

1 Knowledge is em(power)ing: Historically underrepresented groups benefit from exposure to information  
2 about advanced degrees in psychology.

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**ABSTRACT**

Despite the growing interest in Science, Technology, Engineering, and Mathematics (STEM) education and careers, the “leaky pipeline” continues to disproportionately exclude underrepresented minorities from STEM fields. One feature of the leaky pipeline is unequal access to knowledge about graduate education and careers in STEM fields. Disparities in representation can be reduced by making this knowledge more accessible, which may be particularly beneficial at the transition from undergraduate to post-graduate research experience and education. Here, we sought to investigate the value of large-scale, open-access programming as a mechanism for achieving this objective, by using survey data from the 2020 Yale University Research Psychology Bootcamp as a case study. We found that this programming increased confidence and understanding of how to navigate the field of research psychology in all survey respondents, with a targeted benefit for Black and First Generation/Low-Income participants. Based on these findings, we argue that large-scale, open-access programming offers a unique and practical utility as an intervention for eliminating disparities in STEM higher education and STEM fields.

**Keywords:** diversity, higher education, educational opportunities, doctoral education, open-access, online programming

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## INTRODUCTION

The fields of Science, Technology, Engineering, and Mathematics (STEM) have seen rapid professional growth in recent years. In 2018, the Pew Research Center reported a remarkable 79% increase in STEM employment in the US since 1990, and the average STEM professional now earns about two-thirds more than the average non-STEM professional [1]. Despite the lucrateness and popularity of these fields, STEM participation by underrepresented minorities (URMs) is rife with inequality across both racial and socioeconomic lines, particularly at the level of post-graduate research and higher education.

Although 11% of the US workforce is Black and another 17% is Hispanic, Black and Hispanic individuals only make up 9% and 8% of STEM professionals, respectively [2]. Black, Native American, and Latinx students acquire STEM-related degrees at slower and lower rates when compared to their White and Asian American counterparts, despite matched interest in majoring in STEM disciplines [3]. This disconnect between interest and subsequent success in STEM participation is mirrored in first generation and low income (FG/LI) individuals, where first-generation students enroll in [4] and persist with [5] STEM-field related degrees at lower rates than their non-first generation peers. These extant disparities stand at odds with the demonstrated interest in pursuing STEM-related education and careers, with one longitudinal study showing that, despite matched *aspiration* to continue education and acquire an advanced degree, FG/LI students were less likely than their peers to subsequently earn graduate degrees [6]. These findings illustrate the “leaky pipeline” problem, in which structural and systemic barriers disproportionately filter out URM students at every stage of STEM education and professional advancement [7].

Aside from the formal requirements that gate-keep STEM pathways (e.g., high GPA and high standardized test scores, evident research productivity, and strong letters of recommendation), students may benefit from direct access to insider knowledge of the rules of academia that dictate less obvious expectations and knowledge of cultural norms [8]. Underrepresented minority (URM) students may especially benefit, as they are less likely to have access to support systems that can provide full information about academia [9]. Access to this “insider perspective” has tangible value – in one national

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65 survey of Black professors in STEM fields, respondents indicated that advising and mentorship were  
66 critical to their academic and professional success [10].

67 More broadly, the *pathways intervention model* of increasing URM participation in higher  
68 education has yielded promising results, by aiming to elevate students' perceptions of the tangibility of  
69 their desired futures and aid them in progressing towards these aspirational selves [11]. For example,  
70 incoming college students that received programming that aligned with and highlighted their diverse  
71 backgrounds in the context of academic success had higher end of year GPAs than those that received  
72 programming that didn't highlight these differences [12], and were more equipped to handle the stresses  
73 of college over time [13]. Further highlighting the importance of identity-aligned programming, a meta-  
74 analysis of 24 field studies on the presence of URM "ingroup role models" showed a significantly positive  
75 impact on underrepresented students aged 10-21 years pursuing STEM education [14].

76 Critically, much of this work so far has been conducted at the high school and college level.  
77 Consequently, much less is known of the potential value of interventions at the post-graduate level.  
78 Nonetheless, several institutions have taken approaches to provide this programming via application-  
79 based diversity events, such as the University of Virginia's "Diversifying Psychology Visit Day"  
80 ([psychology.as.virginia.edu/diversifying-psychology-visit-day](https://psychology.as.virginia.edu/diversifying-psychology-visit-day)) and Brown University's "Diversity Preview  
81 Day" (<https://www.brown.edu/academics/gradschool/news/2019-08/diversity-preview-day-phd-students> ).  
82 Others have implemented longitudinal STEM mentorship programs, such as the University of Maryland -  
83 Baltimore County Meyerhoff Scholars Program [15] and Central State University's Benjamin Banneker  
84 Scholars Program (BBSP) [16]. While initiatives such as these aim to fill a demonstrated need, they are  
85 limited in two major ways. First, they are limited in scope. Participants apply for a limited number of slots  
86 or are assigned a mentor from a limited number of available academics and professionals. While this  
87 does not take away from the importance of these types of programs, given the demonstrated interest from  
88 URMs in pursuing STEM careers [3, 6], the amount of need for these programs may surpass the extent of  
89 resources available. Second, data on the success of these programs are largely absent. Some initiatives,  
90 like BBSP and the Meyerhoff Scholars program, have published data on the positive impact of their  
91 programming [15, 16], but more data on the variety of programs currently in place are needed to illustrate  
92 the fuller picture. Future efforts to diversify the STEM pipeline would greatly benefit from evidence-based

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93 recommendations about what offerings make the most difference for participants, and particularly those  
94 from underrepresented backgrounds.

95           Here, we evaluate the benefits and efficacy of large scale, open-access programming on the topic  
96 of higher education and careers in STEM, using data from a research psychology “Bootcamp” event as a  
97 case study. Participants of this virtual programming completed a pre-bootcamp and post-bootcamp  
98 survey to explore changes in their knowledge of, and confidence in, pursuing careers in psychological  
99 research. Using an intervention model of analysis, we assessed the impact of the bootcamp on these  
100 response metrics.

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## **METHODS**

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### **Participants**

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A total of 1,378 students registered to either attend the bootcamp or receive the bootcamp materials. Of those registered, 659 started the pre-bootcamp survey, 544 of whom completed it. 318 participants started the post-Bootcamp survey, 224 of whom completed it. Following a data filtering procedure (see Data Filtering and Handling), the subsequent dataset consisted of pre- and post-bootcamp responses from 148 participants. Participant age was not requested in the original survey, but participant academic level revealed that most of the participants were college seniors (n=53), followed by post-baccalaureates (n=52), college juniors (n=33), college sophomores (n=8), and pre-college students (n=2). Full demographic breakdown is provided in Table 1. Exemption determination was made by the Human Research Protection Program Institutional Review Board at Yale University.

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|                    |                                     | Pre-College Student |          | College Sophomore |           |          | College Junior |           |           | College Senior |           |           | Post-Baccalaureate |           |           | Grand Total |
|--------------------|-------------------------------------|---------------------|----------|-------------------|-----------|----------|----------------|-----------|-----------|----------------|-----------|-----------|--------------------|-----------|-----------|-------------|
|                    |                                     | FG/LI               | Total    | FG/LI             | Not FG/LI | Total    | FG/LI          | Not FG/LI | Total     | FG/LI          | Not FG/LI | Total     | FG/LI              | Not FG/LI | Total     |             |
| Asian              | Female                              |                     |          |                   | 1         | 1        | 3              | 1         | 4         | 4              | 2         | 6         | 3                  | 13        | 16        | 27          |
|                    | Gender Non-Binary/Prefer not to Say |                     |          |                   |           |          |                | 1         | 1         | 1              |           | 1         | 1                  | 1         | 2         | 4           |
|                    | Male                                | 1                   | 1        |                   |           |          |                | 1         | 1         |                | 1         | 1         |                    | 3         | 3         | 6           |
|                    | <b>Total</b>                        | <b>1</b>            | <b>1</b> |                   | <b>1</b>  | <b>1</b> | <b>3</b>       | <b>3</b>  | <b>6</b>  | <b>5</b>       | <b>3</b>  | <b>8</b>  | <b>4</b>           | <b>17</b> | <b>21</b> | <b>37</b>   |
| Black/African      | Female                              |                     |          | 3                 |           | 3        | 3              | 7         | 10        | 2              | 7         | 9         |                    | 5         | 5         | 27          |
|                    | Gender Non-Binary/Prefer not to Say |                     |          |                   | 1         | 1        |                |           |           | 1              | 2         | 3         |                    |           |           | 4           |
|                    | Male                                | 1                   | 1        |                   |           |          |                | 2         | 2         |                | 1         | 1         | 1                  | 2         | 3         | 7           |
|                    | <b>Total</b>                        | <b>1</b>            | <b>1</b> | <b>3</b>          | <b>1</b>  | <b>4</b> | <b>3</b>       | <b>9</b>  | <b>12</b> | <b>3</b>       | <b>10</b> | <b>13</b> | <b>1</b>           | <b>7</b>  | <b>8</b>  | <b>38</b>   |
| White              | Female                              |                     |          |                   | 1         | 1        | 1              | 1         | 2         | 3              | 4         | 7         | 3                  | 3         | 6         | 16          |
|                    | Gender Non-Binary/Prefer not to Say |                     |          |                   |           |          |                |           |           |                | 1         | 1         |                    |           |           | 1           |
|                    | Male                                |                     |          |                   |           |          | 1              | 1         | 2         |                |           |           | 1                  | 1         | 2         | 4           |
|                    | <b>Total</b>                        |                     |          |                   | <b>1</b>  | <b>1</b> | <b>2</b>       | <b>2</b>  | <b>4</b>  | <b>3</b>       | <b>5</b>  | <b>8</b>  | <b>4</b>           | <b>4</b>  | <b>8</b>  | <b>21</b>   |
| Hispanic/Latinx    | Female                              |                     |          | 1                 |           | 1        | 3              | 2         | 5         | 5              | 6         | 11        | 6                  |           | 6         | 23          |
|                    | Male                                |                     |          |                   |           |          | 2              |           | 2         | 2              | 1         | 3         | 2                  |           | 2         | 7           |
|                    | <b>Total</b>                        |                     |          | <b>1</b>          |           | <b>1</b> | <b>5</b>       | <b>2</b>  | <b>7</b>  | <b>7</b>       | <b>7</b>  | <b>14</b> | <b>8</b>           |           | <b>8</b>  | <b>30</b>   |
| Multiracial        | Female                              |                     |          |                   | 1         | 1        | 1              | 2         | 3         | 4              | 2         | 6         | 3                  | 2         | 5         | 15          |
|                    | Male                                |                     |          |                   |           |          | 1              |           | 1         |                |           |           | 1                  |           | 1         | 2           |
|                    | <b>Total</b>                        |                     |          |                   | <b>1</b>  | <b>1</b> | <b>2</b>       | <b>2</b>  | <b>4</b>  | <b>4</b>       | <b>2</b>  | <b>6</b>  | <b>4</b>           | <b>2</b>  | <b>6</b>  | <b>17</b>   |
| Did Not Say        | Female                              |                     |          |                   |           |          |                |           |           | 2              | 1         | 3         |                    |           |           | 3           |
|                    | <b>Total</b>                        |                     |          |                   |           |          |                |           |           | <b>2</b>       | <b>1</b>  | <b>3</b>  |                    |           |           | <b>3</b>    |
| Other              | Female                              |                     |          |                   |           |          |                |           |           | 1              |           | 1         |                    | 1         | 1         | 2           |
|                    | <b>Total</b>                        |                     |          |                   |           |          |                |           |           | <b>1</b>       |           | <b>1</b>  |                    | <b>1</b>  | <b>1</b>  | <b>2</b>    |
| <b>Grand Total</b> |                                     | <b>2</b>            | <b>2</b> | <b>4</b>          | <b>4</b>  | <b>8</b> | <b>15</b>      | <b>18</b> | <b>33</b> | <b>25</b>      | <b>28</b> | <b>53</b> | <b>21</b>          | <b>31</b> | <b>52</b> | <b>148</b>  |

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122 **Table 1:** Demographic breakdown of respondents that had valid data in both the pre-bootcamp and post-  
 123 bootcamp surveys.

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## Procedure

### Psychology Bootcamp Event

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The Yale Psychology Committee on Diversity and Inclusion (YPCDI) organized a virtual

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Psychology “Bootcamp” in the summer of 2020, in collaboration with the Yale Office of Graduate Student

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Development and Diversity (OGSDD). Delivered via Zoom Video Webinar

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(<https://explore.zoom.us/en/products/webinar/>), this three-hour event was free of cost and open to all.

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Advertising was targeted towards underrepresented minority students and post-baccalaureates interested

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in pursuing careers in research psychology. The bootcamp was divided into three, 1-hour sections, each

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with a distinct theme. The first hour was dedicated to “Careers in Research Psychology”, the second

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section to “Getting Research Experience”, and the third to “How to Apply to Graduate School”. The video

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recordings from each of these sections are freely available online

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(<https://psychology.yale.edu/graduate/admissions/psychology-graduate-school-bootcamp>).

138

Importantly, the format of this event included presentation and panel discussion and Question

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and Answer from URM graduate students, faculty, and industry professionals. Presenters and panelists

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spoke not only on the insider tips for succeeding in academia, but also on the specific challenges and

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opportunities they experienced as underrepresented scientists and professionals.

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### Survey Data Collection Mechanism

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The pre-bootcamp and post-bootcamp feedback surveys were administered via the Qualtrics

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survey platform (qualtrics.com). The link to the pre-bootcamp survey was sent via email to registered

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participants leading up to the day of the event. In order to encourage participation, participants were

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informed that completion of both the pre-bootcamp and post-bootcamp surveys would enter them in a

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raffle to win one of ten \$50 Amazon gift cards. No information regarding the purpose of this study was

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known to the participants.

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The link to the post-survey was displayed on the last slide of each section’s presentation and

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shared over Zoom. This was done in addition to sharing the link after the event via email to registered

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participants to ensure that people who only attended a subset of the sections would still receive it

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153 immediately after viewing the content. In order to link participants' pre- and post-bootcamp surveys, each  
154 participant was given a randomly generated code in the pre-bootcamp survey that they were required to  
155 enter in the post- survey. Questions consisted of Likert scale and fill-in-the-blank questions, as well as  
156 inputs for demographic information. Likert scales used for participants' responses ranged from "1 -  
157 Strongly disagree" to "5 - Strongly agree." (see Supplementary Table S1 for a complete list of Likert scale  
158 survey questions). The analyses below were conducted using the Likert scale questions and  
159 demographic information.

160

## 161 **Data Analysis**

### 162 Data Filtering and Handling

163 We wanted to limit our analyses to individuals who had completed the pre-bootcamp survey  
164 before viewing the bootcamp, and the post-bootcamp survey after viewing the bootcamp. Because there  
165 was no way to ensure that people who watched the bootcamp videos asynchronously completed the  
166 surveys in the correct order, we limited inclusion to pre-bootcamp surveys completed before the start of  
167 the live bootcamp, i.e. before the post-survey was available. We excluded repeat entries, pre-bootcamp  
168 surveys with no accompanying post-surveys, and vice versa. Prior to analysis, we removed a subset of  
169 Likert Scale survey questions the content of which was not a focus of the bootcamp event. A full list of  
170 included and excluded questions is provided in Supplementary Table S1.

171 First Generation participants were categorized by self-endorsement of first generation status as  
172 defined by the US Department of Education ("if neither parent completed a baccalaureate degree;  
173 <https://nces.ed.gov/pubs2018/2018009.pdf>"). Low Income participants were categorized by self-  
174 endorsement of low-income status, as defined by the US Department of Health and Human Services  
175 2020 Poverty Guidelines (<https://aspe.hhs.gov/2020-poverty-guidelines>).

176 To achieve a more balanced dataset prior to our analyses, we first re-coded some demographic  
177 responses. First, we coded the individuals who selected multiple of the listed racial identities as  
178 "Multiracial." We then coded all individuals who responded to the question of racial identity with either  
179 "Prefer not to Answer" or by only inputting a custom answer as "Other." Because only one respondent  
180 identified as Pacific Islander, we included them in the "Other" category. Next, we re-coded specific custom



181 responses that better fit one of the listed racial identities than the “Other” category. The three respondents  
182 who identified as “South Asian/Indian” and one who identified as “Uyghur” were re-coded as Asian. The  
183 two respondents who identified as “Jewish” and as “Armenian descent” were re-coded as White. Lastly,  
184 the two respondents who identified as “Biracial South Asian and Caucasian” and “Middle Eastern” were  
185 re-coded as Multiracial. We then combined the 46 respondents that identified as Low Income with the 51  
186 who identified as First Generation to create one FG/LI category that encompassed both identities and  
187 their overlap.

188

### 189 Overall Assessment

190 We first sought to assess the overall impact of the bootcamp event. We subset the data to only  
191 include responses to questions from participants who had attended the relevant Section (i.e., excluding  
192 responses to a question pertaining to Section 1 material from participants who did not attend Section 1).  
193 We then calculated a Response Difference measure for each participant and each question by  
194 subtracting their post-bootcamp Likert scale responses from their pre-bootcamp responses. Thus, positive  
195 values indicate increased agreement with the statement being rated. We then conducted one-sample  
196 Wilcoxon signed rank tests to determine whether this Response Difference was significantly above or  
197 below zero for each session.

198

### 199 Participant Demographic Baseline

200 We then sought to identify differences in pre-bootcamp survey responses across participant racial  
201 and socioeconomic groups. The objective of this analysis was to determine the extent to which baseline  
202 knowledge of different aspects of research psychology was unevenly distributed across demographics.  
203 For bootcamp sections 1 and 3, we analyzed the subset of responses from participants who indicated that  
204 they had attended that section. To investigate differences across racial identity, we conducted a linear  
205 mixed effects regression predicting response on a Likert scale, with survey question and racial identity as  
206 predictors, plus an interaction term, as well as random intercepts for each participant. As there was only  
207 one survey question related to Section 2, we performed the same data subsetting procedure and used a

208 linear instead of a linear mixed effects model, with only racial identity as a predictor. We conducted an  
209 analogous set of analyses for differences across FG/LI status.

#### 210 Effect of Event

211 For the subset of survey questions for which there were group differences in baseline response,  
212 we then sought to evaluate the effect of the bootcamp in modulating those differences. Taking a data-  
213 driven approach, we conducted the next set of analyses only on those questions and demographics for  
214 which the baseline differences were significant. The objective of this analysis was to determine whether,  
215 beyond any overall effects, the bootcamp event additionally served to close knowledge gaps between  
216 groups, as evidenced by differences in baseline.

217 To that end, we performed linear mixed effects regressions predicting responses to the questions  
218 showing baseline variability. Racial identity, survey timepoint (pre- or post-bootcamp), and their  
219 interaction served as predictors, with random intercepts per participant. We again conducted an  
220 analogous set of analyses for differences across FG/LI status.

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222

## RESULTS

223

#### 224 Overall Positive Effect of Bootcamp

225 One-sample Wilcoxon signed-rank tests with Bonferroni correction revealed that the positive  
226 change in response was significant for all three sessions (all p's <0.001) (Fig 1).

227

228 **Fig 1.** Participants show positive effect of the bootcamp across all three sessions, as evidenced by  
229 greater post- compared to pre-bootcamp responses.

230

#### 231 Lower Baseline for Black and Low Income/First Generation Participants

232 We first investigated differences in baseline response as a function of racial identity. For Section  
233 1 Pre-bootcamp survey responses across race, linear mixed effects modeling revealed a marginal  
234 interaction between Question and Race ( $F(30,780)=1.144, p=0.063$ ). This model was a better fit to the  
235 data than a main effects model ( $\chi^2(30)=43.85, p=0.049$ ). Given this marginal effect and our a priori

236 predictions, we conducted follow-up pairwise Wilcoxon Signed-Rank tests of which survey responses  
237 varied between which racial identities. However, none of these analyses survived correction for multiple  
238 comparisons ( $p$ 's  $>0.35$ ).

239 Section 2 linear modeling revealed no main effect of Race ( $F(5,125)=1.25, p=0.291$ ).

240 Section 3 linear mixed effects modeling revealed a marginal main effect of Race ( $F(5,127)=2.07,$   
241  $p=0.074$ ) and no interaction  $F(20,508)=1.00, p=0.464$ ). However, this model did not produce a better fit to  
242 the data than a main effects model ( $\chi^2(20)=20.48, p=0.428$ ). The main effects model revealed an effect of  
243 Question ( $F(4,528)=70.24, p<0.001$ ), as well as a marginal effect of Race ( $F(5,127)=2.07, p=0.074$ ).

244 Pairwise Wilcoxon Signed-Rank tests with Bonferroni correction revealed that, overall, participants  
245 endorsed the statements "I know what graduate school interviews look like and how to prepare for them"  
246 and "I'm aware of the unwritten rules and informal expectations of the graduate school application  
247 process" to a lesser extent than other Section 3 statements ( $p$ 's  $<0.001$ ), with no difference in  
248 endorsement between the two statements ( $p$ 's  $>0.79$ ). The remaining three statements also did not differ  
249 in endorsement ( $p$ 's  $>0.79$ ).

250 Given the marginal effect of Race and our a priori predictions, we additionally conducted follow-  
251 up pairwise Wilcoxon Signed-Rank tests with Bonferroni correction to investigate overall differences in  
252 response across race. We found that Black/African participants responded lower overall in comparison to  
253 Asian ( $p=0.004$ ) and White ( $p=0.011$ ) participants (Fig 2).

254

255 **Fig 2.** Black participants, compared to White and Asian participants, report less understanding of the  
256 graduate school application process.

257

258 We then investigated baseline differences as a function of FG/LI status. Linear mixed effects  
259 modeling of responses in Section 1 revealed an interaction between Survey Question and FG/LI status  
260 ( $F(6,822)=2.33, p=0.031$ ). This model fit better than a main effects model ( $\chi^2(6)=14.07, p=0.029$ ).

261 Because the intercept for this model was a meaningful baseline (i.e., not Low Income/First Gen), unlike  
262 that of the linear model predicting effects of Race, we then investigated the beta weights of the specific  
263 contrasts for which there was an effect. FG/LI participants specifically endorsed the statements "I know

264 what a career in research psychology at a university looks like” ( $\beta=-0.56$ ,  $t=-2.70$ ,  $p=0.007$ ) and “I  
265 understand what it takes to earn a PhD in psychology” ( $\beta=-0.66$ ,  $t=-3.20$ ,  $p=0.001$ ) to a lesser extent than  
266 those who did not identify as FG/LI. We conducted follow-up Wilcoxon Signed-Rank tests with Bonferroni  
267 correction on these specific contrasts. Only the difference in responses to the statement “I understand  
268 what it takes to earn a PhD in psychology” showed an effect via this test ( $p=0.022$ ) (Fig 3).

269

270 **Fig 3.** FG/LI participants report less understanding of what it takes to earn a PhD in psychology,  
271 compared to non-FG/LI participants.

272

### 273 Bootcamp Reduces Disparities Revealed in Baseline Responses

274 Given these established differences in baseline response across race and FG/LI status, we  
275 sought to determine whether attendance to the bootcamp had the effect of reducing these disparities. For  
276 the effect of race on Section 3 responses, we focused our analysis on Black/African, Asian, and White  
277 participants given the demonstrated differences in baseline response. Linear mixed effects modeling of  
278 response to Section 3 questions as a function of Time Point (pre- and post- bootcamp) and Race  
279 revealed an effect of Time Point ( $F(1,2222)=608.87, p<0.001$ ), and an interaction between Time Point and  
280 Race ( $F(2,2222)=4.89, p=0.008$ ). This model fit better than a main effects model ( $\chi^2(2)=9.76$ ,  $p=0.008$ ).  
281 Follow-up Wilcoxon Signed-Rank tests with Bonferroni correction revealed an overall increase in  
282 endorsement of Section 3 statements ( $p<0.001$ ). Further, tests revealed that, while Black/African  
283 participants initially endorsed statements less than White ( $p=0.007$ ) and Asian participants ( $p=0.004$ ),  
284 these differences were not evident in the post-bootcamp responses ( $p's>0.22$ ) (Fig. 4).

285

286 **Fig 4.** Participation in the bootcamp eliminates differences between Black and Asian/White participants in  
287 understanding of the graduate school application process.

288

289 Based on our pre-bootcamp survey results, we then ran a linear mixed effects model on  
290 responses to the Section 1 statement “I understand what it takes to earn a PhD in psychology” as a  
291 function of FG/LI status and Time Point. This model revealed an effect of FG/LI status

292 (F(1,137)=4.05,p=0.046), Time Point (F(1,137)=204.87,p<0.001), and an interaction  
293 (F(1,137)=6.12,p=0.015). This model fit better than a main effects model ( $\chi^2(1)=6.07$ , p=0.014). Follow-up  
294 Wilcoxon Signed-Rank tests revealed an overall increase in endorsement of the statement (p<0.001), as  
295 well as lower pre-bootcamp endorsement by FG/LI participants compared to their counterparts (p=0.032).  
296 This difference in endorsement was no longer evident post-bootcamp (p>0.99) (Fig. 5).

297

298 **Fig 5.** Participation in the bootcamp eliminates differences between FG/LI and non-FG/LI participants in  
299 understanding of graduate school and career options in research psychology. FG/LI=First generation/Low  
300 income.

301

302

## DISCUSSION

303 In the current investigation, we examined differences in the understanding of graduate programs and  
304 careers in research psychology in a diverse sample of individuals. We demonstrated a disparity between  
305 individuals from underrepresented groups and their peers in their baseline knowledge of these topics and found  
306 that individuals from underrepresented groups showed a particular benefit from informational programming about  
307 higher education in psychology. Specifically, before the bootcamp, FG/LI students, compared to non-FG/LI  
308 students, reported less understanding of what earning a doctoral degree in psychology entails. However,  
309 attending the bootcamp eliminated these differences between the two groups. In addition, we showed that, Black  
310 students, compared to White and Asian students, reported less understanding of how to apply to graduate school  
311 in psychology before the program. Crucially, differences in understanding among Black, Asian, and White  
312 students equalized after attending the bootcamp.

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### Identifying Disparities in Knowledge of Graduate Education

315 Interest in STEM careers are at an all-time high [1]. Although aspirations to pursue careers in STEM are  
316 similar across demographic groups [6], individuals from historically underrepresented groups pursue STEM  
317 education at a lower rate than their White peers [3]. Here we identified one factor that may contribute to  
318 underrepresentation in doctoral programs: unequal access to diverse and informative insider perspectives. The  
319 level of knowledge individuals have about career opportunities in STEM is associated with their intentions on

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320 pursuing STEM careers in the future [17]. Therefore, reducing disparities in knowledge about how to pursue  
321 graduate studies among underrepresented groups is critical in efforts to increase their representation in doctoral  
322 programs and STEM fields.

323         Our findings suggest that specific underrepresented groups vary in their overall understanding of  
324 graduate programs in psychology and possible career opportunities in psychology with a doctoral degree, aligning  
325 with the large body of literature illustrating resource disparities as a function of race and class [see 18,19, 20].  
326 Specifically, we observed differences across racial group membership and FG/LI income status in two distinct  
327 domains: knowledge of the graduate school application process and knowledge of what graduate school entails,  
328 respectively. Black individuals reported less understanding of the graduate school application process than their  
329 Asian and White counterparts. FG/LI individuals reported less knowledge of what is required in PhD psychology  
330 programs than their non-FG/LI peers. Identifying disparities in knowledge of doctoral programs is a key first step  
331 in developing strategies to address these disparities and increase diverse representation in STEM graduate  
332 studies.

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#### 334 Overall Efficacy of Large Scale, Open-Access, Diversity-Aligned Programming

335         Once disparities in knowledge and opportunities are identified, programs can be implemented to target  
336 problem areas. At present, a majority of programs (e.g. Meyerhoff Scholars Program) take an intensive  
337 mentorship approach. In such university-based programs, a small cohort of students are accepted to receive  
338 regular mentorship, placement in research labs, and professional development opportunities designed to help  
339 them thrive in STEM fields and become competitive applicants for STEM graduate school programs. While these  
340 programs have an important place in increasing diversity in higher education, the time and financial resources  
341 required limit the number of students that can be reached at any given time. Here we highlight that large scale,  
342 open-access programming in a virtual setting offering diverse perspectives is effective at increasing knowledge of  
343 career opportunities and graduate education options in psychology for large and diverse audiences. Across all  
344 three programming sessions, participants as a whole reported more confidence in their knowledge of career  
345 opportunities, how to gain research experience, and how to apply to graduate school in research psychology after  
346 participating in the bootcamp compared to before. Programs with large, virtual formats have the advantage of  
347 reaching individuals across the globe, and in various stages of their early career, from those simply considering

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348 careers in psychology to others who are planning to apply to doctoral programs, while requiring minimal financial  
349 or time commitments.

350 Critically, we demonstrate that this programming structure is effective at eliminating disparities in  
351 knowledge of the graduate school process in multiple underrepresented groups. The diverse group of presenters  
352 and panelists provided identity-specific perspectives on the topics and questions raised by bootcamp participants.

353 Black and FG/LI students showed a disadvantage compared to their majority counterparts in prior  
354 graduate school knowledge before attending the bootcamp. Both of these underrepresented groups showed  
355 increases in knowledge after attending the bootcamp such that their self-reported levels of knowledge became  
356 indistinguishable from non-minoritized counterparts. In other words, the bootcamp programming diminished the  
357 disparities in confidence and knowledge about careers and graduate school in psychology between Black and  
358 FG/LI individuals and their peers. This finding provides evidence that large-scale, open-source programming such  
359 as the bootcamp are effective for general audiences, *and* work to eliminate inequalities in knowledge of graduate  
360 opportunities in disadvantaged populations when diverse perspectives are provided.

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#### 362 Alignment with Principles of Open-Science

363 The philosophy of open-access science has the ultimate goal of advancing society by making science  
364 transparent and available to all [21]. As STEM fields quickly evolve to embrace open-access values [22], it is  
365 important to ensure that graduate education outreach programs evolve with the changing times. With over 1000  
366 individuals registered to receive the program materials, the Yale Psychology Bootcamp is an example of virtual,  
367 open-access programming that allows resources to reach an extremely large audience. Program materials will  
368 exist in perpetuity and can be referenced by subsequent generations of aspirational research psychologists.  
369 Furthermore, the multi-session nature of the Yale Psychology Bootcamp expands the relevance of the  
370 programming to individuals with a wide array of experience and interest in pursuing careers that require doctoral  
371 degrees. With three distinct, open-access sessions, participants can watch the material that is most relevant to  
372 their level of experience, and refer back to the curated materials as they progress towards applying to graduate  
373 school. Programs with the aforementioned features are specifically designed to ensure that the knowledge  
374 required to pursue graduate education and careers in STEM are accessible to all.

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### **Conclusion**

There is little doubt that continued efforts are needed to combat the systemic barriers and climate of inequity that contribute to the leaky pipeline in STEM. The Yale Psychology Bootcamp is a case study for the ways in which higher education outreach programming can be designed to reach large and diverse populations and keep them in the pipeline. Our results quantify that not all individuals are granted equal access to the information necessary to understand and pursue a graduate degree and career in research psychology. Furthermore, we demonstrate that large-scale, open-access programming is not only successful in increasing awareness of graduate education and possible careers in STEM across the board, but also has a specific, targeted benefit for individuals from historically disadvantaged populations. The program model described in this study offers a low cost and effective strategy for increasing diversity in STEM graduate education and beyond.



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## DECLARATIONS

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**Conflicts of interest/Competing interests:** The authors have no relevant financial or non-financial interests to disclose.

**Availability of data and material:** Data and material is available on public repository [xx].

**Code availability:** Code is available on public repository [xx].

**Authors' contributions:** KNG and ERT developed the research question and analysis plan and analyzed the data with input from SWCC. KNG and ERT drafted the manuscript with feedback from SWCC and DAS.

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### Supporting Information

464 **S1 Table.** Post-bootcamp survey questions divided into their respective sections. Questions that were  
465 not addressed in any section were excluded from analysis and are listed under “Excluded.”