Unconscious Bias in the Classroom:

Evidence and Opportunities

2017

Stanford cepa

SCHOOL of PUBLIC AFFAIRS
AMERICAN UNIVERSITY • WASHINGTON, DC

Unconscious Bias in the Classroom: Evidence and Opportunities

2017

Table of Contents

Suggested citation: Dee, T., & Gershenson, S. (2017). Unconscious Bias in the Classroom: Evidence and Opportunities. Mountain View, CA: Google Inc. Retrieved from https://goo.gl/O6Btqi.

Additional reports from Google's Computer Science Education Research are available at g.co/cseduresearch.

Executive Summary

The underrepresentation of women and racial and ethnic minorities in computer science (CS) and other fields of science, technology, engineering, and math (STEM) is a serious impediment to technological innovation as well as an affront to fundamental notions of fairness and equity. These gaps emerge in the early grades and tend to persist, if not widen, throughout the secondary and postsecondary years. The unconscious biases (UB) of teachers, school administrators, and fellow students may contribute meaningfully to the persistence of these gaps. Fortunately, a nascent literature on targeted interventions that directly address UB suggests there may be compelling opportunities to promote broader engagement in CS and STEM education and employment.

The fields of neuroscience, social psychology, economics, and sociology articulate the many possible origins of UB and the ways in which UB can harm stereotyped groups, particularly in educational settings. This interdisciplinary literature yields two troubling, important insights:

- Humans consciously ***and unconsciously*** store experiences in our brains and those experiences (memories) later influence instantaneous, automatic decision-making, which is critical to cognitive functioning and ***cannot be turned off.***
- Exposure to UB can trigger self-fulfilling prophecies by changing stereotyped groups' behaviors to conform to stereotypes, ***even when the stereotype was initially untrue.***

These insights provide specific guidance for mitigating the negative consequences of UB via interventions that disrupt the channels through which UB influences individuals and that highlight the insidiousness of UB, respectively. In particular, the following design insights should be considered when addressing UB systematically:

- Asking individuals to "suppress biases" is likely to be ***counterproductive,*** as this requires a great deal of mental effort and can cause UB to eventually rebound above pre-intervention levels.
- Teachers and classroom climate moderate the impact of UB, suggesting that teacher-facing interventions that carefully leverage the relevant **psychological mechanisms** (e.g., awareness, motivation, individuation, and empathy) have substantial promise to reduce teachers' UB and improve student outcomes.

In sum, UB is a nontrivial problem in education, especially in CS and STEM education, and it is not easily addressed via traditional educational policies and interventions. However, interventions that identify and alter the frequently unconscious psychological processes that harm individuals' outcomes are currently being developed and piloted. Teacher-facing interventions, which can be administered to both pre- and in-service teachers, are particularly promising. In part, this is because by addressing UB among teachers, we can help shape the entire classroom context in supportive ways. Furthermore, teacher-facing interventions are potentially cost-effective and scalable, because infrastructure for teacher training is already in place.

Still, much remains to be learned about the scalability, external validity, and optimal design of such interventions. Given the scope and complexity of the problem, interdisciplinary and inter-sector partnerships between public schools, universities, researchers, and industry will likely play a pivotal role in meeting these objectives.

Introduction

A critical design feature of human decision-making is the tendency to make attributions about people and events subconsciously. Quick decisions, reflexively interpreting new information through existing patterns of thought, are sometimes necessary for human survival (Kahneman, 2011). However, because these reflexive attributions are shaped by the broader social context, they can also constitute unconscious biases (UBs) that are an affront to fundamental notions of fairness.[1] UB exists in many contexts such as schooling, employment, the criminal justice system, and health care, particularly when most experts, gatekeepers, and authority figures are members of a privileged group. The insidiousness of UB is that it can lead to self-fulfilling prophecies that create and perpetuate inequities between groups, even when there was no pre-existing difference in ability and the UB (stereotype) was, by definition, incorrect. UB crosses multiple intersections of identity, including race, gender, class, sexual orientation, religion, and region.

The presence of UB among teachers is likely to be particularly consequential. Teachers are on the front lines of society's efforts to promote equality of opportunity. They spend a substantial amount of structured time with children over their developmental trajectories. When the UBs of well-intentioned teachers influence their judgment towards particular students (e.g., by race, ethnicity, gender), it can influence their instructional practices, the expectations they convey, and their recommendations for relevant outcomes like course placement, special education, and discipline. For example, recent research indicates that non-Black teachers have significantly lower expectations of Black students (Gershenson, Holt, & Papageorge, 2016). Even subtle aspects of classroom environments, such as the gender ratio of students in a class or posters associated with masculine CS stereotypes, can trigger anxiety that affects the performance and academic engagement of females (a phenomenon known as "stereotype threat"). All of these factors can shape students' own attitudes and expectations about school, and recursively influence their field of study, educational attainment, and choice of employment. Moreover, such biases might provide insights into the mechanisms through which teachers, the most important school-provided educational input, affect long-run labor market success. UB may be particularly salient with respect to supporting student success in STEM and CS, fields that are important for technological innovation and economic growth but where persistent underrepresentation among female and Black and Hispanic students has been a long-standing concern.

Encouragingly, however, a number of theoretically informed unbiasing interventions are being developed and tested. These interventions, which can be either student- or teacher-facing, have shown promise, at least in the narrow contexts in which they have been rigorously evaluated. The scalability of these interventions, and whether student- or teacher-facing interventions show more promise, are open questions we address later in this report. Specifically, the report sections proceed as follows:

» **Section 2, Understanding the Gaps in Education Outcomes** documents current and past socio-demographic gaps in academic achievement, employment, and earnings in STEM and CS fields

» **Sections 3 and 4, Theoretical Explanations of UB/Implicit Bias** and **Evidence of UB** describe theoretical and empirical evidence, respectively, on the existence and effects of UB in STEM and CS contexts

» **Section 5, Interventions to Address UB** reviews the available credible field evidence on the efficacy of various theoretically-informed unbiasing interventions

» **Section 6, Conclusions and Future Directions** concludes the report with a discussion of the most promising directions for future research, policy, and practice in this field

1 Unconscious bias is also known as implicit social cognition (Greenwald & Banaji, 1995).

Understanding the Gaps in Education Outcomes

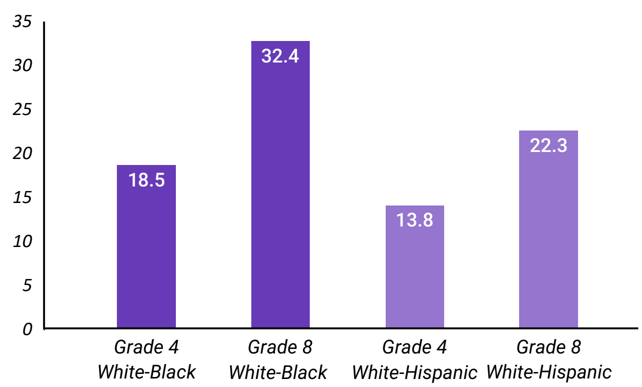
A diverse set of goals motivates both public and private investments in education. These include the desire to promote civic engagement and character as well as economic productivity. Another critical goal of education involves creating equality of opportunity for students regardless of socioeconomic and demographic backgrounds. However, there is also broad concern that schools may sometimes exacerbate, rather than remediate, inequality. Characterizing the gaps in different educational outcomes provides a useful framework for thinking about the policies and practices that might improve the educational outcomes of disadvantaged groups. We focus on Black, Hispanic, and female achievement since these groups are underrepresented in STEM and CS fields.

In the United States, Black students enter public school with achievement in math and reading behind that of their White peers. These gaps at school entry can be explained by a modest set of controls for socioeconomic status (SES) (Fryer & Levitt, 2006). However, the gap widens as students progress through school, in ways that cannot be explained by socioeconomic status (SES) characteristics or measures of school quality. On entering school, Hispanic students also underperform relative to their White peers. This gap narrows somewhat in the first two years of school but then stabilizes (Reardon & Galindo, 2009).

The recently released 2015 results from the National Assessment of Educational Progress (NAEP, "the Nation's Report Card") illustrate the considerable size of these gaps by subject and age. Among 4th graders, Black students perform below White students in mathematics by an amount equivalent to approximately 18 months of learning (0.80 standard deviations [SDs], Figure 1).[2] By grade 8, this math gap has increased to 32 months of learning (nearly 0.87 SDs). Hispanic students underperform relative to White students by a slightly more modest amount. In reading (Figure 2), 4th grade Black students underperform relative to their White peers by 23 months of learning (i.e., 0.70 SDs) and this amount increases to 34 months of learning by grade 8 (i.e., 0.74 SDs). For Hispanic students, these gaps are nearly as large. The reading achievement of Hispanic students is 22 months of learning (i.e., 0.65 SDs) behind their White peers in grade 4 and this amount increases slightly to 28 months of learning by grade 8. Interestingly, the math performance of girls is not meaningfully different from that of boys in the 2015 NAEP.[3] However, boys significantly underperform relative to girls in reading. Specifically, at grade 4, the average performance of boys is substantially below that of girls (i.e., 0.19 SDs or approximately 6 months of learning) and, by grade 8, this gender gap has increased to roughly 1 full year of learning (i.e., 0.26 SDs).

Figure 1.

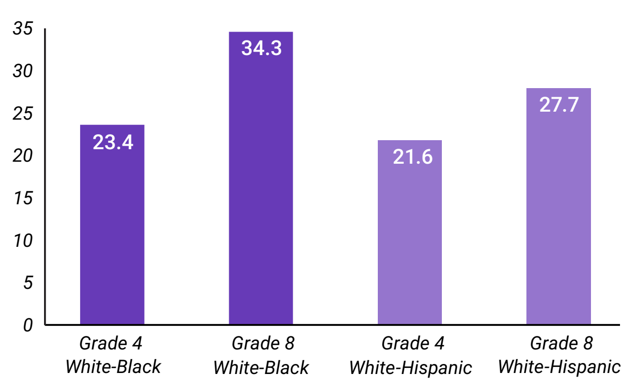
ACHIEVEMENT GAPS IN MATHEMATICS (STANDARD DEVIATION) BY RACE/ETHNICITY AND GRADE, 2015 NAEP



Source: U.S. Department of Education

Figure 2.

ACHIEVEMENT GAPS IN READING (STANDARD DEVIATION) BY RACE/ETHNICITY AND GRADE, 2015 NAEP



Source: U.S. Department of Education

2 In order to convert these achievement gaps into months of learning, we rely on the grade and subject-specific benchmarks provided by Hill, Bloom, Black, and Lipsey (2008).

3 The lack of a qualitatively meaningful gender gap in mathematics is not due to a focus on means. At higher percentiles of math performance, young girls in these grades perform similarly to their male peers.

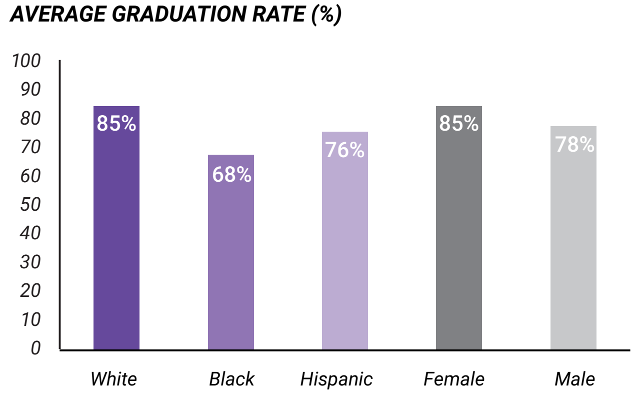
One explanation for the existence (and persistence) of large achievement gaps by race and ethnicity involves the effects associated with poverty (e.g., Lareau, 2011) and poverty's intersection with school quality. However, practices, policies, and social dynamics (e.g., unconscious biases among teachers) that vary within schools may also influence achievement gaps. One useful way to identify the broad sources of achievement gaps is to ask how much of these gaps can be explained by differences across schools (e.g., neighborhood or school quality) versus factors that vary within schools. For example, about half of the Black-White achievement gap is attributable to within-school sources (Bohrnstedt, Kitmitto, Ogut, Sherman, & Chan, 2015). This implies that within-school differences are at least as important as between-school differences associated with neighborhoods and school finances. Qualitative studies similarly suggest that differing experiences by race within schools (e.g., expectations of students, academic tracking, and school discipline) are educationally relevant (Lewis & Diamond, 2015).

For example, about half of the Black-White achievement gap is attributable to within-school sources (Bohrnstedt, Kitmitto, Ogut, Sherman, & Chan, 2015).

There are also racial gaps in behavioral outcomes. For example, the suspension rate for Black high school students is about three times larger than for White students. Boys are also twice as likely to be suspended as girls.Unsurprisingly, these gaps map onto gaps in educational attainment. For example, Figure 3 illustrates that graduation rates for Black students in public schools are 17 percentage points lower than that for White students (68% vs. 85%). A similar, but smaller, Hispanic-White gap in graduation rates is also apparent. Interestingly, the graduation rate for female students is seven percentage points higher than their male peers (85% vs. 78%).

Figure 3.

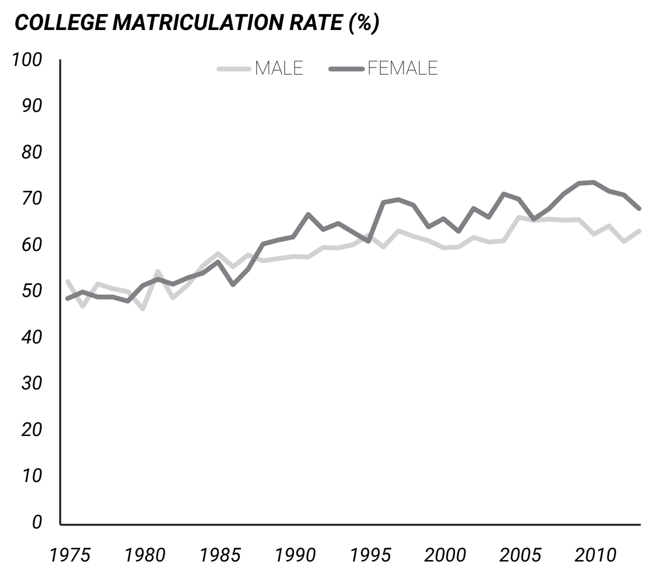
AVERAGE FRESHMAN GRADUATION RATE BY RACE, ETHNICITY, AND GENDER



Source: Stetser & Stillwell, 2014

Figure 4.

COLLEGE MATRICULATION RATES OF RECENT HIGH SCHOOL COMPLETERS BY GENDER, 1975–2013

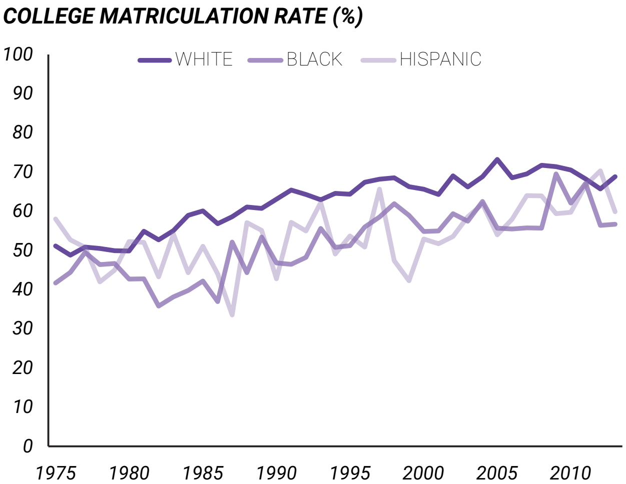


Source: U.S. Department of Education

There are similar patterns in college matriculation: the college attendance rate for girls who have recently graduated from high school (Figure 4) is about five percentage points (8%) higher than that of boys. Also, about two-thirds of White high school graduates enroll in two- or four-year colleges soon after graduation, but this figure is 10 percent lower among Black and Hispanic graduates (Figure 5).

Figure 5.

COLLEGE MATRICULATION RATES OF RECENT HIGH SCHOOL COMPLETERS BY RACE/ETHNICITY, 1975–2013

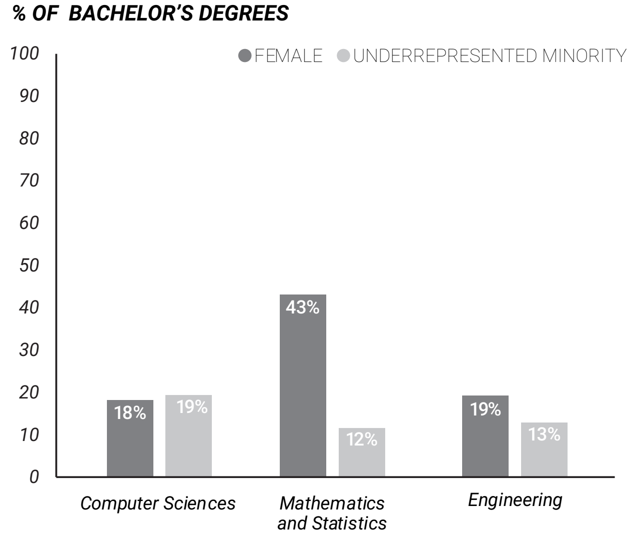


Source: U.S. Department of Education

Female students perform as well as boys in K-12 math assessments, such as the NAEP, and have better outcomes in reading and in educational attainment. Furthermore, a recently released NAEP study that focused specifically on technology and engineering literacy among 8th graders found that girls, on average, performed somewhat higher than boys.[4] Nonetheless, females are dramatically underrepresented in important STEM fields. More specifically, while women received roughly 57 percent of the bachelor degrees awarded in 2012, they accounted for less than half of the bachelor degrees awarded in mathematics and statistics. More dramatically, they accounted for less than 20 percent of bachelor degrees awarded in computer science and engineering. There are similar but less stark gaps for underrepresented minorities, who received a combined 21 percent of the bachelor degrees in 2012, but received only about 12 percent of the degrees awarded in engineering, mathematics, and statistics and 19 percent of those in computer science (Figure 6).

Figure 6.

THE SHARE OF BACHELOR'S DEGREES IN SELECTED STEM FIELDS EARNED BY FEMALES AND UNDERREPRESENTED MINORITIES, 2012



Source: National Science Foundation

Overall, these measures suggest an interesting pattern in the gaps in educational outcomes. For minority students, the gaps in student outcomes start in early grades and persist throughout their educational trajectories. For girls, measured outcomes indicate that they are equivalent to (or outperforming) boys on a variety of metrics, including mathematics. However, in postsecondary schooling, girls stratify dramatically leading to underrepresentation in particular STEM fields. While this may seem to suggest that the sources of the "leaky pipeline" for women are situated in postsecondary settings, some of the relevant factors (e.g., expectations, confidence, mindset, secondary course taking, etc.) are formed in earlier K–12 settings.

4 http://www.nationsreportcard.gov/tel_2014/

Theoretical explanations of UB/Implicit Bias

The fields of social psychology, neuroscience, economics, and sociology articulate the many ways in which unconscious bias can manifest, and harm negatively stereotyped (i.e., "outgroup") populations.[5] Understanding the sources of UB and the channels through which UB affects outcomes such as academic performance, wages, and course of study can inform the creation of interventions that minimize UB's role in perpetuating inequities in CS and STEM fields.

Stereotypes, or attitudes towards specific groups, do not necessarily reflect conscious thought (Devine, 1989). Indeed, individuals can be cognizant of stereotypes without believing them or consciously acting on them. However, unbeknownst to the individual, unconscious patterns of thought (e.g., reflexive assumptions about the academic motivation and capabilities of minorities and women) can influence current decisions.[6] These reflexive assumptions are the basis of UB.

Due to their hierarchical structure, schools and universities may be particularly susceptible to the presence of UB. **Stereotype threat** (Steele, 1997) describes one process through which UB might shape the demographic composition of CS and STEM classrooms. Consider an introductory CS course taught by a male professor who has no overt prejudices and truly believes that all students, regardless of socio-demographic background, are capable of mastering the material. Without realizing it, however, the professor may behave in ways that trigger feelings of self-doubt among the female students. For example, he may signal lower expectations for female students by over-praising females for giving correct answers in class. The resultant stress may cause female students to lose interest in the course, put forth less effort, and ultimately choose not to major in CS. By causing female students to comport to negative stereotypes regarding females' ability and interest in CS, UB and its consequences can persist, because there are fewer female professors and students in CS classrooms. This scenario is particularly troubling because it shows how UB can create a self-fulfilling prophecy in which stereotyped groups underperform in CS and STEM fields, even when the initial UB-related stereotypes were incorrect.[7]

Meanwhile, advances in neuroscience have enhanced our understanding of many psychological phenomena, including UB. For example, we now know one region of the brain (the amygdala) regulates automatic "fast" responses, which are associated with UB, while another (the frontal lobe) regulates conscious (controlled) responses. Thus there are distinct neuro-processes underlying the thinking "fast" and "slow" dichotomy described in Kahneman (2011). Another important insight is that the automatic responses associated with UB are **learned fear responses** that are predicated on lived experiences (Amodio, 2014). *In other words, humans are not born with an innate UB towards a particular group, but rather are exposed to a series of environments and experiences, which are both consciously and unconsciously stored in our brains, and later influence our instantaneous, automatic decisions.* However, this is not to say that humans cannot reduce overall levels of UB, as we have some control over the experiences, environments, and individuals that we, and our children, encounter.

Economics and sociology provide additional insights into how societal and organizational factors can promulgate UB and its consequences. Microeconomics is the study of how individuals make decisions, including such fundamental questions as whom to hire, where to live, what to study, and how much schooling to obtain. Economic theory provides insights into potential roles of UB in the startling, persistent sociodemographic disparities in STEM and CS educational and employment outcomes. First, **statistical discrimination** (Phelps, 1972) suggests that decision makers rely on the average ability of the socio-demographic group to which an individual belongs when the individual's own ability is unobservable (i.e., when employers have **imperfect information** about worker productivity). If it is difficult to ascertain a worker's ability prior to hiring them

5 Our discussion of key concepts and insights is arranged by discipline. However, disciplinary boundaries are sometimes blurry. This is sometimes due to the rise in interdisciplinary research. In other cases, ideas have been independently discovered and pursued by researchers in different disciplinary silos.

6 This is known as implicit social cognition (Greenwald & Banaji, 1995).

7 There are at least two ways in which UB might harm outgroup students' performance. First, **behavior modification** occurs when stereotyped groups modify their own behaviors to conform to negative biases. Second, teachers may modify how they teach, evaluate, and advise outgroup students, again leading to poor educational outcomes for such students.

and stereotyped minorities have objectively lower CS and STEM skills, perhaps due to the phenomenon of stereotype threat discussed above, rational employers in those sectors would respond by hiring few, if any, women and minorities. This would perpetuate the underrepresentation of stereotyped minorities in CS and STEM that triggered the phenomenon of stereotype threat in the first place. Similarly, if talented minority engineering students see themselves being passed over for internships or treated differently in classes, they may respond by making smaller investments in CS and STEM education. A feedback loop is apparent in both cases that can create a self-fulfilling prophecy in which initially incorrect stereotypes (due to UB) affect stereotyped groups' behaviors in ways that then make the stereotype become true (Loury, 2009). Second, **identity economics** (Akerlof & Kranton, 2005) articulates scenarios in which individuals simultaneously choose social identities (e.g., jock, nerd, burnout) and corresponding levels of academic effort that may reinforce the stereotyped identity. The UB of teachers, principals, and peers might affect school climate and students' expectations, effort, and attitudes, in ways that also reinforce such dynamics.

The importance of school climate also appears in sociology's focus on **organizational factors** (Pager & Shepherd, 2008). Organizational factors likely shape the way that teachers' or peers' UB affects students (Reskin, 2000; Petersen & Saporta, 2004). For example, **social networks** within schools or organizations might exacerbate the harm caused by UB if UB contributes to the formation of homogeneous "ingroup" (i.e., a group of people with a shared interest or identity) social networks, and such networks influence organizations' hiring and promotion decisions.[8] Again, this can lead to a perpetual lack of outgroup (minority) role models in leadership positions, and even trigger stereotype threat.

Structural factors such as broader societal norms and policies also likely shape the influence of UB on individuals' choices, behaviors, and outcomes (Pager & Shepherd, 2008). Extant wage inequality, gaps in educational attainment, and occupational sorting by gender and race, which themselves are due to a combination of past explicit and implicit discrimination, mean that even a single instance of UB today, say when a deserving minority is denied a loan, can start a chain reaction that affects housing, credit, children's educational options, wealth, and the intergenerational transmission of SES (DiPrete & Eirich, 2006). A similar chain reaction might occur when a student is counseled out of the advanced math track.[9] In other words, transitory exposure to UB can expose outgroup populations to cumulative disadvantage, which in turn triggers their conformity to stereotypical or negatively biased expectations (Loury, 2003).

In other words, transitory exposure to UB can expose outgroup populations to cumulative disadvantage, which in turn triggers their conformity to stereotypical or negatively biased expectations (Loury, 2003).

Again, the common theme of these interdisciplinary theoretical insights is that UB can occur in numerous contexts and from various sources. And when it does, UB can create feedback loops and self-fulfilling prophecies that perpetuate inequities, and even create inequities where none existed before and the UB or stereotype was incorrect.

8 Loury (2009) refers to this as "discrimination in contact."

9 Counseling-out occurs in public schools. For example, S. Nicholson-Crotty, Grissom, J.Nicholson-Crotty, and Redding (2016) show that Black students are significantly more likely to be assigned to gifted-and-talented tracks by Black teachers than by White teachers.

Evidence of UB

Cognitive Priming experiments provide indirect evidence of UB towards oneself, by showing that seemingly innocuous stimuli associated with stereotypes affects outgroup individuals' performance. For example, Steele and Aronson (1995) showed that Black college students perform worse on standardized exams that are **framed** as "diagnostic of intellectual ability" rather than a "laboratory problem-solving task." Johns, Schmader, and Martens (2005) found similar effects on female performance on math exams. Similar effects have been replicated across outgroup populations, educational contexts, and domains (Steele, Spencer, & Aronson, 2002). The idea here is that framing the exercise as a formal "test of ability" prompts students to recall stereotypes about females' and racial minorities' scholastic aptitude, which in turn creates stress that influences test performance. Situational contexts, such as classroom gender ratios, can produce similar effects by reminding female test takers that females are underrepresented in STEM (Inzlicht & Ben-Zeev, 2000; Bell, Spencer, Iserman, & Logel, 2003). This phenomenon is observed in other contexts as well. For example, the gender composition of the audience in a scientific conference affects females' willingness to participate in the conference (Murphy, Steele, & Gross, 2007). These findings show how seemingly innocuous stimuli can trigger subconscious psychological responses that affect performance in the CS and STEM domains.

Implicit association tests (IAT), first proposed by Greenwald, McGhee, and Schwartz (1998), provide a more direct measure of UB. Importantly, IATs can detect attitudes that participants would consciously try to hide, or might not even be aware of. Numerous IAT studies find evidence of UB across contexts and domains (Nosek et al., 2007; Wilson, Lindsey, & Schooler, 2000). In education, IATs find that both genders unconsciously associate men with hard sciences and women with the liberal arts. Women with higher degrees of UB consciously report being less interested in science and math, perform worse on standardized math exams, and are less likely to enroll in math and science majors (Nosek, Banaji, & Greenwald, 2002). At the macro level, countries with high levels of gender-based UB towards science and math have larger country-level gender gaps in 8th grade math and science performance (Nosek et al., 2009).

A limitation of the priming experiments and IATs discussed above is that they are typically conducted in sterile laboratory settings, and might not adequately reflect human behavior in the real world. **Correspondence (resume audit) studies** are one way around this: researchers submit fictitious applications to real job openings, providing a straightforward way to measure bias in high stakes, real-world scenarios (i.e., in the field). For example, Bertrand and Mullainathan (2004) sent fictitious resumes to job adverts in Boston and Chicago. The resumes were identical except for the "Whiteness" of the names randomly assigned to each resume. White names like Greg were about 50% more likely to be called back for interviews than Black names like Jamal. This result has been documented in numerous contexts and for an array of racial and ethnic minorities (Bertrand & Duflo, 2016). Correspondence studies that investigated gender discrimination in CS jobs found mixed results. Bertrand and Duflo call for further research that can sort out the mechanisms underlying these results. For example, Bartos, Bauer, Chytilová, and Matějka (2014) found that German and Czech employers called back ingroup applicants at higher rates and spent more time reviewing ingroup application materials.

Correspondence studies have also been conducted in academic settings. Milkman, Akinola, and Chugh (2012) sent emails from fictitious prospective doctoral students to professors asking to meet. White male students received more, and faster, responses than female and non-White students in CS and STEM programs (Milkman, Akinoloa, & Chugh, 2015). This highlights the role that bias, whether explicit or implicit, can play even at informal or intermediate steps of the educational process. Similarly, Moss-Racusin, Dovidio, Brescoll, Graham, and Handelsman (2012) conducted a correspondence-type study in the lab, in which science faculty at research universities reviewed fictitious applications for a hypothetical lab assistant position. The scientists, regardless of gender, systematically rated male applicants as more competent than female applicants. It is striking that both male and female faculty were equally biased against female candidates. It is difficult to disentangle UB from explicit or intentional bias in many of these studies, though given extant laboratory evidence on priming and IATs, it is likely that UB plays a nontrivial role in the discrimination documented in field experiments (Bertrand & Duflo, 2016).

Grading biases provide additional evidence of discrimination in the classroom, although not always in the expected direction. In Israel, high school teachers assigned higher grades to females when the exams listed their names than on "blind" exams that hid students' names (Lavy, 2008). A U.S. study suggests that this unexpected gap is almost entirely explained by gender gaps in non-cognitive skills; that is, conditional on teachers' assessments of students' academic engagement, the male-female grading differential disappears (Cornwell, Mustard, & Van Parys, 2013). Hanna and Linden (2012) conducted a field experiment in India that randomly assigned names associated with different castes on exam cover sheets and found significant grading bias against children from lower castes. These results are troubling, as exposure to a biased teacher can harm several long-run educational and labor-market outcomes (Lavy & Sand, 2015).

Grading biases are related to the consequences of the underrepresentation of females and racial/ethnic minorities in certain subjects and levels of the educational system. A seminal study by Dee (2004) found that having a same-race teacher significantly improved students' math and reading achievement. This result has been replicated in other educational contexts, as have effects of student-teacher gender match. Carrell, Page, and West (2010) showed that when female college students have a female math or science professor, they perform better in those classes and are more likely to engage with STEM subjects in the future. It is troubling, then, that De Paola and Scoppa (2015) found that female faculty are significantly less likely to be awarded tenure by all-male committees. These examples show how UB can create a "pipeline problem" that persists into the CS and STEM labor markets.

There are similar effects of mismatch on student and teacher behaviors. In laboratory experiments, Gilliam, Maupin, Reyes, Accavitti, and Shic (2016) found that teachers had systematically graver perceptions of the severity of preschoolers' misbehavior when observing students of a different race other than their own race and that when primed to expect misbehavior, preschool teachers of all races devoted more time to observing black students, especially black boys. Dee (2005) found that, when White and Black teachers simultaneously evaluated the same Black student, White teachers were significantly more likely to perceive the Black student as disruptive, inattentive, and less likely to complete homework. Gershenson et al. (2016) similarly showed that White 10th grade math teachers have lower educational expectations for Black students than do Black teachers. These biased expectations arguably have causal impacts on college completion rates that contribute to racial gaps in educational attainment (Papageorge, Gershenson, & Kang, 2016). Demographic mismatch also affects intermediate outcomes associated with school engagement, such as student absences (Holt & Gershenson, 2015) and office-hours visits (Lusher, Campbell, & Carrell, 2015). Again, as discussed above in the context of priming, these behaviors create spillover effects that affect school climate and other outgroup students. Of course, like in the case of resume audits, it is possible that explicit biases contribute to the grading biases and impacts of student-teacher demographic mismatch discussed above, though UB likely plays an important role.

These sorts of biases can have a variety of detrimental impacts and contribute to pipeline issues in CS and STEM. Most obviously, lower grades can affect students' admission into advanced academic tracks in secondary school and admission to postsecondary institutions. They can also indirectly affect student outcomes by changing how teachers advise and teach outgroup students. For example, a seminal experiment randomly manipulated teachers' expectations of students (i.e., identifying random students as likely to bloom in school), and students for whom expectations were raised subsequently experienced greater achievement gains (Rosenthal & Jacobsen, 1968). This result highlighted the potential for beliefs to create self-fulfilling prophecies, regardless of the accuracy of those beliefs, and has been replicated many times. These modest "Pygmalion Effects" have been replicated in numerous other contexts (Jussim & Harber, 2005).[10]

These instances of UB in K-12 and postsecondary schooling manifest in the underrepresentation of women and minorities in CS employment, though this is not entirely a pipeline issue; there is also UB in CS and STEM

10 Pygmalion Effects are named after the character in Ovid's Metamorphoses who fell in love with a statue of a woman he created.

workplaces. For example, Reuben, Sapienza, and Zingales (2014) experimentally found that when employers were given no information about candidates other than physical appearance, men were twice as likely to be hired for a mathematical task as were women. Cheryan, Drury, and Vichayapai (2013) found that role models who fit CS stereotypes reduce women's interest in CS. For example, a White male instructor who fits the "computer nerd" stereotype of being interested in science-fiction movies and computer games can turn women off to the field. Even posters in the classroom that fit these stereotypes, and change classroom climate accordingly, can dissuade women from pursuing CS.

For example, a White male instructor who fits the "computer nerd" stereotype of being interested in science-fiction movies and computer games can turn women off to the field. Even posters in the classroom that fit these stereotypes, and change classroom climate accordingly, can dissuade women from pursuing CS.

Interventions to Address UB

School policies and practices

A diverse array of federal, state, and local policies address socio-demographic gaps in educational outcomes. Few policies focus specifically on UB. Instead, they address the hypothesized consequences of UB. For example, a report by the National Research Council (2011) found that test-based school-accountability reforms had modest, positive effects on math achievement. Tracking is another prominent school practice, which sorts students into classrooms based on past performance, and likely exacerbates inequality (Hanushek & Woessman, 2006). A recent study by Card and Guiliano (2016) is consistent with the role of access to appropriately challenging curricula. They found that non-gifted Black and Hispanic students experienced achievement gains when granted access to classes for gifted students, perhaps due to UB-related factors such as teacher expectations.

In a study of three Los Angeles high schools, Margolis, Estrella, Goode, Holme, Nao (2010) document how student underrepresentation in CS reflects the interplay of school policies (e.g., course offerings, academic rigor, student counseling) with teacher beliefs and behaviors. Classroom practices such as having positive role models administer exams might also minimize the harm of UB in engineering education (Eschenbach, Virnoche, Cashman, Lord, & Camacho, 2014). This can counter the pernicious effects of stereotype threat. Teachers can also design physical classroom environments so as to avoid prompting traditional stereotypes about engineering and CS that may trigger social identity threat (Cheryan, Plaut, Davies, & Steele, 2009).

Student-facing interventions

Numerous studies have investigated how efforts to "buffer" students against the psychological effects of stereotype threat affect academic performance. The design of these interventions is based on theoretical insights gleaned from lab experiments and aims to reduce the harm of UB rather than the existence of UB. We reviewed "buffering" interventions that (i) were conducted in field settings, (ii) used experimental methods, and (iii) focused on student outcomes. The 21 peer-reviewed studies fit in four mutually exclusive categories (Table 1).[11]

Most (n = 12) were "values affirmation" (VA) exercises. These student-led interventions involved completing a brief worksheet in which students write about their personal values. A second set of studies (n = 5) focused on engagement with external attributions (EA) (e.g., luck, and other factors outside the student's control) for academic difficulties. A third set of studies (n = 5) involved influencing student "mindsets" (MS). These interventions encouraged students to adopt "growth" mindsets that emphasize the malleability of achievement over fixed mindsets that do not. The remaining study examined a "task reframing" (TR) intervention (Good et al., 2008) that involved describing a test in a manner that effectively disarmed stereotypes.

These studies, mostly conducted in real-world middle-school and college settings, generally found large effects (e.g., 0.2 to 0.3 SDs) on academic achievement. Two studies of female STEM undergraduates found uniquely large effects (Miyake et al., 2010; Walton, Logel, Peach, Spencer, & Zanna, 2015). Because these interventions are brief and virtually costless, their cost-effectiveness is extraordinarily high.

However, the impact of these interventions is theorized to rely critically on triggering "recursive" processes (Yeager & Walton, 2011). That is, these interventions are a type of "nudge" that relies on supportive school and classroom contexts to amplify a modest initial treatment into more dramatic and sustained change. Many of the studies in Table 1 rely on small numbers of teachers and schools. For example, the influential study by Cohen, Garcia, Apfel, and Master (2006) involved just three teachers in one middle school. There is some evidence that many studies were conducted in favorable school and classroom settings: effects were smaller in studies with larger numbers of students (e.g., Paunesku et al., 2015; Harackiewicz et al., 2014) and non-existent in studies with the largest numbers of students, teachers, and schools (Dee, 2015, Lauer et al., 2013). These larger studies may have better external

11 These studies could also be situated in a broader field-experimental literature based on motivation theory. In a recent meta-analytic review, Lazowski and Hulleman (2015) find that these interventions generally produce quite large educational gains (i.e., mean effect size of 0.49 SDs).

validity and likely included contexts not as conducive to such interventions. Dee (2015) provided direct evidence on this question in a values-affirmation study conducted in 128 classrooms across six middle schools. Overall, the researcher found no effect of the intervention. However, Dee did find sizable effects in classrooms with effective teachers (as measured by their value-added scores).[12] These results do not impugn the theoretical basis of student-facing interventions but do raise serious doubts about their context-dependent scalability.

12 Value-added scores are statistical estimates of an individual teacher's average contribution to student learning, as measured by standardized tests. See, for example, Chetty, Friedman, and Rockoff (2014).

Teacher-facing Interventions

There are fewer rigorous evaluations of teacher-facing efforts to reduce UB. However, policies and programs that target teacher bias directly are attractive relative to both school and student-level approaches for three reasons. First, engagement at the teacher level reaches into classroom practice in a way that higher-level policies do not. Second, they engage the entire classroom context, creating the possibility of supportive "recursive" processes (e.g., by improving classroom climate or creating positive peer interactions) and, by implication, more promising scalability. Third, the established infrastructure associated with teacher training and professional development (PD)

Table 1.
STUDENT-FACING SOCIAL-IDENTITY INTERVENTIONS

Authors	Study Population (Sample Size	Intervention	Effects
Walton and Cohen (2011)	College students (92)	EA	0.30 GPA points for Black students
Stephens et al. (2014)	College students (168)	EA	0.24 GPA points
Yeager et al. (2014)	High school students (76)	EA	0.34 SD in grades for Black students
Good et al. (2003)	7th graders (138)	EA/MS	0.52 to 0.72 SD (reading); 1.1 to 1.5 SD (math)
Walton et al. (2015)	College students (228)	EA/VA	1.04 SD increase in women's engineering GPA
Oysterman et al. (2016)	8th graders (264)	MS	0.23 GPA points
Blackwell et al. (2007)	7th graders (91)	MS	0.53 GPA points in math
Yeager et al. (2014)	9th graders (78; 150 in 2 studies)	MS	0.34 GPA points in study 2, no effect in study 3
Paunesku et al. (2015)	High school students (1,594)	MS	0.14 GPA points for at-risk students
Good, Aronson, and Harder (2008)	College students (157)	TR	0.36 SD in math test for White females
Cohen et al. (2006)	7th graders (243)	VA	0.34 GPA points for Black students
Cohen et al. (2009)	7th graders (416)	VA	0.24 GPA points for Black students
Woolf et al. (2009)	Medical-school students (348)	VA	-0.18 SD in written assessment for White students, 0.28 SD increase in test performance
Miyake et al. (2010)	College students (399)	VA	0.93 SD for females on physics exams
Cook et al. (2012)	7th graders (121)	VA	GPA gain for Black students
Bowen et al. (2013)	6th to 8th graders (274)	VA	0.57 SD gain in social studies grade
Lauer et al. (2013)	College students (679)	VA	No effect
Sherman et al. (2013)	6th to 8th graders (199)	VA	0.25 GPA points for Hispanic students
Harackiewicz et al. (2014)	College students (798)	VA	0.10 GPA points (biology) for first-generation students
Dee (2015)	7th and 8th graders (2,564)	VA	No effect
Borman et al. (2016)	7th graders (1,012)	VA	0.082 GPA points for minority students

Notes: This table summarizes the findings from field-experimental interventions that focus on social identity mechanisms. The taxonomy of these interventions consists of values affirmation (VA), external attribution (EA), mindset (MS), and task reframing (TR).

provides opportunities to situate such interventions for both pre-service and in-service teachers.

Traditional pre-service teacher training programs might directly or indirectly reduce UB and its harm. Recently, educational experts have argued that all education-program curricula should be augmented to include cultural competency training (NEA, 2008) and an explicit focus on race (Milner & Self, 2014). However, rigorous evidence on the precise pre-service curricula that reduce UB and its harms is lacking.[13] Non-traditional (alternative) teacher training programs such as Teach for America (TFA) also might address UB. Indeed, TFA's five-week summer institute includes an entire unit on the power of high expectations, and TFA teachers improve students' math and science achievement.[14] While the importance of TFA's focus on high expectations cannot be disentangled from that of other institutional features, TFA training does affect graduates' beliefs about the malleability of achievement gaps and UB (as measured by IAT scores; Dobbie & Fryer, 2015).

A diverse literature in social psychology provides more explicit guidance on how to design interventions that may attenuate UB among teachers. For example, Cohen, Steele, and Ross (1999) showed that Black students responded particularly well to critical feedback when it was accompanied by a statement of high standards coupled with assurances about the students' capacity to meet those standards (i.e., "wise" feedback; Walton, 2014). Yeager et al. (2014) examined the effects of this approach in a field-experimental setting in which teacher feedback was experimentally manipulated. They found positive effects of wise feedback on measures of student engagement and performance, particularly for Black students who were mistrustful of school.

A broader psychological literature on reducing UB (i.e., not necessarily in education) focuses on several design themes:[15]

» Nurturing the **motivation** to reduce UB by building an awareness of one's own biases without shaming or blaming (Devine & Monteith, 1993)
» Building **awareness** of the shared psychological basis for UB (Burgess et al., 2007)
» Promoting evaluating individuals through **individuation** (unique attributes) rather than social categorization (group membership) (Blair, 2002)
» Reducing the anxiety of outgroup interactions through increased **contact between two or more social groups** (Schellhaas & Dovidio, 2016)
» Enhancing emotional-regulation skills that promote **positive emotions** when interacting with outgroups (e.g., visualizing the "Best Possible Self"; Sheldon & Lyubomirsky, 2006)
» Increasing **empathy** and perspective-taking (Dovidio et al., 2004; Okonofua, Paunesku, & Walton, 2016)
» Building a sense of **partnership** that reduces outgroup status (Dovidio et al., 2004)

Some of the research on these design features have been situated in education settings. For example, Okonofua et al. (2016) evaluated an intervention that encourages middle school teachers to consider and value student experiences. The study confirms that empathy is malleable and that teachers who use empathic discipline develop better relationships with outgroup students. Ultimately, student suspensions fell by 50%.

Other education-specific studies leveraged an insight from Devine, Forscher, Austin, and Cox (2012): effective UB interventions may combine some or all of the mechanisms enumerated above. For example, Jackson, Hillard, and Schneider (2014) found that a multi-faceted diversity training session reduced UB towards women among male STEM faculty in postsecondary institutions. Similarly, Carnes et al. (2015) found that a 2.5 hour workshop that embeds these psychological mechanisms increased an awareness of personal biases among STEM faculty at the University of Wisconsin.

13 Whether and how the location of teachers' pre-service teaching experience matters is another area of debate. Ronfeldt (2012) finds that teachers who have student-teacher assignments in easier-to-staff schools tend to have higher retention rates and higher value-added scores than teachers whose initial student-teaching placement is in a hard-to-staff school, though it is unclear whether this is a causal relationship.

14 See Glazerman, Mayer, and Decker (2006) and Xu, Hannaway, and Taylor (2011).

15 Burgess, Van Ryn, Dovidio, and Saha (2007) discuss this taxonomy in the context of reducing UB in medical settings.

Conclusions and Future Directions

Section 2 of this report documented troubling, persistent socio-demographic gaps in students' educational attainment and achievement in the CS and STEM fields that manifest in similar gaps in wages and occupational choice in the labor market. Section 3 introduced implicit or unconscious bias (UB) as a likely driver of such gaps and explained the theoretical underpinnings of the existence, and negative implications, of UB. Section 4 then documented evidence of the harmful effects of UB in CS and STEM education and labor markets. Finally, section 5 reviewed the credible evidence on the efficacy of field-tested student- and teacher-facing educational interventions to reduce UB and its associated harms.

Moving forward, the research agenda should privilege teacher-facing interventions over student-facing interventions for several reasons. This may seem odd as there is a thicker field-experimental literature on student-facing interventions and they show a great deal of promise. However, these field studies are typically situated in small, select settings and there is broad acknowledgment that the effectiveness of these student interventions relies critically on classroom context. Because many pilot studies of such programs were conducted in schools and classrooms with climates conducive to such interventions, the external validity of the results of these pilot studies is unclear. Interventions that engage teachers have the potential to improve classroom, and even school, climate in ways that increase the efficacy of many educational interventions and inputs. For example, interventions that reduce teachers' expressions of UB might also indirectly reduce ingroup students' expressions of UB. Additionally, teacher-facing interventions are more logistically feasible than student-facing interventions because there are fewer teachers, their turnover is lower, and they have established opportunities for PD training, both pre-service and in-service.

Moreover, the separation between student- and teacher-facing interventions can be counterproductive. For example, if buffering interventions, which are typically viewed as student-facing, are only effective when implemented in certain types of classrooms, then an intervention that trains teachers to implement such interventions or to organize their classrooms in a way that is conducive to such interventions, is both student- and teacher-facing and might yield large benefits. Future research on this type of hybrid intervention would be useful, as it represents a more holistic approach to addressing UB. For example, there may be multiplicative effects of interventions that simultaneously train teachers to empathize with students, build warm classroom climates, and implement affirmation exercises that are larger than the sum of effects when those interventions are offered independently. This is the type of innovative, potentially high-reward intervention that a partnership between schools, researchers, and industry could implement and evaluate.

It is important that well-established and tested theories inform the design of teacher-PD programs. In particular, interventions that encourage teachers to see students as individuals instead of as categories and that build empathy and high expectations (e.g., visualizing best possible academic selves) are particularly promising (Carnes et al., 2015; Jackson et al., 2014; Okonofua et al., 2016). However, the design of such teacher PD also needs to be mindful of the unintended negative consequences from an intervention that clumsily suppresses biases, as this approach can lead to unproductive rebound effects.

While there are compelling opportunities in this space, the research base is, at present, too thin to guide policy and practice reliably. For example, there are emerging models of teacher training that hold the promise of reducing UB (e.g., simulation-based modules that provide pre-service teachers with practice interacting with minority students in challenging, yet common, classroom situations). However, such interventions have yet to be rigorously evaluated or implemented at scale. Technology and other CS-related industries are uniquely positioned to partner with schools and researchers to design, implement, and evaluate emerging interventions in this mold and ultimately increase the representation of female and racial and ethnic minorities in the STEM and CS sectors.

Specifically, the near-term agenda should focus on an energetic design cycle in which theoretically-informed interventions are designed and rigorously evaluated in field settings. In the case of CS and STEM education, this means at the primary, secondary, and postsecondary levels and in multiple school contexts (e.g., by demographic composition and diversity, students' socioeconomic background, subject, teachers' experience, and school and class size). One potentially important design element, which has yet to be carefully considered, is the medium of the intervention. For example, one cost-saving innovation might be to replace (or augment) simulations and classroom-experiences with role-playing video games or virtual-reality environments. Another novel, potentially important design element to experiment with is the frequency and duration of teacher-facing interventions. For example, the workshops evaluated by Carnes et al. (2015), Jackson et al. (2014), and Okonofua et al. (2016) need not be one-off events, but could be offered on an annual or monthly basis. Shorter, perhaps virtual, workshops and simulations could be offered even more frequently.

In sum, the time is ripe for thoughtfully targeted and comprehensive action. A large and diverse body of evidence indicates that UB among teachers contributes meaningfully to education inequality. And, because this is a particular problem in CS and STEM fields, UB effectively deprives society of the talent and ingenuity that drives technological progress. Fortunately, emerging research indicates that there are likely to be effective ways to reduce the exclusionary effects of UB on CS and STEM education and employment. However, this effort will require the cooperation and coordination of inter-disciplinary, inter-sector teams that thoughtfully design, rigorously evaluate, and implement on a wide scale interventions targeted to both pre- and in-service teachers.

About Google

Google's core mission is to organize the world's information and make it universally accessible and useful. Google creates products to increase access to opportunity, break down barriers and empower people through technology. To help reach these goals, Google works to inspire young people around the world not just to use technology but to create it. There is a need for more students to pursue an education in computer science, particularly girls and minorities, who have historically been underrepresented in the field. More information on Google's computer science education efforts is available at g.co/csedu.

About CEPA

The Stanford Center for Education Policy Analysis (CEPA) is a research center created in 2009 to unite an interdisciplinary array of nationally prominent scholars from across the campus to provide the depth and scale of research needed to affect education practice and policy in meaningful ways. The CEPA community includes Stanford faculty, post-doctoral fellows, graduate and undergraduate students as well as visiting scholars and students from across the world. For more information about CEPA, visit cepa.stanford.edu

About SPA

American University School of Public Affairs is a top-ranked school offering programs to build and enhance careers in public service. The school offers a unique pairing of access to Washington, DC with world-renowned faculty and transformational research—driving progress in policy, politics, and public administration. SPA is ranked fifth in the world, third in the US, and first in the DC area for public affairs research impact. For more information about SPA, visit www.american.edu/spa.

References

Akerlof, G. A., & Kranton, R. E. (2005). Identity and the Economics of Organizations. *Journal of Economic Perspectives, 19*(1), 9-32.

Amodio, D. M. (2014). The neuroscience of prejudice and stereotyping. *Nature Reviews. Neuroscience, 15*(10), 670-682.

Bartos, V., Bauer, M., Chytilová, J., & Matějka, F. (2014). Attention discrimination: Theory and field experiments. IZA Discussion Paper No. 8058.

Bell, A. E., Spencer, S. J., Iserman, E., & Logel, C. E. (2003). Stereotype threat and women's performance in engineering. *Journal of Engineering Education, 92*(4), 307-312.

Bertrand, M., & Duflo, E. (2016). Field experiments on discrimination. Forthcoming, Handbook of Field Experiments.

Bertrand, M., Mullainathan, S. (2004). Are Emily and Greg more employable than Lakisha and Jamal? A field experiment on labor market discrimination. *American Economic Review 94,* 991–1013.

Blackwell, L. S., Trzesniewski, K. H., & Dweck, C. S. (2007). Implicit theories of intelligence

predict achievement across an adolescent transition: A longitudinal study and an intervention. *Child development, 78*(1), 246-263.

Blair, I. V. (2002). The malleability of automatic stereotypes and prejudice. *Personality and Social Psychology Review, 6*(3), 242-261.

Bohrnstedt, G., Kitmitto, S., Ogut, B., Sherman, D., and Chan, D. (2015). School Composition and the Black–White Achievement Gap (NCES 2015-018). U.S. Department of Education, Washington, DC: National Center for Education Statistics. Retrieved from http://nces.ed.gov/pubsearch.

Borman, G. D., Grigg, J., & Hanselman, P. (2016). An effort to close achievement gaps at scale through self-affirmation. *Educational Evaluation and Policy Analysis, 38*(1), 21-42.

Bowen, N. K., Wegmann, K. M., & Webber, K. C. (2013). Enhancing a brief writing intervention to combat stereotype threat among middle-school students. *Journal of Educational Psychology, 105*(2), 427-435.

Burgess, D., Van Ryn, M., Dovidio, J., & Saha, S. (2007). Reducing racial bias among health care providers: lessons from social-cognitive psychology. *Journal of General Internal Medicine, 22*(6), 882-887.

Card, D., & Giuliano, L. (2016). *Can Tracking Raise the Test Scores of High-Ability Minority Students?* (No. w22104). National Bureau of Economic Research.

Carnes, M., Devine, P. G., Manwell, L. B., Byars-Winston, A., Fine, E., Ford, C. E., ... & Palta, M. (2015). The effect of an intervention to break the gender bias habit for faculty at one institution: a cluster randomized, controlled trial. *Academic Medicine, 90*(2), 221-230.

Carrell, S. E., Page, M. E., & West, J. E. (2010). Sex and Science: How Professor Gender Perpetuates the Gender Gap. Th*e Quarterly Journal of economics, 125*(3), 1101-1144.

Cheryan, S., Plaut, V. C., Davies, P. G., & Steele, C. M. (2009). Ambient belonging: how stereotypical cues impact gender participation in computer science. *Journal of personality and social psychology, 97*(6), 1045.

Cheryan, S., Drury, B. J., & Vichayapai, M. (2013). Enduring influence of stereotypical computer science role models on women's academic aspirations. P*sychology of Women Quarterly, 37*, 72-29.

Chetty, R., Friedman, J. N., & Rockoff, J. E. (2014). Measuring the impacts of teachers I: Evaluating bias in teacher value-added estimates. *The American Economic Review, 104*(9), 2593-2632.

Cohen, G. L., Garcia, J., Apfel, N., & Master, A. (2006). Reducing the racial achievement gap: A social-psychological intervention. *Science, 313*(5791), 1307-1310.

Cohen, G. L., Garcia, J., Purdie-Vaughns, V., Apfel, N., & Brzustoski, P. (2009). Recursive processes in self-affirmation: Intervening to close the minority achievement gap. *Science, 324*(5925), 400-403.

Cohen, G. L., Steele, C. M., & Ross, L. D. (1999). The mentor's dilemma: Providing critical feedback across the racial divide. *Personality and Social Psychology Bulletin, 25*(10), 1302-1318.

Cook, J. E., Purdie-Vaughns, V., Garcia, J., & Cohen, G. L. (2012). Chronic threat and contingent belonging: protective benefits of values affirmation on identity development. *Journal of personality and social psychology, 102*(3), 479-496.

Cornwell, C., Mustard, D. B., & Van Parys, J. (2013). Noncognitive skills and the gender disparities in test scores and teacher assessments: Evidence from primary school. *Journal of Human Resources, 48*(1), 236-264.

Dee, T. S. (2004). Teachers, race, and student achievement in a randomized experiment. *Review of Economics and Statistics, 86*(1), 195-210.

Dee, T. S. (2005). A teacher like me: Does race, ethnicity, or gender matter?. *The American Economic Review, 95*(2), 158-165.

Dee, T. S. (2015). Social identity and achievement gaps: Evidence from an affirmation intervention. *Journal of Research on Educational Effectiveness, 8*(2), 149-168.

De Paola, M., & Scoppa, V. (2015). Gender Discrimination and Evaluators' Gender: Evidence from Italian Academia. *Economica, 82*(325), 162-188.

Devine, P. G. (1989). Stereotypes and prejudice: their automatic and controlled components. *Journal of Personality and Social Psychology, 56*(1), 5-18.

Devine, P. G., & Monteith, M. J. (1993). The role of discrepancy-associated affect in prejudice reduction. In: Mackie D. M., & Hamilton D. L., (Eds.) Affect, Cognition and Stereotyping: Interactive Processes In Intergroup Perception. Orlando, FL: Academic Press; 1993: 317–44.

Devine, P. G., Forscher, P. S., Austin, A. J., & Cox, W. T. (2012). Long-term reduction in implicit race bias: A prejudice habit-breaking intervention. *Journal of experimental social psychology, 48*(6), 1267-1278.

DiPrete, T. A., & Eirich, G. M. (2006). Cumulative advantage as a mechanism for inequality: A review of theoretical and empirical developments. *Annual Review of Sociology, 32,* 271 -297.

Dobbie, W., & Fryer, R. (2015). The impact of voluntary youth service on future outcomes: Evidence from Teach For America, B.E. *Journal of Economic Analysis and Policy, 15*(3): 1031-1066.

Dovidio, J. F., Ten Vergert, M., Stewart, T. L., Gaertner, S. L., Johnson, J. D., Esses, V. M., ... & Pearson, A. R. (2004). Perspective and prejudice: Antecedents and mediating mechanisms. *Personality and Social Psychology Bulletin, 30*(12), 1537-1549.

Elmore, K., Oyserman, D., Smith, G., & Novin, S. (2016). When the Going Gets Tough. *AERA Open.* DOI: 10.1177/2332858416664714

Eschenbach, E. A., Virnoche, M., Cashman, E. M., Lord, S. M., & Camacho, M. M. (2014, October). Proven practices that can reduce stereotype threat in engineering education: A literature review. In *Frontiers in Education Conference (FIE), 2014 IEEE* (pp. 1-9). IEEE. DOI: 10.1109/FIE.2014.7044011

Fryer, R. G., & Levitt, S. D. (2006). The Black-White test score gap through third grade. *American Law and Economics Review, 8*(2), 249-281.

Gershenson, S., Holt, S. B., & Papageorge, N. W. (2016). Who believes in me? The effect of student–teacher demographic match on teacher expectations. *Economics of Education Review, 52,* 209-224.

Gilliam, W. S., Maupin, A. N., Reyes, C. R., Accavitti, M., & Shic, F. (2016). Do early educators' implicit biases regarding sex and race relate to behavior expectations and recommendations of preschool expulsions and suspensions? Research Brief. New Haven, CT: Yale Child Study Center.

Glazerman, S., Mayer, D., & Decker, P. (2006). Alternative routes to teaching: The impacts of Teach for America on student achievement and other outcomes. *Journal of Policy Analysis and Management, 25*(1), 75-96.

Good, C., Aronson, J., & Inzlicht, M. (2003). Improving adolescents' standardized test performance: An intervention to reduce the effects of stereotype threat. *Journal of Applied Developmental Psychology, 24*(6), 645-662.

Good, C., Aronson, J., & Harder, J. A. (2008). Problems in the pipeline: Stereotype threat and women's achievement in high-level math courses. *Journal of Applied Developmental Psychology, 29*(1), 17-28.

Greenwald, A. G., & Banaji, M. R. (1995). Implicit social cognition: attitudes, self-esteem, and stereotypes. *Psychological Review, 102*(1), 4-27.

Greenwald, A. G., McGhee, D. E., & Schwartz, J. L. (1998). Measuring individual differences in implicit cognition: the implicit association test. *Journal of Personality and Social Psychology, 74*(6), 1464.

Hanna, R. N., & Linden, L. L. (2012). Discrimination in grading. *American Economic Journal: Economic Policy,* 146-168.

Hanushek, E.A. & Woessmann, L. (2006). Does educational tracking affect performance and inequality? Differences- in-differences evidence across countries. *Economic Journal, Royal Economic Society, 116*(510), C63-C76.

Harackiewicz, J. M., Canning, E. A., Tibbetts, Y., Giffen, C. J., Blair, S. S., Rouse, D. I., & Hyde, J. S. (2014). Closing the social class achievement gap for first-generation students in undergraduate biology. *Journal of Educational Psychology, 106*(2), 375.

Hill, C. J., Bloom, H. S., Black, A. R., & Lipsey, M. W. (2008). Empirical benchmarks for interpreting effect sizes in research. *Child Development Perspectives, 2*(3), 172-177.

Holt, S. B., & Gershenson, S. (2015). The impact of teacher demographic representation on student attendance and suspensions. IZA Discussion Paper No. 9554.

Inzlicht, M., & Ben-Zeev, T. (2000). A threatening intellectual environment: Why females are susceptible to experiencing problem-solving deficits in the presence of males. *Psychological Science, 11*(5), 365-371.

Jackson, S. M., Hillard, A. L., & Schneider, T. R. (2014). Using implicit bias training to improve attitudes toward women in STEM. S*ocial Psychology of Education, 17*(3), 419-438.

Johns, M., Schmader, T., & Martens, A. (2005). Knowing is half the battle teaching stereotype threat as a means of improving women's math performance. *Psychological Science, 16*(3), 175-179.

Jussim, L., & Harber, K. D. (2005). Teacher expectations and self-fulfilling prophecies: Knowns and unknowns, resolved and unresolved controversies. *Personality and Social Psychology Review, 9*(2), 131-155.

Kahneman, D. (2011). T*hinking, fast and slow.* Macmillan.

Lareau, A. (2011). *Unequal childhoods: Class, race, and family life.* Berkeley, CA: University of California Press.

Lauer, S., Momsen, J., Offerdahl, E., Kryjevskaia, M., Christensen, W., & Montplaisir, L. (2013). Stereotyped: Investigating gender in introductory science courses. *CBE-Life Sciences Education, 12*(1), 30-38.

Lavy, V. (2008). Do gender stereotypes reduce girls' or boys' human capital outcomes? Evidence from a natural experiment. *Journal of Public Economics, 92*(10), 2083-2105.

Lavy, V., & Sand, E. (2015). *On the origins of gender human capital gaps: short and long term consequences of teachers' stereotypical biases* (No. w20909). National Bureau of Economic Research.

Lazowski, R. A., & Hulleman, C. S. (2015). Motivation Interventions in Education A Meta-Analytic *Review. Review of Eduvcational Research,* 0034654315617832.

Lewis, A. E., & Diamond, J. B. (2015). *Despite the Best Intentions: How Racial Inequality Thrives in Good Schools.* Oxford University Press.

Loury, G. C. (2003). Racial stigma: Toward a new paradigm for discrimination theory. *American Economic Review, 93*(2), 334-337.

Loury, G. C. (2009). *The Anatomy of Racial Inequality.* Cambridge, MA: Harvard University Press.

Lusher, L., Campbell, D., & Carrell, S. (2015). TAs like me: Racial interactions between graduate teaching assistants and undergraduates. National Bureau of Economic Research Working Paper No. w21568.

Margolis, J., Estrella, R., Goode, J., Holme, J. J., & Nao, K. (2010). *Stuck in the shallow end: Education, race, and computing.* MIT Press.

Milkman, K. L., Akinola, M., & Chugh, D. (2012). Temporal Distance and Discrimination An Audit Study in Academia. *Psychological Science, 23*(7), 710-717.

Milkman, K. L., Akinola, M., & Chugh, D. (2015). What happens before? A field experiment exploring how pay and representation differentially shape bias on the pathway into organizations. *Journal of Applied Psychology. 100*(6), 1678-1712.

Milner, H.R. & Self, E.A. (2014). Studying race in teacher education: Implications from ethnographic perspectives. In A. Dixson's (Ed.), *Researching race in education: Policy, practice and ethnography.* Charlotte, NC: Information Age Publishing.

Miyake, A., Kost-Smith, L. E., Finkelstein, N. D., Pollock, S. J., Cohen, G. L., & Ito, T. A. (2010). Reducing the gender achievement gap in college science: A classroom study of values affirmation. *Science, 330*(6008), 1234-1237.

Moss-Racusin, C. A., Dovidio, J. F., Brescoll, V. L., Graham, M. J., & Handelsman, J. (2012). Science faculty's subtle gender biases favor male students. *Proceedings of the National Academy of Sciences, 109*(41), 16474-16479.

Murphy, M. C., Steele, C. M., & Gross, J. J. (2007). Signaling threat: How situational cues affect women in math, science, and engineering settings. *Psychological Science, 18*(10), 879-885.

National Research Council. (2011). Incentives and Test-Based Accountability in Education.Committee on Incentives and Test-Based Accountability in Public Education, M. Hout and S.W. Elliott, Editors. Washington, DC: The National Academies Press.

National Education Association. Promoting Educators' Cultural Competence To Better Serve Culturally Diverse Students (Washington, DC: NEA, 2008) https://www. nea. org/assets/docs. *PB13_ CulturalCompetence08. pdf.(accessed November 1, 2016*).

Nicholson-Crotty, S., Grissom, J. A., Nicholson-Crotty, J., & Redding, C. (2016). Disentangling the causal mechanisms of Representative Bureaucracy: Evidence from assignment of students to gifted programs. In Press, *Journal of Public Administration Research and Theory.* DOI: 10.1093/jopart/muw024.

Nosek, B. A., Banaji, M. R., & Greenwald, A. G. (2002). Math= male, me= female, therefore math≠ me. *Journal of personality and social psychology, 83*(1), 44.

Nosek, B. A., Smyth, F. L., Hansen, J. J., Devos, T., Lindner, N. M., Ranganath, K. A., ... & Banaji, M. R. (2007). Pervasiveness and correlates of implicit attitudes and stereotypes. *European Review of Social Psychology, 18*(1), 36-88.

Nosek, B. A., Smyth, F. L., Sriram, N., Lindner, N. M., Devos, T., Ayala, A., & Bar-Anan, Y. (2009). National differences in gender-science stereotypes predict national sex differences in science and math achievement. *Proceedings of the National Academy of Science, 106*(26), 10593–97.

Okonofua, J. A., Paunesku, D., & Walton, G. M. (2016). Brief intervention to encourage empathic discipline cuts suspension rates in half among adolescents. *Proceedings of the National Academy of Sciences,* doi: 10.1073/pnas.1523698113.

Pager, D., & Shepherd, H. (2008). The sociology of discrimination: Racial discrimination in employment, housing, credit, and consumer markets. *Annual Review of Sociology, 34,* 181-209.

Papageorge, N. W., Gershenson, S., & Kang, K. (2016). Teacher Expectations Matter. IZA Discussion Paper No. 10165. Institute for the Study of Labor: Bonn, Germany.

Paunesku, D., Walton, G. M., Romero, C., Smith, E. N., Yeager, D. S., & Dweck, C. S. (2015). Mind-set interventions are a scalable treatment for academic underachievement. *Psychological science,* 0956797615571017.

Petersen, T. & Saporta, I. (2004). The opportunity structure for discrimination. *American Journal of Sociology, 109*(4), 852-901.

Phelps, E. S. (1972). The statistical theory of racism and sexism. *The American Economic Review, 62*(4), 659-661.

Reardon, S. F., & Galindo, C. (2009). The Hispanic-White achievement gap in math and reading in the elementary grades. *American Educational Research Journal, 46*(3), 853-891.

Reskin, B.F. (2000). The proximate causes of employment discrimination. *Contemporary Sociology, 29*(2), 319-328.

Reuben, E., Sapienza, P., & Zingales, L. (2014). How stereotypes impair women's careers in science. *Proceedings of the National Academy of Sciences, 111*(12), 4403-4408.

Ronfeldt, M. (2012). Where should student teachers learn to teach? Effects of field placement school characteristics on teacher retention and effectiveness. *Educational Evaluation and Policy Analysis, 34*(1), 3-26.

Rosenthal, R., & Jacobson, L. (1968). Pygmalion in the classroom. *The Urban Review, 3*(1), 16–20.

Schellhaas, F. M., & Dovidio, J. F. (2016). Improving intergroup relations. C*urrent Opinion in Psychology, 11,* 10-14.

Sheldon, K. M., & Lyubomirsky, S. (2006). How to increase and sustain positive emotion: The effects of expressing gratitude and visualizing best possible selves. *The Journal of Positive Psychology, 1*(2), 73-82.

Sherman, D. K., Hartson, K. A., Binning, K. R., Purdie-Vaughns, V., Garcia, J., Taborsky-Barba, S., ... & Cohen, G. L. (2013). Deflecting the trajectory and changing the narrative: how self-affirmation affects academic performance and motivation under identity threat. *Journal of Personality and Social Psychology, 104*(4), 591.

Snyder, T.D., de Brey, C., and Dillow, S.A. (2016). Digest of Education Statistics 2014 (NCES 2016-006). National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Washington, DC.

Steele, C. M., & Aronson, J. (1995). Stereotype threat and the intellectual test performance of African Americans. *Journal of Personality and Social Psychology, 69*(5), 797.

Steele, C. M. (1997). A threat in the air: How stereotypes shape intellectual identity and performance. *American Psychologist, 52*(6), 613-629.

Steele, C. M., Spencer, S. J., & Aronson, J. (2002). Contending with group image: The psychology of stereotype and social identity threat. A*dvances in Experimental Social Psychology, 34,* 379-440.

Stephens, N. M., Hamedani, M. G., & Destin, M. (2014). Closing the social-class achievement gap a difference-education intervention improves first-generation students' academic performance and all students' college transition. *Psychological science, 25*(4), 943-953.

Stetser, M., and Stillwell, R. (2014). Public High School Four-Year On-Time Graduation Rates and Event Dropout Rates: School Years 2010–11 and 2011–12. First Look (NCES 2014-391). U.S. Department of Education. Washington, DC: National Center for Education Statistics. Retrieved from http://nces.ed.gov/pubsearch.

Walton, G. M. (2014). The new science of wise psychological interventions. Current Directions in *Psychological Science, 23*(1), 73-82.

Walton, G. M., & Cohen, G. L. (2011). A brief social-belonging intervention improves academic and health outcomes of minority students. *Science, 331*(6023), 1447-1451.

Walton, G. M., Logel, C., Peach, J. M., Spencer, S. J., & Zanna, M. P. (2015). Two brief interventions to mitigate a "chilly climate" transform women's experience, relationships, and achievement in engineering. *Journal of Educational Psychology, 107*(2), 468-485.

Wilson, T. D., Lindsey, S., & Schooler, T,. (2000). A model of dual attitudes. *Psychological Review, 107,* 101-126.

Woolf, K., McManus, I. C., Gill, D., & Dacre, J. (2009). The effect of a brief social intervention on the examination results of UK medical students: a cluster randomised controlled trial. *BMC medical education, 9*(1), 1-15.

Xu, Z., Hannaway, J., & Taylor, C. (2011). Making a difference? The effects of Teach for America in high school. *Journal of Policy Analysis and Management, 30*(3), 447-469.

Yeager, D. S., & Walton, G. M. (2011). Social-psychological interventions in education They're not magic. *Review of Educational Research, 81*(2), 267-301.

Yeager, D. S., Henderson, M. D., Paunesku, D., Walton, G. M., D'Mello, S., Spitzer, B. J., & Duckworth, A. L. (2014). Boring but important: A self-transcendent purpose for learning fosters academic self-regulation. *Journal of Personality and Social Psychology, 107*(4), 559.

Yeager, D. S., Johnson, R., Spitzer, B. J., Trzesniewski, K. H., Powers, J., & Dweck, C. S. (2014). The far-reaching effects of believing people can change: Implicit theories of personality shape stress, health, and achievement during adolescence. *Journal of Personality and Social Psychology, 106*(6), 867.affirmation. Science, 330(6008), 1234-1237.Moss-Racusin, C. A., Dovidio, J. F., Brescoll, V. L., Graham, M. J., & Handelsman, J. (2012).