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The behavioral immune system in action: Psychological correlates of pathogen disgust sensitivity in healthcare professionals working in a COVID-19 hospital

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ABSTRACT

The behavioral immune system includes a set of proactive mechanisms that inhibit contact with pathogens in the first place. These mechanisms offer a sort of psychological and behavioral prophylaxis against infection. The aim of this study was to assess the functionality of the behavioral immune system under conditions of strong ecological validity. Our hypothesis was that the emotional and more primitive component of the behavioral immune system (i.e. pathogen disgust sensitivity) acts as a powerful predictor of fear of infection. The sample was made up of 101 healthcare professionals working in a COVID-19 hospital when vaccination was not yet available. We conducted a hierarchical regression analysis to assess the role of germ-related disgust in modulating levels of fear. After controlling for the significant effects of depressive symptoms and exposure to people with a confirmed diagnosis of COVID-19, we found that fear of infection was more intense in those healthcare workers who reported higher levels of germ-related disgust. Fear of infection was not related to perceived infectability, an individual variable informed by more rational cognitive appraisals. These findings show that, even in healthcare workers who can take advantage of their professional knowledge and acquired skills for rational appraisals, the most primitive component of the behavioral immune system still plays a major role in eliciting fear of COVID-19. It is likely that the psychological reactions elicited by the behavioral immune system promote preventive health behaviors in modern environments as well.

1. Introduction

In molecular genetics, physiology, and general pathology, the study of the evolution of the human immune system is an expanding research area [16]. Through our biological history, selection pressures have caused the evolution of a sophisticated suite of genetic and physiological adaptations that mediate resistance to infectious diseases. In spite of its paramount importance in fighting infections, a drawback of the physiological immune defense is the fact that it is triggered only after the infection has occurred within the body. This implies considerable energy costs. When stimulated by pathogens, energy demands increase significantly, raising basal metabolic rate between 9 and 30 percent or more (e.g. 50% in the case of sepsis) [26].

Schaller [21] has convincingly demonstrated that selection pressures have reinforced our defenses against infections by causing the evolution of a behavioral immune system that is separate from, and complementary to, the physiological immune system. The behavioral immune system includes a set of proactive mechanisms that inhibit contact with pathogens in the first place. These mechanisms offer a sort of psychological and behavioral prophylaxis against infection [10,22]. Studies of non-human species have shown that pathogen disgust sensitivity is a major adaptation against infection [6,12]. Likewise, in humans, the emotional reaction most strongly associated with the activation of the behavioral immune system is pathogen disgust sensitivity [28].

The discovery of the behavioral immune system is a major contribution of evolutionary thinking to the study and prevention of infectious diseases. A deeper knowledge of its mechanisms, triggering factors and inter-individual variation is likely to improve public health strategies to

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reduce the prevalence of infectious diseases. The COVID-19 pandemic presents a unique opportunity to test the evolutionary hypothesis that emotional reactions are a major component of self-protection against the risk of infection. Since the first wave of the COVID-19 pandemic, several studies have investigated the activation of the behavioral immune system in response to a global infective threat [17,19,23,27]. However, to our knowledge, no study has been conducted in healthcare workers, a subgroup differing from the general population for a number of features that are likely to impact the functionality of the behavioral immune system.

The aim of this study was to assess the functionality of the behavioral immune system under conditions of strong ecological validity. Our sample was made up of healthcare professionals working in a COVID-19 hospital when vaccination was not yet available. Participants were facing a high risk of contracting a potentially severe viral infection as shown by mortality statistics. At the same time, compared to the general population, they had a better knowledge of infection risk factors and were consistently adopting preventive measures because of their professional duties. Thus, they were the ideal sample to study the interaction between emotional and rational psychological factors in modulating individual levels of fear of infection. Our hypothesis was that, after controlling for the effects of confounding variables, the emotional and more primitive component of the behavioral immune system (i.e. pathogen disgust sensitivity) still acted as a powerful predictor of fear of infection.

2. Methods

2.1. Participants

Participants were 101 healthcare professionals working in a major university hospital that was converted into a COVID hospital in spring 2020. Participants were recruited in the period between June and August 2020 as a convenience sample. In Italy, the COVID-19 pandemic was particularly invasive during the period between March and late April, then decreased in both the number of infections and in the seriousness of the illness throughout the summer of 2020 [7]. The study was conducted when vaccination was not yet available. All healthcare workers attending the hospital (including the participants of this study) were obliged to adhere to the same strict preventive measures to reduce the risk of infection, independently of their professional roles.

Participants' mean age was 39.35 years (SD = 11.52, range: 21–70). In total, 64 were women and 67 were physicians. Among physicians, 61% were women. Other professional roles included nurses and laboratory technicians. Paper questionnaires were used to collect data. Participation was voluntary, and anonymity was guaranteed. Written informed consent was obtained prior to participation. The study was approved by the Ethical Committee of the Department of Dynamic and Clinical Psychology, Sapienza, University of Rome (Prot. n. 0,000,453 and Prot. n. 0,000,112).

2.2. Measures

2.2.1. Fear of COVID-19 (FCV-19S)

Ahorsu et al. [2] have developed a brief and valid scale (FCV-19S) to capture an individual's fear of COVID-19. The FCV-19S is a seven-item scale (e.g. "I am most afraid of coronavirus-19″, "My heart races or palpitates when I think about getting coronavirus-19″). The participants are asked to indicate their level of agreement with the statements using a five-item Likert type scale. Answers included "strongly disagree," "disagree," "neither agree nor disagree," "agree," and "strongly agree". The minimum score possible for each question is 1 and the maximum is 5. A total score is calculated by adding up each item score (ranging from 7 to 35). The higher the score, the greater is the fear of COVID-19. The Italian validation of the FCV-19S [25] used in this study showed robust psychometric properties (alpha = 0.82) and confirmed its stable unidimensional structure.

2.2.2. Perceived stress scale (PSS-10)

The PSS is a 10-item self-report measure of the degree to which an individual perceives their life to be unpredictable, uncontrollable, and overburdened in the past month. Respondents are asked to answer 10 questions on a five-point scale ranging from 0 (never) to 4 (very often). Example items include "In the last month, how often have you been upset because of something that happened unexpectedly?" Higher scores indicate higher levels of perceived stress [4]. In this study, we used the validated Italian version of the PSS (alpha = 0.79) [18].

2.2.3. The patient health questionnaire-9 (PHQ-9)

The PHQ-9 is a 9-item self-report scale designed to measure the severity of depressive symptoms [14]. The PHQ-9 score can range from 0 to 27, since each of the 9 items can be scored from 0 (not at all) to 3 (nearly every day). Scores greater than 9 reflect a likely condition of clinical depression. The Italian version used in this study showed good internal consistency (alpha = 0.80).

2.2.4. The perceived vulnerability to disease (PVD) scale

To measure the activation of the behavioral immune system, we used the PVD scale. The PVD scale is a measure assessing participants perceived susceptibility to catching infectious disease and their aversion to pathogens [8]. The PVD consists of 15-items divided into two subscales. The Germ Aversion subscale (GA; 8 items; alpha = 0.81) measures aversive response in relation to potential pathogen transmission (e.g., "I prefer to wash my hands pretty soon after shaking someone's hand"). The Perceived Infectability subscale (PI; 7 items; alpha = 0.78) measures perceived susceptibility to infectious diseases in general (e.g., "I am more likely than the people around me to catch an infectious disease"). Germ Aversion predicts responses rooted in intuitive emotional appraisals of risk, whereas Perceived Infectability predicts responses informed by more rational cognitive appraisals. All ratings of items were made on a scale ranging from 1 ("strongly disagree") to 7 ("strongly agree"). A total score for each subscale was created by adding up each item score. Higher scores reflect greater germ aversion or perceived infectability.

2.3. Statistical analyses

Statistical analysis was performed on a personal computer using SPSS for Windows, version 25.0 (SPSS, Inc., Chicago, Ill.). Pearson correlation coefficient was used to calculate zero-order correlations. Gender differences on the psychometric scales were calculated by using one-way ANOVAs. Hierarchical multiple regression analysis was used to test the hypothesis that germ aversion was a significant predictor of infection fear. There were no violations of the assumptions required by multiple regression. In particular, we used the Durbin–Watson statistic (value = 1.60) to check that the values of the residuals were independent, and variation inflation factors (VIF) scores (ranging from 1.03 to 2.44) and tolerances scores (ranging from 0.41 to 0.97) to check that there was no multicollinearity among the independent variables.

3. Results

Table 1 reports zero-order correlations between the FCV-19S and the other psychometric measures. Fear of infection was greater in participants reporting higher levels of perceived stress, depressive symptoms and germ aversion. The correlation between the FCV-19S and the subscale of the PVD measuring perceived infectability was weak and non-significant. There were no significant differences between women and men in terms of fear of infection, perceived stress, depressive symptoms, germ aversion and perceived infectability (p ranging from 0.08 for perceived stress and 0.75 for depressive symptoms).

A one-way ANCOVA with age and gender as covariates showed that

Table 1
Correlation matrix of the psychometric measures. ** significant at 0.01 level; * significant at 0.05 level.

VARIABLES	FCV-19S	PSS-10	PHQ-9	PVD-GA	PVD-PI
FCV-19S	1				
PSS-10	0.38**	1			
PHQ-9	0.51**	0.72**	1		
PVD-GA	0.49**	0.20*	0.22*	1	
PVD-PI	0.19	0.15	0.25*	0.15	1

Legend: FCV-19S, Fear of COVID-19 scale; PSS-10, Perceived Stress Scale; PHQ-9, The Patient Health Questionnaire; PVD-GA, Germ Aversion subscale of the Perceived Vulnerability to Disease scale; PVD-PI, Perceived Infectability subscale of the Perceived Vulnerability to Disease scale.

participants who had been exposed to people with a confirmed diagnosis of COVID-19 scored higher on the FCV-19S ($F = 10.64$; df = 1,98, $p < 0.01$).

We conducted a hierarchical regression analysis to assess the role of germ-related disgust in modulating levels of fear of infection. The dependent variable was the FCV-19S. In the first step of the regression analysis, we entered age and gender as predictors. In the second step, we entered the PSS-10, the PHQ-9, and direct exposure to people with a confirmed diagnosis of COVID-19. In the third and final step, we entered the two subscales of the PVD (Table 2).

The model including the variables (i.e., age, gender, PSS-10, PHQ-9, and exposure) entered in the first two steps to control for their possible confounding effects explained 34.9% of the variance in FCV-19S scores. The inclusion of the two PVD scales in the final model increased the percentage of explained variance to 47.6%. The three significant predictors were PVD-GA, exposure, and PHQ-9. PVD-GA was the stronger predictor whereas there was no significant correlation between PVD-PI and FCV-19S. In sum, we found that, after controlling for the significant effects of depressive symptoms and exposure to people with a confirmed diagnosis of COVID-19, fear of infection was more intense in those healthcare workers who reported higher levels of germ-related disgust. Fear of infection was not related to perceived infectability.

4. Discussion

Ackerman et al. [1] argued that the evolutionary history of the behavioral immune system, and the cues that activate it, are distinct in many ways from modern human experiences with pandemics. Focusing on emotional mechanisms, they note that: "many of the routes through which COVID-19 is transmitted (e.g., invisible respiratory droplets from asymptomatic individuals) do not involve cues that elicit emotions like disgust. And though people may commonly experience anxiety about aspects of this pandemic, many other emotional reactions associated with the COVID-19 crisis (e.g., anger, frustration, depression) likely do not serve pathogen-avoidance functions" (p. 182). Thus, they conclude that the psychological reactions elicited by the behavioral immune system may have limited utility for combating pandemic diseases like COVID-19.

Table 2
Results of hierarchical regression analysis with fear of COVID-19 as the dependent variable ($N = 101$).

			FCV-19S	
		β	t	p
Step 1	Age	0.29	3.00	< 0.01
	Gender	−0.04	−0.44	0.66
	Model	R^2=0.09	$F = 4.95$	< 0.01
Step 2	Exposure	0.24	2.80	< 0.01
	PSS-10	0.05	0.42	0.67
	PHQ-9	0.39	3.04	< 0.01
	Model	ΔR^2=0.26	ΔF=12.50	< 0.01
Step 3	PVD-PI	0.02	0.20	0.84
	PVD-GA	0.37	4.67	< 0.01
	Model	ΔR^2=0.13	ΔF=11.24	< 0.01
		R^2=0.48	$F = 12.54$	< 0.01

Legend: FCV-19S, Fear of COVID-19 scale; PSS-10, Perceived Stress Scale; PHQ-9, The Patient Health Questionnaire; PVD-GA, Germ Aversion subscale of the Perceived Vulnerability to Disease scale; PVD-PI, Perceived Infectability subscale of the Perceived Vulnerability to Disease scale.

The findings of the present study do not support Ackerman et al.'s argument. We found that germ-related disgust was the most significant predictor of fear of infection in healthcare professionals working in a COVID-19 hospital when vaccination was not yet available. Of note, their scores on a scale measuring perceived infectability were not correlated with fear of infection. Thus, in a sample of individuals with professional knowledge on COVID-19 and adopting strict preventing measures to avoid it, primitive emotional appraisals of risk override more rational cognitive considerations in causing fear of infection.

Our findings are in accord with those of previous studies that have investigated the relationship between pathogen disgust sensitivity and fear of COVID-19. In a nationally representative sample of 1023 individuals residing in the US, Shook et al. [23] found that germ aversion (but not perceived infectability) and pathogen disgust sensitivity were the two variables most consistently associated with COVID-19 concern. Cox et al. [5] found that individual levels of disgust proneness reported by 360 volunteers four years before the COVID-19 outbreak predicted increased coronavirus anxiety during the pandemic. In a large sample recruited online through social media platforms, Makhanova and Shepherd [17] found that both germ aversion and perceived infectability were significantly correlated with higher levels of anxiety about COVID-19. Yet, the correlation with perceived infectability was weaker.

To function as a pathogen-avoidance adaptation, germ aversion and disgust sensitivity should translate into behaviors that are likely to reduce the risk of infection. Findings from the studies reported above suggest that this is the case. In the study by Shook et al. [23], germ aversion correlated with the frequency of preventive health behaviors such as social distancing, avoid touching face, wearing facemask, hand washing and disinfecting objects. In the study by Cox et al. [5], heightened disgust proneness before the pandemic resulted in an increased use of protective behaviors in the midst of the pandemic. In the study by Makhanova and Shepherd [17], germ aversion was negatively associated with the number of face-to-face interactions in the past seven days and positively associated with anxiety about social proximity. Overall, these findings indicate that the psychological reactions elicited by the behavioral immune system may reduce the risk of infection in modern environments as well.

Unlike data on preventive health behaviors, reports on vaccination seem to support Ackerman et al.'s conclusion that "the behavioral immune system is obsolete for the current pandemic battle, as effective as a longbow would be in modern military combat" (2021, p. 183). Pre-pandemic studies showed that individuals with higher pathogen disgust sensitivity and more germ aversion hold more negative vaccine attitudes [3,20]. A possible explanation is that vaccines are administered in ways that in and by themselves are cues to contamination, such as puncturing the skin, and inhalation or ingestion of a foreign substance [3]. Early data on COVID-19 vaccines suggest that germ aversion predicts vaccination hesitancy during the current pandemic as well [13,24], even though there is a study reporting opposite findings [11].

5. Limitations

The cross-sectional design of the study does not allow causal interpretations. Even though a previous study [5] showed that individual levels of disgust proneness measured four years before the COVID-19 outbreak predicted increased coronavirus anxiety during the current pandemic, we cannot rule out the alternative reverse relationship (i.e. greater fear of infection causing greater germ-related disgust). Future research with longitudinal designs will be helpful to confirm our results and extend them by establishing causality of the relationship. Another limitation is the convenience sample. Such a sampling procedure may limit the generalizability of the findings as the recruited participants may not represent the general population of healthcare workers and the data are susceptible to skewed participant demographics.

6. Conclusion

Through evolutionary history, pathogen disgust sensitivity and fear of infection evolved as adaptive psychological mechanisms to reduce the risk of contracting deadly diseases. Studies conducted during the COVID-19 pandemic found that pathogen disgust sensitivity and fear of infection promote preventive health behaviors in modern environments as well [5,17,23]. Fear of COVID-19 is an expected emotional reaction among healthcare workers because the increased morbidity risk due to their occupational role adds to the natural fear of infection [29]. However, excessive levels of fear can put at risk their psychological well-being as well as their occupational efficiency. For example, front-line nurses with greater fear of COVID-19 report less job satisfaction and higher intent to leave the profession [15], and fear of infection has been shown to be a predictor of burnout [9].

Given the strong intercorrelation between pathogen disgust sensitivity and fear of infection, an enhanced understanding of which factors predict individual differences in the activation of behavioral immune system may be useful for the prevention of possible psychiatric complications (e.g., depression and post-traumatic stress disorder) and for the optimization of healthcare workers' professional performance.

Informed consent

The study was carried out according to the Declaration of Helsinki. The study protocol was approved by the Ethical Committee of the Department of Dynamic and Clinical Psychology, Sapienza, University of Rome (Prot. n. 0,000,453 and Prot. n. 0,000,112). All patients provided written informed consent before participating in study-related activities.

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Declaration of Competing Interest

The authors have no competing interests to report.

Data availability

Data will be made available on request.

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