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Could a Rising Robot Workforce Make Humans Less Prejudiced?

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Automation is becoming ever more prevalent, with robot workers replacing many human employees. Many perspectives have examined the economic impact of a robot workforce, but here we consider its social impact: How will the rise of robot workers affect intergroup relations? Whereas some past research has suggested that more robots will lead to more intergroup prejudice, we suggest that robots could also reduce prejudice by highlighting commonalities between all humans. As robot workers become more salient, intergroup differences—including racial and religious differences—may seem less important, fostering a perception of common human identity (i.e., panhumanism). Six studies ($\Sigma N = 3{,}312$) support this hypothesis. Anxiety about the rising robot workforce predicts less anxiety about human outgroups (Study 1), and priming the salience of a robot workforce reduces prejudice toward outgroups (Study 2), makes people more accepting of outgroup members as leaders and family members (Study 3), and increases wage equality across ingroup and outgroup members in an economic simulation (Study 4). This effect is mediated by panhumanism (Studies 5–6), suggesting that the perception of a common human ingroup explains why robot salience reduces prejudice. We discuss why automation may sometimes exacerbate intergroup tensions and other times reduce them.

Public Significance Statement
This article explores how the rise of robot workers will shape social relations. Across six studies, we found that awareness of robot workers reduces prejudice and discrimination because it leads people to perceive more commonality with other human groups.

Keywords: automation, prejudice, social cognition

Supplemental materials: http://dx.doi.org/10.1037/amp0000582.supp

As technology advances, robots are replacing many human workers. Robots already operate our supermarket cash registers and build our cars, and soon they may be mowing our lawns, writing our prescriptions, and teaching our children. Indeed, a 2017 McKinsey Report estimated that 50% of all human work activities could be automated by adapting current robot technology (Manyika et al., 2017)—a forecast that has loomed large in political discussions because of its impact on inequality and poverty (Witt, 2019).

Workplace automation is already changing the global economy (Ford, 2009; Rifkin, 1995) and may also have important social and ethical implications, as did earlier economic disruptions (Hertz & Wiese, 2018; Malle, 2016; Šabanović, 2010; Scheutz & Malle, 2017). For example, the Industrial Revolution amplified ethnic- and class-based hostilities in both Europe and the United States (Temin & Mathias, 1969), and the modern outsourcing of low-income jobs from the United States to India and China led to anti-Asian prejudice in America (Mughan, Bean, & McAllister, 2003). Realistic group conflict theory suggests that increasing automation will also inflame intergroup tensions, especially as immigrants and foreign laborers compete for

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the few remaining jobs (Bobo, 1983; J. W. Jackson, 1993). Consistent with this pessimism, several recent articles have argued that automation's threat to future employment can increase people's perceptions of material insecurity and their support for anti-immigration policies (e.g., Frey, Berger, & Chen, 2018; Im, Mayer, Palier, & Rovny, 2019).

However, the relationship between robot workers and social attitudes may be more nuanced. Some perspectives point out that people tend to either fear immigrants or robots but seldom both (Lepore, 2019). As a case in point, Donald Trump has warned many times about the risks of immigration but not once mentioned the consequences of automation for employment; Barrack Obama has done just the opposite, often warning of growing automation but never of immigration (Lepore, 2019). Obama's rhetoric shows how anxiety about robot workers need not stoke hostility toward immigrants and minorities. It might even be that, under some conditions, the rise of robot workers could actually make people less prejudiced toward outgroups.

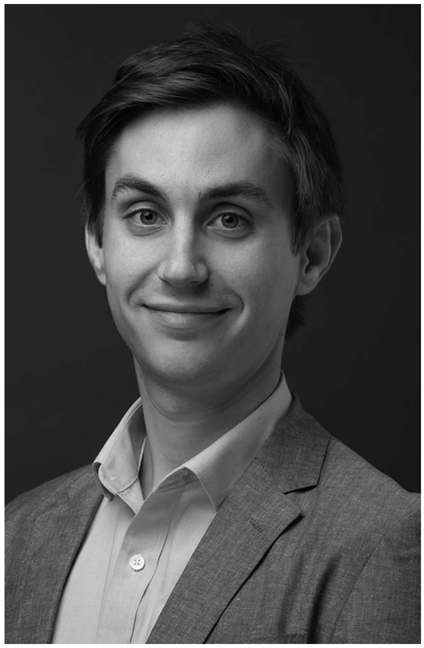
Our article tests competing predictions about how automation may shape social relations. A traditional realistic group conflict perspective suggests that automation should increase intergroup prejudice because it increases competition between groups for resources (Bobo, 1983; J. W. Jackson, 1993). A contrasting possibility that we explore is that the rise of robot workers can often decrease prejudice and discrimination by increasing "panhumanism," or people's perceived closeness with all other humans, regardless of their race, religion, or country of origin (Larsen, 2006; McFarland, Webb, & Brown, 2012). Our test of how automation will affect social relations follows in a recent line of research that applies psychological theory to make sense of the impact of technological innovations, such as self-driving cars (Bonnefon, Shariff, & Rahwan, 2016), violent video games (Ferguson, 2013), and artificial intelligence (Castelo, Bos, & Lehmann, 2019).

When Robots Are Salient, Human Groups Do Not Seem So Different

Psychologists have long recognized the importance of categorization in social judgments. We are much kinder to someone categorized as a member of our "ingroup" than to someone categorized as part of an "outgroup," even if these people are indistinguishable from each other (Tajfel, 1970; Tajfel, Billig, Bundy, & Flament, 1971). For example, when strangers are split into two groups based on random coin flips or the color of their nametag, people evaluate those in their own group more positively (and give them more money) compared with those in the other group (Billig & Tajfel, 1973; C. M. Jackson, Jackson, Bilkey, Jong, & Halberstadt, 2019).

In daily life, features such as race, religion, gender, sexual orientation, and nationality provide markers with which we can assign ingroup and outgroup identities. However, events can sometimes prompt social recategorizations that override these salient markers, making someone from a different race or nationality seem like part of one's ingroup (Gaertner, Dovidio, Anastasio, Bachman, & Rust, 1993; Gaertner, Mann, Murrell, & Dovidio, 1989; Hornsey & Hogg, 2000). Allport (1954) first noted that a person's ingroups can vary hierarchically, ranging from one's family and friends, to one's country or race, to one's status as a human being. Allport proposed that increasing the salience of common superordinate memberships can lead people to be more inclusive in terms of who they identify with and who they will cooperate with. Someone of a different race will be viewed less favorably when identity is classified in terms of one's race but more favorably when the perceiver adopts a broader panhuman identity, in which all humans are viewed as part of the ingroup.

This perspective is now termed the *common ingroup identity* (CII) model (Gaertner et al., 1993), and it can be an effective way of reducing intergroup prejudice. For example, leading people to replace subordinate categories ("us and them") with superordinate categories ("we") can decrease prejudice and discrimination (Dovidio et al., 1997; Gaertner et al., 1989; Guerra et al., 2010; Riek, Mania, & Gaertner, 2006), and interethnicity roommates who define themselves as part of a common human identity are more likely to develop friendships than are roommates who define themselves as part of their ethnic identity (West, Pearson, Dovidio, Shelton, & Trail, 2009). Other research has shown that people's tendency to identify with humanity as a whole (rather than subordinate groups such as one's community or race) predicts less ethnocentrism and more



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outgroup prosociality and concern with global humanitarian issues (McFarland, Brown, & Webb, 2013; McFarland et al., 2012). These studies each suggest that prompting people to adopt a panhuman identity can decrease prejudice and discrimination toward outgroups.

We suggest that the salience of robot workers may increase panhumanism and reduce prejudice by highlighting the existence of a group (robots) that is not human. The large differences between humans and robots may make the differences between humans seem smaller than they normally appear. Christians and Muslims have different beliefs, but at least both are made from flesh and blood; Latinos and Asians may eat different foods, but at least they eat. We therefore predicted that, to the extent that the salience of robot workers increases people's panhumanism, it may decrease prejudice and discrimination against human outgroups.

Overview of Studies

We present six studies ($\Sigma N = 3{,}312$) that test whether the salience of robot workers reduces prejudice and discrimination. Studies 1–4 examine the direct effect of robot salience on prejudice and discrimination with traditional Likert-type scales (Studies 1 and 2) and more intensive multilevel designs (Studies 3 and 4). Study 1 examines whether anxiety about robots correlates with less prejudice toward various human outgroups, exploring whether robot salience is linked with higher or lower outgroup prejudice across individuals. Study 2 tests whether reading about the proliferation of robot workers leads to less prejudice than does reading about a decreasing robot workforce. Study 3 tests whether subtly priming the salience of robots on a questionnaire leads people to report less prejudice toward those of a different religion, race, sexuality, and nationality, and Study 4 uses an economic game to examine whether increasing the salience of robots decreases White people's economic discrimination against minorities.

Studies 5 and 6 focus on the indirect effect of robot salience on reducing prejudice through panhumanism, the tendency to identify with a common human identity. Both studies use structural equation models to test whether robot salience reduces prejudice only when it leads to panhumanism, as would be predicted by the CII model.

Study 1

How does anxiety about the prevalence of automation correlate with prejudice toward human outgroups? Using three measures of outgroup prejudice, we predicted that people's anxiety about robots would predict less prejudice toward human outgroups. In other words, we predicted that the people most anxious about robots would be least anxious about human outgroups.

Method

Participants. A total of 181 ($M_{\text{age}} = 37.14$, $SD = 12.45$; 86 men, 95 women) participants signed up for this study on Amazon Mechanical Turk. A power analysis indicated that, with one numerator degree of freedom, this sample size was powered at over 99% to detect a medium effect size ($f^2 = .15$) and at 86% to detect a smaller effect size ($f^2 = .05$).

Measures.

Automation and outgroup anxiety. We measured participant's anxiety about automation and their attitudes about human outgroups with a series of items that prompted them to "rate the extent that the following groups give you anxiety." Participants responded with reference to (a) "robots," (b) "people of a different race to myself," (c) "people of a different sexual orientation to myself," (d) "immigrants/foreign workers," and (e) "people of a different religion to myself" using a 7-point scale anchored at 1 (*none at all*) and 7 (*a great deal*).

After data collection, we conducted an exploratory factor analysis to test whether it would be more suitable to analyze anxiety about human outgroups (people of a different race people of a different sexual orientation, immigrants or foreign workers, people of a different religion) as separate measures or as a single composite index. We identified a primary factor with an eigenvalue of 2.59, and no other factor had an eigenvalue over .63. Therefore, we averaged across outgroups ($\alpha = .82$) during analyses.

Outgroup aversion. We included four items assessing whether participants would refuse to live near (a) "people of

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a different race," (b) "people of a different religion," (c) "immigrants," and (d) "gay people." We summed these items (α = .75) to create a measure of outgroup aversion.

Symbolic ethnocentrism. Our final measure of outgroup prejudice was an adaptation of the Symbolic Racism scale (Kinder & Sears, 1981) that specifically targeted bias toward immigrants. Using a 7-point scale anchored at 1 (*Strongly disagree*), 4 (*Neither agree nor disagree*), and 7 (*Strongly agree*), participants rated their agreement with a number of statements such as "it's really a matter of some people not trying hard enough; if immigrants would only try harder, they could be just as well-off as Americans" and "immigrants have been pushing too fast for recognition." As in the Symbolic Racism scale, three of these items were reverse-coded. The scale showed high reliability (α = .87).

Analytic strategy. We first correlated anxiety about robots with each of the three outgroup prejudice measures, which were correlated with each other. Symbolic ethnocentrism correlated positively with both outgroup aversion and outgroup anxiety, and outgroup aversion correlated with outgroup anxiety (see Table 1). We then used multiple regression to test for this relationship controlling for conservatism, age, and gender, which could plausibly covary with our dependent and independent variables (Terrizzi, Shook, & Ventis, 2010). We mean-centered responses within-subject prior to these models, which is a common procedure for disentangling meaningful variances in the data from participants' general response tendencies in correlational studies (Gelfand et al., 2011; Hui & Triandis, 1989).

Table 1
Correlations Between Study 1 Measures

Measure	1	2	3
1. Robot anxiety	—		
2. Outgroup anxiety	−.18*	—	
3. Outgroup aversion	−.16*	.52*	—
4. Symbolic ethnocentrism	−.25*	.24*	.12

* $p < .05$.

Results

As predicted, people's anxiety about robots correlated negatively with their anxiety about other human groups, their refusal to live next to outgroups, and their symbolic ethnocentrism. Each of these effects, displayed in Table 1, suggested that people who were most concerned about robots were the least prejudiced toward human outgroups.

The negative correlation between people's anxiety about robots and their outgroup prejudice replicated controlling for age, gender, and self-reported conservatism in multiple regression (see Table 2). Robot anxiety predicted significantly less outgroup anxiety, symbolic ethnocentrism, and marginally less outgroup aversion in these regressions. We also replicated past work showing that conservatism correlates with prejudice (e.g., Terrizzi et al., 2010).

Discussion

Anxiety about robots correlated negatively with three measures of outgroup prejudice. We next tested whether priming the rise of robot workers could decrease outgroup prejudice.

Study 2

Study 2 tested whether priming the proliferation of robot workers reduces outgroup prejudice. We hypothesized that participants who read a newspaper article about increasing automation would report less prejudice toward outgroups than would participants who read about decreasing automation.

Method

Participants. A power analysis of our weakest Study 1 effect (the association between robot anxiety and outgroup aversion) suggested that a two-condition study would need 155 participants per cell (for a total of 310 participants) to detect an effect at 80% power. We recruited 400 participants on Amazon Mechanical Turk to allow for attention-check exclusions. Two participants did not complete the study, and 75 failed attention checks (see below), leaving a final sample of 323 (M_{age} = 36.47, SD = 11.21; 176 men, 145 women, one "other").

Table 2
Robot Anxiety and Outgroup Prejudice in Study 1

Model and variable	*df*	Adj. R^2	*b* (*SE*)	β	*t*	*p*
Model 1: Outgroup anxiety	176	.05				
Robot anxiety			−0.11 (0.05)	−.17	−2.35	.02
Conservatism			0.09 (0.04)	.17	2.28	.02
Gender			−0.04 (0.17)	−.02	−0.26	.79
Age			−0.01 (0.01)	−.07	−0.88	.38
Model 2: Outgroup aversion	176	.19				
Robot anxiety			−0.02 (0.01)	−.12	−1.83	.07
Conservatism			0.06 (0.01)	.43	6.42	<.001
Gender			−0.02 (0.04)	−.05	−0.68	.49
Age			−0.01 (0.01)	−.05	−0.69	.49
Model 3: Symbolic ethnocentrism	176	.20				
Robot anxiety			−0.15 (0.05)	−.19	−2.96	.004
Conservatism			0.37 (0.05)	.49	7.70	<.001
Gender			0.09 (0.18)	.03	0.53	.60
Age			0.01 (0.01)	.09	1.43	.15

Note. Predictor variables appear below each model's dependent variable. Adj. = adjusted.

Manipulation. We manipulated the salience of robot workers between-subjects, using customized news articles. In the robot salience condition, participants read a short article titled "Robots: Here to Stay?" that described how robots were increasingly taking human jobs. In the other condition, participants read an article titled "Robots: Just a Fad?" that described how rising automation was largely a myth and that robots would never be able to perform most human jobs. The articles were otherwise identical in length and format. Both articles are available at https://osf.io/gr2t5/

Outgroup prejudice. Study 2 used the same outgroup prejudice measures as in Study 1. However, due to a research assistant's error, Study 2 used a binary scale for participants to indicate whether the same groups from Study 1 made them anxious about the future. Therefore, our averaged composite index ranged from 0 (if participants indicated no groups) to 1 (if participants indicated all 4 groups).

Attention checks. At the end of the study participants completed two attention checks measuring whether they had read the manipulation articles. The first was "according to research, _ (more/less) jobs are occupied by robots compared with the year 2000," and the second was "according to the study's author, advances in robot ability and intelligence will take _ (longer/shorter) than expected." Both of these answers were clearly stated in the articles. The 75 participants who answered one or more of these questions incorrectly were excluded from analyses.

Analysis strategy. We analyzed the effect of robot salience on prejudice with one-way analyses of variance (ANOVAs) for each of our dependent variables. We used ANOVAs because they are superior to multivariate analyses of variance (MANOVAs) for analysis of dependent variables that are highly correlated, because in these cases the loss of degrees of freedom is not sufficiently offset by the gains provided by MANOVA (French, Macedo, Poulsen, Waterson, & Yu, 2008). This was the case in our study: Symbolic ethnocentrism correlated robustly with outgroup aversion, $r(321) = .49$, $p < .001$, and outgroup anxiety, $r(321) = .42$, $p < .001$, and outgroup aversion correlated robustly with outgroup anxiety, $r(321) = .48$, $p < .001$.

Results

Did robot salience reduce outgroup prejudice? Participants in the robot salience condition reported less outgroup anxiety (*M*s = .12 vs. .17, *SE*s = .02), $F(1, 321) = 4.08$, $p = .044$, $d = 0.22$; indicated fewer outgroups that they would not want as neighbors (*M*s = .38 vs. .59, *SE*s = .07), $F(1, 321) = 3.91$, $p = .048$, $d = 0.22$; and showed marginally less symbolic ethnocentrism (*M*s = 3.17 vs. 3.40, *SE*s = .10), $F(1, 321) = 2.78$, $p = .09$, $d = 0.19$, compared to participants in the control condition (see Figure 1). Though the effect sizes were small, each effect suggested that priming the growing prevalence of robot workers made people more tolerant of other human groups.

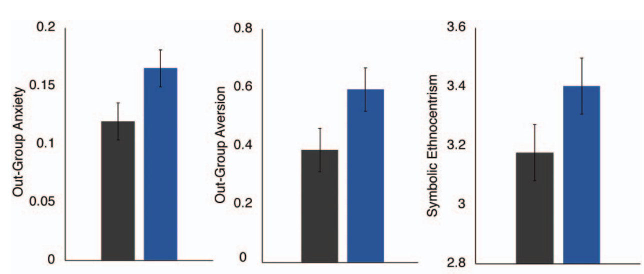

Figure 1. Participants' outgroup anxiety (left), outgroup aversion (middle), and symbolic ethnocentrism (right) as a function of study condition in Study 2. Error bars are standard errors. See the online article for the color version of this figure.

Discussion

Reading about a rising robot workforce led people to report less anxiety about human outgroups, more willingness to live next to individuals from outgroups, and marginally reduced participants' symbolic ethnocentrism. These effects suggest that the salience of robot workers can improve intergroup relations. However, Study 2 did not have a true control condition: Participants read either an article discussing robots taking their jobs or an article discussing how their jobs were safe from robots. Study 3 resolved this issue with a subtler manipulation, which was also less susceptible to demand effects.

Study 3

Study 3 tested whether subtly priming the salience of robot workers on a questionnaire would increase how favorably people viewed outgroup members as doctors, politicians, and partners for their children. We preregistered all hypotheses and study characteristics (see https://osf.io/gr2t5/).

Method

Participants. Given the small effect sizes in Study 2, we recruited 600 participants for Study 3's two-cell design. A total of 599 participants ($M_{\text{age}} = 33.11$, $SD = 11.44$; 308 men, 286 women, five "other") completed the study and were included in analysis.

Procedure and measures.

Outgroup prejudice. Upon signing up for this study, all participants read that they would be making decisions about "what kinds of individuals you may want, or not want, as a doctor, partner, or military commander." In the robot salience condition, participants were notified that they would be evaluating robots as well as other human groups for these roles, whereas in the control condition, the study's instructions did not mention robots.

All participants then rated the acceptability of the four outgroups from Studies 1 and 2 (someone of a different religion, different sexual orientation, different race, or who is an immigrant) for five roles: "marrying one of your children," "managing the company in which you work," "serving as a politician," "serving as your doctor in a high-risk operation," and "serving as your country's military commander." Participants used a sliding scale from 1 (*Very Negatively*) to 100 (*Very Positively*) to indicate how they felt about each group for these roles.

There was a crucial difference critical difference between the two conditions. Participants in the robot salience condition rated the acceptability of "an advanced humanoid robot"—in addition to the human groups—for each of the roles in the study. Participants in the control condition did not rate robots, instead rating only the four human groups.

Analytic strategy. We predicted that the participants in the robot salience condition would show less outgroup prejudice than would participants in the control condition. Given that multiple ratings were obtained from each participant, we used multilevel regression (Hayes, 2006), which nested ratings ($n = 11{,}956$) within participants ($n = 599$), with intercepts varying randomly across participants. Our first regression tested our hypotheses across ratings of all human groups. Next, we tested specifically for effects on each type of human group (e.g., does robot salience decrease prejudice toward racial minorities in particular?) and role (e.g., does robot salience decrease prejudice while evaluating outgroups as doctors specifically?).

Results

As predicted, participants in the robot salience condition rated outgroups more favorably than did participants in the control condition ($b = 7.71$, $SE = 1.77$, $\beta = .14$), $t(596) = 4.35$, $p < .001$, suggesting that the salience of robot workers made people more accepting of human outgroups as partners, managers, doctors, politicians, and military commanders. Figure 2 displays effects broken down by group and role, and Table S1 in the online supplemental materials provides the statistics for these effects.

Discussion

Study 3 showed that subtly priming robot workers decreased outgroup prejudice, leading people to see those of a different religion, race, sexual orientation, and immigrants as better suited as in-laws and for leadership positions.

Study 4

Study 4 tested whether the salience of robot workers influenced behavioral discrimination—rather than just prejudiced attitudes—using a novel economic-game paradigm: Participants acted as treasurer of a futuristic community, where they distributed financial bonuses. We predicted that participants would discriminate against racial minorities when the community consisted of only humans. However, when the community contained both robot workers and humans, people would assign more equal salaries across racial divisions. We preregistered all hypotheses and study characteristics (see https://osf.io/gr2t5/).

Method

Participants. We advertised for 750 participants. We chose a slightly larger sample size in Study 5 given the small effect sizes in Studies 3 and 4 and because our economic paradigm could have elicited more noisy responding. In total, 729 people completed the study ($M_{\text{age}} = 35.53$, *SD*; 397 men, 332 women) and were included in analysis.

Paradigm and procedure. We asked participants to imagine themselves in a futuristic community in which

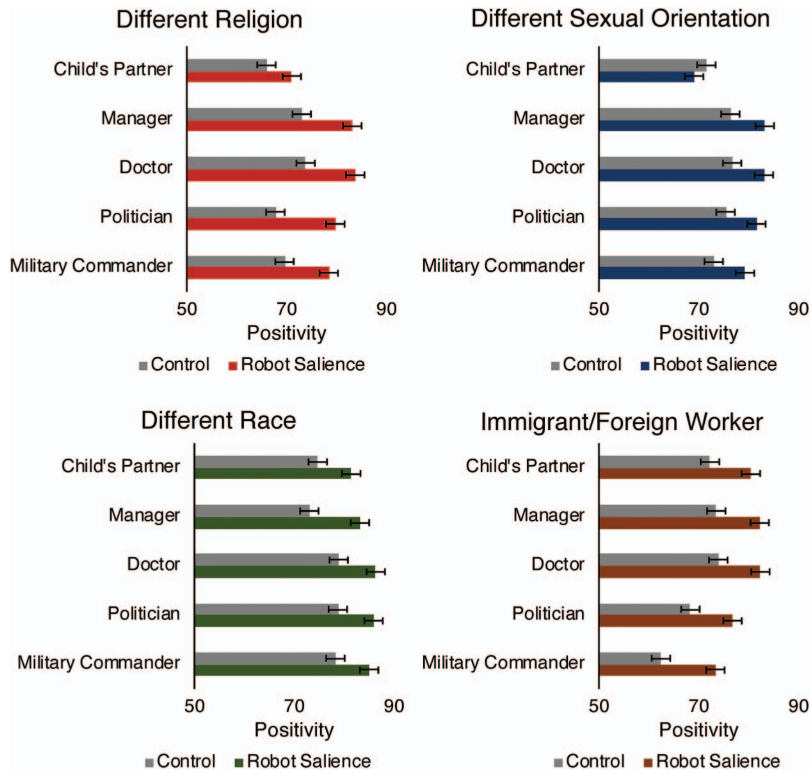

Figure 2. The effect of robot salience on favorability of various outgroups as a child's partner, a manager, a doctor, a politician, and a military commander in Study 3. Error bars are standard errors. See the online article for the color version of this figure.

everyone had a job. Participants read that their job was the treasurer and that they would be in charge of the community budget. Although everyone received the same basic salary to cover necessities, different people could get different bonuses based on their specific job in the community, which they could use to buy clothing, jewelry, decorations, and so forth. Participants saw 30 individuals in the community who each occupied different roles (health care provider, engineer, translator, organizer or leader, teacher, builder, farmer, blacksmith, carpenter, and hunter or scout) and decided how much each would receive from a total budget of $3,000. A totally equal distribution would give each person $100, but participants could decide to give people as little as $0 and as much as $200 to any given person. Once participants indicated that they understood the instructions, they viewed the photographs and job titles of each community member (one at a time) and decided how much money each individual deserved as a bonus.

Manipulation of robot salience. Participants were randomly assigned to either one of two between-subjects conditions. In the control condition, participants' communities consisted of only humans. There were 30 community members (10 White, 10 Black, and 10 Asian; half men and half women[1]) whose photographs came from the MR2 database, which standardizes photos on background, color, and pose (Strohminger et al., 2016). In the robot salience condition, participants read that their community had both robot and human workers. In addition to the 30 human members of the control condition, we added 10 photographs of robots, which we took from the Anthropomorphic roBOT database (Phillips, Zhao, Ullman, & Malle, 2018). Participants were told that robots in this community lived and worked beside humans with relatively equal status, in order to make robots seem deserving of bonuses. Figure 3 depicts three representative stimulus photos.

Participants in the control condition viewed and allocated money to all 30 humans over the course of the study, whereas participants in the robot salience condition viewed and allocated money to a random sample of 30 community members (from the 30 humans and 10 robots). Thus, participants in both conditions made 30 allocation decisions over the course of the study, but approximately 25% of the decisions in the robot salience condition were to robot workers.

Analytic plan. The primary hypothesis was that, in the control condition, participants (who were 75% White)

[1] We hypothesized no gender differences and observed no gender effects or interactions in our data. Therefore, we collapsed across gender for all analyses.

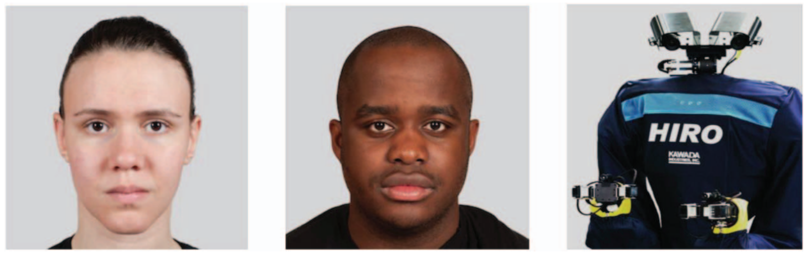

Figure 3. Three representative stimuli from the Study 4 procedure. The left image depicts a White woman. The middle image depicts a Black man. The right image depicts a robot worker. All images come from the publicly available MR2 database. N Strohminger, K. Gray, V. Chituc, J. Heffner, C. Schein, & T. B. Heagins (2016). The MR2: A Multi-Racial, Mega-Resolution Database of Facial Stimuli. *Behavior Research Methods*, 48, 1197–1204. See the online article for the color version of this figure.

would give more to White community members than to minorities—especially Black members, who are often the victims of pay discrimination (Western & Pettit, 2005). As in Study 3, Study 4 had a nested design where participants completed many trials. Therefore, we followed Study 3's analytic strategy, nesting ratings (n = 29,040) within participants (n = 729). This regression included a dummy-coded Level 2 parameter representing participants' experimental condition and dummy-coded Level 1 parameters representing whether participants were evaluating Black (vs. White) or Asian (vs. White) community members. We also included the cross-level interaction between experimental condition and community member identity, so that we could test (a) whether there were group-based discrepancies in the control condition and (b) whether these discrepancies were mitigated in the robot salience condition.

Prior to hypothesis testing, we identified two aspects of our data that we hadn't anticipated during preregistration. First, four respondents did not appear to follow instructions, either giving $200 to each target (therefore overspending the budget) or giving $0 to each target (therefore spending none of their budget). We chose to exclude these four participants from our analyses, although analyzing data with these participants showed the same significant effects. Second, we predicted Black and Asian targets would be considered as only outgroups by White participants, but 185 non-White participants took our survey. For the sake of comprehensiveness, we first ran analyses testing how all participants distributed money to Black community members and Asian community members (as we preregistered) and then analyzed White participants' discrimination against minority (Black and Asian) community members.

Results

Robot salience and outgroup prejudice. Did the salience of robot workers make people less discriminatory? Table 3 displays the pay gap between White workers and Black workers, Asian workers, and minority workers by condition. The following paragraphs summarize the analyses for each racial contrast.

White versus Black pay gap. In the control condition, participants gave an average of $4.67 less to Black workers than to White workers (b = −4.67, SE = 0.89), $t(17338.46) = -5.23$, $p < .001$. In the robot salience condition, though, participants gave a similar amount, on average, to White and Black workers (b = −1.29, SE = 1.10), $t(17385.41) = -1.18$, $p = .24$. Our multilevel regression revealed a significant interaction between Black versus White discrimination and robot salience (b = −3.37, SE = 1.42), $t(17366.94) = -2.38$, $p = .02$, indicating that the robot salience condition closed the Black versus White pay gap by $3.37.

Asian versus White pay gap. In the control condition, participants gave an average of $2.58 less to Asian workers than to White workers (b = −2.58, SE = 0.89), $t(17338.33) = -2.89$, $p = .004$. In the robot salience condition, participants gave an average of $1.18 less to Asian workers than to White workers (b = −1.18, SE = 1.10), $t(17386.10) = -1.07$, $p = .28$. Though the pay gap

Table 3
Pay Gap Between White and Minority Individuals by Study 4 Condition

Condition	Black pay gap	Asian pay gap	Minority pay gap
Robot salience	−$1.29 [−$3.45, $0.86]	−$1.18 [−$3.33, −$0.98]	−$1.50 [−$3.62, $0.61]
Control	−$4.67 [−$6.42, −$2.92]	−$2.58 [−$4.33, −$0.83]	−$4.37 [−$6.12, $2.62]

Note. Coefficients indicate mean pay gaps, and brackets indicate 95% confidence intervals by condition. All participants are included in the Black and Asian estimates. Only White participants are included in the minority estimates.

was reduced in the robot salience condition, the interaction between Asian versus White discrimination and robot salience did not reach significance ($b = -1.40$, $SE = 1.42$), $t(17367.26) = -.99$, $p = .32$, perhaps because there was less discrimination between Asian versus White targets in the control condition than there was between Black versus White targets ($2.58 vs. $4.67).

Minority versus White pay gap. We next isolated White participants and tested how robot salience affected their giving toward minority (Black and Asian) versus White individuals, arguably a better test of whether the salience of robot workers reduces outgroup discrimination. This model revealed a significant interaction between robot salience and minority status ($b = -2.87$, $SE = 1.40$), $t(12893.31) = 2.05$, $p = .04$. In the control condition, White people gave significantly less to minorities than they did to White targets ($b = -4.37$, $SE = 0.89$), $t(12869.82) = -4.90$, $p < .001$. In the robot salience condition, however, White participants gave equally to minority and White targets ($b = -1.50$, $SE = 1.08$), $t(12909.10) = -1.39$, $p = .16$.

Discussion

In a hypothetical future community, participants allocated minority workers—especially Black workers—a smaller "bonus" salary than White workers for the same job. However, when robots were also members of the community, participants showed less discrimination, consistent with a negative individual-level association between automation and prejudice.

The CII model (Gaertner et al., 1993) suggests that robot salience decreases prejudice because it highlights a panhuman ingroup. This model suggests that panhumanism should mediate the effect of robot salience on lower outgroup prejudice. Studies 5 and 6 tested this indirect effect using structural equation path models.

Study 5: Panhumanism as a Mechanism

Study 5 tested for the indirect effect of robot salience on prejudice through panhumanism. Participants in the robot salience condition first reflected on the rising robot workforce and then reported their perceived panhumanism (via the number of human groups that participants identified with) and prejudice (using the measures from Studies 1 and 2). Study 5 included two control conditions—a pure neutral condition and also a negativity control condition—which allowed us to examine the impact of robot salience above and beyond the general negativity.

Method

Participants. Study 5 advertised for 600 participants on Amazon Mechanical Turk. We determined this sample size using the same parameters (~150–200 individuals per cell) that we had derived from the power analysis in Study 2, which employed the same dependent variables as in Study 5. A total of 583 ($M_{age} = 36.47$, $SD = 11.21$; 176 men, 145 women, one "other") completed the whole procedure and were included in analysis.

Manipulation. Study 5 manipulated robot salience between-subjects through a writing prompt. In the robot salience condition, participants wrote a short essay (five–six sentences) about "the growing robot workforce." In the negativity control condition, participants wrote an essay about "a situation in which you were very anxious." In the neutral control condition, participants wrote an essay about "what you had for breakfast."

Panhumanism. To measure panhumanism, we included a measure of our own creation, inserted directly after the manipulation. Participants dragged 13 human groups (*African Americans, immigrants, Hispanics, gay people, Christians, right-wing extremists, left-wing extremists, people with a disease, Jews, Catholics, Muslims, Asian Americans,* and *you*) into one of two boxes. We operationalized panhumanism through the number of groups that people added to the box that contained their own identity (*you*). Figure 4 depicts how two participants completed this measure.

Outgroup prejudice. Study 5 used the same Likert-scale outgroup prejudice measures as in Study 1.

Analytic strategy. Study 5 had a more comprehensive set of hypotheses than did Studies 1–4, because we tested for indirect effects as well as direct effects. Our primary analyses involved structural equation path models that estimated (a) the effect of robot salience on panhumanism, (b) the effects of panhumanism on each of our outgroup prejudice measures, (c) the total effect of robot salience on each form of outgroup prejudice, and (d) the indirect effects of robot salience on outgroup prejudice through panhumanism. We estimated this path model using the lavaan package in R (Rosseel, 2012). The full path model is displayed in Figure 5, but the Results section reports key statistics from this path model. We collapsed across our control conditions (coding negativity control and breakfast control as 0 and robot salience as 1) in this path model because Tukey's tests showed that these control conditions had similar effects on panhumanism (Tukey $p = .80$), outgroup anxiety (Tukey $p = .65$), outgroup aversion (Tukey $p = .94$), and symbolic ethnocentrism (Tukey $p = .99$). For the sake of consistency with previous studies, we also report ANOVA-based tests in the online supplemental materials.

Results

Robot salience and panhumanism. The path model revealed that, as we predicted, participants in the robot threat condition expressed more panhumanism than did

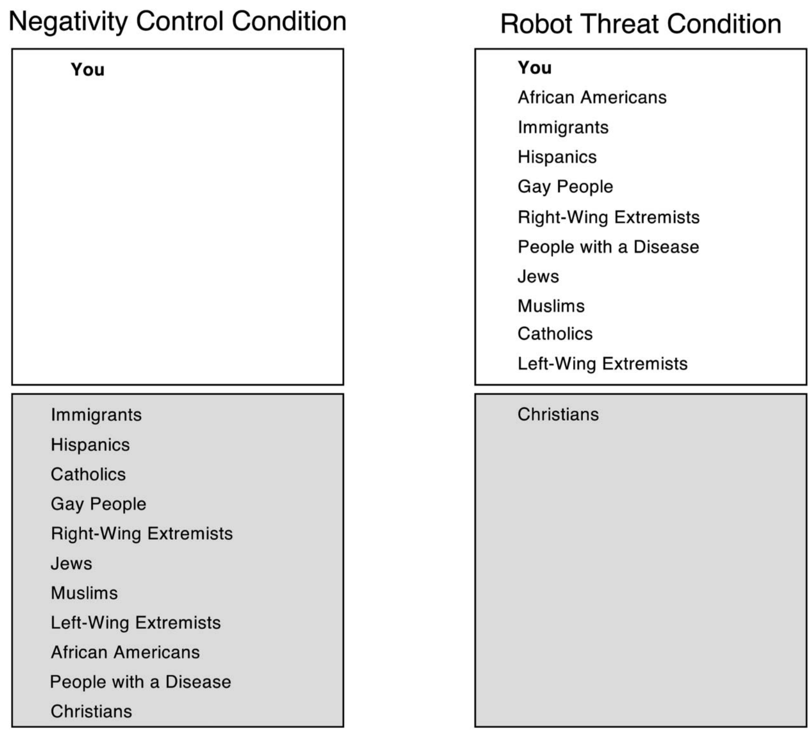

Figure 4. An illustration of how two participants in the study completed our panhumanism measure in Study 5. The participant in the negativity control condition (left) classified all groups in a category different from his or her own, whereas the participant in the robot threat condition classified all but one (Christians) group with him- or herself. The participant on the right received a higher panhumanism score than did the participant on the left.

participants in the control conditions ($b = 1.00$, $SE = 0.34$, $\beta = .13$, $z = 2.88$, $p = .004$). Writing about the threat of robots led people to identify with more human groups.

Panhumanism and outgroup prejudice. Panhumanism correlated negatively with each form of outgroup prejudice, including anxiety about outgroups ($b = -0.12$, $SE = 0.02$, $\beta = -.30$, $z = -6.98$, $p < .001$), outgroup aversion ($b = -0.02$, $SE = 0.003$, $\beta = -.21$, $z = -4.82$, $p < .001$), and symbolic ethnocentrism ($b = -0.09$, $SE = 0.02$, $\beta = -.25$, $z = -5.78$, $p < .001$).

Indirect and direct effects of robot salience on outgroup prejudice. We predicted that robot salience would decrease prejudice and that panhumanism would mediate this effect. As predicted, there were significant indirect effects on each measure of prejudice, suggesting that robot salience decreased anxiety about outgroups (95% confi-

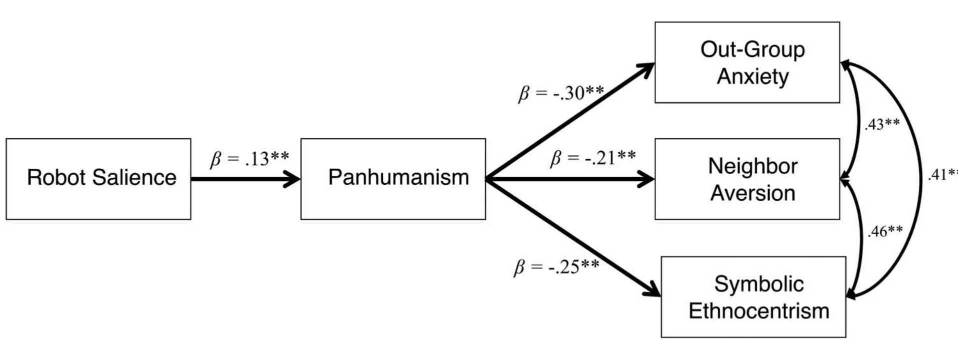

Figure 5. A path model from Study 5 showing the effects of robot threat on three measures of outgroup prejudice via panhumanism. Robot salience had significant indirect effects on all three measures of prejudice. ** $p < .005$.

dence interval [CI: −.20, −.03]), outgroup aversion (95% CI [−.03, −.003]), and symbolic ethnocentrism (95% CI [−.15, −.02]) by virtue of its effects on panhumanism. The direct effects in this model were each nonsignificant (ps > .65), suggesting that condition only affected prejudice by virtue of its shared variance with panhumanism.

However, we note that—in contrast to Studies 1–4—this study did not reveal the previously revealed total effect of robot salience on anxiety about outgroups ($b = 0.05$, $SE = 0.13$, $\beta = .02$, $z = 0.35$, $p = .73$), outgroup aversion ($b = -0.008$, $SE = 0.02$, $\beta = -.01$, $z = -0.33$, $p = .75$), or symbolic ethnocentrism ($b = 0.05$, $SE = 0.11$, $\beta = .02$, $z = 0.45$, $p = .65$). We suspect that the dynamic nature of our new panhumanism measure may have obscured these total effects because the panhumanism measure was novel (using box dragging instead of Likert scales) and attentionally absorbing, which can diminish the impact of primes (Wheeler, DeMarree, & Petty, 2014).

Discussion

Priming the salience of robot workers led people to express a greater sense of panhumanism, which in turn reduced prejudice. Robot salience affected prejudice only to the extent that people expressed more panhumanism, suggesting that perceptions of a common human ingroup are critical to automation's potential to reduce prejudice. Unexpectedly, robot salience had no total effect on prejudice, which may reflect sampling error or the absorbing nature of our panhumanism task. Study 6 addressed this issue through a simpler and previously validated measure of panhumanism and also provided a broader demographic sample.

Study 6: Panhumanism as a Mechanism (2)

To provide generalizability, Study 6 tested for the indirect effect of robot salience on prejudice through panhumanism with a different set of outgroup prejudice measures (those from Study 3); a simpler and better validated panhumanism measure (McFarland et al., 2012); and a more diverse sample, oversampling Black and Hispanic Americans (the two largest racial minorities in the United States). These broader sample demographics also allowed us to examine potential racial differences in our effects. We preregistered our hypotheses and study characteristics (see https://osf.io/gr2t5/).

Method

Participants. We based our sample size on a pilot study, which is summarized in the online supplemental materials. This pilot study suggested that a sample of 200 people would be sufficient to observe our effects. We advertised for a sample of 600 participants—200 White Americans, 200 Black Americans, and 200 Hispanic Americans—using a prescreening question to test for differences across these groups with appropriate power. In total, 607 ($M_{age} = 35.88$, $SD = 11.64$; 342 men, 263 women, one "other") completed the survey and were included in the analysis. Our postsurvey demographics indicated that we recruited 222 White participants, 173 Black participants, and 153 Hispanic participants (58 "other"). This was less than our advertised numbers but nevertheless large enough to probe for differences on the basis of race.

Manipulation. At the beginning of the study, participants in the robot salience condition read the following prompt:

> Robots are becoming increasingly sophisticated. Many futurists believe that, within the next decade, robots may be marrying people, taking human jobs, and even running for office. Consider how you might feel about other humans if robots begin to become more prevalent in society.

The prompt was accompanied by a picture of a human and a robot. Participants in the control condition read the instructions from the control condition in Study 3: "People differ in who they want as leaders, doctors, military commanders, and other social roles. This survey was designed to quantify the scope of these differences." This prompt was accompanied by a picture of two humans.

Prejudice. Prejudice was measured as in Study 3, via participants' favorability toward four sociocultural outgroups (someone of a different religion, different sexual orientation, or different race or who is an immigrant) for five roles: "marrying one of your children," "managing the company in which you work," "serving as a politician," "serving as your doctor in a high-risk operation," and "serving as your country's military commander."

Panhumanism. Panhumanism was measured with a previously validated scale (McFarland et al., 2012) that we piloted in Study 3 (see the online supplemental materials). Participants viewed six sets of two circles that varied in their overlap. One of the circles was always rated *You,* and the other was always rated *Humanity.* Participants were told to select the circle that best represented how they viewed the relationship between their own identity and humanity. For example, selecting two completely separate circles expressed disconnection with the human species as a whole, whereas two completely overlapping circles expressed extreme closeness with all other human beings.

Analysis strategy. We conducted the same analyses as in Study 5. We conducted our primary analyses in a path model (see Figure 6) that estimated (a) the effect of robot salience on panhumanism, (b) the effects of panhumanism on outgroup prejudice (aggregated to the person level), (c) the total effect of robot salience on outgroup prejudice, and (d) the indirect effects of robot salience on outgroup prejudice through panhumanism. For the sake of comprehensiveness, the online supplemental materials also summarize an ANOVA to examine whether robot salience increased

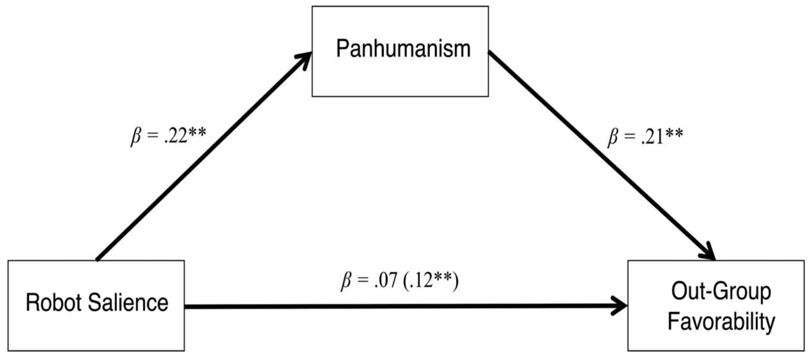

Figure 6. The path model from Study 6 showing the effects of robot threat on outgroup favorability via panhumanism. Robot salience significantly increased outgroup favorability through panhumanism. Participant ethnicity (Black vs. White; Hispanic vs. White) did not moderate the effects of robot salience on panhumanism or outgroup favorability. ** $p < .005$.

panhumanism and a multilevel regression to examine whether robot salience decreased prejudice, as we reported the results in Study 3.

Secondary analyses tested whether the effects of robot salience on panhumanism and outgroup prejudice differed across races (White vs. Black vs. Hispanic). We did this by creating dummy-coded variables representing whether participants were Black or Hispanic and then interacted these with the effect of robot salience on panhumanism and outgroup prejudice. This allowed us to estimate whether these effects were significantly different for Hispanic and Black participants than for White participants.

Results

Robot salience and panhumanism. Our path model revealed that, as we predicted, participants in the robot threat condition displayed more panhumanism than did participants in the control conditions ($b = 0.65$, $SE = 0.12$, $\beta = .22$, $z = 5.60$, $p < .001$). Writing about the threat of robots led people to view humanity as their ingroup.

Panhumanism and outgroup prejudice. Panhumanism correlated with how favorably people viewed outgroups ($b = 3.16$, $SE = 0.60$, $\beta = .21$, $z = 5.26$, $p < .001$). People expressing higher levels of panhumanism also showed less prejudice.

Indirect and direct effects of robot salience on outgroup prejudice. We predicted that robot salience would increase people's favorability of outgroups and that panhumanism would mediate this effect. Each of these predictions was supported. There was a significant indirect effect of robot salience on how favorably people viewed outgroups through panhumanism (95% CI [.99, 3.08]). There was also a significant total effect of robot salience on how favorably people viewed outgroups ($b = 5.19$, $SE = 1.75$, $\beta = .12$, $z = 2.97$, $p = .003$), but this was only marginally significant after controlling for panhumanism ($p = .07$), suggesting that panhumanism fully mediated the effect of robot salience on outgroup favorability. Robot salience led to prejudice reduction, but this effect was significant among only people who displayed more panhumanism.

Effects across racial groups. Finally, we examined whether the effects of robot salience on panhumanism and outgroup prejudice varied across racial groups. Analyses revealed that effects of robot salience on panhumanism did not differ for White versus Black participants ($b = -0.19$, $SE = 0.21$, $\beta = -.05$, $z = -0.89$, $p = .37$) or for White versus Hispanic participants ($b = 0.31$, $SE = 0.21$, $\beta = .08$, $z = 1.48$, $p = .14$). Similarly, the effect of robot salience on people's favorability of outgroups did not differ for White versus Black participants ($b = -0.08$, $SE = 3.08$, $\beta = -.001$, $z = -0.02$, $p = .98$) or for White versus Hispanic participants ($b = 4.15$, $SE = 3.11$, $\beta = .07$, $z = 1.33$, $p = .18$). Robot salience facilitated panhumanism and reduced prejudice similarly across racial groups.

Discussion

Priming the salience of robot workers increased panhumanism, which reduced people's prejudice toward outgroups, consistent with our predictions and those of the CII model. This study also suggests that null total effect in Study 5 may have been an aberration due to sampling error or the nature of our novel panhumanism measure, because Study 6, like Studies 1–4, revealed a significant total effect of robot salience on prejudice.

General Discussion

Automation looms over the world's workforce, and it is all but certain that many people will soon lose their jobs to robot workers. Much less certain, however, is how the rise of robot workers will affect social relations. Some have suggested that automation will exacerbate intergroup tensions, much like major economic shifts of the past. Here, we show that under a variety of conditions, the threat and salience of robot workers can do just the opposite: Robots can highlight our common human identity and reduce outgroup prejudice.

Six studies support our hypothesis. Study 1 shows that people's anxiety about robots correlates negatively with their prejudice toward human outgroups, Studies 2–4 show that experimentally priming the salience of robot workers reduces outgroup prejudice, and Studies 5 and 6 show that robot salience decreases outgroup prejudice via increased panhumanism, which supports the CII model of prejudice reduction. Study 6 further demonstrates that these effects are similar across non-Hispanic White, non-Hispanic Black, and Hispanic Americans.

The online supplementary materials provide an internal meta-analysis lending robust support for the hypothesis that robot salience reduces outgroup prejudice, with a meta-analytic effect of $r = -.13$ ($d = -0.26$). This meta-analysis also shows no significant variation in effect size across studies and finds that the effect size is similar across income and political groups.

An open question remains about when automation helps versus harms intergroup relations. Our evidence is optimistic, showing that robot workers can increase solidarity between human groups. Yet other studies have been pessimistic, showing that reminders of rising automation can increase people's perceived material insecurity, leading them to feel more threatened by immigrants and foreign workers (Frey et al., 2018; Im et al., 2019), and data that we gathered across 37 nations—summarized in the online supplemental materials—suggest that the countries that have automated the fastest over the last 42 years have also increased more in explicit prejudice toward outgroups, an effect that is partially explained by rising unemployment rates.

To explain these divergent effects, we encourage future research to examine how people conceptualize automation. When robot workers are conceptualized as a distinct social identity (e.g., humanoid robots in manufacturing plants), this may increase people's panhumanism and reduce prejudice. But when robot workers are conceptualized as representing an economic advance rather than a social identity (e.g., self-checkout counters at grocery stores), people may view automation as inducing competition between themselves and other groups, which may increase prejudice. People's awareness of automation may also be important. Rising unemployment due to automation may reduce prejudice only if people know that robot workers are forcing them out of their jobs. If people are not aware of the true reason behind rising unemployment, they may blame immigrants and foreigners, ultimately increasing prejudice. Managing the factors that moderate automation's effects on intergroup relations will likely be a key policy issue as robot workers continue to grow more prevalent.

We also encourage future research to investigate the role of threat in the relationship between automation and prejudice. Automation represents a shared threat to white-collar and blue-collar employees (Levitan & Johnson, 1982), and priming shared threat can be a powerful means of emphasizing common identity and reducing prejudice (Nadler, Harpaz-Gorodeisky, & Ben-David, 2009). In our studies, some manipulations were more threat-focused than were others. But even in studies that did not use threat-based manipulations (e.g., Studies 3–4), robot salience reduced prejudice. This suggests that the shared threat of automation it is not necessary to reduce prejudice. Viewing automation as a threat may even have adverse consequences unrelated to social relations, decreasing people's trust in robot workers. Indeed, some studies are already exploring the consequences of decreased trust in robot workers (e.g., Waytz & Norton, 2014).

In sum, our research shows that robot workers need not divide human groups. Whereas decades of past literature in social psychology has shown that people discriminate based on factors like religion, politics, and ethnicity (Hornsey & Hogg, 2000), the rise of robot labor could help to transcend these social identities by highlighting our common human character.

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