-white, research-intensive and doctoral universities.

We controlled for postdocs’ ages and if they were in their first year of their postdoc. We also controlled for the length of time they had been interested in STEM with a dichotomous variable (1 = before high school and 0 = high school or later). Each of these factors are approximate indicators of how much time respondents had invested in constructing their science identities. Furthermore, given that recognition from family and friends is particularly important for students of color to construct their science identities ([Carlone and Johnson, 2007](#)), we also included a dichotomous variable measuring the respondents’ perceptions of their family and friends seeing them as scientists. Respondents who indicated that two statements – “My family members view me as a scientist” and “My friends view me as a scientist” – both described their feelings were coded “1,” and all other respondents were coded “0.”

Finally, many STEM fields are overwhelmingly white or Asian, male and heterosexual. Therefore, having less-represented identities can result in greater discrimination and thus less science identity centrality. Thus, we controlled for whether or not respondents identified as a member of a URM group. If the respondent identified as Black, Latinx, Cambodian or Vietnamese, they were coded as “1,” and white respondents and respondents from other

Asian groups were coded as “0.” We also controlled for gender, which was dummy coded with men as the reference category, and for sexual orientation, with heterosexual as the reference category.

Analytical model. To address our first research question, we used ordinary least squares regression modeling to determine the relationship between our primary independent variable (perceived racial discrimination) and our primary dependent variable (science identity centrality). To answer our second research question, i.e. the extent to which broad science-community recognition might mediate the relationship between local identity nonverification processes (perceived discrimination) and science identity centrality, we tested a mediation model. We used the Preacher and Hayes’ (2008) indirect effects approach using the fourth model of the PROCESS macro in SPSS (Hayes, 2012), using nonparametric bootstrapping with 5,000 resamples (Preacher and Hayes, 2008), which is recommended for small sample sizes because it does not violate assumptions of normality.

Analyses and results

The results are presented in Table 1. Model 1 (which shows path *c* in Figure 1) shows science identity centrality regressed on perceived racial discrimination and the covariates; Model 2 (which shows path *a* in Figure 1) shows science-community recognition regressed on perceived racial discrimination and the covariates; and Model 3 (which shows paths *b* and *c*’ in Figure 1) is identical to Model 1, but controls for the respondents’ perceptions that they enjoy broad scientific-community recognition of their competence as scientists.

Model 1, which has an adjusted R^2 of 0.231, answers our first research question. It shows a significant, negative association of perceived racial discrimination (identity nonverification) with science identity centrality, which supports our *H1*. The more often postdocs feel that those in their workplace treat them poorly because of their race, the less likely they describe a science identity as central to their sense of themselves. Thus, racial discrimination is significantly associated with a decrease in the level of importance STEM postdoctoral scholars placed on their science identity as a component of their self-concept. Unsurprisingly, length of time interested in STEM and greater perceptions that one’s family and friends see them as scientists had positive associations with science identity centrality.

Model 2, with an adjusted R^2 of 0.119, shows that while controlling for the covariates, perceived racial discrimination significantly predicts decreased perceived science-community recognition (our measure of positive reflected appraisals), such that greater discrimination results in less perceived recognition from one’s community.

Model 3, with an adjusted R^2 of 0.339, essentially adds perceived science-community recognition to Model 1 to answer our second research question. When science-community recognition is added to the model, the coefficient for racial discrimination becomes nonsignificant, showing a full mediation of the relationship between racial discrimination and science identity centrality. Therefore, the inclusion of perceived science-community recognition, our measure of broader positive reflected appraisals, ultimately decreases the impact of perceived racial discrimination, thus explaining much of why racial discrimination negatively predicts science identity centrality. Because zero, which would indicate that there is no effect, is not within the lower and upper confidence intervals of the indirect effect, this indicates significant mediation and supports our *H2*.

Discussion and conclusion

Overall, this study supports the importance of perceived science-community recognition as a mediator of the relationship between perceived racial discrimination and the centrality of postdocs’ science identities. To succeed in their scientific roles long-term, postdocs must

Table 1.
Regressions
predicting the impact
of perceived racial
discrimination on
science identity
centrality

	Model 1		Model 2		Model 3	
	Science identity centrality	SE	Positive reflected appraisals	SE	Science identity centrality	SE
	B		B		B	
Perceived racial discrimination	-0.213**	0.075	-0.341***	0.073	-0.082	0.074
Positive reflected appraisals					0.384***	0.068
In a biological science (yes = 1)	-0.471	0.714	0.297	0.694	-0.586	0.664
In their first year of postdoc (yes = 1)	0.781	0.736	0.309	0.716	0.662	0.685
Has a STEM master's degree (yes = 1)	0.643	1.330	3.016*	1.293	-0.516	1.253
Length of time interested in STEM (before high school = 1)	2.347**	0.731	1.085	0.711	1.930**	0.684
Perceptions that both one's family and friends see them as a scientist (very clearly = 1)	3.121***	0.711	0.176	0.691	3.053***	0.661
URM (URM = 1)	-1.737	1.373	0.761	1.335	-2.029	1.278
Gender (woman = 1)	-0.995	0.742	-0.880	0.722	-0.657	0.693
Sexual orientation (not heterosexual = 1)	-0.293	1.100	-1.929	1.070	0.448	1.031
Age (in years)	0.115	0.102	0.183	0.099	0.045	0.096
Constant	38.888***	3.839	20.474***	3.732	31.022***	3.829
$p < 0.001$ ***, $p < 0.01$ **, $p < 0.05$ *	Adjusted $R^2 = 0.231$		Adjusted $R^2 = 0.119$		Adjusted $R^2 = 0.339$	
<i>Standardized indirect effects of perceived racial discrimination on community recognition</i>						
B	Upper level CI		Lower level CI		Upper level CI	
SE	-0.065		-0.199		-0.065	
-0.126	0.035					

Notes: 5,000 samples for percentile bootstrap confidence intervals; URM = underrepresented minority; SE = standard error; CI = confidence interval

Notes: 5,000 samples for percentile bootstrap confidence intervals; URM = underrepresented minority; SE = standard error; CI = confidence interval

place importance on being a scientist, and to do so, their science identities need to be recognized, reflected and validated by others in the scientific community. Our analysis reveals that this validation at a more global level may be more beneficial than having this validation in one's local environment.

Perceived discrimination in their STEM postdoctoral assignments translates to feeling unrecognized as scientists in STEM spaces. Considering how others evaluate them – in this case, negatively – has the important implication of potentially affecting postdocs' science identity centrality. Because our measure of perceived racial discrimination reveals how often (i.e. “never” to “always”) a postdoc experiences local nonverification of their science identity, our findings support Burke and Stets' argument that more frequent or persistent sources of identity nonverification produce stronger effects than infrequent events of identity nonverification or discrimination in our study (Burke, 1991; Stets, 2005). When discrimination was experienced more often, we found a stronger negative effect on science identity centrality compared with when discrimination was experienced less often. The fact that this non-verification is happening in their local environment, with people (postdoc advisors, other postdocs) with whom they have close and consistent interactions, especially exacerbates the potential effects of feeling discriminated against on their sense of themselves as scientists.

That said, as we show in our mediation analysis, postdocs' perceptions that they enjoy the support and recognition of the broader scientific community fully mediated the relationship between local racial discrimination and science identity centrality. The pathway between perceived racial discrimination and science identity centrality became nonsignificant when broad science-community recognition was added to the model, even after controlling for length of time interested in STEM and perceptions of one's friends and family, which were strongly linked to science identity centrality. Ultimately, the threat to science identity centrality is not simply local nonverification of the science identity in their postdoc appointment. The real threat is not feeling validated by the broader scientific community beyond their STEM postdoc appointment. Having that support and recognition renders local discrimination irrelevant.

These results support Cooley's original notion of the “looking glass self” (Cooley, 1902) that individuals shape their self-concepts based on others' impressions they see reflected back to them. While some models of science identity (Carlone and Johnson, 2007) posit that recognition by others is, in fact, a dimension of science identity, we found support for its role as an antecedent to science identity centrality. These findings also support research on stereotype threat showing that the threat of confirming a negative, ability-based stereotype about one's social group can lead to domain disidentification, in which an individual bases less of their self-esteem on their success in that particular domain (Woodcock *et al.*, 2012).

Furthermore, our findings support Burke and Stets' (2009) theory of identity verification because they show the importance of congruence between one's own science identity and their perceptions of the reflected appraisals of others. When the broader scientific community recognizes and validates a postdoc's science identity, their identity as a scientist is strengthened, exhibited through an increase in centrality of this identity for the postdoc. On the other hand, when a postdoc's science identity is not validated, science identity centrality decreases.

This study is not without its limitations. We recognize that the generalizability of this study is limited by the fact that our conclusions are drawn from a postdoc-only sample. Evidenced by the pursuit and successful completion of a science PhD, STEM postdocs are likely to have strong science identities; the mean is 31 out of a possible 40 points and 61% of our respondents scored higher than that. In that sense, STEM postdocs are “extreme cases”

compared to a sample comprising undergraduates or even graduate students in STEM disciplines. Given this limitation, it is all the more interesting that even among these extreme cases, broad science-community recognition is still a potent contributor to their science identity. Even among individuals who have been pursuing careers in science through at least two college degrees (89% of our postdocs have STEM undergraduate degrees), feeling like they belong and that scientists recognize them as one of their own remains critical to their understanding of themselves as scientists. Certainly, our understanding of these phenomena would benefit from applying our analysis to undergraduate and graduate students in STEM disciplines as well.

That said, while its focus on postdoctoral trainees limits its generalizability to all STEM trainees, that focus makes this an important contribution as well. Relative to research about STEM trainees at all other levels (i.e. undergraduate, graduate), research about postdoctoral trainees is scarce. As taking on a postdoctoral appointment is becoming increasingly normative in STEM disciplines in the USA, particularly in the biological and biomedical sciences (Ahmed *et al.*, 2015; Pitt *et al.*, 2021), understanding the behaviors, motivations and issues of identity among individuals at this level is important for building a more complete picture of influences on attrition from and persistence in STEM disciplines and careers.

Further, our study is limited in that we pooled several racial categories into one URM category and that it does not consider intersectionality. We were unable to consider racial groups separately due to the low number of participants in each subgroup and, similarly, were unable to consider intersectionality due to a limited number of respondents that identified as possessing multiple marginalized identities. It is our hope that future researchers are able to measure and analyze the experiences of those in STEM who possess particular racial backgrounds and multiple identities (e.g. Black women). Understanding the unique ways in which science identity intersects with distinct and multiple identities is vitally important in broadening participation in all levels of STEM education and occupations.

Future research in this area would also benefit from applying a more focused lens on what experiences with the broader scientific community might lead respondents to feel the kind of recognition our measure of perceived scientific-community recognition reflects. For example, science communities validate scholars' scientific identities by accepting their scientific ideas in publications and conference presentations. Are there some forms of validation that are more (or less) available at various stages of a STEM scholars' training and career? If so, are the pathways to more global positive reflected appraisals limited in early stages of STEM training (e.g. undergraduate training) compared to later stages like the postdoctoral appointment? Are there interventions that organizations interested in broadening URM participation in STEM might use which could capitalize on our findings – interventions that expand the networks and mentoring opportunities for URM students beyond their local environments?

While answering these questions is beyond the scope of our study, we suggest that expanding the extant diversity programming for undergraduate students into the graduate and postdoctoral levels may be a good start. Research has found that this programming has facilitated the formation and validation of strong science identities as well as effective career preparation and higher levels of matriculation (Alston *et al.*, 2017; Burt *et al.*, 2020; Maton *et al.*, 2016; Russell *et al.*, 2018; Wright-Harp and Cole, 2008). Unfortunately, however, this programming is generally for undergraduates only (Thomas *et al.*, 2007; Wright-Harp and Cole, 2008). We believe that expanding this programming, which generally includes trips to national conferences, professional development events, invitations to academic lectures and brown bag lunches (Thomas *et al.*, 2007; Wright-Harp and Cole, 2008), into the postdoctoral

level, could enhance community recognition. In particular, research has found that, while Black graduate students lament the loss of diversity-related programming upon entering their graduate programs, some have successfully filled this gap through active participation in STEM conferences and/or national organizations (Brockman *et al.*, 2022). Facilitating this participation for postdoctoral scholars could be a helpful initiative that institutions could implement.

While we are confident in the predictive validity of our findings, the cross-sectional nature of our data makes it impossible to speak to causality. Even a simple longitudinal approach to these data may be insufficient to fully capture how local identity nonverification vs more global identity verification dynamics might affect – rather than be associated with – identity centrality. Controlled experimental research that manipulates experiences of discrimination and community recognition and then measures one’s science identity centrality would increase our confidence in the presumed causality underlying our theoretical model (Stone-Romero and Rosopa, 2011).

We also hope that future research explores the connections between science identity and stressful aspects of the postdoc role, such as the oversupply of PhDs in relation to decreasing amounts of tenure track positions and competition for funding to maintain research labs. The intersections between science identity and stressful aspects of the postdoc role could be extra oppressive for minoritized scientists, and we hope that future research examines these relationships.

Researchers of diversity in STEM education have argued that the white, male, Eurocentric and heteronormative climate of many STEM fields drives away promising and talented scholars. This study demonstrates the important role of positive reflected appraisals – particularly from the broad science community – in this process, even among postdoctoral scholars who have successfully demonstrated scientific achievements. In addition to minimizing racial discrimination through policies that transform STEM cultures to be more inclusive, these findings imply that STEM departments and STEM disciplines more broadly should capitalize on instating measures to recognize and affirm the science identities of historically underrepresented STEM scholars through publicly recognizing their contributions to their fields. This is one way to counteract the chronic and cumulative identity nonverification that leaves talent unrecognized and disrupts scholars’ science identities.

Notes

1. We use the term “minoritized” to refer to Black, Latinx and Native American scientists because, while they *are* fewer in number than white and Asian scientists, their experiences of marginalization reflect a socially-constructed status (“minority”) rather than any accounting of their representation in these disciplines (Benitez 2010 and Gillborn, 2009 for more).
2. To be certain that mean differences between our white and URM respondents do not exist because of biases in the way we measure our three dependent and independent variables, we used a multigroup confirmatory factor analysis to check measurement equivalence. By engaging in an omnibus modeling of the equality of these groups’ covariance matrices, we affirmed that the matrices did not differ across the groups, thereby establishing measurement equivalence.
3. We checked for measurement invariance for both the dependent and independent variables, so the prior note (ii) applies for this section as well.

4. Our respondents come from only 25 institutions, and while some researchers have recommended a minimum of 20–25 groups at the second level of a HLM (O'Dwyer and Parker, 2014), others have cited a minimum of 50 groups necessary for unbiased estimates of the standard errors at the group-level (Hox and Maas, 2002). We coded the institutions as public or private and controlled for it in the models, and this made no difference in the results (this analysis available upon request).

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