Immune System and Intergroup Bias: Increases in Cytokines Associated with Worse

Evaluations of Resume for Latina Job Applicant

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V1 Submitted to PsyArXiv on 11/6/2023

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Imagine Alex, a manager in a medium-scale company. One of Alex's main responsibilities is hiring new talent. One Tuesday, Alex wakes up feeling under the weather—but not quite "bad enough" to use sick leave. Alex gets ready and makes the usual commute into work. Upon sitting down at the office, Alex finds a few new job applications in the portal. Still under the weather, Alex begins to sort and evaluate the resumes. Could being sick lead Alex to make different decisions about these resumes than Alex would have made otherwise? The present research attempts to answer this question.

Everyone falls prey to social biases at one time or another. Numerous situational factors can increase the likelihood that biases will affect people's decision-making and social cognition (e.g., Bodenhausen, 1998; Fein & Spencer, 1997; Gilbert & Hixon, 1991; Kruglanski & Freund, 1983; Rogers & Prentice-Dunn, 1981). In the present research, we draw on literature in psychoneuroimmunology (PNI) to propose that another important situational factor that may increase intergroup bias is illness. Specifically, we theorize that acute activation of the immune system may increase intergroup bias.

The Immune Systems and Their Behavioral Influences

The immune system is complex and consists of several different systems that work together to dynamically combat health threats (Segerstrom & Miller, 2004). These systems include those that are threat-specific (i.e., the adaptive immune system) and those that are threat-general (i.e., the innate immune system). Threat-general systems can become activated quickly in response to perceived or actual threats to one's health. One component of the threat-general response is acute inflammatory activity, which can be measured by an increase in pro-

inflammatory cytokines. Pro-inflammatory cytokines are proteins that upregulate inflammatory

activity and act as messengers between the central nervous system and other facets of the

immune systems. Increases in cytokines are observed in early stages of (fighting off) an illness.

Increases in cytokines prompt changes in behavior (Dantzer & Kelley, 2007). Some of

these behavioral changes are thought to facilitate rest and recuperation from illness by reducing

energy demands of one's typical behavior and thereby balancing the necessary increased energy

demands of mounting a cytokine response (Dantzer, 2001; Dantzer & Kelley, 2007). These

behavioral changes are collectively termed "sickness behaviors" and include changes in mood

(e.g., anhedonia, depression), lethargy, and social withdrawal. Increases in cytokines also

increase anxiety (Kullman et al., 2013; Reichenberg et al., 2001) and appear to draw attention

inward to focus on one's physiological processes (Harrison et al., 2009). Several other

downstream consequences of increased cytokines include reduced self-regulation and motivation

(Dantzer & Kelley, 2007; Harrison et al., 2015; Shields et al., 2017), as well as a shift toward

more immediate gratification (Gassen et al., 2019).

Increases in cytokines also affect social behavior (Eisenberger et al., 2017). On the one

hand, increases in cytokines have been linked to greater attunement toward close others (Inagaki

et al., 2014; Jolink et al., 2022, Muscatell et al., 2016). On the other hand, increases in cytokines

have also been linked to greater vigilance toward and avoidance of socially distant others

(Inagaki et al., 2012; Jolink et al., 2022). These findings come from research that experimentally

increases cytokine levels via the administration of a substance that simulates a pathogen (e.g.,

endotoxin, vaccine). In response to such manipulations that simulate the state of illness, increases

in cytokines are associated with greater amygdala activation in response to socially threatening

images (Inagaki et al., 2012) and greater automatic avoidance of unknown social targets (Jolink

et al., 2022). Overall, increases in cytokines seem to facilitate greater desire for closeness with close others yet a greater desire for distance from distant others. This link is also supported by insights from computational modeling of the spread of viral infections demonstrating that selective withdrawal from others on the periphery of people's social networks is more effective for halting the spread of illness than generalized social withdrawal from everyone (Cole, 2006).

Changes in social behavior in response to increases in cytokines may also have adaptive function beyond preservation of energy resources. Illness is a time of increased vulnerability, when an individual often needs care and assistance from others and is more vulnerable to threats. Indeed, increases in cytokines appear to sensitize people to both positive and negative social information, which may function to regulate approach and avoidance behaviors (Eisenberger et al., 2017). Close others are likely to offer an individual care and support and would thus be adaptive to approach (Muscatell & Inagaki, 2021). Strangers, however, are sources of threat and would be adaptive to be vigilant of and avoid (Neuberg, Kenrick, & Schaller, 2011).

Acute Inflammation and Bias

In the present research, we hypothesize that acute inflammation will be associated with greater intergroup bias. Support for this hypothesis comes from three distinct literatures. First, increases in cytokines may lead to greater intergroup bias due to reduced cognitive effort and motivation. The links between increases in cytokines and anxiety (Kullman et al., 2013; Reichenberg et al., 2001), as well as greater attention toward internal processes (Harrison et al., 2009), parallels social psychology research guided by the distraction hypothesis (Bodenhausen, 1993; Wilder & Simon, 2003). States characterized by heightened physiological arousal—for example, arousing emotions (Baron et al., 1990; Bodenhausen & Kramer, 1990), exercise (Kim & Baron, 1988; Wann & Branscombe, 1995), and stress (Keinan et al., 2000)—limit the

cognitive resources used to understand the social environment and consequently lead to biased

social judgments. Furthermore, the use of bias-reduction strategies requires motivation and self-

regulation (Devine, 1989; Devine & Sharp, 2009; Monteith, 1994). Consequently, the reduced

motivation and capacity for self-regulation stemming from acute increases in cytokines (Dantzer

& Kelley, 2007; Harrison et al., 2015; Shields et al., 2017) may reduce people's typical use of

bias-reduction strategies and, consequently, any automatically activated stereotypes (Devine,

1989) may result in increased intergroup bias.

Second, increases in cytokines may lead to greater intergroup bias due to greater ingroup

favoritism and outgroup derogation. That is, the link between increases in cytokines and desire

for closeness with close others, but desire for distance from distant others, parallels the opposing

attitudes toward one's ingroup versus one's outgroup. Even in the context of novel or lab-created

groups, people demonstrate an affinity toward ingroup members and antipathy for those in the

outgroup (Brewer, 1979; Tajfel et al., 1971). Indeed, simply categorizing someone as an

outgroup member initiates social withdrawal (Paladino & Castelli, 2008). Consequently, the

avoidance of strangers (Jolink et al., 2022) and vigilance to social threats (Inagaki et al., 2012)—

which are often associated with outgroups (Cottrell & Neuberg, 2005; Zarate et al., 2004)—

resulting from increased cytokines may also extend to greater intergroup bias. Moreover, because

people engage in less frequent contact with groups they are prejudiced against (Allport, 1954;

Maunder et al., 2019; Schwab et al., 2019), those groups would be likely targets of selective

withdrawal from those on the periphery of one's social network.

Finally, increases in cytokines may lead to greater intergroup bias due to heightened

pathogen avoidance motives. Pathogen avoidance motives facilitate people's use of proactive

and reactive strategies that function to mitigate the threat of illness (Ackerman et al., 2018;

Schaller & Park, 2011).[1] Such psychological strategies are theorized to complement immune

system processes by serving as a first round of defense against pathogen threat, which is a

defense that may require the expenditure of far fewer energetic or immune resources than a full-

fledged inflammatory response. When pathogen avoidance motives are high, people demonstrate

pathogen-defensive behavior against targets who may not actually be harboring illness but are

only *heuristically* associated with illness (Schaller & Park, 2011). Indeed, the link between

pathogen avoidance motives and intergroup bias has been widely documented (Aarøe et al.,

2017; Brown et al., 2019; Faulkner et al., 2004, Fessler & Navarrete, 2006; Makhanova et al.,

2021; O'Shea et al., 2019). It has been suggested that because both pathogen avoidance

strategies and the immune system serve the same functional purpose of pathogen defense, there

may be crosstalk between these processes (Ackerman et al., 2018; Clark & Fessler, 2014;

Murray et al., 2019). Consequently, increases in cytokines may cue the activation of pathogen

avoidance strategies, including greater intergroup bias.

Current Research

To examine whether increases in cytokines lead to greater intergroup bias, we conducted

an experiment using a protocol adapted from PNI that activates the threat general response of the

immune system by administering the seasonal influenza vaccine (Boyle et al., 2019; Kuhlman et

al., 2018; Jolink et al., 2022). To strengthen the internal validity of the present study, we added a

control condition in which participants received a saline placebo injection. Condition was

randomly assigned, and participants were blind to condition until the conclusion of the study.

Approximately 24-hours after they received either the vaccine or placebo at the clinic, when the

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[1] The psychological strategies aimed at pathogen avoidance are frequently termed "the behavioral immune system." Because we are focused on psychoneuroimmunology and immune system activity, we opted not to use that term to increase clarity and to avoid creating a false dichotomy between the two systems (i.e., increases in cytokines also prompt behavioral changes).

peak increase in cytokines was expected to occur (Radin et al., 2021), participants completed

measures of intergroup bias with instructions provided over Zoom. We assayed saliva samples

participants provided before the clinic appointment and before the Zoom meeting for three pro-

inflammatory cytokines associated with the threat general immune response: interleukin-1β (IL-

1β), interleukin-6 (IL-6), and tumor necrosis factor-α (TNF-α).

Our primary measure of intergroup bias was a resume evaluation task in which

participants saw and evaluated two resumes, one from a Latina applicant and one from a White

applicant. Resume evaluation tasks are a common method to examine discrimination and biased

behavior (Bertrand & Mullainathan, 2004; Moss-Racusin et al., 2012). For example, research

examining bias among science faculty found that the same resume for a lab manager position

with a female-typical name (vs. a male-typical name) was rated as less competent and offered a

lower starting salary (Moss-Racusin et al., 2012). Resume tasks have also been used to document

instances of discrimination due to race and ethnicity (Bertrand & Mullainathan, 2004; Derous et

al., 2009; Wilder & Chicoine, 2011).

Participants also completed a general ethnocentrism scale (Neuliep & McCroskey, 1997).

Ethnocentrism reflects people's beliefs that their group is superior in its customs compared to

other groups. Such beliefs promote and reinforce negative attitudes toward people belonging to

outgroups (Segall, 1979). Indeed, people who report greater ethnocentrism report having lower

frequency of contact with people from different cultures (Neuliep & McCroskey, 1997).

Moreover, ethnocentrism was negatively associated with perceived competence of and hiring

recommendations for an Asian job applicant (Neuliep et al., 2007).

We tested pre-registered hypotheses that participants who received the influenza vaccine,

compared to those who received the placebo, would demonstrate greater cytokine change and

greater intergroup bias. Specifically, we hypothesized that participants in the vaccine condition, compared to those in the placebo condition, would rate the Latina applicant as less competent and would recommend that she receive a lower starting salary, as well as report greater ethnocentrism. We did not predict that condition would affect evaluations of the White applicant. Because we conceptualized cytokines as having a mechanistic role in prompting bias, we hypothesized that cytokine change would mediate the effect of condition on bias. Furthermore, consistent with the analytic strategy used in past research (Boyle et al., 2019; Kuhlman et al., 2018; Jolink et al., 2022), we examined whether greater cytokine change among participants who received the vaccine would be positively associated with bias. However, it is worth noting that although we preregistered specific hypotheses,[2] this was a novel interdisciplinary investigation and we anticipated that we may not have foreseen all possible patterns of associations between cytokine change and intergroup bias.

Method

Participants

Participants were recruited from the community. All participants completed a phone screening to determine eligibility. Participants were eligible if they (a) were between 18 and 40 years old, (b) had a BMI between 18.5 and 30, (c) have not received the annual influenza vaccine that season, (d) have never had an allergic reaction to the influenza vaccine or other vaccines, (e) were not pregnant, (f) did not have any illnesses known to affect cytokine levels (e.g., auto-immune disorders, hypothyroidism, sleep disorders), (g) were not taking medication known to affect cytokine levels (e.g., SSRIs, steroids), and (h) did not smoke or use tobacco products. See

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[2] We preregistered three additional hypotheses pertaining to factors that could attenuate the association between increases in cytokines and intergroup bias. We report the tests of these hypotheses in the Supplemental Materials because we did not have the statistical power and experimental control in our final sample to draw strong conclusions about those findings (or lack thereof).

Supplemental Materials for the full list of exclusion criteria. Participants were compensated with a $40 Amazon gift card for participating in the study.

Because data collection took place during the COVID-19 pandemic, we had to rely on participants completing tasks and providing saliva samples remotely. Unfortunately, this led to a higher-than-typical number of exclusions due to technological problems and failure to follow instructions, especially regarding the timing of saliva samples. In the manuscript, we report results from a subsample of 103 participants who most closely followed the protocol. We provide more details about our target sample size, exclusions, and analyses with larger subsamples in the Analytic Strategy section and in Supplemental Materials.

Participants were on average 25 years old ($M = 25.43$, $SD = 5.81$, range: 18-40). The majority of participants ($n = 71$) identified their gender as female; 31 identified as male, and 1 ran out of time during the Zoom session and did not complete the demographics questionnaire. We did not exclude participants based on race and ethnicity; the majority of participants identified as White ($n = 72$); 8 participants identified their race as Asian, 3 as Black, 1 as Native American, and 7 as multiracial and other. Eleven participants identified their ethnicity as Hispanic/Latine. When asked to describe their political orientation on a scale of 1 (*Very Liberal*) to 10 (*Very Conservative*), participants' responses were on average slightly more liberal than the scale midpoint ($M = 4.17$, $SD = 2.14$, range: 1-9). This skew is more pronounced when examining frequencies: Only 29 participants identified their political orientation as more conservative than the midpoint.

Procedure and Materials

Data collection took place during two influenza vaccine administration seasons (Season 1: October 13, 2020 and March 5, 2021, $n =41$; Season 2: September 22, 2021 and March 18,

2022, $n = 62$). Participants completed eligibility screening and informed consent over the phone.

After providing consent, participants were scheduled for an appointment at the clinic, where they

received either a placebo injection ($n = 42$) or the seasonal influenza vaccine ($n = 61$).[3] Condition

assignment did not differ between the two seasons, $\chi^2(1) = 0.01$, $p = .908$. Vaccines were

Flucelvax Quadrivalent egg-free vaccines manufactured by Seqirus (see Supplemental Materials

for strain information). Placebo injections were 0.5mL of saline solution. The nurses

administering the vaccines were not blind to participant condition, but participants and research

assistants were blind to condition until the end of the study. After they were unblinded,

participants in the placebo condition returned to the clinic to get their vaccine.

Before their clinic appointment, participants picked up study instructions and supplies,

including those for providing saliva samples. Participants in this subsample provided their

baseline saliva sample before getting the vaccine or placebo injection and their second saliva

sample within the 2 hours before the start of the Zoom session during which they completed the

dependent measures. On average, there was a 24-hour difference between samples ($M = 24.56$,

$SD = 3.58$, range: 17.24-33.83), which corresponds to the peak in cytokine responses anticipated

following the influenza vaccine (Radin et al., 2021). Samples were assayed for interleukin-1β

(IL-1β), interleukin-6 (IL-6), and tumor necrosis factor-α (TNF-α).

During the Zoom session, the resume evaluation task was the first task participants

completed. Participants saw two sets of application materials for entry level corporate jobs, one

from a Latina applicant (Gabriela Hernandez) and one from a White applicant (Mary Loftis). The

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[3] The difference in frequencies between conditions is due to the fact that random assignment was done in advance for the entire anticipated sample size as part of the Vaccine Administration Log using simple random assignment (i.e., without the use of a block design). But, we did not reach the anticipated sample size. Although there was some attrition between the consent phone call and clinic appointment, because participants were blind to the condition they were assigned to until the end of the Zoom session, it was unlikely there was systematic attrition based on condition at that step.

sets were presented in counterbalanced order. In each set, participants saw a resume and listened

to six brief audio recordings of answers to interview questions purportedly answered by the

applicant. The Latina applicant was voiced by a native Spanish speaker currently living in

Panama for whom English was the second language. According to past research on employment

discrimination, a combination of ethnic name and accent is especially likely to produce bias

(Purkiss et al., 2006). Because some participants had technological issues, analyses of this

dependent measure include data from 93 participants.

After viewing the resume and listening to the recordings for each applicant, participants

rated the applicant on perceived competency using a measure adapted from past research (Moss-

Racusin et al., 2012). Participants answered 3 questions about perceptions of applicant

competence (e.g., "Did the applicant strike you as competent?"), 3 questions about perceptions

of applicant hireability (e.g., "How likely would you be to invite the applicant to interview for

the job?"), and 1 question about potential mentoring (e.g., "If you were to hire the applicant, how

likely would you be to give her advice about working at the company?"). Although we intended

to use the three different perceptions individually, because the internal consistency of responses

across all 7 questions was very high (Cronbach's α = .93-.94), we decided to create a single

composite. Participants additionally provided an open-ended recommendation for the applicant's

starting salary in response to the question "If you were to hire the applicant, what salary would

you suggest to HR? The average entry level salary in AR is $42,000."

Participants completed self-report questionnaires toward the end of the session. We

assessed participant ethnocentrism by using the first half of the Generalized Ethnocentrism Scale

(Neuliep & McCroskey, 1997); the scale was shortened due to study time constraints.

Participants rated their agreement with 12 statements (e.g., "Most other cultures are backward

compared to my culture;" α = .74) on a scale of 1 (*Strongly Disagree*) to 7 (*Strongly Agree*).

Because some participants ran out of time and did not finish the block of questionnaires, analyses

of this dependent measure include data from 100 participants.

Analytic Strategy

As typical in PNI research, we transformed cytokine levels via natural log transformation

to correct skew (e.g., Gassen et al., 2019; Shields et al., 2016). To model cytokine change, we

used residualized change between the two samples. We controlled for the time difference

between samples in all analyses involving cytokines. In primary analyses, we include all

participants regardless of race and ethnicity in order to retain a larger sample size. In ancillary

analyses, we conducted the same analyses in subsamples of participants who were non-Hispanic

of any race and those who were non-Hispanic White.

We additionally carried out numerous robustness checks with different configurations of

the subsamples and covariates, which are reported in detail in the Supplemental Materials.

Specifically, we estimated the same models but (a) including participants who further deviated

from the protocol in terms of saliva sample timing, (b) including participants who participated in

a similar study through another clinic (see Supplemental Materials for a description of this

sample), and (c) including additional covariates (e.g., vaccine season, age, gender, political

orientation, socioeconomic status, sleep quality, BMI, whether they have been sick in the last

week, whether they had caffeine).

Rather than focus on whether an effect was significant with the varied analysis choices,

we examined the magnitude of the effects (in terms of regression coefficients) and the precision

of those estimated effects using Bayesian regression models. In the appendix, we report

posterior distribution of the regression coefficients for condition and cytokine change from a

variety of models. We also report model comparisons indicating the relative posterior weight given to models including or excluding each factor and the interaction. Generally, the regression coefficients varied very little across analysis choices and posterior model weights generally agreed with the qualitative conclusions reported in the results section.

Transparency and Openness

Between the text and the Supplemental Materials, we report how we determined our sample size, all data exclusions, all manipulations, all measures relevant to the current hypothesis, and we follow JARS (Kozak, 2018). Hypotheses for this study were pre-registered. All materials—including the data, detailed codebook, and data analysis code—will be accessible on OSF at the time of publication. Data were analyzed in SPSS and R.

<div align="center">Results</div>

First, we examined whether participants in the vaccine condition demonstrated greater social bias than participants who received the placebo injection. As can be seen in Table 1, condition did not affect participants' ratings of either applicant's competency, either applicant's recommended starting salary, or ethnocentrism. Thus, our hypothesis was not supported.

Next, we examined whether participants in the vaccine condition demonstrated greater cytokine change than participants who received the placebo injection, controlling for the time difference between samples. Greater cytokine change in the vaccine condition compared to the placebo condition was only observed for change in IL-1β, $b = 0.43$, $SE = 0.21$, $t(100) = 2.06$, $p = .043$, 95% CI [0.02, 0.85], semi-partial $r = .20$. There was a trend for participants demonstrating greater TNF-α change in the vaccine condition compared to the placebo condition, $b = 0.26$, $SE = 0.15$, $t(105) = 1.66$, $p = .099$, 95% CI [-0.05, 0.56], semi-partial $r = .16$; there was no

Table 1

Difference in Social Bias Between Participants in the Placebo and Vaccine Conditions

Dependent Measure	Placebo M (SD)	Vaccine M (SD)	t	df	p	d
Latina Applicant						
Competency	7.25 (1.29)	7.02 (1.22)	0.86	91	.393	0.18
Salary Recommendation	$43,333.33 ($4,884.63)	$42,063.20 ($5,803.03)	1.11	91	.269	0.24
White Applicant						
Competency	6.80 (1.43)	6.93 (1.20)	-0.46	91	.648	0.09
Salary Recommendation	$42,256.41 ($6,243.81)	$41,413.20 ($5,815.75)	0.67	91	.505	0.14
Ethnocentrism	2.63 (0.75)	2.55 (0.64)	0.60	98	.549	0.12

difference between condition for IL-6 change, $b = 0.07$, $SE = 0.15$, $t(105) = 0.46$, $p = .646$, 95%

CI [-0.23, 0.37], semi-partial $r = .04$. Overall, findings provide partial support for our hypothesis.

Evaluation of Latina Applicant

To test our central hypothesis that cytokine change would be associated with greater

intergroup bias, we first regressed evaluations of the Latina applicant's competency onto

condition (-0.5 = placebo, 0.5 = vaccine), residualized IL-1β change (z-scored), and the

condition × IL-1β change interaction to assess whether any effects of IL-β differed between

participants who received the placebo or the vaccine. Models controlled for the time difference

between samples and evaluations of the White applicant's competency. There was a significant

main effect of IL-1β change: Participants who experienced greater IL-1β change rated the Latina

applicant as less competent, $b = -0.23$, $SE = 0.11$, $t(87) = -2.17$, $p = .033$, 95% CI [-0.45, -0.02],

semi-partial $r = -.18$. The main effect was qualified by a significant IL-1β change × condition

interaction, $b = -0.42$, $SE = 0.21$, $t(87) = -2.05$, $p = .044$, 95% CI [-0.84, -0.01], semi-partial $r = -$

.17. We probed the interaction by examining the simple effects of IL-1β change among

participants who received the vaccine and among those who received the placebo. See Figure 1.

Among participants who received the influenza vaccine, IL-1β change was negatively associated

with perceptions of the Latina applicant's competency, $b = -0.45$, $SE = 0.16$, $t(87) = -2.78$, $p =$

.007, 95% CI [-0.75, -0.12], semi-partial $r = -.22$. Conversely, among participants who received

the placebo, there was no association between IL-1β change and evaluations of the Latina

applicant's competency, $b = -0.02$, $SE = 0.14$, $t(87) = -0.16$, $p = .876$. In ancillary analyses, the

interaction and simple effect of IL-1β change in the vaccine condition remained significant in

both the subsamples of non-Hispanic and non-Hispanic White participants. A similar, albeit

weaker, pattern of results emerged for IL-6 change; there were no significant associations with

TNF-α change. See Supplemental Materials for full results.

Figure 1

*Association between increases in IL-1β and evaluation of Latina applicant's competency*
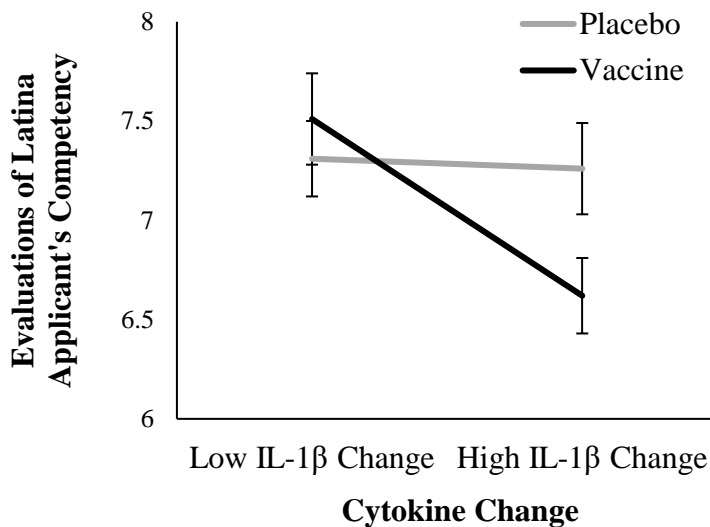
Note. IL-1β change is represented at ± 1*SD*. Error bars are *SE*.

We conducted a parallel analysis to examine participants' recommendation for the Latina applicant's starting salary. Again, there was a significant main effect of IL-1β change: participants who experienced greater IL-1β change recommended lower starting salaries for the Latina applicant, $b = -814.77$, $SE = 373.87$, $t(87) = -2.18$, $p = .032$, 95% CI [-1557.88, -71.65], semi-partial $r = -.15$. This main effect was also qualified by a significant IL-1β change × condition interaction, $b = -1621.88$, $SE = 746.32$, $t(87) = -2.17$, $p = .032$, 95% CI [-3105.27, -138.50], semi-partial $r = -.14$. See Figure 2. Among participants who received the influenza vaccine, IL-1β change was negatively associated with salary recommendation for the Latina applicant, $b = -1625.71$, $SE = 567.36$, $t(87) = -2.87$, $p = .005$, 95% CI [-2753.40, -498.02], semi-

partial $r = -.19$. Conversely, among participants who received the placebo, there was no

association between IL-1β change and salary recommendation for the Latina applicant, $b = -3.82$,

$SE = 485.96$, $t(87) = -0.01$, $p = .994$. Again, in ancillary analyses, both the interaction and simple

effect of IL-1β change in the vaccine condition remained significant in the subsample of non-

Hispanic participants. In the subsample of non-Hispanic White participants there was a main

effect of IL-1β change but no interaction with condition. A similar pattern of results emerged for

IL-6 change; there were no significant associations with TNF-α change. See Supplemental

Materials for full results.

Figure 2

Association between increases in IL-1β and starting salary recommendation for the Latina
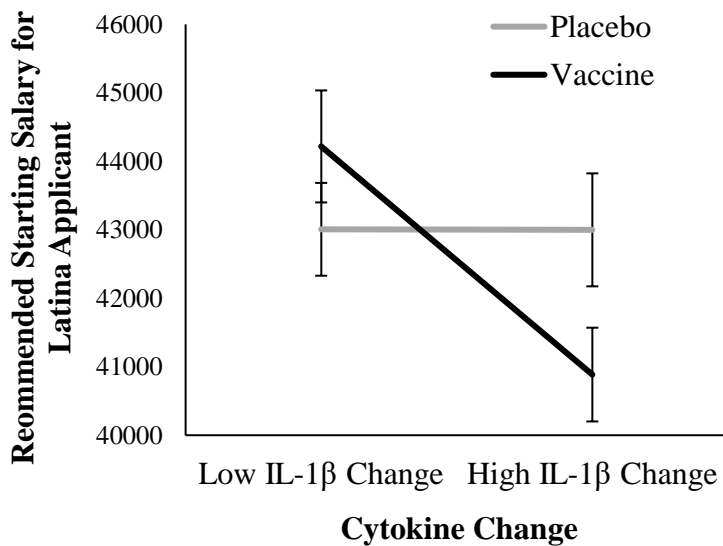
applicant

Note. IL-1β change is represented at ± 1*SD*. Error bars are *SE*.

Evaluations of White Applicant

We next examined the association between IL-1β change and evaluations of the White applicant's competency. In this model, there was neither a main effect of IL-1β change, $b = 0.04$, $SE = 0.12$, $t(87) = 0.34$, $p = .735$, nor an IL-1β change $\times$ condition interaction, $b = 0.26$, $SE = 0.22$, $t(87) = 1.19$, $p = .236$. The same pattern was observed for the parallel model examining starting salary recommendations. There was neither a main effect of IL-1β change, $b = 681.33$, $SE = 426.81$, $t(87) = 1.60$, $p = .114$, nor an IL-1β change $\times$ condition interaction, $b = 169.85$, $SE = 864.07$, $t(87) = 0.20$, $p = .845$. Overall, evaluations of the White applicant's competency and starting salary recommendations were not related to IL-1β change.

For IL-6 change, there was a significant IL-6 change by condition interaction for both evaluations of competency and starting salary recommendations. For competency, there was a negative simple effect of IL-6 change in the placebo condition, but a non-significant trend in the opposite direction in the vaccine condition. For salary recommendations, there was a non-significant negative trend in the placebo condition and a non-significant positive trend in the vaccine condition. There were no significant associations with TNF-α change. See Supplemental Materials for full results.

Ethnocentrism

Finally, we examined whether cytokine change was associated with social bias using our second dependent measure of outgroup bias: self-reported ethnocentrism. We regressed ethnocentrism onto condition (-0.5 = placebo, 0.5 = vaccine), residualized IL-1β change (z-scored), the condition X IL-1β change interaction, controlling for the time difference between samples. There was a marginal main effect of IL-1β change, $b = 0.13$, $SE = 0.07$, $t(95) = 1.77$, $p = .080$, 95% CI [-0.02, 0.28], semi-partial $r = .18$, but the interaction between condition X IL-1β

change was not significant, $b = 0.13$, $SE = 0.14$, $t(95) = 0.90$, $p = .369$. Notably, the main effect

was significant in analyses controlling for political orientation, $b = 0.14$, $SE = 0.06$, $t(94) = 2.13$,

$p = .036$, 95% CI [0.01, 0.26], semi-partial $r = .18$. However, the main effect of IL-1β change

was not significant in the subsamples of non-Hispanic and non-Hispanic White participants.

For both IL-6 and TNF-α change, there was a significant main effect but no interaction.

As with IL-1β change, the main effect of cytokine change was robust to inclusion of political

orientation as a covariate but was not statistically significant in the subsamples of non-Hispanic

and non-Hispanic White participants.

Robustness Analyses

As reported in detail in the Supplemental Materials, we estimated the same models when

(a) including participants who further deviated from the protocol in terms of saliva sample

timing, (b) including participants who participated in a similar study through another clinic, and

(c) including additional covariates (e.g., vaccine season, age, gender, political orientation,

socioeconomic status, sleep quality, BMI, whether they have been sick in the last week, whether

they had caffeine).

Across analyses, there was a consistent negative association between IL-1β change and

evaluation of the Latina applicant's competency and recommendations for the Latina applicant's

starting salary. Notably, the positive association between IL-1β change and ethnocentrism

became stronger with larger sample sizes; there was additional preliminary evidence that this

association emerged primarily among participants who would typically have lower levels of

prejudice (e.g., those with higher internal motivation to respond without prejudice and those with

more frequent contact with immigrants).

Discussion

In this study, we tested the hypothesis that acute inflammation—as measured by changes in pro-inflammatory cytokines—would be associated with greater intergroup bias. Participants were randomly assigned to the immune challenge condition that simulated a state of mild illness via administration of the influenza vaccine, or a placebo. We assessed intergroup bias with (a) a resume evaluation task in which participants evaluated competency and recommended a starting salary for a Latina job applicant and (b) a self-reported ethnocentrism. Cytokine change was assessed from saliva samples, which were assayed for IL-1β, IL-6, and TNF-α; the most robust findings were for IL-1β change. Although participants in the vaccine condition demonstrate greater IL-β change, there were no between-condition differences in intergroup bias. Nevertheless, we found support for our hypothesis that IL-1β change would be positively associated with bias. Among participants who received the vaccine, IL-1β change was associated with lower perceptions of the Latina applicant's competency and lower starting salary recommendations. The findings for ethnocentrism were overall less robust but there was a generally consistent main effect of cytokine change such that greater cytokine change was associated with more ethnocentrism. Overall, results provide first direct evidence that experimental inductions of immune activity contribute to intergroup bias.

These findings extend research in PNI to the study of prejudice. Past research in PNI has been suggestive of a relationship between increases in cytokines and antipathy toward unknown or unliked others, though there has not been a direct test. Unlike the increased desire to approach close others when experiencing increases in cytokines (Jolink et al., 2022; Muscatell et al., 2016), people tend to demonstrate greater desire for avoidance of strangers (Jolink et al., 2022) and increased vigilance to negative emotions on strangers' faces (Inagaki et al., 2012).

Moreover, computational modeling of the spread of viral infections have suggested that people may selectively withdraw from those on the periphery of their social networks (Cole, 2006), who are likely to be outgroup members (Allport, 1954). The current results indicate that the tendency to avoid distant social partners may extend to intergroup bias and discrimination.

These findings also extend research in social psychology to highlight novel situational factors that affect intergroup bias—acute inflammation and illness. Past research has emphasized important situational factors that affect intergroup bias, such as when people are experiencing arousing emotions (Baron et al., 1990; Bodenhausen & Kramer, 1990), when they are under time pressure (Kruglanski & Freund, 1983), when they are under cognitive load (Gilbert & Hixon, 1991), during the time of day opposite of their chronotypes (Bodenhausen, 1990), when they are threatened (Fein & Spencer, 1997) and when they are angry (Rogers & Prentice-Dunn, 1981). The present research suggests that times when people experience illness and inflammation also affect intergroup bias. This is consequential because illness is a common occurrence.

Although our findings demonstrate that acute inflammation is associated with intergroup bias, we cannot speak to the sociocognitive mechanism that would explain why inflammation results in increased bias. As mentioned previously, we drew on three separate literatures when proposing our hypothesis and each literature puts forth a unique plausible mediator: increased reliance on social heuristics, greater ingroup favoritism and outgroup derogation, and greater pathogen avoidance motives. Which of these mediators explain the relationship between inflammation and intergroup bias should be directly examined in future research.

To the extent that we found support for a mechanistic role of pro-inflammatory cytokines in intergroup bias, other situations that correspond to acute increases in pro-inflammatory cytokines are likely to also increase intergroup bias. Indeed, some situational factors that have

been shown to increase intergroup bias are also characterized by increases in pro-inflammatory

cytokines. For example, exercise is associated with both increases in intergroup bias (Kim &

Baron, 1988; Wann & Branscombe, 1995) and increases cytokines (Cerqueira et al., 2020).

Likewise, acute stress is associated with both increases in intergroup bias (Keinan et al., 2000)

and increases in cytokines (Szabo et al., 2020). These associations may be fruitful to examine

further, especially with an emphasis on the mechanistic role cytokines may play in regulating

social decision-making during these states.

Furthermore, if one process within the immune system—acute inflammation associated

with a threat-general response as was examined in the present research—is linked to greater

intergroup bias, there may be other processes within the immune system that are worth

examining in the social domain. For example, chronic inflammation may also affect social

decision-making. Indeed, some research has demonstrated that people with rheumatoid arthritis,

a chronic health condition that is characterized by high inflammation and increased vulnerability

to other illnesses, demonstrated greater intergroup bias than people in the matched healthy

control group (Oaten et al., 2018).

Several limitations of the present research relate to data collection during the pandemic.

We were unable to recruit our target sample size and then had to exclude many participants

because they failed to follow instructions for the remote protocol. Nevertheless, as demonstrated

in our ancillary analyses, there was a robust and consistent pattern of associations between

change in IL-1β and our intergroup bias measures. We assessed salivary cytokines, which can be

viewed as another limitation given that past research using the influenza vaccine to upregulate

cytokines has assessed those in blood (Jolink et al., 2022; Kuhlman et al., 2018). Although other

research has demonstrated that IL-6 responses to stress, for example, are similar when assessed

in saliva or blood (La Fratta et al., 2018), the responses have not been compared for the influenza vaccine challenge. It would behoove future research to comprehensively examine cytokine responses to the influenza vaccine challenge, including the administration of a saline placebo for the control group.

Conclusion

Remember Alex, the hiring manager who sorted through applicants' resumes when under the weather? The present findings would suggest that Alex could have indeed had different perceptions of applicants—if any of them happened to be from racial or ethnic minoritized groups—than on another Tuesday when Alex was not feeling under the weather. Given the lack of federal sick leave policies in the United States, it is important to continue investigating the effects working while sick may have on hiring and promotion decisions because the lack of such policies may be hampering goals related to diversity, equity, and inclusion.

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