Reversing the Lens on Public Engagement with Science: Positive Benefits for Participating Scientists

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Scientists increasingly seek to respond to urgent calls for equity in science but may be unsure how to engage with underserved public groups. Prisons, jails, and detention centers are venues in which scientists may use their educational privilege to serve and empower diverse populations that are underserved by science education and underrepresented in science disciplines. We reversed the lens that traditionally focuses on the benefits of public engagement to the audience by documenting the impacts of delivering science lectures on the scientists who offered seminars to incarcerated people. The scientists who engaged in carceral settings gained professional benefits, shifted their preconceptions of incarcerated people, raised their perceived value of community engagement, and increased their interest in social justice. Some took direct actions for social change. This program could model effective engagement for other underserved groups in our society. We provide guidance to initiate such a program in other institutions.

Keywords: broader impacts, informal science education, incarceration, public engagement with science, underserved groups

Scientists recognize that increasing human diversity in the enterprise of science will strengthen STEM research, contribute to the global competitiveness of our workforce, and increase appreciation for science by all members of the public. Despite investment by the National Science Foundation (NSF) and other agencies to broaden the participation of ethnic groups underrepresented in STEM and those with low socioeconomic status and limitations in their education (Gonzalez 2014, National Science Foundation 2019), equity in STEM is an as yet unrealized academic aspiration (Committee on Underrepresented Groups and the Expansion of the Science and Engineering Workforce Pipeline 2011).

In June 2020, calls from social activists and the public prompted many members of the scientific community to pause in their work, listen, and reflect on how scientists can individually and collectively be a force for change. Hundreds of scientific organizations, including the American Institute of Biological Sciences, supported #ShutDownSTEM and similar antiracist initiatives (Chen 2020). However, many scientists recognize that neither the large-scale bold new initiatives that envision large-scale centers (Committee on Equal Opportunities in Science and Engineering 2019) nor simply reflecting on their actions and attitudes will bring diversity, equity, and inclusion to the scientific enterprise. Academics now ask how they can directly participate in meaningful and immediate ways to realize one goal of broadening participation and in ways that can be both empowering for underserved audiences and sustained within the existing academic reward system.

One way for scientists to contribute to broadening participation is through direct public engagement of science (PES) with scientifically underserved and underrepresented groups, such as adults and youth who are incarcerated. The American criminal justice system holds a large population (approximately 2.3 million adults and youth in over 7100 correctional facilities, including federal and state prisons, local jails, juvenile detention facilities, immigration detention centers, and Indian Country jails; Sawyer and Wagner 2020). Individuals that are underrepresented minorities in science are overrepresented in correctional institutional populations; nearly 60% of prisoners are African American or Latino, although they make up only 13% and 16% of the total population in the United States, respectively (de Brey et al. 2019). They come largely from the most disadvantaged segments of the population, often have histories of physical and emotional abuse, and tend to be poorly served by our education systems, frequently sustain problems with substance addictions, and lack work training or experience (National Research Council 2014).

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Most states (84%) offer some kind of general education for the incarcerated population, most of which focus on basic and secondary education, life skills, vocational training aimed at postrelease employment, and social behavior rather than on topics or approaches of science (Harlow 2003). The number of formal higher education programs is growing (35% of state prisons provide college-level courses), but these programs only serve 6% of incarcerated individuals nationwide (Davis 2019). With very few exceptions, the incarcerated lack access to remote educational opportunities due to restrictions on internet access.

However, these populations also hold enormous potential to contribute to society. There is a growing body of literature on the positive impacts of science education and engagement on outcomes (increased science content knowledge, reduced recidivism, greater probability of postrelease employment, and greater self-esteem; Wilson et al. 2000, Davis et al. 2013, Pompoco et al. 2017, Nadkarni and Morris 2018) for incarcerated people. There is also evidence for the positive educational values for students in situations in which scientists are placed in nonuniversity venues, e.g., scientists in K–12 classrooms, which generates authentic exchanges, evokes interest in science, and creates new views of science and scientists (Woods-Townsend et al. 2016).

However, to provide sustainable pathways for academic scientists to contribute to PES for diverse and underserved public sectors such as the incarcerated requires that the scientists who provide such interventions gain benefits that are viewed as positive within the academic system. A growing number of scientists and science administrators perceive the values of broadening the impacts of their research to public groups (Burchell 2015, Pew Research Center 2015, Besley et al. 2018). But even researchers who have good intentions in this area—particularly early career scientists—find challenges in implementing broader impacts activities (which includes broadening participation; Watts et al. 2015), because the traditional academic reward system has tended not to prioritize direct engagement with society (Jacobson et al. 2004, Poliakoff and Webb 2007). When scientists choose to engage, they have tended to do so with communities in traditional venues for science education (e.g., schools, museums, science centers) because those venues are relatively easy to reach, and their audiences tend to have similar values, experiences, interests, and curiosity as those in academia (Falk et al. 2016). However, if PES—including engagement with underserved and other diverse groups—can be documented as yielding outcomes that are congruent with academic and personal values of scientists, then there is a greater probability that these efforts will persist because they will be viewed as imperative for a healthy and well-educated society and as a benefit, rather than a burden, to members of the scientific community.

In the present article, we describe the impacts of scientist-driven engagement with incarcerated people inside prisons, jails, and juvenile detention centers on scientists. Nearly all studies of correctional education and engagement have been focused on impacts of education and engagement on the incarcerated populations. We reversed the lens and documented impacts on academic scientists who provided science lectures to people living in carceral settings. We asked how these short-term interventions might provide professional and academic benefits and how they might shift awareness of and intent to take actions on issues of social justice, including mass incarceration, underrepresentation, and inequity in science. We first describe effects of these activities on the scientists, including impacts on professional skills, personal attitudes, and behaviors, and awareness of and actions on social justice issues. Second, we describe the benefits, challenges, and costs of this program.

Program background

In 2013, we created the Initiative to Bring Science Programs to the Incarcerated (INSPIRE), which grew from the Sustainability in Prisons Project, initiated in 2004 (Ulrich and Nadkarni 2009). Our approach of informal science education (ISE; noncredit, voluntary participation, with no structured curriculum) contrasts with the majority of formal education that characterizes most correctional education (Davis et al. 2013). The aim is to guide academic scientists to provide science research and education lectures to incarcerated adults and youth at state prisons, county jails, and youth-in-custody facilities. Three of our past studies documented the impacts of this intervention that accrue to the incarcerated participants. Attendance at lectures was voluntary, with approximately 55%–95% participation, based on the number of incarcerated attending science education events relative to the cellblock occupancy on the date of the lecture.

Our first study occurred in Utah, which documented that the delivery of monthly lectures held in prisons and jails by scientists in a broad range of science disciplines resulted in a significant positive effect on participants' science content knowledge, significant positive change in their attitudes about science and scientists, and an increase in their behavioral intentions to seek out more information about science, suggesting that ISE delivered by scientists can be an effective path between scientists and this audience (Nadkarni and Morris 2018).

The second study, also in Utah, documented that the desire of the incarcerated to seek out more scientific information, their self-perception as science learners, and interest in science all increased significantly from before to after each lecture. Attending a greater number of lectures was positively correlated with a desire to seek out additional information (Horns et al. 2020).

The third study explored the generality of results of scientist-delivered lectures to incarcerated populations in other geographical locations and types of correctional institutions. Scientists affiliated with the National Aeronautics and Space Administration (NASA) presented a single science lecture (to adults) or workshop (to youth) on astrobiology inside 16 correctional institutions in three other states. Presentations significantly increased incarcerated participants' science content knowledge, positively shifted attitudes about science and scientists, increased a sense of science self-identity, and enhanced behavioral intentions about communicating science with others. These positive impacts were significant across participants' ethnicity, gender, education level, and across institution type, size, location, and state, suggesting that even limited exposure to voluntary, ISE can be an effective way to broker relationships to science for this underserved group (Nadkarni et al. 2020).

In the current study, we recognized these positive outcomes on the incarcerated but focused on impacts of these activities on the scientists. We asked four questions: How did participating scientists perceive their experience in terms of professional outcomes? Did participating scientists change their views about the capacity of their incarcerated audiences to understand and appreciate science? Did this intervention affect their awareness of and desire to take actions relating to broad social justice issues? And how did scientists' gender, career level, and number of lectures delivered affect the self-perceived degree of impact of their experience?

Surveys for participating scientists

Scientists participated voluntarily. Formal recruitment was through announcements sent via departmental administrative staff to all faculty and graduate students at the beginning of each semester (total pool of approximately 620; 182 faculty and 438 graduate students). We used the approach of ISE, lifelong learning in science that takes place across a multitude of designed settings and experiences outside of the formal classroom. We did not present an ordered curriculum, nor did we provide academic credit. Among the 71 presenters represented in this study, the topics and disciplines presented varied widely, reflecting the interests and expertise of the individual researchers. The majority of the scientists and presentations concerned biology (67% of the total presenters; 71% of the 160 presentations), with the remainder filled by presenters in the physical sciences, social scientists, and art and humanities. The topics in biology (in descending order of frequency) included ecology, zoology, genetics, human biology, astrobiology, virology, anatomy, physiology, parasitology, botany, microbiology, biochemistry, anatomy, and molecular biology. The nonbiology STEM topics (29% of presenters, 28% of presentations) included physics, chemistry, engineering, and mathematics. The social sciences (3% of presenters, 1% of presentations) included the topics of psychology and anthropology. The arts and humanities topics offered in tandem with science presentations (1% of presenters, 1% of presentations) included yoga and dance.

Survey development and deployment. To develop a survey program for the participating scientists, our evaluation instruments were based in part on the theory of planned behavior and the theory of reasoned action to assess science motivation and interest (Ajzen and Fishbein 1980, de Leeuw et al. 2015). Where possible, we used items from validated surveys. Where preexisting surveys did not address key factors or topics, we modified items and developed new questions. The survey was designed in collaboration with the Utah Education Policy Center. In May 2019, retrospective surveys were provided to all of the scientists who had given at least one lecture at a correctional facility in Utah through INSPIRE or STEM Community Alliance Program (STEMCAP), which bring scientists to youth-in-custody facilities (n = 98; days from most recent lecture to survey, minimum = 2, mean = 591, maximum = 1859). The surveys were disseminated online through Qualtrics (www.Qualtrics.com). To gauge the volunteers' attitudes about how the experience affected them personally and professionally, the surveys asked 27 five-point Likert-scale questions and four short-answer questions (supplemental table S1).

Quantitative survey questions. The questions were grouped into seven categories: perception of the experience, benefits of assistance from INSPIRE or STEMCAP staff, the challenge of preparing the presentation, the challenge of being in a correctional environment, professional value, perception of the incarcerated students, and perception of science communication. The answers were standardized to a scale of –2 to 2, where greater values indicated a more positive perception, greater benefits derived from staff support, less challenge experienced, and greater value derived.

Each participant's responses were summed across questions in each of the seven categories. Because there were different numbers of questions in each category, we standardized the responses by dividing the sum by the maximum possible value (the number of questions multiplied by two). This resulted in responses from each participant for each category of questions that fell between –1 (if all responses were strongly negative) and 1 (if all responses were strongly positive). We then ran a series of two-sided t-tests ($p < .05$) on each question category to determine whether there was any significant pattern of responses.

To examine how the responses varied by demographic information, we ran a series of ordinal regressions on the nonsummed Likert responses using cofactors for gender, career stage, number of talks delivered, and institution type. Separate regressions were run for each question category. The surveys that were completed anonymously and, therefore, carried no demographic information, were excluded. The career stage for scientists was defined as early (undergraduate and graduate students), middle (postdoctoral researchers and associate and assistant professors), or late (professors, long-term governmental or nongovernmental organization staff). The categories for the number of lectures delivered were one, two to four, and five or more. The institution type categories were adult, youth, or both. To explore whether there were differences between the effects of lectures that concern biology versus nonbiology, we carried out a post hoc test with biology and nonbiology (physical sciences, social sciences, and arts and humanities) as an additional cofactor in the ordinal models. Quantitative analyses were done in the R statistical environment (version 3.5.1; R Development Core Team 2020). Ordinal regressions were performed using the R package "ordinal" (Christensen 2019).

Open-ended survey questions. The short-answer, open-ended questions we asked scientists were these: "Why would (or wouldn't) you recommend this to other scientists?" "Did this interaction motivate you to take more interest in social justice issues?" "Did this interaction motivate you to take actions relating to social justice issues?" And "was there anything that surprised you about the program or audience?" Two coders who were blind to the research questions independently coded the scientists' responses. The coders' agreement on dichotomous measures was assessed by Cohen's kappa, and their agreement on continuous measures was assessed with Cronbach's alpha. Kappa values greater than .40 and alpha values greater than .70 indicate acceptable agreement (Fleiss 1981). The reliability indices exceeded acceptable agreement levels and are reported with the corresponding measures below. Disagreement on the dichotomous measures was coded by a third assessor, who was also blind to the research questions.

We coded whether the scientists would recommend the lecture (yes or no). If they answered yes, we coded into categories the reasons that they provided: personal value (e.g., was a rewarding experience), professional value (e.g., improves public speaking skills), and value for incarcerated participants. The coding of whether the scientists recommended the lecture was perfect. The coders' agreement on the scientists' reasonings exceeded the standards of moderate agreement (personal value, $\kappa = .55$; professional value, $\kappa = .47$; value for incarcerated individuals, $\kappa = .77$). Statistical analyses of the open-ended survey questions were done with SPSS (George and Mallery 2003).

We also coded the scientists' interest in social justice ($\alpha = .97$) and motivation ($\alpha = .95$) for collective action resulting from the experience into three categories: yes, no because I'm already interested or no because I already take action, and no. We used chi-squared tests to determine whether the scientists' responses to these questions significantly differed by rank or gender.

We coded the scientists' answers to what surprised them about the program or audience along three dimensions. First, we coded to what degree they mentioned that their audience possessed traits that are counterstereotypical to portrayals of incarcerated people; they are generally stereotyped as low in competence, low in warmth, and dangerous. Second, we coded to what degree the scientists mentioned humanizing perceptions (views that affirm uniquely human characteristics, such as engagement and curiosity, and the commonality of these human traits among all people; for a review, see Haslam 2006) and counterstereotypical perceptions (views in opposition to the stereotypical associations of negative traits with incarcerated people; MacLin and Herrera 2006). For both of these dimensions, the coders rated the responses as 0, not mentioned; 1, somewhat mentioned; and 2, mentioned in detail. Third, to what extent the scientists mentioned having negative preconceptions about incarcerated people prior to their lecturing experience using the following codes: 0, not mentioned; 1, implied; and 2, yes. The reliability was good for all three ratings (counterstereotypical, $\alpha = .81$; humanizing, $\alpha = .73$; preconceptions, $\alpha = .77$). To analyze these ratings, we ran a series of two-sided *t*-tests comparing whether the respondents' interest in social justice (or motivation to act) correlated with perceived personal value, professional value, or an experience counterstereotypical to preconceived notions. The respondents who reported previous interest in or action on social justice were excluded from these *t*-tests. To test for demographic differences, we conducted two-sided *t*-tests to compare the differences between the early career and mid- to late-career scientists' counterstereotypical perceptions, humanizing perceptions, and reporting of negative preconceptions. We also tested whether these effects were different by scientists' gender using ANOVAs, but these were nonsignificant.

Scientist responses to the survey

Of the pool of scientists from which we recruited the participants by departmental email announcements (approximately 620 science faculty and graduate students), 98 (16%) chose to participate by delivering one or more lectures in a set of correctional facilities, and of those, 71 (72%) completed surveys.

Quantitative survey questions. In each of the seven question categories (table S1), the summed responses of the participants were significantly positive (*t*-test, $p < .001$ in all categories). Figure 1 shows the summed responses in each category where a value of 1 indicates a strongly positive response across all questions within the category, and −1 indicates a strongly negative response across all questions within the category. In all seven categories, the median response across all the presenters was greater than 0, indicating an overall positive perception across all aspects of the experience. In four of the categories, not a single participant reported an overall negative perception. The questions relating to the participants' perception of their experience showed the greatest percentage of positive responses, with 59% of the respondents giving strongly positive answers in all five questions and only one respondent reporting an overall negative perception.

Seventy of the returned surveys (99%) were completed nonanonymously, which we used in analyses comparing responses with demographic information. Gender, number of talks given, and career stage all significantly affected responses in at least one of the seven question categories ($p < .05$, ordinal regressions). Women and those that had given five or more presentations tended to view the experience more favorably than men and those that had given fewer presentations ($t = 2.28$, $p = .023$ and $t = 1.98$, $p = .048$,

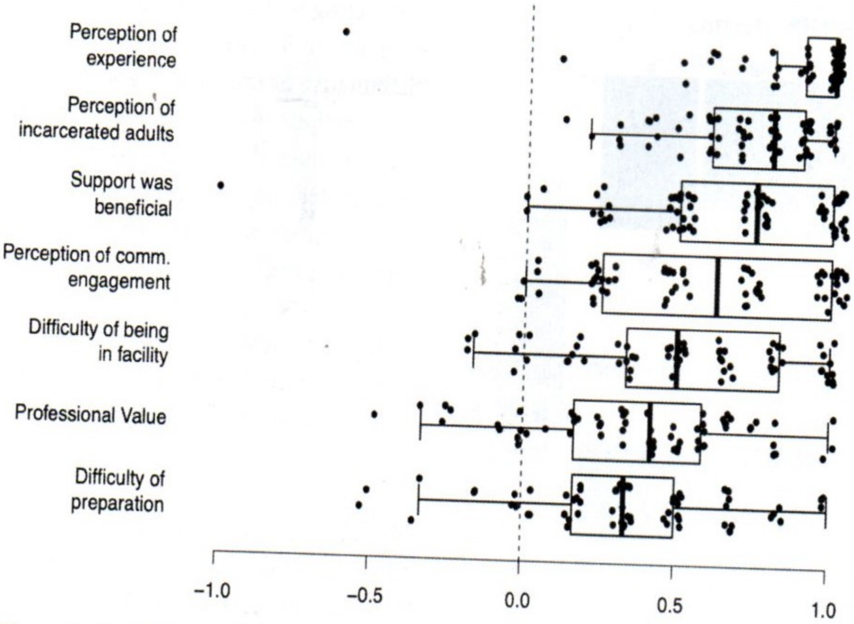

Figure 1. Overall responses to Likert-scale questions grouped into seven categories. The boxes show median, first and third quantiles, and 95% range of variation. The points show actual distribution of data. Responses in each category were assigned a numerical value (−2 for strongly negative answers, 2 for strongly positive) and summed. The total was then divided by the maximum possible magnitude (number of questions in category × 2) to scale categories with differing numbers of questions. Any points at −1 represent participants who gave responses that were completely strongly negative. Points at 1 represent participants who gave responses that were completely strongly positive. The distributions of responses in all seven categories were significantly above 0 (t-test, p < .001 in all categories).

respectively; figure 2a). Similarly, the participants at early stages in their careers tended to report a more positive change in their perception of incarcerated people compared with the participants in midcareer ($t = 2.39, p = .017$) or late-stage career ($t = 2.04, p = .042$; figure 2b). Early stage career participants also showed a more positive change in their perception of community engagement than participants in late-stage career ($t = 3.58, p < .001$; figure 2c, supplemental table S3). Two of the categories (perception of incarcerated people and perception of community engagement) showed a significantly more favorable perception from presenters whose seminars were on topics of biology versus nonbiology areas ($t = 2.37, p = .018$ and $t = 2.53, p = .011$, respectively; supplemental table S4). For the remainder of the questions, there were no significant differences due to the biology versus nonbiology presentation topic cofactor. Our study design, with a relatively small sample size of nonbiology participants, did not allow us to determine whether the lack of favorable perceptions of the experience of presenting to inmates by the small percentage of individual presenters in fields outside biology is an artifact of the topics presented or previous communication skills of the presenters.

Open-ended survey questions. All of the scientists said that they would recommend the experience to others (supplemental table S2). Of these, 62% mentioned professional and academic benefits of the experience, with many comments about how the experience helped them better communicate with laypeople about the importance of their research and to reframe their research to themselves. For example, "[It] Made you really break down your research into terms that a general audience could appreciate" and "It's insightful sharing your research and expertise with a new audience because it causes you to understand your own material differently than you had previously. This is especially true with nonexpert audiences."

Nearly half (48%) of the sample mentioned personal benefits to the experience, including positive feelings and increased motivation. For example, "Good thing to do, sense of helping others" and "I felt positive (invigorated, happy, and refreshed) afterward." Thirty-three percent of the sample mentioned benefits to the incarcerated participants: "They were so willing to learn," and "They have little access to intellectual stimulation (but clearly want and appreciate it)".

When asked if anything about the experience surprised them, the scientists frequently mentioned having altered perceptions of the incarcerated adults. The statements that follow were taken verbatim from the respondents' surveys before they had contact with the people inside correctional institutions. They are somewhat unsettling, because they indicate that some of the presenters seemed to express implicit bias that may be due to a lack of previous experience with incarcerated populations (or other scientifically underserved groups) or that these presenters have only been exposed to the generally negative image of incarcerated people that is disseminated in popular culture. Specifically, a quarter of the respondents mentioned having at least somewhat negative preconceptions of incarcerated people prior to their lecture experience (e.g., "It helped me reevaluate all my original assumptions about incarceration, shaped only by what I learned from others" and "It was surprising to see how smart incarcerated people are"). Furthermore, 53% of the scientists expressed surprise at the participants' high level of engagement with the lecture (e.g., "I was surprised with how interested they were with our presentations. All the members of the audience were deeply engaged and willing to learn"), and 64% reported being surprised by how smart and polite the audience was (e.g., "I was surprised by the quality and insight of questions I received during my presentation" and "Their [seemingly] genuine curiosity, politeness, and respect"). They also became aware of the obstacles for correctional education

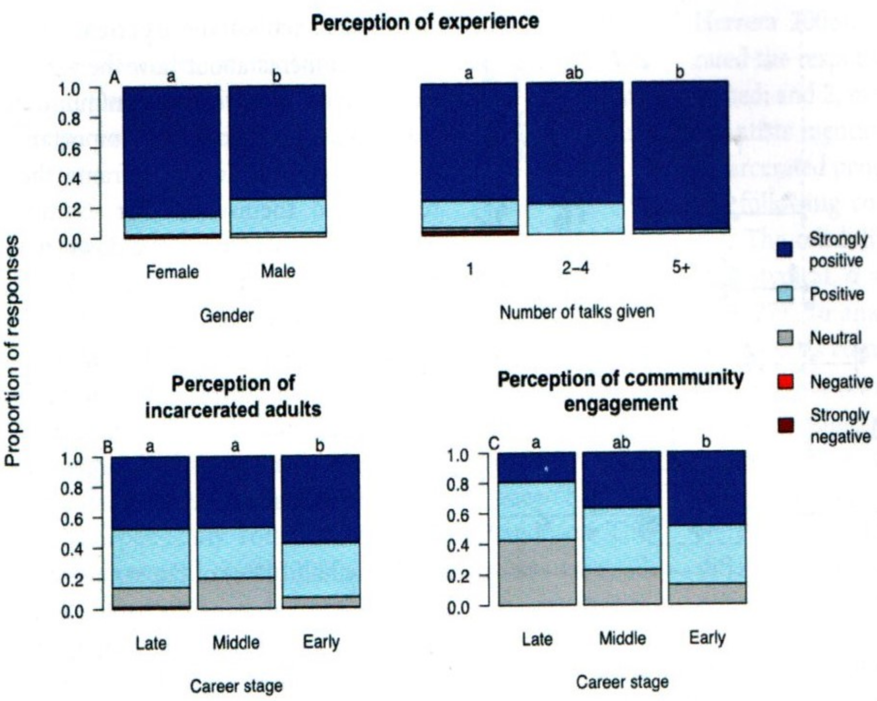

Figure 2. Responses to three Likert-scale question categories that differed significantly demographically. The letters over the bars represent statistically significant differences in ordinal regression **(p < .05).**

(e.g., "It was also a variable—if upsetting—experience to be in a jail environment and get a sense of the huge obstacles the inmates [sic] face in their personal lives").

The scientists reported on the impacts of the experience on their attitudes and motives related to social justice, with 23% reporting that they were already interested in social justice, and 30% reporting no change. All of the remaining 47% of the scientists (27 respondents) reported that the experience increased their interest in social justice issues. Furthermore, 35% of the scientists said that the experience increased their interest in taking action for social justice (versus 12% reporting already taking action and 53% reporting no change). There were no significant differences in academic rank and gender between the increasingly interested or motivated scientists and those who reported no change ($p > .53$).

We followed up on these results to investigate differences between the scientists whose attitudes and motivations were affected by the experience and those who reported no impact. Specifically, 36 scientists had indicated that the experience increased their interest in social justice issues, and 23 reported no change. Those who became more interested in social justice were more likely than the unchanged scientists to see professional value ($\chi^2(1) = 24.15, p < .001$) and personal value ($\chi^2(1) = 4.94, p < .03$) in the experience (figure 3a). Also, the scientists with increased interest were more likely to report having counterstereotypical perceptions of the incarcerated participants ($t(57) = -3.09, p = .003$) and marginally more humanizing perceptions of them ($t(57) = -1.73, p = .09$) relative to the unchanged scientists (figure 3b). Selected quotes from the scientists with increased interest in social justice are below:

"Interacting with inmates [sic] makes the issues more real. It's clear that a rehabilitative or educational approach to corrections would be ideal and it's unfortunate that our punishment-based system of incarceration does not suit human needs or help people avoid recidivism."

"Seeing the harsh environments that these people live in makes me want to give more and to help them in ways that I can."

"My interaction with incarcerated individuals really opened my eyes. Previously, these individuals were a number or statistic that I hear on the news. After meeting individuals, I felt empathy for people in this situation."

We compared the 27 respondents who indicated that the experience increased their motivation to act for social justice change with the 41 who reported no change. Scientists who had increased motivation were more likely to mention the professional value of the experience than those who were unchanged ($\chi^2(1) = 24.14, p < .001$; figure 4). They also reported marginally more humanizing perceptions of incarcerated participants compared with the unchanged scientists ($t(66) = -1.95, p = .06$; figure 4). Selected quotes from scientists are below:

"I've shared my opinions on social justice issues more often and with a deeper understanding."

"It has made me a much stronger advocate for bringing similar programs to the incarcerated."

"My research has been on a trajectory toward having applied goals for some time. I believe this experience was part of that."

"It has motivated me to take more actions. A couple of years from now, I plan to design programs for young adults from minority families."

"Yes, I would write to my congressman to advocate for criminal justice reform."

"[I] joined the [local] chapter of Black Lives Matter."

The early career scientists ($n = 45$) were significantly more likely than more the senior scientists to report a perception of the incarcerated participants that differed from their

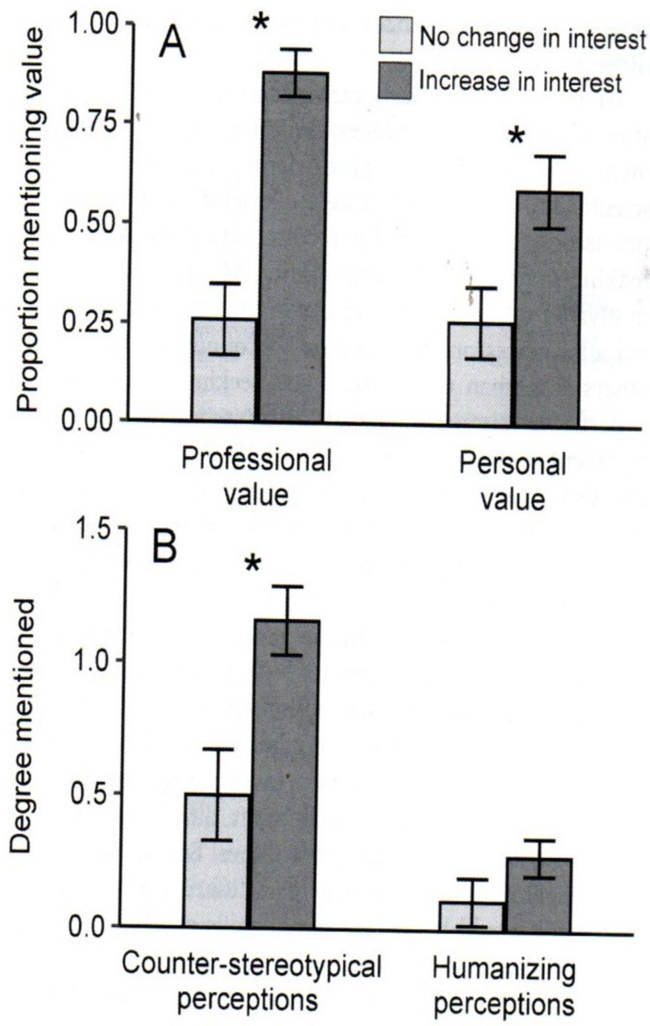

Figure 3. Differences in (a) perceived value of the experience and (b) counter-stereotypical and humanizing perceptions of the audience between scientists who reported increased interest in social justice (n = 36) versus those who reported no change in interest in social justice (n = 23). In panel (b), the perceptions of audience was coded as 2, mentioned in detail; 1, mentioned somewhat; 0, not mentioned. The error bars represent the standard error. *p < .05, χ^2 test or t-test.

preconceptions. The early career scientists were more likely to report being surprised at the participants' counterstereotypical attributes, humanizing attributes, and having their negative preconceptions of incarcerated people violated (figure 5). Although these findings suggest that the interventions have the greatest impact on early career scholars, these differences could also represent generational differences in how people react to contact with diverse populations.

Projected costs. We calculated the costs of this ISE program relative to formal correctional education programs. We based estimated costs on the INSPIRE program in Utah (12 lectures per year and 80 attendees per lecture). The costs include a part-time director and program manager, two student interns, a consulting external evaluator, printing for lecture handouts, and transportation between academic and correctional institutions. That is equivalent to $31 per lecture per incarcerated individual. In comparison, the estimate for the direct costs of providing such education for formal correctional education programs in state prisons range from $140,000 to $174,400 for 100 incarcerated participants ($1400 to $1744 per person; Davis 2019). This cost is equivalent to 45–56 lectures with the ISE approach. Clearly, there are advantages to formal programs that the ISE approach cannot achieve, but ISE represents a low-cost option that can increase access to science and scientists, complement formal education programs, and benefit both incarcerated people and scientists.

Impact of participation on scientists

We present novel evidence that public engagement with scientifically underserved and diverse incarcerated population is perceived by scientists as providing academic and personal benefits. Our results support the recent shift away from the traditional academic viewpoint that taking time to engage with the public falls outside of an academic researcher's responsibility (Burchell 2015). In many quarters, commitment to public engagement by scientists has deepened, with activities that foster broadening participation such as PES activities becoming more institutionalized and professionalized in academic institutions. Since 2020, an unprecedented urgency has arisen to increase equity and inclusivity in the scientific enterprise (Dawson 2018, 2019, Özdemir and Springer 2018).

Offering ISE in carceral settings represents one way to include and serve populations typically neglected by academia and science education. Such activities have generally been promoted for their benefits to the underserved groups. However, if these activities can also be shown as providing rewards for scientists, then these and other actions that broaden participation may be integrated, supported, and sustained within the academic system. These shifts would help increase access to science and scientists in sectors of society that currently have limited access to both—one step toward empowering underserved populations and increasing representation in the sciences.

We focused on scientists directly engaging with one underserved societal sector, the incarcerated, and found that scientists rated their experience as overwhelmingly positive, with 100% of the respondents stating that they would recommend the experience to their peers. The scientists articulated that their participation provided both traditional academic benefits (gaining professional skills in the form of increased science communication skills and better insights into their own work) and nonacademic benefits (being personally affected by the experience, including feeling that they were able to make a difference and help others). As with other research that involves voluntary participation, such as ISE programs in museums, zoos, and botanical gardens (Falk et al. 2016), we acknowledge that we could not control for self-selection biases. Both the incarcerated participants and the scientists volunteered to participate in the program

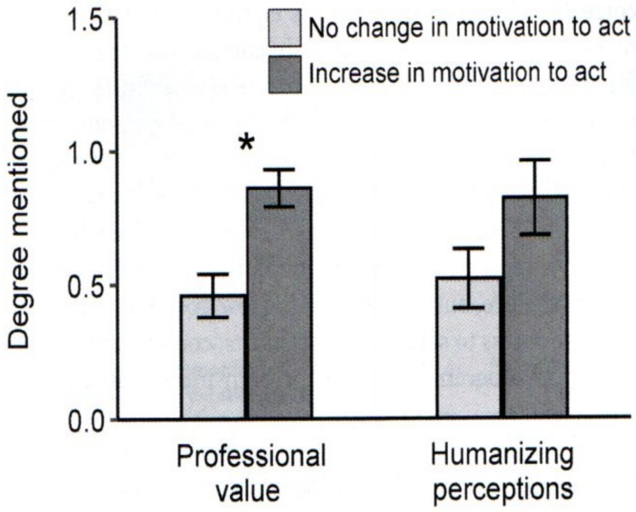

Figure 4. Differences in perceived professional value of the experience and humanizing perceptions of the audience between scientists who reported increased motivation to act for social justice as a result of the experience (n = 27) versus those who reported no change in motivation to act for social justice as a result of the experience (n = 41). The perceptions were coded as 2, mentioned in detail; 1, mentioned somewhat; 0, not mentioned. The error bars represent the standard error. *p < .05, χ^2 test or t-test.

(55%–95% of incarcerated populations and 16% of the potential pool of scientists).

A surprising impact was the scientists' shifts in their awareness and perceptions of the incarcerated, motivating them to take actions on their behalf. Based on their written comments, some of the participating scientists who engaged in these activities stated that before their contact, they considered incarcerated individuals as unintelligent or lacking curiosity, an unsettling pattern that revealed that some scientists lack direct exposure to public groups who may not have had positive experiences with science learning, but who are interested in and capable of learning more about science. A quarter of respondents spontaneously stated that participating in the ISE program led them to revise their preconceptions about the incarcerated. Many noted how attentive and appreciative the audience members were and were struck by how intelligent and curious the audience members were. These attributes are well known among many people who regularly engage with incarcerated populations, but are seemingly counter to common public perceptions. Only one-quarter of the scientists self-reported having preexisting interest in social justice issues but nearly half of the respondents reported that their participation led increased their interest in social justice and raised their motivation to take more action on behalf of the incarcerated. This result supports previous studies showing that people who have had experiences with the criminal justice system, either through being incarcerated themselves or through knowing someone who has been incarcerated, are more likely to have negative views of the formal control system of incarceration than people without experiences with the criminal justice system (Rose and Clear 2004).

We found that the early career scholars may be the most affected by these experiences, indicating that such engagement opportunities are particularly valuable for young scientists to deepen their interest in addressing social justice issues and sharpen their communication skills while making impacts on the community. Many individuals are motivated toward fields and careers that provide communal affordances or opportunities to connect with and help others (Diekman et al. 2017), and seeking communion is a particularly strong motivation for women and underrepresented minorities (Allen et al. 2018), populations that are also underrepresented across science fields (National Science Foundation 2019). By providing more opportunities for early career scientists to engage with the public, including incarcerated people, science may also be able to attract and retain a more diverse future generation of scholars. We also found that the presenters of biological topics had a significantly more positive perception than other disciplines. However, the relatively small numbers of presentations from other areas (physical sciences, arts, etc.) required lumping these disparate specialties making it difficult to discern detailed differences between disciplines. Further work with a larger sample size of presenters in different subdisciplines of science would help clarify the details of any differences between presenters from disparate disciplines.

This study provides some evidence of significant positive change—at least in the short term—on the scientists themselves with respect to personal and professional benefit and their perceptions of incarcerated populations. However, we were not able to show longer-term professional impacts on academic careers for this type of activity because our study was not designed as a longitudinal study of individual scientists. Therefore, we do not know whether participating scientists are more likely to accelerate or sustain their career trajectory as a result of their participation in this activity and can only speculate that the self-reported changes in perception of incarcerated populations by early career scientists, from a social justice viewpoint, might be sufficient regardless of any other professional benefits. Further studies should examine the medium- and long-term effects of these interventions, and the number of interactions that are needed to have such effects.

This raises a larger question about the motivation of scientists to include such activities in their academic work. Engagement work has not traditionally been rewarded in academia, but is increasingly valued by science administrators and many scientists as being a part of the responsibilities and expectations of researchers (Pew 2015, Besley et al. 2018). Because greater positive changes in attitudes about the scientifically underserved participants were seen in early career faculty, benefits or risks with this kind of public engagement should be considered. In some cases, from the standpoint of individual researchers, the self-reported rewards of contributing to the enhancement of social justice

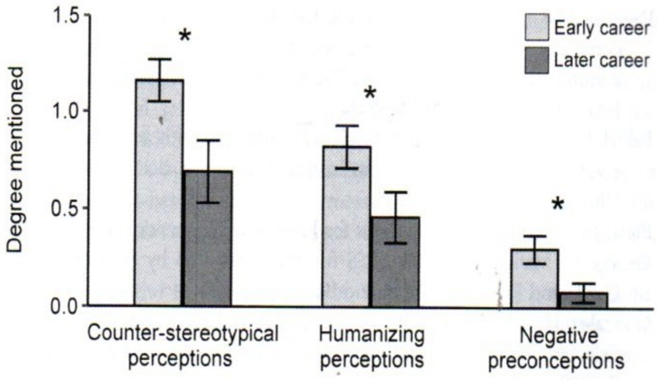

Figure 5. Career stage differences (early career* n *= 45, later career* n *= 24) in surprising perceptions about the experience. The responses were coded as 2, mentioned in detail; 1, mentioned somewhat; 0, not mentioned. The error bars represent the standard error. *p < .05, χ^2 test or t-test.

appeared to be compelling, However, whether these perceived benefits counteract the structural disincentives to participate in these types of programs, especially for early career researchers, is still unknown, because we were not able to assess the longer-term impacts on these individuals at this time. How might faculty members calculate the social justice aspects of the experience in terms of the overall value of the engagement for promotion and tenure? Will the perceived personal, societal, and academic benefits of shifting attitudes and actions with respect to public engagement be sufficient to sustain such activities in the light that such actions may not push forward their scientific research trajectories? Our study can, at this point, only raise but not answer these questions.

In a previous study (Horns et al. 2020), we documented that even a relatively small number of scientists can create significant effects through ISE programming. Exposure to even a single scientist-delivered lecture has positive impacts on incarcerated participants' science content knowledge, self-identification as science learners, and desire to seek further, science information (Horns et al. 2020). Placing these results into a national context, there are 6.9 million scientists and engineers in the United States (Sargent 2017). If we take a conservative view that only 10% of the scientists (16% in our study) have the interest and capacity to engage the incarcerated population, that would be 690,000 scientists. With 7147 correctional facilities in the United States (Sawyer and Wagner 2020), the ratio of participating scientists to incarcerated individuals would be approximately 95 scientists per facility. If each of these scientists gave one lecture per year to an incarcerated audience size of four participants (note that our incarcerated audiences ranged between 30–80 individuals), every incarcerated person in the United States would have access to a scientist's presentation.

Offering science education and engagement for underserved groups such as the incarcerated population has nearly always been justified because of the direct and indirect benefits to incarcerated individuals or to economic goals, because it reduces recidivism and increases postrelease employment outcomes (Davis 2019). However, this study suggests a way to involve academic scientists in PES that contributes to the larger goal of fostering a scientifically educated public, which lies at the foundation of the scientific enterprise (National Research Council 1996). And science, in its best light—especially the pursuit of scientific exploration—is a humanity-scale endeavor. The United Nations' Declaration of Universal Human Rights states that everyone has the right to education and that education shall be directed to the full development of the human personality and to the strengthening of respect for human rights and fundamental freedoms (United Nations General Assembly 1948). Therefore, scientists' dissemination of their discoveries and knowledge and the inspiration that it generates helps fulfill this imperative, in which all humans, incarcerated or not, have the right to share. We suggest that fostering direct engagement of scientists with incarcerated individuals can be a potentially replicable model for academics to engage with audiences in which minorities are disproportionately represented, potentially open to involvement in science, and capable of becoming science-aware and science-informed people.

In summary, scientists, educators, and administrators are ready to act to promote changes in the composition of people aware of and working within the scientific enterprise, but many do not know how to begin making these changes. Scientists are moving beyond simply having more awareness of how racism manifests in science and society, and are seeking examples of programming that works to promote actual change. This study describes an effective example of that type of program, one that can be initiated and maintained with modest investments of an academic's time and resources, and can result in synergistic outcomes for both the scientists and the participants. The guidance we provide on how members of the scientific community can contribute to an ISE program can be used not only to reach incarcerated population, but also how to engage other scientifically underserved groups in our society.

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Supplemental material

Supplemental data are available at *BIOSCI* online. These include tables S1–S4 and supplementary text guidelines for scientist lecture programs for the incarcerated. The data are also available from Nalini M. Nadkarni.

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