How is the Behavioral Immune System Related to Culturally-Learned Disease Avoidance Strategies?

by

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ABSTRACT

Infectious disease presents a serious threat to our fitness. The biological immune system provides several mechanisms for dealing with this threat. So too does another system: the behavioral immune system. This second system is proposed to consist of a set of evolved cognitive, affective, and behavioral strategies for reducing the likelihood of infection, including xenophobia, traditionalism, and food neophobia. In the present work, I investigate how another suite of fairly novel culturally-learned disease avoidance strategies, namely hygiene behaviors and knowledge of germ theory, are related to the behavioral immune system. Across two studies, I find that individuals who engage in more hygiene behaviors show less evidence of reliance on several elements of the behavioral immune system (i.e., xenophobia, traditionalism, food neophobia). Similarly, individuals who know more about germ theory show less engagement in behavioral immune system components. These findings suggest that effective cultural strategies for avoiding infectious disease may supplant older, evolved psychological strategies with the same purpose.

DEDICATION

To my parents, Jody and Gumby, for editing my papers, listening to my day, and supporting my education from the first grade to the first graduate degree. I could not, and would not have wanted to, do this without you.

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INTRODUCTION

Humans have evolved a variety of defenses to counteract infectious disease. Some of these adaptions involve our biological immune system, including T-cells, cytokines, and other cellular mechanisms to combat such threats (Schultze & Aschenbrenner, 2021). Another proposed suite of adaptations to avoid infectious disease involves our behavior and cognition. This behavioral immune system has been conceptualized as a toolbox containing emotional, interpersonal, and cognitive tools for avoiding infectious disease threats (Ackerman et al., 2018; Boggs et al., 2021; Murray & Schaller, 2016; Schaller et al., 2015).

One component of the behavioral immune system is xenophobia, prejudice against members of outgroups, especially those from other countries (van der Veer et al., 2011). Historically, human populations were more separated than they are today, and contact with other populations meant contact with people who might carry novel germs to which one did not have immunity (Faulkner et al., 2004; Van de Vliert, 2020). In fact, during European colonization of the Americas, pathogens from Europe killed more Native Americans than violence between the two groups (Diamond, 1997). Thus, xenophobia, to the extent it motivates avoidance of close contact with outgroup members, may have served as a means of avoiding novel pathogens. It follows then that when the threat of infectious disease is greater, one should expect more xenophobia (Faulkner et al., 2004; Jackson et al., 2019; Moran et al., 2021; Neuberg & Schaller, 2016; Schaller & Neuberg, 2012).

Consistent with this idea, numerous studies have found a connection between xenophobia and disease threat both in and out of the lab. Archival data shows that levels of prejudice towards outgroups are higher in countries where there are higher levels of pathogens (Van de Vliert, 2020). Similarly, individuals who perceive themselves as more vulnerable to infectious disease also exhibit greater in-group bias (Navarrete & Fessler, 2006) and greater prejudice toward foreigners (Faulkner et al., 2004). This link has also been confirmed experimentally. Faulkner et al. (2004) showed that temporarily increasing the salience of infectious disease leads to greater budget allocations towards familiar versus unfamiliar immigrants. In a similar vein, Huang et al. (2011) report that participants who were exposed to a disease prime scored higher on a measure of anti-immigrant attitudes. Thus, xenophobia may be one component of an evolved behavioral system designed to help individuals avoid becoming infected.

Just as avoiding unfamiliar people might be a behavioral defense against infectious disease, so too might be the avoidance of unfamiliar foods (Pliner & Salvy, 2006). Rozin and Fallon (1980; 1983) propose that individuals may reject food if it appears to pose a danger or elicits disgust. Foodborne pathogens, especially those from meat, can be deadly and remain a frequent cause of illness; in fact, such pathogens sicken over 9 million people annually in the United States (Painter et al., 2013). One method for avoiding these pathogens is to avoid foods that are unfamiliar (e.g., "foreign" foods) or elicit disgust. Although unfamiliar foods may be safe, they may be perceived to carry greater risk of disease transmission, as ancestrally familiar foods and food prepared in familiar ways were likely safer options, especially in areas where/when the threat of

infectious disease was high. In support of this view, recent work has found that individuals high in food neophobia have higher scores on the Perceived Infectibility subscale of Perceived Vulnerability to Disease (Santisi et al., 2021). Further, the Germ Aversion subscale of Perceived Vulnerability to Disease is also positively associated with food neophobia (Çınar et al., n.d.). Thus, individuals especially concerned with disease appear to use food neophobia as a means to avoid foodborne pathogens.

A third facet of the behavioral immune system is traditionalism, a preference for behaviors, norms, and values that have been typical in society historically (Inglehart & Baker, 2000). Traditionalism reinforces norms and practices which may prevent illness, such as proper food handling and rules for interpersonal contact (Murray, 2014; Tybur et al., 2016). Consistent with this view, studies have found evidence of links between traditionalism and disease threat at the individual (Wormley, 2020) and cultural levels (Tybur et al., 2016).

These three components—xenophobia, food neophobia, and traditionalism— are among many proposed aspects of the behavioral immune system, which also includes individualism-collectivism (Cashdan & Steele, 2013; Fincher et al., 2008; Na et al., 2021) and tight social norms (Gelfand, 2019; Gelfand et al., 2017; Harrington & Gelfand, 2014). This system may be activated either by temporary or chronic disease concerns and is proposed to operate like a smoke detector given the high costs of infection relative to the costs of a false alarm (Miller & Maner, 2012; Schaller & Park, 2011). This overgeneralized perception can lead to avoidance of individuals displaying innocuous but heuristic cues of disease such as age, obesity, or facial disfigurement (Miller & Maner,

2012). In a similar vein, perfectly safe foodstuffs are forgone if they appear gross (Rozin et al., 1986) or have come into contact with something associated with disgust, even if it's still in its original packaging (Morales & Fitzsimons, 2007). Further, the behavioral immune system may not be calibrated to differentiate infectious diseases from other illnesses; we cannot, for example, reliably tell the difference between a contagious cough and a benign one (Michalak et al., 2020). Thus, in many ways the behavioral immune system is a costly and inaccurate system, that may cause us to forego social connections, calories, and mating opportunities.

Humans also possess a third system for avoiding infectious disease— culture. Dual inheritance theory holds that in addition to biological pathways for inheriting cognitive processes and behavioral tendencies via genetics, cultural learning provides tools and knowledge for adapting to environmental affordances and threats (Boyd et al., 2011; Boyd & Richerson, 2005). Throughout human history, cultural tools have enabled us to overcome threats and utilize affordances beyond what biology would otherwise allow. For example, as Uchiyama et al. (2021) note, millennia of evolution have afforded groups living near the equator with darker skin to protect them from UV rays. However, humans can migrate towards or away from the equator faster than their genes can adapt to this, creating a mismatch between genes and the environment. This is where cultural evolution may step in—offering tools like sunscreen or Vitamin D supplements—to counteract the deleterious effects of this mismatch. Another example of culture providing the tools necessary to live in environments differing from those of our ancestors is the use of clothing. While biological evolution would take millions of years to build up the

physiological adaptations to enable life in the Artic Circle, cultural groups have adapted to life in the extreme cold by developing fur clothing to retain body heat (Eicher et al., 2014; Ruse, 1974).

In the case of disease threat, hygienic behaviors represent a cultural tool which provides effective ways to mitigate the risk of infectious diseases. The experimental work of Louis Pasteur and others in the 1850's formed the basis of germ theory (Roll-Hansen, 1979), which holds that infectious diseases are caused by microorganisms (e.g. bacteria, fungi, viruses) specific to different illnesses (Pasteur, 1881; Rivers, 1937). Based on this theory, behaviors such as hand washing, chemical disinfection, vaccination, and the use of prophylactics like masks, gloves, and condoms are recommended to avoid disease transmission. As a result of widespread adoption of hygiene practices, the development of antibiotics, and widespread vaccinations, rates of infectious disease deaths in the United States went from 797 per 100,000 in 1900 to just 59 in 1996 (Armstrong et al., 1999). Certainly, some of these behaviors were practiced prior to the advent of germ theory, but their widespread, consistent usage is relatively novel in the course of human history. Thus, unlike the behavioral immune system, which is comprised of a set of strategies that are putatively evolved, rooted in our ancestral past, and transmitted (at least partially in most formulations) through genetic inheritance (Faulkner et al., 2004; Fincher & Thornhill, 2012; Murray et al., 2019; Schaller, 2011), germ theory and hygiene behavior are cultural innovations that are very recent in evolutionary terms and are transmitted by learning.

It is also worth noting that germ theory is not the only cultural explanation for the etiology and treatment of infectious diseases, nor does it offer the only culturally-learned set of strategies intended to prevent or avoid illness. In ancient Greece, Hippocrates championed the idea that an imbalance of the body's four "humors" or "bad air" was the source of illness, including disease we now know to be infectious (Duffy, 1993; Karamanou et al., 2012). Today, complementary and alternative medicine practices abound, including those that are both relatively novel such as chiropractic and homeopathy, and those with older roots, such as traditional Chinese Medicine and Ayurveda (Ernst, 2001; Nahin & Straus, 2001). Importantly, these alternative forms of medicine are not consistently effective at preventing or combatting infectious disease (Ventola, 2010; Verma & Thuluvath, 2007). Thus, in the present work we also assess the extent to which engagement in alternative medicine behaviors relates to use of behavioral immune system strategies in order to assess whether culturally-learned strategies for avoiding disease that are versus are not efficacious might differentially relate to this older, evolved set of strategies.

How might effective cultural strategies, like engagement in hygiene behaviors, relate to the evolved behavioral and psychological adaptations of the behavioral immune system? There are several possibilities. First, it may be that the hygienic behaviors rooted in germ theory may be too new to overcome the older, evolved psychology of the behavioral immune system. That is, the behavioral immune system may be too deeply rooted so to speak to be affected by the use of these new, culturally-learned methods of avoiding infection. In this case, there would be no relationship between the components

of the behavioral immune system and engagement in hygiene behaviors. Alternatively, it might be that individuals who frequently use the tools within the behavioral immune system tend to use all cultural tools for avoiding infection made available to them. If this is the case, there would be a positive association between the components of the behavioral immune system and engagement in hygiene behaviors (as well as with alternative medicine behaviors). Finally, it might be that engaging in hygiene behaviors leads to less reliance on the behavioral immune system, as the former set of strategies provides an effective means of avoiding illness, making reliance on the latter unnecessary. If this is the case, then one would expect a negative relationship between these two sets of strategies to avoid infection.

Here, I conducted two studies to investigate the relationship between the behavioral immune system and culturally-learned disease management strategies. In Study 1, I explored the relationship of hygiene behaviors, knowledge of germ theory, and alternative medicine behaviors with three components of the behavioral immune system: xenophobia, traditionalism, and food neophobia. In Study 2, I pre-registered a series of hypotheses as I replicated the findings from Study 1, as well as extending to additional components of the behavioral immune system: collectivism, individualism, and perceived cultural tightness.

STUDY 1

The goal of Study 1 was to provide a first test of the relationships between use of culturally-learned disease avoidance strategies and components of the behavioral immune system. In this study, I developed and tested three new scales assessing engagement in hygiene behaviors, knowledge of germ theory, and engagement in alternative medicine practices.

Methods

Participants. Per Tabachnick and Fidell (2001), I strove to have 10 times the number of items on the scale for a sample size, or a sample of at least 200 people. Therefore, I recruited 300 participants from the Arizona State University psychology research participation pool, who took part in the study for course credit. Of the 300 participants recruited, all but one completed the survey resulting in a final sample size of 299 (197 F, M_{age}= 19.39, SD_{age} = 2.66). Any missing data was handled by pairwise deletion. See Table 1 for details.

Procedure. Participants completed a Qualtrics survey consisting of a series of questionnaires, followed by a demographic section. All data was collected in October 2021. For the full scales and survey flow, see Appendix A.

Measures.

Hygiene Behavior Questionnaire. The Hygiene Behavior Questionnaire is a novel measure designed to test how often participants engage in six illness prevention behaviors supported by germ theory, such as “washing your hands” or “wearing masks”.

Participants are asked to rate how often they engage in these behaviors on a scale of 1 (*never*) to 5 (*always*). Higher scores indicate greater engagement in hygiene behaviors. This scale had an acceptable Cronbach's alpha (α = .66).

Knowledge of Germ Theory. The Knowledge of Germ Theory Questionnaire is a novel scale which asks participants to rate how much they agree with twenty statements related to knowledge about germs, disease transmission, and disease prevention. Sample items include "The flu is transmitted via airborne particles" and "Vaccinations reduce the spread of infectious disease." Greater agreement measured on a 1 (s*trongly disagree*) – 7 (s*trongly agree*) Likert scale with these items indicates greater knowledge of germ theory. This scale had an acceptable Cronbach's alpha (α = .77).

Alternative Medicine Behaviors. The Alternative Medicine Behaviors Questionnaire is a novel scale which asks participants how often they engage in eleven alternative medicine behaviors such as acupuncture, herbal medicine, and hypnotherapy. They rate their engagement in these behaviors on a 1 (*never*) to 5 (*always*) scale. Higher scores on this scale indicate greater engagement in alternative medicine behaviors. This scale had an acceptable Cronbach's alpha (α =.85).

Xenophobia. Xenophobia was measured using the Fear-Based Xenophobia scale (van der Veer et al., 2011). This five-item scale focuses on participants' fearful attitudes towards immigrants. Participants rate agreement with statements like "Interacting with immigrants makes me uneasy" on a 1 (*strongly disagree*) – 7 (*strongly agree*) Likert scale. Greater scores on this scale indicate greater fear towards immigrants, which is indicative of greater behavioral immune system activation.

Food Neophobia. The Food Neophobia Scale captures participants' willingness to try new and unfamiliar foods (Pliner & Hobden, 1992). Participants rate their agreement with ten items, such as "I don't trust new foods" on a scale of 1 (*strongly disagree*) to 7 (*strongly agree*). Greater scores on this scale indicate greater hesitance towards new foods, indicating greater behavioral immune system activation.

Traditionalism. Traditionalism was measured using an abbreviated, six-item version of the Traditionalism subscale of the Authoritarianism-Conservatism-Traditionalism scale (Duckitt et al., 2010). Participants indicate agreement with statements like "It is important that I preserve our traditional values and moral standards" on a scale of 1 (*strongly disagree*) to 7 (*strongly agree*). Greater scores on this scale indicate a greater preference for traditional values, indicating greater behavioral immune system activation.

Perceived Vulnerability to Disease Questionnaire. The Perceived Vulnerability to Disease Questionnaire is a fifteen item scale measuring participants' aversion to germs and perceived infectability (Duncan et al., 2009). Participants rate agreement with items such as "I prefer to wash my hands pretty soon after shaking someone's hand" and "If an illness is 'going around', I will get it" on a scale of 1 (*strongly disagree*) to 7 (*strongly agree*). Greater scores on this measure indicate greater concern about getting sick and aversion towards germs.

Political Ideology. Given the politicization of responses to the COVID-19 pandemic, we measured participants political ideology on a scale of 1 (*extremely*

conservative) to 6 (*extremely liberal*) to assess whether any links observed between our key variables hold above and beyond their links to different political ideologies.

Personality. Neuroticism and Openness were measured using their respective subscales in the Big Five Inventory (BFI; John & Srivastava, 1999). Participants rate how well phrases describe them on a scale of 1 (*strongly disagree*) to 7 (*strongly agree*). Items for neuroticism include "is depressed, blue" and "can be tense". Items for openness include "is curious about many different things" and "likes to reflect, play with ideas". Higher scores on neuroticism and lower scores on openness have previously linked to greater concern about disease threat (Duncan et al., 2009). Further, in places with higher levels of pathogens, scores on openness tend to be lower (Schaller & Murray, 2008). Although these traits might be conceptualized as components of the behavioral immune system, they may also be viewed as potential third variable explanations for any observed relationships. For example, people high in neuroticism may be concerned with not only disease avoidance but may generally be more fearful and concerned with self-protection or avoiding potentially negative experiences.

Demographics. We also gathered data age, sex, and parental education. For parental education, we asked participants to indicate each parent's level of education using an eight-point scale ranging from "Less than High School Degree" to "Professional Degree". Both parents' education levels were used as control variables in later analyses.

Table 1. Descriptive Statistics for Study 1.

Sex	
Female	197 (66%)
Male	100 (34%)
Unknown	2
Age	$M = 19.39$, $SD = 2.66$
Political Orientation	
Extremely conservative	10 (3.4%)
Moderately conservative	45 (15%)
Somewhat conservative	58 (20%)
Somewhat liberal	56 (19%)
Moderately liberal	98 (34%)
Extremely liberal	25 (8.6%)
Unknown	7
Education of Parent 1	
Less than high school degree	15 (5.1%)
High school or equivalent	34 (12%)
Some college but no degree	35 (12%)
Associates degree	19 (6.4%)
Bachelor's degree	88 (30%)
Master's degree	65 (22%)
Doctoral degree	17 (5.8%)
Professional degree	22 (7.6%)
Unknown	4
Education of Parent 2	
Less than high school degree	23 (7.9%)
High school or equivalent	56 (19%)
Some college but no degree	52 (18%)
Associates degree	33 (11%)
Bachelor's degree	81 (28%)
Master's degree	35 (12%)
Doctoral degree	2 (0.7%)
Professional degree	8 (2.8%)
Unknown	9

Results

Correlations for variables of interest were computed for the 299 participants (except in the case of knowledge of germ theory, where N = 298, due to pairwise deletion; Table 2). Engaging in hygiene behaviors was significantly, negatively correlated with the three behavioral immune system components: traditionalism (r = -.28, p < .001), xenophobia (r = -.39, p < .001), and food neophobia (r = -.16, p = .004).

Similarly, knowledge of germ theory was significantly, negatively correlated with the three behavioral immune system components: traditionalism (r = -.27, p < .001), xenophobia (r = -.34, p < .001), and food neophobia (r = -.22, p < .001).

Conversely, engaging in alternative medicine behaviors was significantly, positively correlated with two of the three behavioral immune system components: traditionalism (r = .21, p < .001) and xenophobia (r = .25, p < .001). There was no relationship between engaging in alternative medicine behaviors and food neophobia.

Robustness Analyses. To assess the robustness of links between engagement in hygiene behaviors and the behavioral immune system, I next conducted a series multiple regression analyses that separately controlled for political ideology, sex, parental education, perceived vulnerability to disease, openness, and neuroticism. In the analysis controlling for parental education, each parent's highest level of education was entered as a predictor in the same regression equation.

The relationship between hygiene behaviors and xenophobia remained significant when controlling for these variables, βs ≤ -.238, ps < .05, as did the relationship between hygiene behavior and food neophobia, βs ≤ -.128, ps < .05. The relationship between

hygiene behaviors and traditionalism remained significantly when controlling for sex, perceived vulnerability to disease, openness, parental education, and neuroticism, βs ≤ -.248, *p*s < .05. However, the relationship was no longer significant when controlling for political ideology, β = -.071, *p* = .17 (Table S1).

Next, I assessed whether links between knowledge of germ theory and the behavioral immune system components held when separately controlling for the same suite of variables. The relationship between knowledge of germ theory and xenophobia remained significant when controlling for these behaviors, βs ≤ -.106, *p*s < .05, as did the relationship between knowledge of germ theory and traditionalism, βs ≤ -.194, *p*s < .05, and the relationship between knowledge of germ theory and food neophobia, βs ≤ -.180, *p*s < .05 (Table S2).

I also ran similar analyses to assess the robustness of links between alternative medicine behaviors and the behavioral immune system when controlling for the same variables. The relationship between alternative medicine behaviors and xenophobia remained significant when controlling for these variables, βs ≥ .153, *p*s < .05. The relationship between alternative medicine behaviors and traditionalism remained significantly when controlling for sex, perceived vulnerability to disease, openness, parental education, and neuroticism, βs ≥ .204, *p*s < .05. But, the relationship was no longer significant when controlling for political ideology, β = .071, *p* = .15. The relationship between alternative medicine behaviors and food neophobia remained null when controls were added to the regression (Table S3).

Perceived Vulnerability to Disease. Curiously, we found a pattern of relationships between perceived vulnerability to disease and the selected behavioral immune system components that was largely inconsistent with prior work. Only the correlation with food neophobia was in the direction predicted by prior research ($r = .17$, $p = .003$). For all correlations, see Table S4 and S5.

Table 2. Means, Standard Deviations, and Correlations for Study 1.

	M	*SD*	*Alpha*	*1.*	*2.*	*3.*	*4.*	*5.*
1. Xenophobia	1.98	1.21	.91					
2. Traditionalism	3.48	1.10	.76	.37**				
3. Food Neophobia	2.93	1.24	.91	.21**	.13*			
4. Hygiene Behaviors	4.26	0.56	.66	-.39**	-.28**	-.16**		
5. Knowledge of Germ Theory	5.60	0.56	.77	-.34**	-.27**	-.22**	.27**	
6. Alternative Medicine Behaviors	1.49	0.59	.85	.25**	.21**	.05	-.06	-.43**

Note. M and *SD* are used to represent mean and standard deviation, respectively. * indicates $p < .05$. ** indicates $p < .01$.

STUDY 2

In Study 2, I sought to replicate the key findings of Study 1 in a larger, pre-registered sample (https://osf.io/2p4gu). Specifically, I pre-registered the hypotheses that hygiene behaviors and knowledge of germ theory would be negatively correlated with our measures of the behavioral immune system, xenophobia, food neophobia, and traditionalism. Additionally, I sought to extend the findings of Study 1 by assessing links between this set of culturally-learned disease avoidance strategies and three other putative components of the behavioral immune system: collectivism, individualism, and tightness.

Methods

Participants. In Study 1, the smallest observed correlation within our six main analyses was between food neophobia and engagement in hygiene behaviors (r = -.16). A power analysis using GPower 3.1.9.7 (Erdfelder et al., 1996) suggested that, assuming a correlation of -.16, I needed a sample size of 237 to achieve sufficient (.80) power. To ensure sufficient power, I oversampled, recruiting 450 participants from the Arizona State University psychology research participation pool, who took part in the study for course credit. Of these participants, all but nine completed the survey resulting in a final sample size of 441 (245 female; M_{age} = 19.30, SD_{age} = 2.66; Table 3). Missing data were handled by pairwise deletion.

Procedure. The procedure was the same as in Study 1, with the exception of the two additional scales: Individualism-Collectivism (Triandis & Gelfand, 1998) and Support of Cultural Tightness (Jackson et al., 2019). Also in Study 2, the Ten Item

Personality Inventory (TIPI; Gosling et al., 2003) was used instead of the BFI. All data was collected between January – February 2022. For the full scales and survey flow, see Appendix A.

Measures. All measures were the same as those used in Study 1, with the exception of the scales described below.

Individualism and Collectivism. The Individualism and Collectivism Scale consists of sixteen items to tap collectivism, evenly distributed across four subscales—horizontal individualism, vertical individualism, horizontal collectivism, and vertical collectivism (Triandis & Gelfand, 1998). To obtain a collectivism score, I took the average of the eight collectivism items such as "I feel good when I cooperate with others." To obtain an individualism score, I took the average of the eight individualism items, such as "I'd rather depend on myself than others". All items are measured on a scale of 1 (*strongly disagree*) to 7 (*strongly agree*). Higher scores on this scale indicate greater agreement with collectivistic or individualistic values, respectively.

Tightness. The Support of Cultural Tightness scale measures participants' support for tight vs. loose social norms (Jackson et al., 2019). Each of the ten items has unique scale points that are equivalent to too tight at the low end (1) and too loose (7) on the high end. Example items are "People in my country [*follow the rules too much/don't follow the rules enough*]" and "Criminal punishment in my country is currently [*too harsh/too lenient*]". Higher scores on this scale indicate greater support for tighter social norms.

Personality. The Ten-Item Personality Inventory (Gosling et al., 2003) asks participants to rate whether a pair of trait describes them. As in Study 1, I was especially interested in assessing neuroticism (e.g., "anxious, easily upset") and openness (e.g., "open to new experiences, complex"), measured on a scale of 1 (*does not describe me*) to 5 (*describes me extremely well*). Greater scores on these subscales indicate greater identification with the respective personality trait.

Table 3. Descriptive Statistics for Study 2.

Sex	
Female	245 (56%)
Male	192 (44%)
Unknown	4
Age	M = 19.30, SD = 2.66
Political Orientation	
Extremely conservative	57 (13%)
Moderately conservative	112 (26%)
Somewhat conservative	101 (23%)
Somewhat liberal	117 (27%)
Moderately liberal	30 (6.9%)
Extremely liberal	0 (0%)
Unknown	23
Education of Parent 1	
Less than high school degree	34 (7.7%)
High school or equivalent	44 (10%)
Some college but no degree	34 (7.7%)
Associates degree	28 (6.4%)
Bachelor's degree	141 (32%)
Master's degree	105 (24%)
Doctoral degree	13 (3.0%)
Professional degree	41 (9.3%)
Unknown	1
Education of Parent 2	
Less than high school degree	51 (12%)
High school or equivalent	80 (18%)
Some college but no degree	44 (10%)
Associates degree	44 (10%)
Bachelor's degree	154 (35%)
Master's degree	47 (11%)
Doctoral degree	3 (0.7%)
Professional degree	14 (3.2%)
Unknown	4

Results

Pre-Registered Analyses.

Hygiene Behaviors. Consistent with my pre-registered predictions, I found that engaging in hygiene behaviors was significantly, negatively correlated with the three behavioral immune system components: traditionalism (r = -.19, p < .001), xenophobia (r = -.41, p < .001), and food neophobia (r = -.12, p = .01).

Knowledge of Germ Theory. Also consistent with my pre-registered predictions, I found that knowledge of germ theory was significantly negatively correlated with these three behavioral immune system components: traditionalism (r = -.23, p < .001), xenophobia (r = -.41, p < .001), and food neophobia (r = -.19, p < .001).

Exploratory Analyses.

Additional Behavioral Immune System Components. In addition to the three pre-registered behavioral immune system components, we looked at three additional psychological tendencies that have been proposed to be, at least in part, adaptations that help to avoid infectious disease: individualism, collectivism, and tightness. Greater engagement in hygiene behaviors was positively correlated with individualism (r = .14, p = .003), positively correlated with collectivism (r = .27, p < .001), and not significantly associated with tightness (r = -.03, p = .51). Knowledge of germ theory was marginally significantly correlated with individualism (r = .08, p = .09), positively correlated with collectivism (r = .12, p = .02), and negatively correlated with tightness (r = -.20, p < .001).

Alternative Medicine. Engaging in alternative medicine behaviors was positively correlated traditionalism ($r = .27$, $p < .001$), xenophobia ($r = .28$, $p < .001$), and food neophobia ($r = .11$, $p = .03$). Alternative medicine behavior was marginally positively correlated with individualism ($r = .09$, $p = .055$), significantly positively correlated with collectivism ($r = .12$, $p < .009$), and tightness ($r = .17$, $p < .001$).

Robustness Analyses. Following the same procedure as in Study 1, I ran a series of multiple regressions to assess whether links between hygiene behavior and the three components of the behavioral immune system held when controlling separately for political ideology, sex, parental education, perceived vulnerability to disease, openness, and neuroticism. The relationship between hygiene behaviors and xenophobia remained significant when controlling for these variables, $\beta s \leq -.272$, $ps < .05$. The relationship between hygiene behaviors and traditionalism remained significantly when controlling for sex, perceived vulnerability to disease, openness, parental education, and neuroticism, $\beta s \leq -.174$, $ps < .05$. However, the relationship was no longer significant when controlling for political ideology, $\beta = .004$, $p = .93$. The relationship between hygiene behaviors and food neophobia remained significantly when controlling for sex, perceived vulnerability to disease, parental education, and neuroticism, $\beta s \leq -.118$, $ps < .05$. However, the relationship between hygiene behaviors and food neophobia was no longer significant when controlling for political ideology, $\beta = -.085$, $p = .10$, or for openness, $\beta = -.063$, $p = .15$ (Table S6).

I also ran similar analyses assessing the links between hygiene behavior and tightness, individualism, and collectivism, controlling for the same set of variables in

separate multiple regressions. The relationship between hygiene behaviors and tightness remained insignificant when controlling for sex, perceived vulnerability to disease, openness, parental education, and neuroticism. However, the relationship between hygiene behaviors and tightness was significant when controlling for political ideology, $\beta = .141$, $p = .004$. The relationship between hygiene behaviors and individualism remained significant when controlling for these variables, $\beta s \geq .123$, $ps < .05$, as did the relationship between hygiene behavior and collectivism, $\beta s \geq .243$, $ps < .05$ (Table S6).

Next, I assessed whether links between knowledge of germ theory and the behavioral immune system components held when separately controlling for the same suite of variables. The relationship between knowledge of germ theory and traditionalism remained significant when controlling for these variables, $\beta s \leq -.099$, $ps < .05$, as did the relationship between knowledge of germ theory and xenophobia, $\beta s \leq -.305$, $ps < .05$, and the relationship between knowledge of germ theory and food neophobia, $\beta s \leq -.104$, $ps < .05$. Among our additional components of the behavioral immune system, the relationship between tightness and knowledge of germ theory remained significant when controlling for these variables, $\beta s \leq -.094$, $ps < .05$. The relationship between knowledge of germ theory and collectivism remained significantly when controlling for sex, perceived vulnerability to disease, openness, parental education, and neuroticism, $\beta s \geq .117$, $ps < .05$; however, the relationship was no longer significant when controlling for openness, $\beta = .077$, $p = .11$. The relationship between knowledge of germ theory and individualism remained null when sex, parental education, perceived vulnerability to disease, openness, and neuroticism were added to the regression. However, the relationship between

knowledge of germ theory and individualism was significant when controlling for political orientation, β = .110, p = .03 (Table S7).

To assess the robustness of links between engagement in alternative medicine behaviors and the behavioral immune system, I next conducted a series multiple regression analyses that separately controlled for the same suite of variables. The relationship between alternative medicine behaviors and xenophobia remained significant when controlling for these variables, βs ≥ .188, ps < .05, as did the relationship between alternative medicine behaviors and traditionalism, βs ≥ .196, ps < .05, as well as the relationship between alternative medicine behaviors and food neophobia, βs ≥ .096, ps < .05, and the relationship between alternative medicine behaviors and tightness, βs ≥ .111, ps < .05. The relationship between alternative medicine behaviors and collectivism remained insignificant when control variables were added. The relationship between alternative medicine behaviors and individualism remained insignificant when controlling for sex, openness, political ideology, and neuroticism. However, this relationship was significant when controlling perceived vulnerability to disease, β = .105, p = .04, and when controlling for parental education, β = .098, p = .03 (Table S8).

Perceived Vulnerability to Disease. As in Study 1, classic findings from the behavioral immune system literature were not replicated. Of the six behavioral immune system components examined in this study, only one was significantly related to perceived vulnerability to disease—xenophobia (r = -0.13, p = .005). However, this relationship is in the opposite direction of that predicted by previous literature (Tables S9 and S10).

Table 4. Means, Standard Deviations, and Correlations for Study 2.

	M	*SD*	*Alpha*	*1.*	*2.*	*3.*	*4.*	*5.*	*6.*	*7.*	*8.*
1. Food Neophobia	2.02	1.18	.89								
2. Traditionalism	3.57	0.97	.69	.35**							
3. Xenophobia	3.02	1.17	.90	.22**	.20**						
4. Collectivism	5.10	0.85	.79	-.18**	.16**	-.21**					
5. Individualism	4.38	0.82	.73	-.06	-.05	-.04	.35**				
6. Tightness	3.82	0.81	.84	.34**	.48**	.15**	.15**	.06			
7. Hygiene Behaviors	4.23	0.62	.74	-.41**	-.19**	-.12**	.27**	.14**	-.03		
8. Knowledge of Germ Theory	5.45	0.70	.85	-.41**	-.23**	-.19**	.12*	.08	-.20**	.48**	
9. Alternative Medicine Behaviors	1.61	0.73	.91	.28**	.27**	.11*	.12**	.09	.17**	-.15**	-.48**

Note. M and *SD* are used to represent mean and standard deviation, respectively. * indicates $p < .05$. ** indicates $p < .01$.

DISCUSSION

In two studies, I found consistent links between use of a culturally-learned set of strategies (hygiene behaviors) to avoid infectious disease and several psychological and behavioral tendencies, previously described as components of the behavioral immune system. People who reported more frequent engagement in hygiene behaviors reported lower levels of xenophobia, food neophobia, and traditionalism. I also found negative associations between knowledge of germ theory and these three behavioral immune system components in both studies. Interestingly, in both studies, I observed a positive association between engagement in alternative medicine behaviors and these behavioral immune system components. All of these relationships hold when controlling for parental education, neuroticism, perceived vulnerability to disease, and sex. These relationships also generally, but not always, held when controlling for political orientation and openness. In Study 2, I replicated these findings. I also explored whether other psychological tendencies that have sometimes been conceptualized as part of the behavioral immune system (i.e. individualism, collectivism, and support for tight social norms) might also be negatively related to reliance on hygiene behavior, finding that these links were less consistent.

Taken together, these findings suggest that culturally-learned strategies for avoiding infectious disease may supplant evolved psychological strategies for disease avoidance. However, it does not appear to be the case that relying on any set of culturally-learned disease avoidance strategies reduced reliance on the behavioral immune system. Indeed, in both studies, I found that engaging in alternative medicine

behaviors, such as hypnotherapy and acupuncture, was positively related to the components of the behavioral immune system like xenophobia and food neophobia. This may suggest that culturally-learned disease avoidance strategies might need to be effective to reduce reliance on the behavioral immune system.

These findings have both practical and theoretical implications. For example, this work suggests that engaging in hygiene behaviors may help prevent infectious disease while also reducing costly and socially-problematic behaviors such as xenophobia and food neophobia. These behaviors can be detrimental to our fitness, resulting in lost social connections, violence, and lost calories.

From a theoretical perspective, dual inheritance theory suggests that we have two pathways for inheriting behavioral tendencies—biology and culture. Here, I demonstrate that culturally-transmitted strategies may sometimes trump evolved psychological strategies with the same function. This raises the question of what other aspects of our evolved psychological and behavioral tendencies might be altered or "overridden" so to speak by newer, learned strategies for accomplishing the same functional goal. However, we would not always expect this to be the case. For example, the availability and widespread use of effective birth control does not seem to have eliminated evolved sex differences in mating preferences and behavior (Buss, 1989; Lehmiller et al., 2011; Pedersen et al., 2002; Schmitt, 2005). In future work, it would be interesting to systematically explore which evolved psychological or behavioral tendencies may be easier or harder to override with culturally-transmitted strategies or tools, and whether

there may be systematic principles that can predict which facets of evolved psychology should be more or less likely to be supplanted by such learned strategies and tools.

The present studies also raise other interesting questions for further empirical explorations. For example, in both studies I observed negative relationships between knowledge of germ theory and several behavioral immune system components. This may suggest that simply knowing more about the etiology of infectious diseases may also be sufficient to supplant the behavioral immune system. Future work might try to tease apart the extent to whether knowledge versus behavior matters more in this context.

One limitation of the present work is that it employed correlational designs, which limit the degree to which one can infer causality. Future work should seek to test links between hygiene behavior and various aspects of the behavioral immune system experimentally. It may also be worth considering the extent to which such relationships may hold at state versus trait levels or might be sensitive to the extent of disease threat in the environment. Longitudinal designs may also be useful in understanding how such tendencies may shift and relate to each other over time within individuals and how such relationships themselves may vary over time. Additionally, this work should be tested in a more representative sample outside of a university population.

Another potential limitation of these studies is that they were conducted during a pandemic. Different results might have been observed before the COVID-19 pandemic or in the years to come. However, I observed similar patterns of results at both time points (Study 1: October 2021 and Study 2: January-February 2022). Further, it is not clear why one would expect different relationships among various strategies for avoiding infection

as opposed to different mean levels of those strategies as a function of general disease threat in the environment. Nonetheless, it may be informative to attempt to assess these relationships again when the general salience of infectious disease threat (e.g., COVID-19) is lower.

Further, some of the links between hygiene behaviors or knowledge of germ theory and various behavioral immune system components were less robust when controlling for political orientation. Given the currently politicized nature of some hygiene behaviors in the US such as vaccination and mask-wearing, this is perhaps unsurprising. This is one reason why it would be useful to attempt to replicate the current work in different societies, especially in those where the public health response to the pandemic was less politically polarizing. More generally, this would be worthwhile as it would also allow us to assess the extent to which such links are fairly universal or whether they show patterns of systematic variation around the world.

It is also worth noting that in Study 2 we found less consistent evidence linking greater engagement in hygiene behavior and knowledge of germ theory with additional facets of the behavioral immune system (collectivism, individualism, and support for tight social norms). Consistent with the notion that use of effective culturally-learned disease avoidance strategies is linked to reduced use of the behavioral immune system, engagement in hygiene behaviors was positively correlated with individualism, as was knowledge of germ theory (albeit marginally so), and knowledge of germ theory was negatively correlated with support for tight social norms. However, hygiene behavior was not significantly associated with support for tight norms, and both hygiene behavior and

knowledge of germ theory were positively associated with collectivism. A number of studies suggest that collectivism and tightness may be positively associated with compliance with various public health regulations during the pandemic (Gelfand et al., 2021; Lu et al., 2021; Maaravi et al., 2021). It may be that such relationships would look different in circumstances when the ecological threat of disease is lower than at present. It may also be that tendencies like individualism/collectivism or tightness are less integral parts of the behavioral immune system than say, xenophobia, and indeed they were included in Study 2 as exploratory variables for which I made no a priori predictions. It would be interesting in future work to further probe how various proposed components of the behavioral immune system relate and interact with each other and whether/when they are differentially affected by cultural and environmental factors.

Although not the central focus of this work, it is somewhat surprising given prior research that I did not observe consistent correlations between perceived vulnerability to disease and the behavioral immune system components. In fact, often these relationships were null or in the opposite direction observed or predicted by previous work (see Tables S4 and S8). It is worth noting that when we examined the two subscales of perceived vulnerability to disease separately and controlled for political ideology, we did observe a handful of significant correlations with behavioral immune system components that were consistent with prior work, though some relationships remained negative when analyzed in this fashion (see Tables S5 and S10). However, this still constitutes weaker evidence for such linkages than prior studies have reported. Why might there be this inconsistency with previous findings? Perhaps this may be a consequence of sampling during a

pandemic. Or it may be the case that other measures of disease concern or perceived disease threat are more reliably associated with these behavioral immune system components. It may also be that our sample, consisting of young adults attending a university, might not show the same range or distribution of perceived vulnerability to disease as is found in the broader population. In any case, further work should attempt to assess the robustness and replicability of links between measures of disease concern or threat and various components of the behavioral immune system.

CONCLUSION

Infectious disease has historically presented a major fitness challenge to human beings. Such diseases were historically one of the leading sources of human mortality and in the present day have re-emerged as a leading cause of death during the COVID-19 pandemic. In the present work, I explored how culturally-learned strategies to reduce such threats (i.e., engaging in hygienic behaviors) are related to use of older, evolved psychological strategies to avoid infection. In two studies, I found that people who engage in more frequent hygiene behavior (and those who know more about germ theory) appear to rely less on several components of the behavioral immune system. Thus, people who rely more on this culturally-learned suite of disease avoidance strategies appear to make less use of older psychological adaptations to avoid infectious disease. Interestingly, engagement in *ineffective* culturally-learned suites of behavior to avoid infectious disease, namely alternative medicine practices, was not linked to reduced reliance on the behavioral immune system. If anything, those who used such strategies tended to be *more* reliant on this older, evolved disease avoidance psychology. Future

work should extend the present findings by using longitudinal and experimental designs, in order to enable stronger tests of these relationships and to assess their dynamics over time. Further, given that the present work was conducted during a time when the threat of infectious disease was higher in most places than it had been in decades, it would be interesting to assess the extent to which my key findings might hold or vary as function of ecological levels of infectious disease.

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APPENDIX A

MATERIALS USED IN STUDIES 1 & 2

	Knowledge of Germ Theory	1 (Strongly disagree) – 7 (Strongly agree)
1	Certain diseases are caused by microscopic organisms.	
2	The immune system fights pathogens.	
3	Communicable diseases are only caused by poor health and underlying conditions.	R
4	Germs do not cause infectious diseases.	R
5	Most diseases are punishments for immoral behavior.	R
6	All diseases are caused by imbalance of the body's basic forces.	R
7	Not all contagious diseases are transmitted in the same way.	
8	The flu is transmitted via airborne particles.	
9	Diseases like malaria and dengue fever are transmitted by mosquitoes.	
10	Disease like cancer or heart disease are contagious.	R
11	Contagious illness is caused by germs, such as viruses and bacteria.	
12	Infectious diseases may spread by different vectors like the air or animals.	
13	Washing your hands can prevent the spread and contraction of many contagious diseases.	
14	Getting vaccinated is an effective way to prevent contagious diseases.	
15	Vaccinations reduce the likelihood of becoming infected by the germs you have been vaccinated against.	
16	Vaccinations reduce the spread of infectious disease.	
17	Soap, bleach, heat, and radiation can be used to kill germs.	
18	By avoiding contact with viruses and bacteria, I can avoid becoming sick.	
19	A good diet and exercise provides all the protection I need to keep from getting sick.	R
20	Antibiotics kill viruses as well as bacteria.	R

	Hygiene Behaviors	1 (Never), 2 (Sometimes), 3 (About half the time), 4 (Most of the time), 5 (Always)
1	Washing your hands	
2	Cooking food until it reaches recommended internal temperatures	
3	Refrigerating perishable foods	
4	Practicing safe sex	
5	Wearing masks	
6	Take vaccines that are available to me (ex. flu, COVID-19)	
7	Disinfecting surfaces	

	Alternative Medicine Behaviors	1 (Never), 2 (Sometimes), 3 (About half the time), 4 (Most of the time), 5 (Always)
1	Prayer	
2	"Laying hands" or faith healing	
3	Acupuncture	
4	Herbal medicine	
5	Massage	
6	Chiropractic medicine	
7	Magnetic Field Therapy	
8	Aromatherapy	
9	Hypnotherapy	
10	Meditation	
11	Homeopathic medications	

	Xenophobia	1 (Strongly disagree) – 7 (Strongly agree)
1	Interacting with immigrants makes me uneasy.	
2	With increased immigration, I fear that our way of life will change for the worse.	
3	I am afraid that our own culture will be lost with increase in immigration.	
4	Immigration in this country is out of control.	
5	I doubt that immigrants will put the interest of this country first.	

	Traditionalism	1 (Strongly disagree) – 7 (Strongly agree)
1	Nobody should stick to the "straight and narrow". Instead people should break loose and try out lots of different ideas and experiences.	R
2	This country will flourish if young people stop experimenting with drugs, alcohol, and sex, and pay more attention to family values.	
3	Traditional values, customs, and morality have a lot wrong with them.	R
4	Everyone should have their own lifestyle, religious beliefs, and sexual preferences, even if it makes them different from everyone else.	R
5	It is important that we preserve our traditional values and moral standards.	
6	People should pay less attention to the bible and the other old-fashioned forms of religious guidance, and instead develop their own personal standards of what is moral and immoral.	R

	Food Neophobia	1 (Strongly disagree) – 7 (Strongly agree)
1	I am constantly sampling new and different foods.	R
2	I don't trust new foods.	
3	If I don't know what is in a food, I won't try it.	
4	I like foods from different countries.	R
5	Ethnic food looks too weird to eat.	
6	At dinner parties, I will try a new food.	R
7	I am afraid to eat things I have never had before.	
8	I am very particular about the foods I will eat.	
9	I will eat almost anything.	R
10	I like to try new ethnic restaurants.	R

	[*STUDY 2 ONLY*] Collectivism	1 (Strongly disagree) – 7 (Strongly agree)
1	I'd rather depend on myself than others. [INDIVIDUALISM]	
2	I rely on myself most of the time; I rarely rely on others. [INDIVIDUALISM]	
3	I often do "my own thing." [INDIVIDUALISM]	
4	My personal identity, independent of others, is very important to me. [INDIVIDUALISM]	
5	It is important that I do my job better than others. [INDIVIDUALISM]	
6	Winning is everything. [INDIVIDUALISM]	
7	Competition is the law of nature. [INDIVIDUALISM]	
8	When another person does better than I do, I get tense and aroused. [INDIVIDUALISM]	
9	If a coworker gets a prize, I would feel proud. [COLLECTIVISM]	
10	The well-being of my coworkers is important to me. [COLLECTIVISM]	
11	To me, pleasure is spending time with others. [COLLECTIVISM]	
12	I feel good when I cooperate with others. [COLLECTIVISM]	
13	Parents and children must stay together as much as possible. [COLLECTIVISM]	
14	It is my duty to take care of my family, even when I have to sacrifice what I want. [COLLECTIVISM]	
15	Family members should stick together, no matter what sacrifices are required. [COLLECTIVISM]	
16	It is important to me that I respect the decisions made by my groups. [COLLECTIVISM]	

[*STUDY 2* ONLY] Perceived Cultural Tightness		Anchors 1 - 7
1	My country is currently	Not Permissive Enough – Too Permissive
2	People in my country are currently	Overly Adherent of My Country's Customs – Overly Ignorant of My Country's Customs
3	People in my country	Follow the Rules Too Much – Don't Follow the Rules Enough
4	My country currently has	Too Many Rules – Too Few Rules
5	Social norms in my country are	Too Rigid – Too Flexible
6	People in my country who break the law are currently	Punished Too Often – Punished Too Rarely
7	Criminal punishment in my country is currently	Too Harsh – Too Lenient
8	My country's norms are currently	Enforced Too Strictly – Not Enforced Strictly Enough
9	People who don't conform to the norms in my country are	Treated Too Harshly – Treated Too Kindly
10	My country is currently	Too Tight – Too Loose

Perceived Vulnerability to Disease		1 (Strongly disagree) – 7 (Strongly agree)
1	If an illness is "going around", I will get it.	
2	My immune system protects me from most illness that other people get.	R
3	I am more likely than the people around me to catch an infectious disease.	
4	My past experiences make me believe I am not likely to get sick even when my friends are sick.	R
5	I have a history of susceptibility to infectious disease.	
6	I am unlikely to catch a cold, flu, or other illness even if it is "going around".	R
7	I prefer to wash my hands pretty soon after shaking someone's hand.	
8	In general, I am very susceptible to colds, flu, and other infectious diseases.	
9	I avoid using public telephones because of the risk that I may catch something from the previous user.	
10	I do not like to write with a pencil someone else has obviously chewed on.	
11	I dislike wearing used clothes because you do not know what the last person who wore it was like.	
12	I am comfortable sharing a water bottle with a friend.	R
13	It really bothers me when people sneeze without covering their mouths.	
14	It does not make me anxious to be around sick people.	R
15	My hands do not feel dirty after touching money.	R

[STUDY 1 ONLY] Big Five Inventory		*1 (Strongly disagree) – 7 (Strongly agree)*
1	Is talkative [EXTRAVERSION]	
2	Tends to find fault with others [AGREEABLENESS]	R
3	Does a thorough job [CONSCIENTIOUSNESS]	
4	Is depressed, blue [NEUROTICISM]	
5	Is original, comes up with new ideas [OPENNESS]	
6	Is reserved [EXTRAVERSION]	R
7	Is helpful and unselfish with others [AGREEABLENESS]	
8	Can be somewhat careless [CONSCIENTIOUSNESS]	R
9	Is relaxed, handles stress well [NEUROTICISM]	R
10	Is curious about many different things [OPENNESS]	
11	Is full of energy [EXTRAVERSION]	
12	Start quarrels with others [AGREEABLENESS]	R
13	Is a reliable worker [CONSCIENTIOUSNESS]	
14	Can be tense [NEUROTICISM]	
15	Is ingenious, a deep thinker [OPENNESS]	
16	Generates a lot of enthusiasm [EXTRAVERSION]	
17	Has a forgiving nature [AGREEABLENESS]	
18	Tends to be disorganized [CONSCIENTIOUSNESS]	R
19	Worries a lot [NEUROTICISM]	
20	Has an active imagination [OPENNESS]	
21	Tends to be quiet [EXTRAVERSION]	R
22	Is generally trusting [AGREEABLENESS]	
23	Tends to be lazy [CONSCIENTIOUSNESS]	R
24	Is emotionally stable, not easily upset [NEUROTICISM]	R
25	Is inventive [OPENNESS]	
26	Has an assertive personality [EXTRAVERSION]	
27	Can be cold and aloof [AGREEABLENESS]	R
28	Perseveres until the task is finished [CONSCIENTIOUSNESS]	

29	Can be moody [NEUROTICISM]	
30	Values artistic, aesthetic experiences [OPENNESS]	
31	Is sometimes shy, inhibited [EXTRAVERSION]	R
32	Is considerate and kind to almost everyone [AGREEABLENESS]	
33	Does things efficiently [CONSCIENTIOUSNESS]	
34	Remains calm in tense situations [NEUROTICISM]	R
35	Prefers work that is routine [OPENNESS]	R
36	Is outgoing, sociable [EXTRAVERSION]	
37	Is sometimes rude to others [AGREEABLENESS]	R
38	Makes plans and follows through with them [CONSCIENTIOUSNESS]	
39	Gets nervous easily [NEUROTICISM]	
40	Likes to reflect, play with ideas [OPENNESS]	
41	Has few artistic interests [OPENNESS]	R
42	Likes to cooperate with others [AGREEABLENESS]	
43	Is easily distracted [CONSCIENTIOUSNESS]	R
44	Is sophisticated in art, music, or literature [OPENNESS]	

[*STUDY 2 ONLY*] Ten-Item Personality Inventory	1 (Does not describe me) – 5 (Describes me extremely well)	
1	extraverted, enthusiastic [EXTRAVERSION]	
2	critical, quarrelsome [AGREEABLENESS	R
3	dependable, self-disciplined [CONSCIENTIOUSNESS]	
4	anxious, easily upset [NEUROTICISM]	
5	open to new experiences, complex [OPENNESS]	
6	reserved, quiet [EXTRAVERSION]	R
7	sympathetic, warm [AGREEABLENESS]	
8	disorganized, careless [CONSCIENTIOUSNESS]	R
9	calm, emotionally stable [NEUROTICISM]	R
10	conventional, uncreative [OPENNESS]	R

Demographic Section

What is your sex?	1 – Male 2 – Female
Enter your age in years.	
Overall, how politically conservative or liberal are you?	1 – Extremely conservative 2 – Moderately conservative 3 – Somewhat conservative 4 – Somewhat liberal 5 – Moderately liberal 6 – Extremely liberal
Growing up, what was your family's average annual income?	
What is the highest level of formal education achieved by one of your parents?	1 – Less than high school degree 2 – High school graduate (high school diploma or equivalent, including GED) 3 – Some college but not degree 4 – Associate degree in college (2-year) 5 – Bachelor's degree in college (4-year) 6 – Master's degree 7 – Doctoral degree 8 – Professional degree (e.g., JD, MD)
What is the highest level of formal education achieved by your other parent?	1 – Less than high school degree 2 – High school graduate (high school diploma or equivalent, including GED) 3 – Some college but not degree 4 – Associate degree in college (2-year) 5 – Bachelor's degree in college (4-year) 6 – Master's degree 7 – Doctoral degree 8 – Professional degree (e.g., JD, MD)

APPENDIX B

SUPPLEMENTAL TABLES

LIST OF SUPPLEMENTAL TABLES

Table S1. Hygiene Behaviors and the Behavioral Immune System in Study 1.

Covariates	Traditionalism	Xenophobia	Food Neophobia
No Covariates	-0.277*	-0.392*	-0.165*
Parental Education	-0.282*	-0.394*	-0.172*
Sex	-0.262*	-0.355*	-0.173*
Perceived Vulnerability to Disease	-0.260*	-0.413*	-0.218*
Political Orientation	-0.071	-0.238*	-0.183*
Neuroticism	-0.248*	-0.385*	-0.173*
Openness	-0.264*	-0.383*	-0.128*

Note: Partial, standardized regression coefficients using the three behavioral immune system components as the criterion and hygiene behaviors as the predictor in Study 1. * indicates $p < .05$.

Table S2. Knowledge of Germ Theory and the Behavioral Immune System in Study 1.

Covariates	Traditionalism	Xenophobia	Food Neophobia
No Covariates	-0.272*	-0.335*	-0.219*
Parental Education	-0.282*	-0.348*	-0.211*
Sex	-0.261*	-0.316*	-0.223*
Perceived Vulnerability to Disease	-0.279*	-0.336*	-0.212*
Political Orientation	-0.106*	-0.194*	-0.208*
Neuroticism	-0.270*	-0.334*	-0.220*
Openness	-0.258*	-0.324*	-0.180*

Note: Partial, standardized regression coefficients using the three behavioral immune system components as the criterion and hygiene behaviors as the predictor in Study 1. * indicates $p < .05$.

Table S3. Alternative Medicine Behaviors and the Behavioral Immune System in Study 1.

Covariates	Traditionalism	Xenophobia	Food Neophobia
No Covariates	0.210*	0.249*	0.047
Parental Education	0.211*	0.271*	0.035
Sex	0.206*	0.243*	0.048
Perceived Vulnerability to Disease	0.218*	0.251*	0.039
Political Orientation	0.071	0.153*	0.027
Neuroticism	0.204*	0.247*	0.049
Openness	0.222*	0.261*	0.069

Note: Partial, standardized regression coefficients using the three behavioral immune system components as the criterion and hygiene behaviors as the predictor in Study 1. * indicates $p < .05$.

Table S4. Full Correlation Table for Study 1.

Variable	*M*	*SD*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
			Behavioral Immune System Components			Cultural Disease Avoidance Strategies			Covariates					
1. Xenophobia	1.98	1.21												
2. Traditionalism	3.48	1.10	.37**											
3. Food Neophobia	2.93	1.24	.21**	.13*										
4. Hygiene Behaviors	4.26	0.56	-.39**	-.28**	-.16**									
5. Knowledge of Germ Theory	5.60	0.56	-.34**	-.27**	-.22**	.27**								
6. Alternative Medicine Behaviors	1.49	0.59	.25**	.21**	.05	-.06	-.43**							
7. Perceived Vulnerability to Disease	3.90	0.78	-.01	-.13*	.17**	.24**	-.04	.05						
8. Openness	4.79	0.76	-.12*	-.12*	-.26**	.15**	.17**	.08	-.05					
9. Conscientiousness	4.85	0.84	-.08	.18**	-.07	.09	.07	-.04	-.12*	.03				
10. Extraversion	4.22	1.06	.04	.19**	-.01	-.06	-.01	.13*	-.19**	.18**	.20**			
11. Agreeableness	5.20	0.80	-.26**	-.02	-.26**	.17**	.25**	-.08	-.11	.20**	.39**	.20**		
12. Neuroticism	4.10	1.10	-.11	-.29**	.06	.11	.01	-.02	.32**	.01	-.35**	-.24**	-.20**	
13. Political Orientation	3.90	1.34	-.52**	-.59**	-.07	.39**	.29**	-.24**	.14*	.21**	-.16**	-.12*	.06	.26**

Table S5. Perceived Vulnerability to Disease Correlations in Study 1.

	Perceived Vulnerability to Disease		**Germ Aversion**		**Perceived Infectibility**	
	No Control	*Political Orientation*	*No Control*	*Political Orientation*	*No Control*	*Political Orientation*
Traditionalism	-.13*	- .06	.03	.03	-.08	-.06
Xenophobia	-.01	.05	-.03	-.05	.01	.03
Food Neophobia	.17**	.17**	-.10	-.09	.12*	.14*

* $p < .05$, ** $p < .01$

Table S6. Hygiene Behaviors and the Behavioral Immune System in Study 2.

Covariates	Traditionalism	Xenophobia	Food Neophobia	Individualism	Collectivism	Tightness
No Covariates	-0.187*	-0.408*	-0.123*	0.142*	0.266*	-0.032
Parental Education	-0.189*	-0.407*	-0.118*	0.144*	0.263*	-0.025
Sex	-0.179*	-0.397*	-0.139*	0.184*	0.304*	-0.059
Perceived Vulnerability to Disease	-0.185*	-0.411*	-0.172*	0.171*	0.302*	-0.023
Political Orientation	0.004	-0.272*	-0.085	0.201*	0.328*	0.141*
Neuroticism	-0.183*	-0.409*	-0.126*	0.142*	0.270*	-0.028
Openness	-0.174*	-0.393*	-0.063	0.123*	0.243*	-0.021

Note: Partial, standardized regression coefficients using the three behavioral immune system components as the criterion and hygiene behaviors as the predictor in Study 2. * indicates $p < .05$.

Table S7. Knowledge of Germ Theory and the Behavioral Immune System in Study 2.

Covariates	Traditionalism	Xenophobia	Food Neophobia	Individualism	Collectivism	Tightness
No Covariates	-0.233*	-0.413*	-0.189*	0.080	0.115*	-0.197*
Parental Education	-0.245*	-0.441*	-0.184*	0.076	0.122*	-0.188*
Sex	-0.223*	-0.396*	-0.193*	0.089	0.118*	-0.214*
Perceived Vulnerability to Disease	-0.229*	-0.403*	-0.205*	0.087	0.117*	-0.197*
Political Orientation	-0.099*	-0.305*	-0.164*	0.110*	0.136*	-0.094*
Neuroticism	-0.224*	-0.415*	-0.196*	0.081	0.125*	-0.188*
Openness	-0.219*	-0.397*	-0.104*	0.051	0.077	-0.189*

Note: Partial, standardized regression coefficients using the three behavioral immune system components as the criterion and hygiene behaviors as the predictor in Study 2. * indicates $p < .05$.

Table S8. Alternative Medicine Behaviors and the Behavioral Immune System in Study 2.

Covariates	Traditionalism	Xenophobia	Food Neophobia	Individualism	Collectivism	Tightness
No Covariates	0.266*	0.277*	0.106*	0.060	0.124*	0.173*
Parental Education	0.279*	0.293*	0.096*	0.105*	0.118*	0.160*
Sex	0.262*	0.264*	0.106*	0.092	0.129*	0.178*
Perceived Vulnerability to Disease	0.278*	0.299*	0.096*	0.098*	0.126*	0.179*
Political Orientation	0.196*	0.188*	0.099*	0.072	0.097*	0.111*
Neuroticism	0.271*	0.277*	0.103*	0.092	0.129*	0.182*
Openness	0.265*	0.276*	0.105*	0.092	0.124*	0.172*

Note: Partial, standardized regression coefficients using the three behavioral immune system components as the criterion and hygiene behaviors as the predictor in Study 2. * indicates $p < .05$.

Table S9. Full Correlation Table for Study 2.

Variable	*M*	*SD*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*
			Behavioral Immune System Components						Cultural Disease Avoidance Strategies			Covariates					
1. Xenophobia	2.02	1.18															
2. Traditionalism	3.57	0.97	.35**														
3. Food Neophobia	3.02	1.17	.22**	.20**													
4. Collectivism	5.10	0.85	-.18**	.16**	-.21**												
5. Individualism	4.83	0.82	-.06	-.05	-.04	.35**											
6. Tightness	3.82	0.81	.34**	.48**	.15**	.15**	.06										
7. Hygiene Behavior	4.23	0.62	-.41**	-.19**	-.12**	.27**	.14**	-.03									
8. Knowledge of Germ Theory	5.45	0.70	-.41**	-.23**	-.19**	.12*	.08	-.20**	.48**								
9. Alternative Medicine Behaviors	1.61	0.73	.28**	.27**	.11*	.12**	.09	.17**	-.15**	-.48**							
10. Perceived Vulnerability to Disease	4.00	0.80	-.13**	-.06	.09	-.00	-.04	-.03	.34**	.13**	.13**						
11. Openness	3.76	0.85	-.16**	-.11*	-.41**	.19**	.15**	-.08	.15**	.22**	-.00	-.04					
12. Conscientiousness	3.80	0.84	-.13**	.03	-.07	.14**	.22**	.06	.23**	.17**	-.05	.09	.21**				
13. Extraversion	2.92	1.09	-.00	.11*	-.13**	.26**	.11*	.05	-.02	-.02	.08	-.05	.20**	.03			
14. Agreeableness	3.54	0.83	-.10*	.03	-.09	.18**	-.11*	.02	.12*	.10*	-.05	-.00	.16**	.08	-.06		
15. Neuroticism	2.87	0.98	.01	-.17**	.11*	-.15**	-.00	-.17**	.02	.06	.03	.25**	-.06	-.12*	-.14**	-.14**	
16. Political Orientation	3.76	1.29	-.50**	-.50**	-.13**	-.04	-.05	-.39**	.40**	.30**	-.12*	.24**	.06	-.05	-.14**	.04	.17**

Table S10. Perceived Vulnerability to Disease Correlations in Study 2.

	Perceived Vulnerability to Disease		**Germ Aversion**		**Perceived Infectibility**	
	No Control	*Political Orientation*	*No Control*	*Political Orientation*	*No Control*	*Political Orientation*
Traditionalism	-.06	.06	-.05	.05	-.05	.05
Xenophobia	-.13**	-.03	-.11*	-.02	-.13**	-.03
Food Neophobia	.09	.13**	.06	.10*	.11*	.14**
Individualism	-.04	-.02	-.00	.01	-.07	-.06
Collectivism	-.00	-.00	.06	.06	-.07	-.07
Tightness	-.03	.07	.01	.09*	-.06	.02

* $p < .05$, ** $p < .01$