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How and When Crowd Salience Activates Pathogen-Avoidant Motives

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Social affiliation in humans is ubiquitous and adaptive, albeit bounded. For example, crowding is experienced as aversive, and fosters reticent behaviors to mitigate contact with potentially threatening conspecifics. Given the integral role of physical proximity in disease transmission, crowd salience could activate pathogen-avoidant motives in response to personal space violations from others. Three preliminary studies investigated how crowd salience heightens pathogen-avoidant motives and shapes interpersonal perceptions. Crowd salience heightened preferences for good genes cues (facial symmetry; Study 2), but not aversion to bad genes cues (obesity; Study 1). Crowd salience was additionally unrelated to anti-immigration attitudes (Study 3). Although crowd salience elicited no significant differences in pathogen-avoidant motives in Studies 1 and 2, it significantly heightened perceived infectability, but not germ aversion, in Study 3. Study 4 was a preregistered, high-powered replication and demonstrated crowd salience heightened both state levels of perceived infectability and germ aversion, necessitating consideration for subtlety in detecting state-level differences. We discuss potential bases for inconsistencies in the findings while offering recommendations for future research.



Public Significance Statement

With world populations increasing exponentially in recent years, high levels of population density may elicit greater disease threat and therefore motivate individuals to avoid sources of pathogens in their environment as an evolved response to this threat. Across four studies, we found mixed evidence for this hypothesis. Crowd salience heightened preferences for cues to good health, but not poor health or aversion to immigration. Further, although two studies found no significant differences in pathogen-avoidant motives following a crowding threat, crowd salience heightened such motives in a large sample. Results suggest that changes in pathogen-avoidant motives are especially subtle.

Keywords: crowding, disease, face perception, prejudice, avoidance

Humans evolved to reap the benefits of consistent sociality within small populations of conspecifics throughout history, ranging in sizes from 120–150 (Dunbar, 1993). Though beneficial, sociality costs must be managed, including

competition for access to scarce resources, exploitation, and communicable disease transmission. Certain features of modern human ecologies exacerbate concerns of such threats, particularly experiences of crowding attributable to unprecedented population growth. The human population, having reached 1 billion in 1800, is now estimated at 7.6 billion and projected to be 9.8 billion by 2050 (United Nations Department of Economic and Social Affairs, 2017). Crowding is an increasingly pervasive modern environmental stressor paralleling these growth trends in human population. Such changes in population density have adaptively

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shaped human behavior to assist in the identification, and avoidance, of interpersonal threats stemming from crowded ecologies. For example, cultures adopt restrictive interpersonal norms as the population increases (Gelfand et al., 2011) with individuals exhibiting deference toward group members and cautious consumer behavior to minimize costs to their health (Baum & Valins, 1979; Maeng, Tanner, & So-man, 2013).

One possible reason for these increases in reticence could be the result of one especially deleterious consequence of crowding. Highly dense populations are specifically prone to infectious diseases (Jones et al., 2008; Møller, Dufval, & Allander, 1993). This vulnerability to infection would thus necessitate vigilance toward pathogenic cues and elicit behavioral repertoires ensuring individuals continue to gain the benefits of group living while minimizing costs of disease (e.g., Schaller & Murray, 2008). Despite a conspicuous gap in the literature on the effects of crowding since the 1970s, a resurgence of interest has begun assessing the effects of crowds on threat management (e.g., Maeng & Tanner, 2013; Sng, Neuberg, Varnum, & Kenrick, 2017). Importantly, recent findings suggest a necessary interplay between feelings of crowding and pathogen concern, with disease salience amplifying perceptions of crowds as threatening (Wang & Ackerman, 2019). These findings would suggest that crowding experiences would also heighten vigilance toward disease. The current program of research sought to identify how crowd salience activates pathogen-avoidant motives while identifying how these motives predict interpersonal preferences based on others' exhibition of virulence cues.

Crowding and Threat Management

The adaptive problem of increasing population density has contributed to a significant increase in understanding the psychological experience of crowding. Crowding is the psychological stress individuals experience in environments with threateningly high ratios of conspecifics within an area too constrictive for that population, ostensibly activating crowding-avoidant motives (Gochman & Keating, 1980; Stockdale, 1978). Such experiences subsequently heighten perceptual acuity toward inter-

personal threats by bolstering avoidance motives following personal boundary violations. Selection would have favored those attuned to violations, given the historical threat to physical safety posed by crowds (Neuberg, Kenrick, & Schaller, 2011). This attunement manifests as social withdrawal, occurring across various social species, including humans (Baum & Valins, 1979), macaques (Judge & de Waal, 1993), and chimpanzees (Aureli & de Waal, 1997). Increased personal proximity further heightens anxiety (Schaeffer & Patterson, 1980) and corresponding sympathetic nervous system responses (e.g., skin conductance, amygdalic activity; Aiello, DeRisi, Epstein, & Karlin, 1977; Kennedy, Gläscher, Tyszka, & Adolphs, 2009).

Subsumed within the social withdrawal of crowding is a suite of other cautious responses. This withdrawal would serve to minimize risks to one's physical safety and health while simultaneously retaining access to critical resources. Within densely populous countries, individuals adopt slow life history strategies, a behavioral repertoire typified by risk aversion, including long-term mating and investing in the future (Sng et al., 2017). Experimentally induced concerns for overpopulation further foster disinterest in promiscuity and having multiple children (Sng et al., 2017). Crowd salience further elicits prevention focus in individuals, heightening interest in purchasing pharmaceuticals and first aid (Maeng et al., 2013). These findings indicate crowd salience downregulates interest in risky behavior, suggesting environmental threats posed by crowding extend beyond threats to physical safety.

Behavioral Immune System

Though many species', including humans, primary strategy to ameliorate pathogen threat has been the evolution of a complex biological immune system, this system remains metabolically costly. For example, one immunological responses to pathogen threat, raising body temperature (i.e., fever) to create a suboptimal environment for pathogen propagation, is energetically demanding (Baracos, Whitmore, & Gale, 1987). Energy-consuming biological immune system responses to pathogen threat would critically divert resources from other physiological systems implicated in other fitness-enhancing behaviors (e.g., mating). It would have been

adaptive for individuals to recognize pathogenic threats to elicit avoidant responses prior to infection, thereby reducing necessity of initiating biological immunological responses (Neuberg et al., 2011). Previous research posits that humans evolved a behavioral immune system (BIS) as a suite of cognitive, affective, and behavioral responses to identify and mitigate contact with conspecifics likely posing pathogenic threat (Murray & Schaller, 2016). Much like crowding, disease salience fosters interpersonal reticence, aversion to interpersonal contact, and reduced interest in affiliation (Mortensen, Becker, Ackerman, Neuberg, & Kenrick, 2010; Sacco, Young, & Hugenberg, 2014; Sawada, Auger, & Lydon, 2018).

From an error management perspective, aversive responses to pathogenic threats operate via principles of overgeneralization, whereby overabundance of social stimuli are categorized as infectious to minimize costly failures in classifying actual pathogenic stimuli as such (Haselton & Nettle, 2006). Consequently, liberal identification criterion results in withdrawal from those whose appearance heuristically connotes disease threat. BIS responses to such information include heightened vigilance toward facial disfigurement (Ackerman et al., 2009), stigmatization of obesity (Miller & Maner, 2012; Park, Schaller, & Crandall, 2007), and perceptions of outgroup members as virulent (Petersen, 2017; van Leeuwen & Petersen, 2018).

Within these inferred virulence cues, population density is a cue to pathogenic threat to which BIS responses would be sensitive to minimize detection errors. Highly dense populations are associated with increased infection likelihood across species (Jones et al., 2008; Møller et al., 1993), implicating crowds as infection risks. Crowded environments reduce individuals' inclusiveness toward outgroups members while tightening cultural restrictiveness (Gelfand et al., 2011; Maeng & Tanner, 2013), consequences of heightened pathogen load (e.g., Brenner & Inbar, 2015; Murray, Trudeau, & Schaller, 2011). Disease salience further amplifies perceptions of crowds as threatening (Wang & Ackerman, 2019). Given these aversive responses to disease salience, activation of crowd-avoidant motives seems likely to elicit similar BIS activation, thereby facilitating identification of pathogenic conspecifics.

Current Research

The purpose of the current program is two-fold. We first sought to extend previous findings demonstrating how crowd salience shapes aversive responses toward potential environmental threats and its subsequent influence on interpersonal behaviors (e.g., Maeng & Tanner, 2013; Sng et al., 2017), specifically considering how crowding influences perceptions of pathogen threats. Second, given that previous findings suggesting disease salience heightens perceptions of social cues as threatening (Brown & Sacco, 2016; Wang & Ackerman, 2019), down-regulates affiliative interest (Sacco et al., 2014), and upregulates sensitivity to health cues (Young, Sacco, & Hugenberg, 2011), crowd salience should elicit pathogen-avoidant responses. We conducted four experiments in which we manipulated crowd salience before tasking participants to indicate their BIS activation across various measures. Data and materials for all studies, and the preregistration plan for Study 4, are available at: osf.io/xwtvg/.

Study 1

This initial study considered the effects of crowd salience on self-reported concerns of pathogenic threat at a state level and how it shapes interpersonal preferences. One widely researched BIS response is stigmatization of individuals with non-normative appearances that may represent a pathogenic threat (Crandall & Moriarty, 1995; Kurzban & Leary, 2001). Crowding could thus heighten aversion to heuristic cues of disease. We considered obesity as a heuristic disease cue, as obesity itself is not a contagious condition that could further restrict available space within a crowd (Park et al., 2007). We primarily predicted that crowd salience would heighten aversion to obesity. Given crowd salience should activate concerns over environmental threats, we further predicted that crowding would heighten participants' pathogen-avoidant motives, which would serve as a mediator for the proposed crowd-induced aversion to obesity.

Method

Participants. We recruited 320 undergraduates from a university in Southeastern U.S. in

exchange for course credit in an online study (284 women, 36 men; $M_{\text{Age}} = 20.00$ years, $SD = 4.21$; 58.4% White). Although we did not conduct an a priori power analysis, we sought to collect as much data as possible over the course of two weeks at the end of a semester. No participants were excluded from analyses in all four studies unless stated otherwise.

Materials and procedure.

Crowding prime. Participants were initially tasked with envisioning being in one of two large public spaces described as a meeting of students at a university forum, which were represented by one of two images. Images presented scenarios that varied in crowd size, such that one was of a large mass of people, which would ostensibly activate crowding-avoidant motives, and the other being a few individuals spread far apart from each other (Maeng et al., 2013).¹ Participants additionally described how they would feel in these situations in a brief writing task. After completing this task, participants responded to a single-item general affect item on a 7-point scale ($-3 = \textit{Extremely Negative}$; $3 = \textit{Extremely Positive}$), then a 4-item manipulation check assessing individuals feeling of being crowded, constricted, overwhelmed, and tense ($1 = \textit{Not at All}$; $7 = \textit{Very Much}$; manipulation check items were presented in randomized order; $\alpha = .95$).

Pathogen-avoidant motives. We assessed individuals' self-reported pathogen-avoidant motives using a modified version of the Perceived Vulnerability to Disease Scale (PVD; Duncan, Schaller, & Park, 2009). Although pathogen-avoidant motives assessed through PVD are typically considered on a chronic level, previous research indicates that modification of this scale are capable of assessing acute sensitivity to environmental factors, necessitating our use of a version that considers momentary feelings of pathogenic concern (Sacco et al., 2014). This scale contains 15 items assessing two separate processes of pathogen-avoidant motives modified to indicate state-level motivation (e.g., subjunctive language): germ aversion (GA, e.g., "It would really bother me if someone were to sneeze right now and not cover their mouth," $\alpha = .63$) and perceived infectability (PI, e.g., "Currently, I feel very susceptible to colds, flu, and other infectious diseases," $\alpha = .85$), utilizing 7-point scales ($1 = \textit{Strongly Disagree}$; $7 = \textit{Strongly Agree}$).

Obese targets. We then tasked participants with imagining themselves interacting with several obese and nonobese target individuals. We utilized before and after weight loss pictures from 6 men and 6 women (Miller & Maner, 2012). Participants indicated the extent to which they would be interested in interacting with these targets ($1 = \textit{Not at All Interested}$; $7 = \textit{Very Interested}$) and targets' perceived valence ($1 = \textit{Completely Negative}$; $7 = \textit{Completely Positive}$) using single, face-valid items (e.g., Bernstein, Sacco, Brown, Young, & Claypool, 2010). Targets were presented in random order.

Consenting participants were initially primed with either the crowd or control image. Then, they indicated their state-level PVD. This was followed by the target assessment task. Finally, participants provided demographics information and were debriefed.

Results and Discussion

Manipulation check. Crowding-primed participants reported more negative affect ($M = -0.19$, $SD = 0.57$) than did control participants ($M = 0.57$, $SD = 1.25$), $t(318) = -5.30$, $p < .001$, $d = 0.59$. Crowding-primed participants reported feeling more crowded ($M = 5.18$, $SD = 1.39$) than did control participants ($M = 2.10$, $SD = 1.38$), $t(318) = 19.81$, $p < .001$, $d = 2.21$.

Primary analyses.

Pathogen-avoidant motives. We conducted a MANOVA using GA and PI as separate outcomes. No multivariate effect of Condition emerged, $F(2, 317) = 1.53$, $p = .218$, $\eta_p^2 = 0.010$. Univariate analyses additionally revealed no main effects for either subscale emerged, $F_s < 2.20$, $p_s > 0.145$. See Table 1 for relevant descriptive statistics for PVD across all 4 studies.

Obesity. We conducted a 2 (Condition: Crowding vs. Control) \times 2 (Target Health: Obese vs. Non-Obese) a mixed-model MANOVA with repeated factors over the latter factor, one for liking and another for valence of targets. For aversion, a main effect of Target Health emerged, such that participants liked nonobese targets ($M = 3.39$, $SD = 1.28$) more than obese targets ($M = 2.84$, $SD = 1.26$), $F(1,$

¹ See the OSF files for the crowding images used in all four studies.

Table 1
 Descriptive Statistics for State-PVD Subscales in All Four Studies

Study	GA		Cohen's <i>d</i>	PI		Cohen's <i>d</i>
	Crowd	Control		Crowd	Control	
Study 1	3.74 (1.21)	3.55 (1.14)	.16	4.39 (.98)	4.24 (.98)	.15
Study 2	4.26 (.94)	4.05 (.93)	.22	3.50 (1.19)	3.26 (1.08)	.21
Study 3	4.43 (1.08)	4.33 (.96)	.09	3.64 (1.36)	3.13 (1.09)	.37*
Study 4	4.31 (1.02)	4.06 (1.03)	.24**	3.47 (1.32)	3.23 (1.25)	.18*

Note. PVD = Perceived Vulnerability to Disease Scale; GA = germ aversion; PI = perceived infectability.
 * $p < .05$. ** $p < .01$.

318) = 189.51, $p < .001$, $\eta_p^2 = 0.373$. No main effect for Condition emerged, nor did the interaction, $F_s < 1.64$, $p_s > 0.202$.

For valence, another main effect of Target Health emerged, such that participants were more positive toward nonobese targets ($M = 4.32$, $SD = 0.78$) than obese targets ($M = 3.85$, $SD = 0.93$), $F(1, 318) = 158.73$, $p < .001$, $\eta_p^2 = 0.333$. Neither the main effect for Condition nor the interaction were significant, $F_s < 0.02$, $p_s > 0.900$.

No difference in aversion to obesity emerged as a function of crowd salience. This lack of influence could reflect an already pervasive, and multifaceted, stigma toward obesity that would persist irrespective of context (Puhl & Brownell, 2003). Perhaps a crowding manipulation was unnecessary in heightening stigma toward obesity, as obesity is already heavily stigmatized beyond its pathogenic connotation. Additionally, findings may suggest interpersonal preferences for healthy conspecifics during crowd salience may not reflect aversion to poor health, rather active preferences for good health. Especially heightened preferences toward features veridically connoting health similarly emerge among those with heightened BIS activation (Ainsworth & Maner, 2019; Young et al., 2011), thus suggesting crowd-induced BIS responses may serve to heighten vigilance toward good health cues.

Study 2

The lack of conditional effects for obesity suggests crowd salience may not elicit aversion to *unhealthy* conspecifics so much as it elicits preferences for *healthy* conspecifics. We thus found it prudent to consider cues to good health, particularly those with no other

social connotations. We considered facial symmetry in Study 2, as it is a robustly veridical cue to health. Individuals with symmetrical faces are more resistant to infectious disease, whereas deviations from symmetry (i.e., fluctuating asymmetry) are associated with an increased pathogen load (Thornhill & Gangestad, 2006; Van Dongen & Gangestad, 2011; but see Pound et al., 2014). Symmetrical faces are additionally perceived as healthy (Rhodes et al., 2007), forming the basis of subsequent preferences (Welling, Conway, DeBruine, & Jones, 2007). In fact, pathogen-avoidant motives heighten symmetry preferences both chronically and acutely (Ainsworth & Maner, 2019; Young et al., 2011), thus leading us to predict that crowd salience heightens preferences for facial symmetry.

We predicted that crowd salience would heighten preferences for cues to good health, such that crowding-primed individuals would report an especially heightened preference for symmetrical faces. Furthermore, previous findings demonstrating individual differences in pathogen-avoidant motives upregulate preferences for symmetrical faces (Ainsworth & Maner, 2019; Young et al., 2011), prompting us to consider state-level pathogen-avoidant motives in this study as a potential mediator for this effect.

Method

Participants. We recruited 221 undergraduates from a medium-sized public university in Southeastern U.S. for course credit (137 women, 83 men, 1 other; $M_{\text{Age}} = 20.43$ years, $SD = 5.02$, 68.3% White). We conducted no a priori power analysis but sought to collect as

many participants as possible over the course of the first half of a semester.

Materials and procedure.

Symmetry preferences. Participants indicated their preferences among face pairs manipulated to connote either symmetry or asymmetry (Quist et al., 2012). Specifically, the face pairs contained 10 male and 10 female faces and were presented in a randomized and counterbalanced order. Participants selected their preferred face in each pair, framed as a general context for preference, in a self-paced task assessing general preferences, with trials ending after participants indicated their preference. Symmetry preferences were coded as “1” and asymmetry as “0,” with higher values reflecting preferences for symmetry. We calculated relative composite symmetry preference scores by comparing frequency participants selected a symmetrical face by summing the frequency of selection and dividing it by total number of trials, separately for male and female targets.

Consenting participants initially experienced the priming procedure with being randomly assigned either to immerse themselves into a crowded or uncrowded environment; this procedure was identical to Study 1. This was followed by participants indicating their feelings of crowding ($\alpha = .95$) and affect before completing the state-level PVD measure ($\alpha_{GA} = 0.62$; $\alpha_{PI} = 0.83$). Then, participants indicated their symmetry preferences. Participants finally provided demographics information and were debriefed.

Results and Discussion

Manipulation check. Crowding-primed participants reported less positive affect ($M = -0.05$, $SD = 1.56$) than did control participants ($M = 0.59$, $SD = 1.22$), $t(219) = 3.41$, $p = .001$, $d = 0.46$. Further, crowding-primed participants reported feeling more crowded ($M = 5.10$, $SD = 1.46$) than control participants ($M = 2.05$, $SD = 1.37$), $t(209) = 15.99$, $p < .001$, $d = 2.15$.

Primary analyses.

Pathogen-avoidant motives. A MANOVA indicated no multivariate effect of Condition for both subscales, $F(1, 218) = 2.09$, $p = .126$. Univariate subscale analyses indicated no effect of Condition on either subscale individually, $F_s < 2.96$, $p_s > 0.086$.

Symmetry preferences. We conducted a 2 (Condition: Crowding vs. Control) \times 2 (Target Sex: Male vs. Female) with repeated factors over the latter factor. Participants preferred symmetry to a greater extent in female faces ($M = 0.92$, $SD = 0.13$) than in male faces ($M = 0.89$, $SD = 0.15$), $F(1, 219) = 19.97$, $p < .001$, $\eta_p^2 = 0.082$. Crowding-primed participants additionally reported greater preferences for facial symmetry ($M = 0.92$, $SD = 0.11$) than control-primed participants ($M = 0.89$, $SD = 0.14$), $F(1, 219) = 3.96$, $p = .048$, $\eta_p^2 = 0.018$. No Condition \times Target Sex interaction emerged, $F(1, 219) = 0.89$, $p = .347$, $\eta_p^2 = 0.004$.

Unlike obesity, crowd salience heightened preferences for facial symmetry. That is, the basis of crowding-induced interpersonal preferences appears to have a basis in selecting healthy conspecifics rather than avoiding those who appear unhealthy. Given the potential difficulty in removing oneself from a crowd, it would seem more efficient for individuals to identify healthy affiliative opportunities within such an environment. As with Study 1, no significant difference emerged for state-level pathogen-avoidant motives. Nonetheless, as indicated in Table 1, crowd-primed participants ultimately reported descriptively higher levels of germ aversion and perceived infectability than did control-primed participants. We thus found it prudent to continue considering such self-reports as potential mechanisms for interpersonal preferences.

Study 3

Moving away from evaluations of social targets' facial and bodily features connoting health, we sought to consider how crowd salience influences higher-order processes of group formation related to disease threat in Study 3. We specifically considered how crowd salience shapes prejudicial attitudes toward novel outgroup members in the service of limiting exposure to those heuristically associated with disease (e.g., Faulkner, Schaller, Park, & Duncan, 2004). Indeed, aversion to ethnic outgroups is partially based on overgeneralization of groups as virulent to ingroup members (Petersen, 2017; van Leeuwen & Petersen, 2018), implicating immigrants as heuristic disease threats that could be amplified in crowded settings. Disease salience heightens both anti-

immigration attitudes and endorsement of similar policies, which suggests crowding-induced pathogen avoidance could facilitate such attitudes (Aarøe, Petersen, & Arceneaux, 2017; Brenner & Inbar, 2015; Brown, Keefer, Sacco, & Bermond, 2019).

Previous research additionally indicates a composition of outgroup members heightens individuals' perceptions of a crowd as physically threatening (Maeng & Tanner, 2013), suggesting that outgroup crowding could be pathogenically threatening. In this study, we predicted that crowd-induced BIS responses would be especially heightened among individuals perceiving themselves as part of an outgroup environment. Specifically, we predicted that crowd salience would heighten aversion toward immigration. We additionally considered state-level pathogen-avoidant motives again to identify potential mediational effects between crowd salience and anti-immigration attitudes, although the primary focus of this study was to identify the effects of crowding on immigration attitudes.

Method

Participants. We recruited 164 undergraduates for a laboratory study in exchange for course credit. We excluded 6 participants from final analyses based on undergraduate research assistants' observations of the participants being nonconscientious throughout the study (e.g., quickly clicking through instructions, using phone during experiment), leaving a total of 158 participants (122 women, 35 men, 1 other; $M = 20.08$, $SD = 2.93$; 51.3% White). The goal for this study was to collect as many participants possible in the lab throughout the course of the semester while stopping before the final week of data collection. Given that this study considered immigration issues, we asked participants their political affiliation using a single-item measure (1 = *Very Liberal*; 7 = *Very Conservative*; $M_{Grand} = 3.96$, $SD = 1.51$). When considering political affiliation in the model, it did not influence our results, prompting us to consider it no further.

Materials and procedure.

Anti-immigration attitudes. We assessed participants' general anti-immigration sentiment using a 15-item measure of endorsement for various anti-immigration policies (Mukher-

jee, Molina, & Adams, 2012). Items operated on a 7-point scale with higher scores indicating greater endorsement of anti-immigration policies (e.g., "States should have the right to question people about their immigration status if they suspect they are in the U.S. illegally," 1 = *Strongly Disagree*; 7 = *Strongly Agree*) and demonstrated acceptable reliability ($\alpha = .85$; $M_{Grand} = 3.33$, $SD = 1.04$).

Public health threat. We assessed the extent to which participants perceived immigrants as a threat to public health using a 6-item measure (Brown et al., 2019). Items operated along with a 7-point scale with higher scores greater perceptions of immigrants posing a threat to public health (e.g., "Allowing immigrants into our country is a threat to public health," $M_{Grand} = 3.16$, $SD = 1.39$; 1 = *Strongly Disagree*; 7 = *Strongly Agree*; $\alpha = .88$).

Border walls. We also assessed the degree to which participants endorsed building physical barriers from potential disease threats by erecting border walls with Mexico and Canada (Brown et al., 2019). Participants' decisions operated on 10-point scales ranging from 0 to 40 + feet. Participants specifically indicated the height they wanted the wall to be within increments of five (i.e., 1–5 feet). Because the location of the border wall did not interact with study conditions, we collapsed across them for primary analyses ($M_{Grand} = 2.54$, $SD = 3.09$).

Social distance. We assessed participants' desire for social distance from immigrants using a single, face-valid item through which participants indicated the type of relationships they would find most comfortable for them with an immigrant (Szczurek, Monin, & Gross, 2012). The scale operated on a 7-point scale, with 1 indicating a close, person friend or romantic partner and 7 indicating someone living in my state (i.e., considerable distance from the participant; $M_{Grand} = 2.74$, $SD = 2.01$).

Upon entering the laboratory, consenting participants were initially randomly assigned to either a crowding or control condition, as in the previous two studies. In addition to this manipulation, participants were also instructed to view the environment in question as being either within the United States or abroad. It should be noted that the laboratory sessions occurred at separate cubicles with a desk's distance between participants, and research assistants being required to keep considerable dis-

tance, to minimize uncontrolled physical contact to ensure only the computerized manipulation was influencing crowd salience. This was followed by the manipulation checks for affect and crowding ($\alpha = .95$) and then the state-level PVD scale ($\alpha_{GA} = 0.68$; $\alpha_{PI} = 0.87$). Then, participants completed the four anti-immigration measures in random order. Finally, participants completed demographic information and were debriefed.

Results

Manipulation check. We conducted a pair of 2 (Condition: Crowding vs. Control) \times 2 (Location: Domestic vs. Foreign) ANOVAs for affect and feelings of crowding separately. Crowding-primed participants reported less positive affect ($M = 0.46$, $SD = 1.45$) than control-primed ($M = 1.21$, $SD = 1.20$), $F(1, 153) = 12.40$, $p = .001$, $\eta_p^2 = 0.075$. Crowding-primed participants reported feeling more crowded ($M = 4.99$, $SD = 1.62$) than control-primed participants ($M = 1.84$, $SD = 1.10$), $F(1, 154) = 203.91$, $p < .001$, $\eta_p^2 = 0.570$. No main effects of Location emerged, nor were there interactions, $F_s < 1.58$, $p_s > 0.210$.

Pathogen-avoidant motives. We conducted a 2 (Condition: Crowding vs. Control) \times 2 (Location: Domestic vs. Foreign) MANOVA with both subscales of PVD as outcomes. A multivariate effect emerged for Condition, indicating that crowd salience generally heightened pathogen-avoidant motives ($M = 4.03$, $SD = 1.22$) than did the control condition ($M = 3.73$, $SD = 1.02$), $F(2, 153) = 3.33$, $p = .038$, $\eta_p^2 = 0.042$. Univariately, a main effect of Condition for PI indicated crowd-primed participants reported higher PI than did control-primed, $F(1, 154) = 6.69$, $p = .011$, $\eta_p^2 = 0.042$. No difference emerged in GA for crowd- and control-primed participants, $F(1, 154) = 0.39$, $p = .534$, $\eta_p^2 = 0.003$. Neither the main effect of Location emerged nor did the interaction, $F_s < 1.25$, $p_s > 0.288$.

Anti-immigration. We conducted a 2-way MANOVA for the four anti-immigration measures. Neither main effects nor interactions were significant, $F_s < 2.18$, $p_s > 0.143$.

Although our measures for anti-immigration attitudes were not affected by the crowding manipulation, the corpus of our findings may nonetheless represent a nuance in how crowd

salience influences threat perception. This lack of effects could be rooted in the distal nature of the measures. These measures addressed long-term plans to mitigate contact with immigrants rather than addressing the proximal concerns more salient with our more acute prime of crowd salience. Crowding activates sympathetic nervous system responses, which would be in the service of creating distance with immediate danger (e.g., Aiello et al., 1977; Baum & Valins, 1979; Stockdale, 1978). Dependent measures assessing desire for social policies to restrict immigration (e.g., border walls) may be too far removed from the proximal goals individuals must satisfy when crowd salience provides an immediate threat.

Crowd location did not moderate these effects. This lack of moderation could have occurred for several reasons. First, crowd salience could have sufficiently heightened pathogen concerns regardless of that crowd's content. Conversely, it may be possible that the manipulation for the crowd's nationality less capable of eliciting a disease cue compared to other manipulations of conspecifics' group status. For example, previous findings have used visual stimuli to connote group membership, whether it be displaying images of conspecifics as belonging to another race (e.g., Petersen, 2017) or having an image of the crowd wearing a color associated with the assigned color of an out-group in a minimal group paradigm (Maeng & Tanner, 2013). Future research would benefit from considering other salient cues to group membership in crowds.

Unlike in Studies 1 and 2, we found evidence of crowd salience significantly heightening pathogen-avoidant motives on a multivariate level. When considering which aspect of these motives was affected, crowd salience heightened participants' perceived infectability. This difference could reflect recognition of others' close proximity leaving them vulnerable to physical contact that could facilitate disease transmission. Indeed, densely populated areas pose considerable risk of infection (Jones et al., 2008) and individuals may recognize this risk when crowding cues are salient (Wang & Ackerman, 2019). Conversely, no effect emerged for germ aversion, which could indicate a level of specificity in pathogen-avoidant responses toward crowds. Heightened germ aversion may not be a functional response for individuals

already in densely populated areas with no ability to increase distance from others.

The preceding three studies identified how crowd salience specifically influences preferences for physical and social features connoting pathogenic threat. Specifically, whereas crowd salience heightens preferences toward cues indicative of good health, namely facial symmetry, it appears unrelated to aversion to cues indicative of poor health or pathogenic novelty (i.e., immigration). These findings suggest that crowd salience specifically heightens perceptual acuity toward features veridically indicative of pathogen load rather than features heuristically associated with infection risk (see Miller & Maner, 2012; Petersen, 2017). Additionally, all three studies descriptively revealed crowd salience heightened perceived pathogen-avoidant motives, with Study 3 revealing a statistically significant effect of crowd salience enhancing perceived infectability. We thus conducted Study 4 with the statistical power sufficient to determine the robustness of this relation between crowd salience and perceived vulnerability to disease, which also included additional manipulation checks to ensure that the effect was due to crowding perceptions specifically, and not negative affect more generally.

Study 4

The purpose of Study 4 was to identify the extent of the effects of crowd salience on pathogen-avoidant motives in a large-scale replication. Given the possibility that the three previous studies could have been underpowered, we sought to amplify our sample size to ensure ourselves the capability of detecting subtle effects. Additionally, although crowd-avoidant motives appeared activated throughout the previous studies, as evidenced by the manipulation check items, an anonymous reviewer indicated in a previous draft of this paper that these items may possess demand characteristics about them and not necessarily address other negative motivational states that could have been activated. These concerns prompted us to consider the extent to which crowding-avoidant motives may be activated relative to other motives with additional motivational assessments. We specifically preregistered the hypothesis that crowd salience would heighten pathogenic motives. We additionally specified in this preregistration

the materials and measures used and the sample size.

Method

Participants. We recruited 505 workers through Amazon's Mechanical Turk in exchange for \$0.40 (US) for their participation (273 men, 229 women, 2 other, 1 undisclosed; $M_{\text{Age}} = 37.04$ years, $SD = 11.85$; 73.3% White). This sample size was determined a priori as part of our preregistration effort using a small effect-size power analysis (Cohen's $d = 0.25$, $\beta = 0.80$). The preregistration plan for this study is provided in the OSF link.

Materials and procedure. We modified the crowding prime to reflect a more general context of individuals in a public space, because this sample was not primarily comprised of college students. Participants were then presented the same affect and manipulation check items, in addition to 3 items we designed to address concerns of demand characteristics assessing anxiousness, motivation to withdraw, and motivation to confront others (item was reverse-scored); the latter two items were selected given previous research indicating that crowd salience facilitates deference toward others and the fact that they brought greater subtlety to identifying whether crowding-avoidant motives were activated (Baum & Valins, 1979). Items demonstrated acceptable reliability when aggregated ($\alpha = .88$).

Additionally, given the previous studies demonstrating a general affective difference between conditions, we assessed participants' activation of two additional negative states to identify that crowding-avoidant motives were specifically activated through this prime. Specifically, we assessed how lonely participants felt, a proxy for activation of affiliative motives, and how hungry they felt, a proxy for more basal survival needs that could be activated in the presence of competition cues; items operated on the same 7-point scales described previously for manipulation checks. This was followed by state-PVD ($\alpha_{\text{GA}} = 0.63$; $\alpha_{\text{PI}} = 0.84$). Finally, participants provided demographics information before debriefing and compensation.

Results and Discussion

Manipulation checks. Like with previous studies, crowding-primed participants reported

less positive affect ($M = 0.12$, $SD = 1.65$) than did control-primed participants ($M = 1.22$, $SD = 1.31$), $t(491.52) = -8.26$, $p < .001$, $d = 0.74$. Crowding-primed participants additionally reported greater activation of crowding-avoidant motives ($M = 4.96$, $SD = 1.23$) than control-primed participants ($M = 2.77$, $SD = 1.28$), an effect that persisted with the inclusion of the new items, $t(502) = 19.50$, $p < .001$, $d = 1.70$. Furthermore, no differences emerged for loneliness and hunger between both conditions, $|t| < 1.43$, $ps > 0.150$, $ds < 0.30$. This suggests affect effects appear most attributed to the activation of negative motivational states specific to crowding.

Primary analysis. We conducted a MANOVA as we did in the previous studies with both subscales as the outcomes. A multivariate effect emerged for Condition indicating higher levels of pathogen-avoidant motives among crowding-primed participants ($M = 3.89$, $SD = 1.17$) than control-primed participants ($M = 3.64$, $SD = 1.14$), $F(2, 501) = 4.32$, $p = .001$, $\eta_p^2 = 0.017$. Univariately, crowding-primed participants reported greater state-level GA than did control-primed participants, $F(1, 502) = 7.32$, $p = .007$, $\eta_p^2 = 0.014$. Crowding-primed participants also reported greater state-level PI than control-primed participants, $F(1, 502) = 4.42$, $p = .036$, $\eta_p^2 = 0.009$.

In a high-powered preregistered study, we found evidence of how crowd salience heightens pathogen-avoidant motives. Although inconsistent with results of the previous three studies, these results may provide a more representative example of the overall effect, as our sample was substantially larger, thereby increasing the likelihood of detecting subtle effects. With the saturation of affiliative motives through extensive affiliative contact, individuals may begin to recognize the interpersonal costs of such contact and favor of affiliation with those who appear less pathogenically threatening (Brown & Sacco, 2016; Sacco et al., 2014). Effects in Study 4 are consonant with previous research implicating crowded environments as pathogenically threatening, with humans possessing acuity toward the potential risks of affiliation (e.g., Jones et al., 2008; Wang & Ackerman, 2019). As individuals identify considerable density within a salient environment, participants appeared to recognize the personal space violations from others that necessitate prudence in interper-

sonal behavior, manifesting as heightened perceived vulnerability to disease (Gochman & Keating, 1980).

In replicating the multivariate effect from Study 3, crowd-primed participants were indeed more pathogen-avoidant compared to control-primed participants. However, unlike Study 3, this effect was apparent for both PI and GA. The continued heightened PI could reflect heightened vigilance toward pathogen cues. For GA, which was not significantly heightened in Study 3, the significant effect in the current study may reflect the decontextualized immersion into the image. That is, whereas the previous studies presented the environment as a college campus to college students, which could have arguably been familiar to undergraduates, this study utilized a more generic environment that may have fostered greater environmental uncertainty and would therefore amplify the effects in a manner previous studies could not.

General Discussion

The current program of research sought to identify how activation of crowding-avoidant motives subsequently activates pathogen-avoidant responses toward potential disease threats. Specifically, we found that crowd salience heightened preferences for facial symmetry, but not aversion to obesity or endorsement of anti-immigration policies. These findings could suggest that acute activation of crowding concerns elicits threat management processes toward proximal threats, but not distal (Kenrick, Griskevicius, Neuberg, & Schaller, 2010). That is, participants could have been motivated to avoid diseased conspecifics within close proximity, whereas concerns about long-term policy-making could have been downregulated in the service of more immediate threats; such discernment could explain the discrepancy in effects across Study 3. The salience of proximal goals could further have led participants to identify threats pertaining to acute health problems rather than chronic. Given that facial asymmetry is associated with infection risk (Thornhill & Gangestad, 2006), and disease salience heightens aversion to asymmetry (Young et al., 2011), it would be advantageous for those who feel crowded to prefer those whose faces connote reduced susceptibility to infection. Conversely, although obesity is heuristically associated with

disease (Miller & Maner, 2012; Park et al., 2007), it is nonetheless a chronic health issue and crowd salience may specifically attune individuals to identify direct infection risks relative to inferred risk because of the fight-or-flight response elicited by personal space violations.

We additionally considered self-reported pathogen-avoidant motives through a state-level modification of the Perceived Vulnerability to Disease Scale, which yielded mixed findings. That is, whereas crowd salience elicited no significant difference in pathogen-avoidant motives in Studies 1 and 2, Studies 3 and 4 found both multivariate evidence for crowd salience heightening such motives, albeit with mixed evidence on a univariate level. This inconsistency in effects could reflect a subtlety in the effects of crowding responses or the fact that activation of such motives may require more chronic salience of an ecological threat. Indeed, previous findings demonstrate that acutely activating concerns of population density is less robust in slowing down individuals' life history relative to a chronic presence of such threats, with larger samples being more capable of identifying these subtleties (Sng et al., 2017).

Limitations and Future Directions

Given the amount of discrepancy in findings across all four studies, results should be interpreted with caution, which should ultimately inform directions for future research. The inconsistencies in responses to state-PVD may reflect a stable manifestation of pathogen-avoidant motives that could be less resistant to momentary infection concerns. Although we considered these individual differences on a state level, given that personality manifests through both chronic and acute activation (McConnell, 2011), perceived infectability and germ aversion are nonetheless largely dispositional differences and any change in these motives could be especially subtle and require the larger sample in Study 4. The potential subtlety could largely reflect chronic salience of a threat being the basis of whether individuals' pathogen-avoidant motives are activated. Repeated exposure to pathogenically threatening cues would likely heighten pathogen-avoidant motives to a greater degree relative to momentary disease salience (Tybur, Frankenhuis, & Pollet, 2014). Similar principles may be applied to

crowd salience in future work, wherein changes in participants' pathogen-avoidant motives are tracked as a function of chronic population density (Sng et al., 2017).

Research could additionally consider using actual crowded environments beyond merely rendering them salient. Specifically, an experiment could place participants in a room either densely populated with confederates (or not) before assessing state pathogen-avoidant motives (e.g., Aiello et al., 1977; Baum & Valins, 1979). Even further, utilizing confederate manipulations provides an outlet to consider dynamic disease cues. Confederates within a laboratory setting could start coughing or sneezing while interacting with participants, thereby amplifying crowd virulence (Lee, Schwarz, Taubman, & Hou, 2010). Conversely, such manipulations could lend themselves to determining whether healthy crowds ameliorate BIS responses, including comparing state-PVD for those in crowds of highly attractive or unattractive people (Fink, Neave, Manning, & Grammer, 2006; Rhodes et al., 2007; Thornhill & Gangestad, 2006; but see Cai et al., 2019).

Individual differences in responses to crowd salience. The considerable asymmetry in men and women in the first two studies and lack of a priori predictions for sex differences in Study 4, precluded us from considering participant sex differences, which could have elucidated on the lack of effects in Studies 1 and 2. Recent findings indicate pathogen-avoidant motives heighten women's preferences for symmetry and introversion in male faces (Ainsworth & Maner, 2019; Brown & Sacco, 2016), implicating such motives as serving to mitigate contact with diseased mates and reduce the likelihood of contracting sexually transmitted infections. Women already experience dispositionally higher levels of pathogen and sexual disgust relative to men (Al-Shawaf, Lewis, & Buss, 2018), suggesting crowd salience could influence their decisions when interacting with prospective mates more than men. Future research would benefit from considering cross- and same-sex perceptions of social targets following a crowding prime with larger male samples.

Considering crowd salience in mating domains could position researchers to address individual differences in life history. Although previous research indicates that individuals in densely populated environments report slower

life history strategies, as indexed by restricted sociosexuality (Sng et al., 2017), dispositionally slow life history could potentially render individuals especially sensitive to threat cues in their environment. Those adopting slow life histories invest more resources to reduce contact with pathogenic threat (Hill, Boehm, & Prokosh, 2016), which may suggest cautious behavioral repertoires in response to crowd salience could only be apparent in such individuals. Future research would benefit from assessing life history speed to clarify which individuals are prone to effects of crowd salience.

Additional pathogen-avoidant responses to crowd salience. Future research would benefit from considering specific approach/avoidance behaviors following a crowding experience. In an embodied flexion/extension task, participants could flex or extend a joystick, behavioral proxies for approach and avoidance responses, respectively, toward pathogenically threatening and nonthreatening stimuli (Mortensen et al., 2010). Given the heightened neural activity implicated in avoidance elicited by crowds (Kennedy et al., 2009), another study could consider utilizing a line bisection task to determine how facial features connoting health and disease elicit approach/avoidance responses, as evidenced by visual field biases (Brown, Sacco, & Medlin, 2019; Slepian, Young, & Harmon-Jones, 2017). Future studies could also employ measures of desired proximity relative to healthy or unhealthy confederates, with crowding making participants especially prone to sitting a greater distance from someone who appears ill (Kawakami, Phillips, Steele, & Dovidio, 2007).

Throughout this program of research, we identified physical cues indicative of health that predict interpersonal preferences following crowd salience. Nonetheless, several other physical cues to health did not appear affected by the manipulation, thus necessitating further consideration of other physical cues, particularly those related to acute infection risk. Beyond the potential communicative properties of symmetry is a typical facial appearance of an individual infected with a communicable disease for which humans demonstrate considerable perceptual acuity (Axelsson et al., 2018; Tskhay, Wilson, & Rule, 2016). Future studies could consider how crowding affects this sensitivity.

Conclusion

The current program of research investigated the interplay between crowding- and pathogen-avoidant motives. Specifically, these findings identified how crowd salience shapes interpersonal preferences in terms identifying healthy affiliative opportunities as well as recognizing the subtlety of these effects. This preliminary evidence for how proximity violations motivate the mitigation of pathogenic threats and when. It additionally provides bases for future research to investigate how ecological factors influence human motivation.

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