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Avoidance Behaviors Toward Sick People in Concrete Interpersonal Interactions

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The behavioral immune system is a proactive system whose ultimate function is to help organisms protect themselves against potential sources of contamination. We investigated "avoidance responses" in adults since these are an important manifestation of the behavioral immune system. Participants were asked to imagine taking a seat in a waiting room with two people shown in photographs already seated at either end of the room: one healthy and the other described in one of three ways: (a) very sick, with a transmissible disease and visible symptoms, (b) very sick, with a nontransmissible disease and no visible symptoms, and (c) healthy. In the second part of the study, the participants rated their willingness to perform various actions in imaginary social situations involving different levels of contact (e.g., "shaking hands") with each of the targets and their level of disgust at the thought of performing these actions. The findings showed greater avoidance of contagious people than of noncontagious or healthy people: (a) as indexed by the path taken to reach a seat and the number of empty chairs left between the protagonists (no significant modulations of these effects were found when individual differences in perceived vulnerability to disease (Duncan et al., 2009) were taken into account) and (b) as revealed by the propensity to perform certain actions (and by the disgust they evoked), especially those involving greater physical proximity (i.e., "shake her hand" and "take her in your arms"), with these tendencies being greater in the more germ-averse individuals.

Public Significance Statement

The ultimate function of the behavioral immune system is to proactively protect against contamination, and one way to achieve this is by promoting avoidance responses. Here, we provide further evidence for this function of the behavioral immune system. We studied imagined social interactions: taking a seat in a waiting room; performing certain actions involving different levels of physical contact (e.g., shaking hands, working at the same table). Adults showed greater avoidance of contagious people than of noncontagious or healthy people. In the waiting room scenario, this was reflected in the path taken to reach a seat and the number of empty chairs left between the protagonists. In the actions scenario, it took the form of greater reluctance to perform (and more disgust toward) actions requiring a higher degree of physical contact.

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The authors have no relevant financial or nonfinancial interests to disclose. This study was performed in line with the principles of the Declaration of Helsinki. All the study procedures were approved by the Statutory Ethics Committee of the University of Bourgogne Franche-Comté. Written informed consent was obtained from all participants before the beginning of the study. The data sets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Patrick Bonin served as lead for conceptualization, methodology, investigation, data curation, project administration, formal analysis, visualization, writing–original draft, and writing–review and editing. Gaëtan Thiebaut contributed equally to conceptualization, methodology, investigation, data curation, project administration, formal analysis, visualization, writing–original draft, and writing–review and editing. Pavol Prokop served in a supporting role for investigation, project administration, writing–original draft, and writing–review and editing. Alain Méot served in a supporting role for investigation, project administration, data curation, formal analysis, writing–original draft, and writing–review and editing.

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Pathogens are ubiquitous and have long been, and continue to be, a major source of threat to humans (Fumagalli et al., 2011; Smith & Guégan, 2010). This comes as no surprise, as pathogens have been historically responsible for more human deaths than any other cause (Inhorn & Brown, 1990). Two systems have been shaped by natural selection to help us cope with pathogens. The behavioral immune system (BIS) is a first line of defense against pathogens (Ackerman et al., 2018; Murray & Schaller, 2016; Schaller, 2006, 2011, 2016; Schaller & Park, 2011), whereas the biological immune system is a reactive system which comes into play when pathogens enter the body (Allen & Wynn, 2011; Sompayrac, 2016). The BIS is thought to consist of several components: Cognitive, emotional and motivational mechanisms all involved in keeping pathogens at bay (Schaller & Duncan, 2007). This system permits us to determine relatively quickly, and also relatively efficiently, whether the person we are currently dealing with is potentially contaminated by pathogens. We are able to detect various cues indicating that people we come into contact with are potential carriers of pathogens: more rigid and slower gaits (Hansson et al., 2023; Sundelin et al., 2015), more intense and unpleasant smells (Olsson et al., 2014; Sarolidou et al., 2020). However, the BIS is particularly attuned to detecting visual cues, especially those on the face (Arshamian et al., 2021; Axelsson et al., 2018). This is perhaps not surprising since most contagious diseases leave traces on the face (Wolfe et al., 2007).[1] The BIS may have been shaped to detect certain sources of contamination better than others, particularly those that affect conspecifics rather than those that originate from certain animals, although this aspect is still debated (see Ackerman et al., 2021; Dezecache et al., 2020). Another related aspect is the visibility of disease symptoms (Oaten et al., 2011). The deadliest diseases of the past millennia were easier to identify (e.g., the rashes and infected pustules of smallpox; Thèves et al., 2014) than some more recent ones (e.g., asymptomatic carriers of COVID-19; Ackerman et al., 2021).

The ultimate function of the BIS is to protect organisms against pathogens, and the emotion of disgust lies at the heart of this system (Oaten et al., 2009; Schaller & Park, 2011; Tognetti et al., 2023), by seemingly motivating avoidance behaviors (Curtis et al., 2011; Faulkner et al., 2004; Rozin et al., 2000; Schaller, 2020; Seitz et al., 2020; Shook et al., 2017; Terrizzi et al., 2023; Thiebaut et al., 2021; van Leeuwen & Petersen, 2018) and ultimately protecting the body from the risk of contamination. Animals exhibit avoidance behaviors when they are faced with potential sources of contamination (Case & Stevenson, 2024): infected conspecifics (e.g., Kavaliers et al., 2003 in mice; Kiesecker et al., 1999 in tadpoles) and contaminated environments (e.g., Brambilla et al., 2013 in domestic ungulates). In humans, physical contact with contaminated individuals is prevented or reduced (e.g., LoBue et al., 2022; Schaller et al., 2003; Tybur et al., 2014), especially in the case of people who are perceived to be contagious (Crandall & Moriarty, 1995; LoBue et al., 2022). Individuals are also less comfortable making physical contact with people who have facial signs that suggest illness (Houston & Bull, 1994; Kouznetsova et al., 2012; Rumsey et al., 1982; Tapp et al., 2020; Tognetti et al., 2023; van Leeuwen & Petersen, 2018). For example, Kouznetsova et al. (2012) manipulated the perceived health status of targets (e.g., [in]visibly ill and contagious, [in]visibly ill and not contagious) and participants had to rate their level of avoidance when interacting with these people. The findings indicated that visible contagious (e.g., influenza) and noncontagious diseases (e.g., acne) led to greater avoidance responses than invisible sicknesses (e.g., hemorrhoids, intestinal worms). However, this was only observed at the highest level of contact, such as a social kiss. Similarly, when people are caused to

[1] Sick individuals emit specific sounds that can be used for the detection of illness (e.g., sniffles, prolonged cough), but these cues—coughing and sneezing sounds—are not used very efficiently for detecting pathogen threats (Michalak et al., 2020).

be more vulnerable to diseases through experimental manipulation, they become more cautious in their interpersonal behavior (Faulkner et al., 2004; Laakasuo et al., 2018).

Because pathogens are so small as to be invisible to the human sensory systems (Schaller et al., 2022), disease is recognizable only by the stigma above the surface. The perception of this "visible sign" causes the BIS to behave like a smoke detector (Nesse, 2005)—following the "better safe than sorry" principle—by overgeneralizing to prioritize the avoidance of individuals who appear infected, regardless of their actual health status. Because the cost of a false-negative error (e.g., not avoiding a sick person) exceeds the cost of a false-positive error (e.g., avoiding a suspect person who is actually healthy), the BIS produces a response bias that limits the risk of infection, making the system biased toward false alarms (Oaten et al., 2011; Park et al., 2013). Symptom visibility is therefore an important factor driving avoidance behavior.

Surprisingly, although avoidance behaviors are core outcomes of the BIS, the way the motivational component of the BIS that underlies such behaviors operates in different concrete social contexts has not been extensively investigated. Park (2015) explored this issue in a neutral setting by asking participants to move toward a third person and stop when they felt that they were at a comfortable physical distance to hold a conversation. Park found that the physical distance chosen was greater for the participants who were the most easily disgusted. In a study involving a fictitious humanitarian crisis with contamination risk, participants who felt most vulnerable to pathogens preferred donating money over providing aid involving direct physical contact (Laakasuo et al., 2018). Strong evidence that adults avoid contact with people exhibiting signs of a contagious disease in a natural setting was recently provided by LoBue et al. (2022). Adults were given the choice of sitting at one of two workstations that had previously been occupied by two confederates. One confederate had visible signs of a contagious disease (e.g., a cold), one wore a lower-leg orthopedic boot and used crutches because of a broken leg, and one had no signs of disease or physical injury. Adults reliably avoided contact with the potentially contagious individual's workstation, and importantly, they explicitly justified their choice by referring to the risk of contamination.

In the present research, we focused on the motivational component of the BIS, the ultimate function of which is to elicit pathogen avoidance behaviors (Schaller et al., 2003) (i.e., by increasing physical distance from contaminated people or objects). More specifically, we sought to determine how the BIS is deployed in concrete interpersonal settings. Very few studies to date have addressed the question of how pathogen-avoidance motivation is mobilized in interpersonal situations that can be found in everyday life, such as being in the same waiting room, sitting in the same train car, working at the same table in a library, and having to shake hands with someone we are introduced to. We chose a situation in which the BIS should be "optimally" activated, that of a person with an infectious disease and showing signs of this disease on the face. We compared this situation with a control condition (i.e., a person described as healthy and showing no particular signs on the face). Finally, we decided to include a special exploratory situation, that of a person suffering from a modern chronic disease, namely cancer. Cancer can be categorized as a "modern lifestyle" chronic disease (Balwan & Kour, 2021) because it arises as a result of various factors, including the adoption of a sedentary lifestyle combined with the consumption of ultraprocessed foods (Jew et al., 2009; Silva et al., 2022), the consumption of alcohol and tobacco (Balwan & Kour, 2021). Since the BIS was not shaped by modern chronic diseases (Ackerman et al., 2021), we need to be cautious regarding the possible involvement of the BIS in this type of situation. The cancer condition included in our study was one without stigma, and the disease status was indicated only by a verbal label. Walters et al. (2024) have shown that a disease label assigned to a healthy-looking individual can elicit an avoidance response. Thus, despite the absence of visual signs of disease, a conceptual understanding of the label generates thoughts of contamination and disease which indirectly trigger the BIS (Oaten et al., 2011). The BIS may therefore be involved in cancer because of its conceptual relationship to other diseases. We suggest that the cancer condition can be viewed as "intermediate" between the contagious disease condition, which clearly poses a health risk, and the good health control condition, where there is no proven risk.

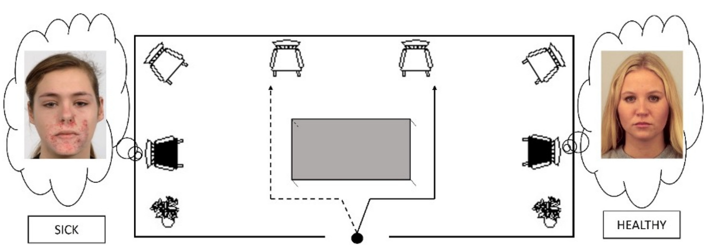
In the first part of our study, we considered the well-known situation of a waiting room where newcomers have to find a seat. In all the conditions, two people were already seated in the waiting room, one at either end (see Figure 1 for an illustration). Of the two individuals, one was always described as healthy and also had no facial deformities. The other individual was the target, and the health status varied across the experimental conditions. The target was either (a) described as very sick and affected by a transmissible disease (e.g., rubella) and had disease-connoting cues on her face; (b) described as very sick, affected by a nontransmissible disease (cancer) and exhibited no facial deformities; or (c) described as being healthy (and had no facial deformities). Avoidance behavior was indexed by the choice of the path to take a chair from the entrance to the room (see Figure 1) and the number of empty chairs left between the participant and the target.

When people are in close proximity, the risk of infection is generally greater (WHO, 2020). We were therefore interested in assessing the potential modulation of the motivation to avoid individuals by presenting different social situations in which the degree of physical proximity was varied. For example, Kouznetsova et al. (2012) observed that the degree of proximity (e.g., "social kissing," "sitting next to someone") influences avoidance behaviors, with the result that greater proximity leads to more avoidance. In the second part of our study, we used the same pairs of descriptions and faces as in the waiting room setting. For each target/nontarget pair, the participants had to rate their willingness to perform each of the depicted actions (e.g., "shake her hand," "work at the same table") and their level of disgust at imagining performing that action. The same ratings were collected for the nontargets. However, we only report the analyses on the targets. The results for the nontargets are available in the Supplemental Material A in the online supplemental materials. It should be noted that in the situation where the two women in the photographs were presented as healthy, the proportion of participants who made a choice that reflected a desire for distance from, rather than proximity to, the target photograph did not differ from 50% ($p > .10$ both for the path chosen and the number of empty chairs). Moreover, paired t tests revealed no reliable difference in the number of empty chairs or in either the willingness or disgust ratings (min[ps] = .261), suggesting that there were probably no particular features that could have significantly biased the results in the situations where the cues indicating illness were added.

We predicted that participants would be less willing to perform the action and feel more disgust in situations involving people with a transmissible disease, especially when they were physically close,

Figure 1

Illustration of a Waiting Room With Two People, One Described as Being Sick and Having Cues of a Contagious Disease (Left) and the Other as Healthy and Showing No Sign of Illness (Right)



Note. Solid arrow describes an "avoidance behavior," and dotted arrow describes a "nonavoidance behavior." The Rafd090_16_caucasian_female-face adapted from "Presentation and Validation of the Radboud Faces Database," by O. Langner, R. Dotsch, G. Bijlstra, D. H. J. Wigboldus, S. T. Hawk, and A. van Knippenberg, 2010, *Cognition and Emotion*, *24*(8), pp. 1377–1388 (https://doi.org/10.1080/02699930903485076). Copyright 2010 by the American Psychological Association. The AF27NES Face adapted from The Karolinska Directed Emotional Faces—KDEF, CD ROM From Department of Clinical Neuroscience, Psychology section, by D. Lundqvist, A. Flykt, and A. Öhman, 1998, Karolinska Institute (https://doi.org/10.1037/t27732-000). Copyright 1998 by the American Psychological Association. See the online article for the color version of this figure.

than they would be in situations in which there was no risk of contracting a disease. We also anticipated that these reactions should be modulated by individuals' perceived vulnerability to infectious disease (Duncan et al., 2009), with the effect being greater among individuals who perceive themselves as being highly vulnerable to disease.

Method

Participants

The participants were 150 psychology students ($M = 20.71$ years, $SD = 1.16$, 128 women) at the Université Bourgogne Europe. They were all native speakers of French, and none were taking medication known to affect the central nervous system. We planned to be more conservative than LoBue et al.'s (2022) Experiment 1, which tested 30 adults per condition. This experiment gave an estimation of the φ effect size of .382 (G*Power, Version 3.1.9.7; Faul et al., 2007), which allowed us to estimate a *w* in G*Power of .44. Thus, a sample of 109 participants was needed to obtain an effect of similar size with a power of .99 (χ^2 tests: goodness-of-fit tests). Written informed consent was obtained from all participants before the beginning of the study. The full study procedure was approved by the Statutory Ethics Committee of the University of Bourgogne Franche-Comté.

Face Stimuli

Faces of women with no visible signs of disease were taken from the Karolinska Directed Emotional Faces (Lundqvist et al., 1998) and from the Radboud Facial Database (Langner et al., 2010). The sick face was taken from Bonin et al.'s (2019) Study 5 and was manipulated with Gimp (https://www.gimp.org) software to portray the infectious disease rubella (see Figure 2 for faces used in the experiment). We used faces of women because we anticipated that most of the participants would be women. The use of faces of men may have potentially "sexualized" the different responses, and we wanted to avoid activating the adaptive aspect of "finding a mate" (Pandeirada et al., 2020).

Questionnaires

A proximity questionnaire (inspired by Kouznetsova et al., 2012) was designed to assess the degree of willingness and the level of disgust when imagining performing various actions with the targets. The five statements to be rated were "be in the same compartment as her on a train," "talk to her face-to-face," "shake her hand," "take her in your arms," and "work at the same table." For each statement, participants were required to indicate their response using two 5-point Likert scales: one for "degree of willingness" (1 = *impossible to do*, 5 = *I would do it without any problem*) and one for "level of disgust" (1 = *not at all disgusted*, 5 = *extremely disgusted*). The perceived vulnerability to diseases (PVD) questionnaire (Duncan et al., 2009) was also used. This consists of two subscales. The first subscale, "perceived infectability," includes seven statements such as "I have a history of susceptibility to infectious disease," "My immune system protects me from most illnesses that other people get." The second subscale, "germ aversion (GA)," is composed of eight statements such as "I prefer to wash my hands pretty soon after shaking someone's hand," "It really bothers me when people sneeze without covering their mouths." For each statement, participants are required to indicate their agreement using 7-point Likert scales (1 = *strongly disagree* vs. 7 = *strongly agree*).

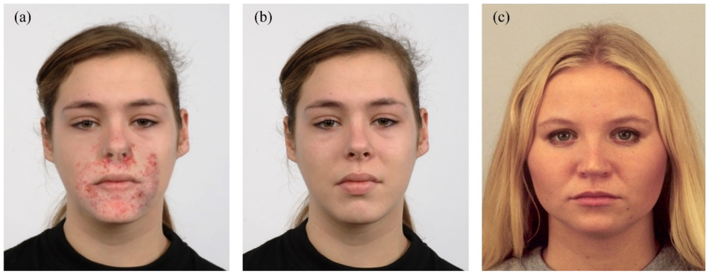
Procedure

Participants were tested during collective sessions and randomly assigned to one of the three conditions (contagious, cancer, healthy), counterbalanced across the position of targets in the waiting room (e.g., person with a contagious disease on the left and healthy person on the right, or the reverse). They were first asked to provide demographic information (i.e., age, gender, native language, medication), and the following instructions were projected on a large screen:

> In this experiment, we want you to imagine that you have an appointment to take part in an experiment. As you arrive in the waiting room, you notice that two people are also waiting. You see their faces and you are told that (1) one is actually very ill and contagious or (2) suffers from cancer, and the other is perfectly healthy or you are told that (3) these two people are in perfect health. We now ask you to evaluate these two faces on different dimensions. To do so, look at them carefully.

The pair of faces was displayed on the large screen, and the participants had to estimate the age and symmetry of the faces using 5-point

Figure 2
Faces Used in the Present Research



Note. (a) Transmissible disease, (b) nontransmissible disease of cancer/healthy face, and (c) healthy face used in every waiting room. The Rafd090_16_caucasian_female-face adapted from "Presentation and Validation of the Radboud Faces Database," by O. Langner, R. Dotsch, G. Bijlstra, D. H. J. Wigboldus, S. T. Hawk, and A. van Knippenberg, 2010, *Cognition and Emotion*, *24*(8), pp. 1377–1388 (https://doi.org/10.1080/02699930903485076). Copyright 2010 by the American Psychological Association. The AF27NES Face adapted from The Karolinska Directed Emotional Faces—KDEF, CD ROM From Department of Clinical Neuroscience, Psychology section, by D. Lundqvist, A. Flykt, and A. Öhman, 1998, Karolinska Institute (https://doi.org/10.1037/t27732-000). Copyright 1998 by the American Psychological Association. See the online article for the color version of this figure.

Likert scales (1 = *not at all symmetrical*, 5 = *entirely symmetrical*). This phase was essentially designed to encourage deep facial processing. The instructions regarding the waiting room were then presented as follows:

> Here is the plan of the waiting room with the chairs where the people waiting are located. Please choose the chair you would like to sit on. Please also indicate your path from the entrance (see Figure 1 for an illustration).

After performing this task on a sheet of paper, the participants completed the proximity questionnaire for the target face and the PVD questionnaire.

Data Analyses

Perceived infectability and GA (i.e., the PVD subscales) were first introduced as dependent variables in a between-participants analysis of variance (ANOVA) with experimental conditions (infectious disease, cancer, and healthy) as the independent variable. We conducted these analyses to check whether, despite the post hoc nature of these measures, participants were matched between conditions on these dimensions and whether they could be considered as control variables when analyzing behavioral outcomes.

Second, logistic regressions were performed to analyze the differences that emerged between the three experimental conditions with respect to (a) the path that the participant chose to reach the (chosen) chair and (b) the number of empty chairs that the participant left between the chosen chair and the chair occupied by the target. The dependent variable was the logit of the proportion of participants who made a choice that reflected a desire for distance from rather than proximity to the target (see below for the details and rationale). Dummy variables coding for the experimental conditions were used as independent variables (with alternating reference category) to test all within-condition odds ratios and between-conditions differences. Given the prediction of greater distantiation when the target corresponded to the sick face, odds were computed as the ratio of the proportion of participants in the distancing category to the proportion in the second category.

Third, within-subjects ANOVAs were run on willingness and disgust ratings when imagining performing different actions with the target faces, with the five proximity statements toward the target as a repeated factor and experimental conditions as a between-participants independent variable.

Fourth, the PVD subscales and their interactions with the targets were included separately in the models for each outcome variable in turn to test whether the differences that appeared between the different targets were still present when these dimensions were controlled for and were modulated by them. A backward approach was adopted, with the interaction effect discarded if it was not significant. Conversely, if this effect was significant, the differences between pairs of targets were tested at the mean and at 1 *SD* below or above the mean of the PVD subscale used (e.g., Aiken & West, 1991). The results of these tests are reported in the ms as the patterns appearing at low, medium, or high levels of the subscale. In addition, the same analyses were carried out on the willingness and disgust scores averaged over the proximity contexts.

Finally, gender was also included as a control variable in the above analyses. Given the relatively small and variable number of men within conditions (five, six, and 11 male participants in the cancer, disease, and healthy conditions, respectively), we did not include gender when controlling for PVD subscales and their interactions with the target.

Results

Perceived Infectability and Germ Aversion

To characterize our sample in relation to the two scales—GA and perceived infectability—and therefore to describe how the scores compare with "normality," we calculated whether the average scores for these two scales differed from the theoretical scale midpoint (see Table 1 for the mean ratings and their standard deviations). We found that the mean GA scores were not significantly different from 4, $t(149) = 0.35$, $p = .7237$, $M = 4.02$ (i.e., the theoretical scale midpoint), while perceived infectability scores were on average significantly lower than this point, $t(149) = -2.9$, $p = .0043$, $M = 3.62$. The differences between the experimental conditions were not significant for either the GA subscale, $F(2, 147) = 2.14$, $p = .1208$, $\eta_p^2 = .03$, or the perceived infectability subscale, $F(2, 147) = 1.63$, $p = .1993$, $\eta_p^2 = .02$. In addition, the correlation between the two scales was significantly positive but was relatively low ($r = .27$, $p = .0007$).

The different groups of participants in the various experimental conditions (healthy vs. cancer vs. disease) therefore did not differ in terms of perceived infectiousness or aversion to germs, and also did not score particularly well on these two dimensions, which are generally considered to be proxies for BIS activation.

Table 1
Mean Ratings (and Their Standard Deviations) for the GA and PI Subscales

PVD subscale	Infectious disease	Cancer	Healthy
GA	3.85 (1.16)	4.25 (0.92)	3.98 (0.90)
PI	3.33 (1.65)	3.90 (1.50)	3.65 (1.58)

Note. Participants responded to each statement on a 7-point Likert scale (1 = *strongly disagree* to 7 = *strongly agree*). PVD = perceived vulnerability to diseases; GA = germ aversion; PI = perceived infectibility.

Path

The proportions of participants who chose not to pass in front of the target are shown in Table 2. Across all experimental conditions, the proportion was slightly above 50%, $\chi^2(1) = 3.2$, $p = .0735$, *Odd* = 1.34. The overall model fit was significantly higher than for the empty model, $\chi^2(2) = 19.26$, $p < .0001$, McFadden $R^2 = .094$. In the healthy condition, the proportion in the distancing category was not reliably different from chance, $\chi^2(1) = 0.32$, $p = .572$, *Odd* = 1.17. Conversely, when the target was the sick face, it was significantly higher than 50%, $\chi^2(1) = 15.37$, $p < .0001$, *Odd* = 4, and it was also significantly higher than in the other two conditions: cancer, $\chi^2(1) = 16.76$, $p < .0001$, *OR* = 6.53; healthy, $\chi^2(1) = 7.31$, $p = .0068$, *OR* = 3.41. Finally, the proportion in the distancing category was marginally lower than 50% for the target face associated with cancer, $\chi^2(1) = 2.82$, $p = .0929$, *Odd* = 0.61, and was not significantly different from the proportion found for the healthy face, $\chi^2(1) = 2.55$, $p = .1101$, *OR* = 0.52.

When choosing where to sit in a waiting room, participants were thus more likely to avoid passing in front of a target affected by an infectious disease. This was not the case for the "cancer" and "healthy" targets.

Number of Empty Chairs

As can be seen in Table 2, only one participant chose to leave three empty chairs between themselves and the target face (i.e., they chose the chair next to the [control] healthy face). There

Table 2
Numbers (and Percentages) of Participants in Terms of Their Choice Not to Pass in Front of the Target and the Number of Empty Chairs Left Between Them and the Target

	Target face			
Avoidance behavior	Cancer	Infectious disease	Healthy	Total
Avoidance path	19 (38%)	40 (80%)	27 (54%)	86 (57%)
Empty chairs				
0	2 (4%)	1 (2%)	1 (2%)	4 (3%)
1	30 (60%)	10 (20%)	22 (44%)	62 (41%)
2	18 (36%)	39 (78%)	26 (52%)	83 (55%)
3			1 (2%)	1 (1%)

were also only four participants who chose the chair next to the target, two of them when the target was presented as having cancer and one in each of the other conditions. Conversely, 96% of the participants chose not to sit next to either the target or the other face, a percentage well above chance (binomial test, $p < .0001$). In order to analyze the differences between the three experimental conditions, the data were grouped into two categories: The first category, referred to as "distancing" below, corresponds to choosing a seat separated by more empty chairs (i.e., two or three empty chairs, from the target face than from the other [healthy] face), and the second category is the opposite (zero or one empty chairs).[2] This was the resulting binary outcome variable, which was analyzed using logistic regression. In the empty model, the intercept was not significant, $\chi^2(1) = 2.15$, $p = .1426$, $Odd = 1.27$, indicating that the proportion of participants in the distancing category was not significantly higher than 50% across experimental conditions. The overall model was significant, $\chi^2(2) = 18.75$, $p < .0001$, McFadden $R^2 = .091$. Within conditions, the proportion of participants in the distancing category was significantly higher than 50% when the target was the diseased face, $\chi^2(1) = 13.74$, $p = .0002$, $Odd = 3.55$, while, by contrast, it failed to reached significance for the cancer face, $\chi^2(1) = 3.81$, $p = .0508$, $Odd = 0.56$, and did not differ from 50% in the healthy condition, $\chi^2(1) = 0.32$, $p = .572$, $Odd = 1.17$. This proportion was greater for the diseased face than for the other two faces: healthy, $\chi^2(1) = 6.2$, $p = .0128$, $OR = 3.02$; cancer, $\chi^2(1) = 16.67$, $p < .0001$, $OR = 6.3$. The difference between the cancer and healthy face was not significant, $\chi^2(1) = 3.23$, $p = .0721$, $OR = 0.48$, with, however, a lower proportion being observed in the former condition.[3]

Compared to what we observed for targets with "cancer" or in "good health," participants therefore avoided sitting close to a person with an infectious disease in a waiting room—as reflected in the greater number of empty chairs left between them and the infectious target.

Willingness and Level of Disgust

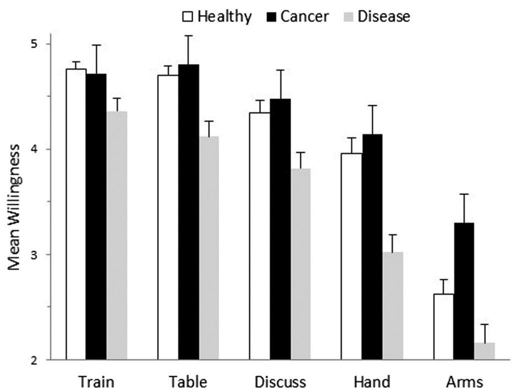
In the ANOVA including the five proximity statements regarding the target as a repeated-measures factor and the conditions as a between-participants independent variable, the main effects were significant for both willingness, Conditions: $F(2, 147) = 15.68$, $p < .0001$, $\eta_p^2 = .18$; Proximity statements: $F(4, 588) = 196.98$, $p < .0001$, $\eta_p^2 = .57$; and disgust, Conditions: $F(2, 147) = 12.97$, $p < .0001$, $\eta_p^2 = .15$; Proximity statements: $F(4, 588) = 65.01$, $p < .0001$, $\eta_p^2 = .31$. More importantly, the interaction between the two factors was also significant (see Figures 3A and 3B), $F(8, 588) = 4.06$, $p = .0001$, $\eta_p^2 = .05$ and $F(8, 588) = 3.55$, $p = .0005$, $\eta_p^2 = .05$. The results of pairwise comparisons with Šidák correction for p values are summarized in Tables 3A and 3B.

[2] We chose these two categories because of the large proportion of completely or almost empty cells, which leads to both convergence difficulties and underpowered tests in logit models with categorical predictors (e.g., Menard, 2002).

[3] With the exception of the difference between cancer and healthy conditions, which was clearly not significant, $\chi^2(1) = 2.66$, $p = .103$, $OR = 0.51$, the same pattern of results was obtained when participants who chose to leave zero or three empty chairs between themselves and the target were excluded.

Figure 3A

Willingness Ratings for Each Condition × Proximity Statement



Note. Error bars represent the standard error of the means.

Proximity and Conditions Pairwise Comparisons

Apart from the proximity statement "take her in your arms," for which willingness was higher for the cancer target than for the healthy target, $t(147) = 2.85$, $p = .0149$, *hedges' g* $= .57$, disgust and willingness scores for these targets did not differ significantly. Again, with the exception of the proximity statement "take her in your arms," for which the difference in willingness between the infectious and healthy targets was not reliable, $t(147) = -1.93$, $p = .1579$, *hedges' g* $= -.39$, disgust scores were significantly higher and willingness scores significantly lower for the diseased face than for the other two faces. In addition, the willingness ratings for "be in the same compartment on the train" and "work at the same table" were not significantly different for any target and were significantly higher than for all other statements, except for "talking to face to face" for the cancer target, for which the differences were not reliable.

As far as willingness ratings are concerned, all other differences between statements were significant, with willingness to "take her in your arms" and "shake her hand" having the lowest and second lowest means respectively. Finally, disgust ratings between the "train," "table," and "discussion" statements did not differ for the healthy and infectious disease targets and were reliably lower than those attributed to the "shake her hand" and "take her in your arms" items, while the "shake

Table 3A

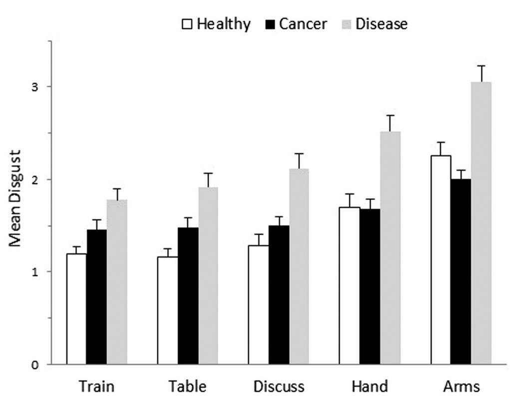
Mean Willingness Scores (and Standard Deviations) and Across Conditions/Within-Conditions Comparisons Results

Statement	Healthy	Cancer	Disease
Train	4.76 (0.52)	4.72 (0.64)	4.36 (0.85)[b]
Table	4.70 (0.65)	4.80 (0.53)	4.12 (1.04)[b]
Discuss	4.34 (0.87)[a]	4.48 (0.79)	3.82 (1.08)[a,b]
Hand	3.96 (1.03)[a]	4.14 (1.11)[a]	3.02 (1.2)[a,b]
Arms	2.62 (0.99)[a]	3.3 (1.34)[a,b]	2.16 (1.22)[a]

Note. Participants responded to each statement on a 5-point Likert scale (1 = *impossible to do* to 5 = *I would do it without any problem*).
[a] Values that are significantly different from all other values within conditions. [b] Values that are significantly different from all other values within statements.

Figure 3B

Disgust Ratings for Each Condition × Proximity Statement



Note. Error bars represent the standard error of the means.

Table 3B

Mean Disgust Scores (and Standard Deviations) and Across Conditions/Within-Conditions Comparisons Results

Statement	Healthy	Cancer	Disease
Train	1.20 (0.53)	1.46 (1.03)	1.78 (0.91)[b]
Table	1.16 (0.42)	1.48 (0.97)	1.92 (0.99)[b]
Discuss	1.28 (0.64)	1.50 (1.04)	2.12 (1.02)[b]
Hand	1.70 (0.89)[a]	1.68 (1.08)	2.52 (1.2)[a,b]
Arms	2.26 (1.05)[a]	2.00 (1.12)	3.06 (1.32)[a,b]

Note. Participants responded to each statement on a 5-point Likert scale (1 = *not at all disgusted* to 5 = *extremely disgusted*).
[a] Values that are significantly different from all other values within conditions. [b] Values that are significantly different from all other values within statements.

her hand" statement was rated as significantly less disgusting than the "take her in your arms" statement. The same pattern of disgust ratings was observed for the cancer target, except that the "shake her hand" statement did not differ reliably from the "train", "table," and "discussion" statements on the one hand, and from the "take her in your arms" statement on the other.

Overall, participants showed a greater aversion to the infectious target than to the other two targets, and this characteristic tended to increase with more intimate interactions. However, an exception was observed in the willingness scores for the action involving the greatest physical closeness—take her in your arms—for which the difference from the healthy target was smaller and nonsignificant. The differences between the cancer and healthy conditions were not significant, except, once again, for the willingness scores for the "take her in your arms" statement, which were higher for the cancer target than for the healthy target. In addition, aversion increased with physical proximity, with the same pattern of significant differences between statements being observed for the healthy and disease conditions, whereas these differences were smaller and sometimes never reached significance in the cancer condition.

PVD Subscales as Covariates

When GA or perceived infectability and their interactions with experimental conditions were entered backwardly into the models, none of the effects involving either PVD subscale were reliable in the analyses of the number of empty chairs, the path chosen to sit and the disgust and willingness ratings for the "be in the same compartment as her on a train," "work at the same table," and "talk to her face-to-face" proximity statements. The same result was found for perceived infectability and ratings averaged across the statements.

All of the main effects of the conditions were significant except for disgust scores for the "take her in your arms" statement. Significant main effects of GA on disgust and willingness scores were present for the "shake her hand" and "take her in your arms" statements, as well as when ratings were averaged across statements, with higher levels of GA being associated with higher levels of disgust and lower levels of willingness. There was no reliable main effect of perceived infectability, except in the analysis of disgust ratings for the "take her in your arms" statement. Finally, for the "take her in your arms" statement, context effects significantly interacted with GA on willingness and perceived infectability on disgust (see Supplemental Material B in the online supplemental materials for a figure of these interactions). Regarding the context by germ aversion interaction, the willingness ratings decreased significantly with GA only for the cancer and disease targets. However, the decrease was more pronounced for the cancer than for the disease target. As a result, the differences in willingness ratings between the cancer and disease targets, although significantly positive at both low, medium and high levels GA, decreased as this variable increased. In addition, willingness in the healthy condition was significantly lower than in the cancer condition for low and medium levels of GA, and higher than in the disease condition for medium and high levels. The significant effect of the Context by Perceived infectability interaction on disgust ratings was because of a significant increase in disgust with perceived infectability in the disease condition only. The means in this condition became ever larger than in the other two conditions as perceived infectability increased, while the differences between the cancer and healthy targets were not reliable.

Overall, the ratings of willingness and disgust were found to be related to aversion to germs only for the two statements that involved a greater degree of physical proximity.

Gender as Covariate

Including gender as a covariate in the analyses did not change the patterns of differences between the targets regardless of the outcome variable under consideration. Although the small and different numbers of men per condition makes comments on gender differences highly speculative, it should be noted that the mean GA score was significantly higher for women ($M = 4.14$) than for men ($M = 3.36$), $F(1, 146) = 11.98$, $p = .0007$, $\eta_p^2 = .08$. For perceived infectability, the mean difference between women ($M = 3.72$) and men ($M = 3.08$) was not significant, $F(1, 146) = 3.05$, $p = .083$, $\eta_p^2 = .02$.

General Discussion

When we meet unfamiliar people, we form a subjective impression, perhaps because this impression helps us decide whether it is safe to approach them or whether it might be better to avoid them (Bressan, 2023). One of the threats that encounters with other people cause us to flee is the threat of contamination. According to certain researchers, this threat is more salient than any other factor, with the result that our first impressions of a new face are shaped by contamination issues (Bressan, 2023).

As set out in the introductory part, although a number of studies have investigated the attitudes and beliefs of people when confronted with diseased conspecifics, very few of them have provided direct evidence of avoidance behaviors toward such conspecifics. This is somewhat surprising, given the central role of motivational mechanisms underlying avoidance behaviors in the BIS. In particular, the variety of contexts in which this motivation can manifest itself has not been fully explored. We therefore investigated the motivation to avoid personal physical contact in the context of concrete interpersonal relationships such as choosing a seat in a waiting room, being in the same compartment on a train, working at the same table, talking face to face, shaking hands, and taking in arms.

First, we investigated the social situation of a waiting room. When an individual enters a waiting room and other people are already seated, the question of where to sit (i.e., which seat to take) arises, and a crucial question is that of choosing a seat where one feels safe. We therefore made use of a paradigm that, surprisingly, has rarely been adopted in the literature (e.g., Guéguen, 2012; Noesjirwan, 1977). Specifically, when two people are already seated and we have a choice of where to sit relative to them, do we sit further away from the person who seems to be the most threatening, in this case the one showing signs of a contagious disease, compared to the other who is either in good health, or sick but not contagious (cancer)? Do we avoid passing in front of the sick, contagious person (i.e., do we go around him or her)? The findings from our study provide clear answers to these two questions. Indeed, we observed that the participants chose a trajectory that avoided the sick contagious person, choosing more often not to pass in front of the person whose face showed signs of a contagious disease compared to the other two situations (person with cancer, healthy person). In addition, participants chose a seat that allowed them to distance themselves from the person with a contagious disease. It is interesting to note that in the cancer condition, there was a tendency to move closer to this participant than to the healthy person in the waiting room situation, probably because of empathy and/or rational appraisals (Troisi et al., 2022). Also, in the condition where the participant was described as being in good health, we observed that very few participants sat next to the person in question. This last observation is undoubtedly explained by a social norm, according to which it is intrusive, or even rude, to sit very close to someone in a public place when seats are available elsewhere. Analyses with the two PVD scales taken as covariates revealed no significant modulations of the effects observed on the choice of trajectories for sitting or on the distance as measured by number of empty chairs.

Second, we also sought to better understand avoidance motivation by using social mini-scenarios in which an action demanding a greater or lesser degree of physical contact has to be addressed to a person. We used the same three experimental conditions as in the waiting-room scenario: sick contagious person, sick noncontagious person (cancer), and healthy person. The scores for the willingness to perform each of the actions depicted in the mini-social scenarios involving a greater or lesser degree of physical proximity (e.g., "shake hands" vs. "work at the same table") revealed some interesting trends, but also some unexpected results. The participants were less likely to perform actions such as "being in the same compartment on a train," "working at the same table," "talking face to face," and "shaking hands" when the person had a contagious disease than when she was healthy or had cancer. Motivation to avoid the target, as indexed by willingness scores, was also higher when physical proximity between individuals was reduced. It is interesting to note that in the healthy and contagious disease conditions, the scores for "being in the same compartment on a train" and "working at the same table" were similar, but higher than for the other situations involving greater physical proximity (i.e., "talking to her face to face," "shaking her hands," "taking her in your arms"). The difference between the "train" and "table" situations and "talking face to face" were not significant for the cancer condition. Disgust scores ran broadly in "parallel" to willingness scores. The data from the mini-social scenarios clearly support the existence of a BIS whose primary function is to help humans avoid situations in which contact with pathogens is likely.

The "take her in your arms" statement deserves special comment. The willingness scores did not differ significantly between the healthy and contagious targets, which could partly be explained by the fact that such physical proximity greatly increases the risk of catching a disease, and could partly be because hugging a stranger is also not a socially harmless act, as it involves intimacy that can be embarrassing. The fact that individuals in the cancer condition seemed more inclined to hug the target than the healthy person seems to be due in some part to compassion, although our data do not allow us to confirm this interpretation, which must therefore remain speculative. At the same time, the disgust scores did not differ statistically between the healthy and cancer conditions, suggesting that hugging the person with cancer was nevertheless associated with some apprehension.

Willingness and disgust ratings were found to be related to GA only for the two statements involving a greater degree of physical proximity, namely the "shake her hand" and "take her in your arms" statements, with more germ-averse individuals being more disgusted and less inclined to perform these actions. However, the action of hugging again stood out. Indeed, it was the sole action for which the GA effect on willingness ratings was modulated by the different health conditions, in such a way that it was less pronounced for the disease than for the cancer condition and not observed with the healthy target. As a result, the positive difference between the cancer target and the other two conditions in the inclination to perform this action decreased with increasing GA levels, and even turned out to be not reliable for high germ-averse participants confronted with the healthy target. The observation of this relationship between willingness ratings and GA is consistent with the idea that cancer is somehow treated as a disease by the BIS. The "take her in your arms" statement was also the only statement for which an effect involving perceived infectability was found: There was an effect of the interaction between Perceived infectability and Context on disgust, with the level of disgust increasing with greater perceived infectibility (PI) in the "disease" condition.

With regard to the two PVD scales, it is interesting to note that when gender was taken into account in the analyses, we found that aversion to germs was higher overall in women than in men, as has already observed in previous studies (e.g., Chiesi et al., 2022; Coninck et al., 2020; Díaz et al., 2020; Duncan et al., 2009). However, no gender difference was observed for the other variables of interest (path, number of empty chairs, willingness, and disgust scores). It should nevertheless be remembered that the number of men in our study was small. Given this asymmetry, it is clear that further work will be needed to investigate the impact of gender on avoidance behavior in more depth. Park (2015) reported that the participants who were the most easily disgusted maintained the greatest physical distance. Given the evidence showing that women are more disgust-sensitive (e.g., Al-Shawaf et al., 2018; Duncan et al., 2009; Fleischman, 2014; Sparks et al., 2018), and germ-averse (Chiesi et al., 2022; Coninck et al., 2020; Díaz et al., 2020; Duncan et al., 2009) than men, it is possible that they may exhibit more extensive avoidance behaviors.

The results of the above analyses between the PVD scores (and more precisely the scores obtained on the two GA and PI subscales) and the motivation to perform certain actions (and the related disgust scores) point to relatively complex relationships and therefore suggest that activation of the BIS is highly context-dependent. However, one important result of our analysis of PVD measures is that the GA and PI measures are independent of the avoidance behaviors observed in the waiting room situation for the contagious person. How can this be explained? Firstly, we cannot completely rule out the possibility that PVD measures do not perfectly index BIS mobilization. Even if the PVD has been the subject of some criticisms (e.g., Díaz et al., 2016; Rokvic & Karan, 2021), the fact remains that this tool has been, and continues to be, widely used internationally by BIS researchers (Do Bú et al., 2023; Karakulak et al., 2023), suggesting that it is a reliable index of BIS mobilization. Secondly, it is worth noting that the pattern of results we obtained for the waiting room situation is not unique in the literature. Indeed, LoBue et al. (2022) also observed that neither PI nor GA scores were related to avoidance behavior in an experimental situation in which participants could choose whether or not to occupy the seat of a person who had previously been perceived as contagious, had a broken leg, or showed no signs of illness or physical injury. For these researchers: "That avoidance was not predicted by either subscale of the PVD is not surprising; adults' explicit knowledge of germs and contagion would very likely have swamped individual differences in perceived susceptibility to illness or aversion to germs." We cannot, however, exclude the possibility that the lack of a significant association between the PVD measures and avoidance in the waiting room situation reflects the nonmobilization of the BIS. However, if this is the case, what mechanism might be responsible for these avoidance behaviors? It is possible that they may be because of the activity of a domain-general threat avoidance mechanism. However, if this is the case, can we continue to speak of a BIS to explain avoidance in situations involving pathogens? Finally, it should be noted that the fact that avoidance behaviors occur when the BIS is mobilized does not mean that these avoidance behaviors cannot occur as a result of other adaptations. An adaptation requires the activation and coordination of a set of mechanisms; the same mechanisms (be they cognitive, emotional, and motivational) can be recruited within different adaptations. As claimed by Nairne and Coverdale (2022): "In fact, evolved adaptations often co-opt other evolved mechanisms to achieve their intended effect." The avoidance behaviors observed here are therefore not specific to the BIS but can be co-opted for other purposes. For example, when confronted with a person whose face shows anger in a waiting room, he or she may be avoided just as much as someone who shows signs of illness. Indeed, avoidance behaviors have been found in people who are confronted with angry faces (e.g., Lebert et al., 2024; Miller et al., 2013; see also Veenstra et al., 2017), or with a suspicious, threatening-looking confederate (Guéguen, 2012).

Limitations

It is important to acknowledge some limitations of the present work to help and guide future research. Firstly, the experimental waiting room situation that we tested is somewhat artificial in the sense that, in reality, patients in a waiting room know that there are potentially contagious people around them, even though they do not have any precise information about the disease status of these people. Second, the participants in our experimental situation had to perform several tasks: See the seated person, decide on a trajectory, and then choose a chair. This may have inadvertently created further demand effects. Third, in our study, we did not assess actual avoidance behavior, but rather intentions to avoid the target. Future research will need to examine the actual behaviors of individuals in a waiting room, in a train, etc. rather than "simulated" behaviors such as we studied here. Similarly, the choice of a highly contagious condition with a photograph showing facial stigmata indicating a disease such as rubella is perhaps not sufficiently ecological. Future studies should test more common infectious diseases such as influenza or COVID-19. Fourth, we conjectured that the participants were more empathetic toward the person with cancer based on their greater willingness to hug her. However, as no measures of empathy were collected, we were unable to provide evidence to support this assumption. Future studies of people with cancer should therefore include measures of empathy such as the basic empathy scale (Jolliffe & Farrington, 2006). Fifth, it would be interesting to conduct research with children to determine the developmental point at which avoidance behaviors such as those studied here begin. Research indicates that 5-year-olds view flu and cancer similarly, while children aged 7–10 start to differentiate between them, with 10-year-olds perceiving cancer as less contagious than flu (Bares & Gelman, 2008). Children aged 4–9 understand the link between physical distance and the risk of contagious diseases (Kister & Patterson, 1980). Additionally, 5- to 6-year-olds are better at predicting disease transmission because of proximity than 3- to 4-year-olds (DeJesus et al., 2021). Children aged 4–5 interact equally with sick and healthy individuals, but those aged 6–7 prefer to play with healthy peers rather than sick ones (Blacker & LoBue, 2016). Thus, we might expect some of the avoidance behaviors we observed in social situations such as the waiting room or in mini-scenarios to be present relatively early and to then gradually come to resemble adult patterns more closely. Finally, two limitations pertaining to our experimental design should be mentioned. The first is that an effect of the timing of PVD administration cannot be ruled out. In future research, it would be interesting to introduce an interval between the administration of the PVD and the completion of the main study tasks. The second is that participants were tested in groups.

As a result, social desirability or the reactions of other participants may have influenced responses.

Conclusion

The present findings provide further evidence for the BIS view that we are equipped with a set of evolved mechanisms that help us keep different sources of potential contamination at bay. In the social context of a waiting room, conspecifics who are described as being very sick with a transmissible disease and show signs of disease are avoided by being kept at a greater physical distance than others who are described as being healthy or as very ill with a nontransmissible disease, but with no visible signs of disease, as in the case of cancer. Similarly, when imagining interactions with strangers in different social settings, the motivation to engage in joint actions is significantly lower with infected conspecifics, in particular in the case of actions requiring greater physical proximity.

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