THE IMPLICATIONS OF DISEASE THREAT FOR ATTITUDES, BEHAVIOR, AND CULTURE

by

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ABSTRACT

Disease threat has posed one of the greatest threats to human survival throughout history. However, only recently has research begun to elucidate humans' psychological, behavioral, and cultural adaptations to the threat posed by infectious disease. Across a set of empirical studies using both individuals and cultures as units of analysis, this thesis investigates the implications of disease threat for attitudes, behavior, and cultural value systems. Chapter Two reports results from an experiment which show that perceived threat of disease is linked to more sexually restrictive attitudes across three measures. These results emerged most clearly for women. Chapter Three reports results from an experiment which show that temporary disease salience leads to relatively higher behavioral and attitudinal conformity (across four diverse measures). Further analyses show that dispositional worry about disease transmission is also positively associated with conformity. Chapter Four introduces a tool—an historical disease index—for investigating the origins of cross-cultural differences. Analyses reveal that this historical disease index is a better predictor of cross-cultural differences than are contemporary measures of disease. Chapter Five reports two studies which investigate the relationship between regional variation in disease prevalence and cross-cultural variation in authoritarianism. Results from Study 1 show that country-level mean authoritarian personality scores largely mediate the previously-documented relationship between pathogen prevalence and institutional authoritarianism. Using a sample of traditional societies (from the Standard Cross-Cultural sample), results from Study 2 reveal a link between historical pathogen prevalence and twelve measures of authoritarian governance. These relationships cannot be accounted for by controlling for other threats to human welfare. Chapter Six reports results from a cross-national analysis showing that historical disease prevalence positively predicts five measures of scientific and technological innovation. This relationship cannot be accounted for by variation in wealth, education, or life expectancy. Further analyses reveal that this relationship is largely mediated by cross-national variation in individualism and collectivism. Chapter Seven considers the possible causal mechanisms by which disease influences these individual and cultural differences, and considers the implications of this set of results.

PREFACE

Student's contribution to the design, execution, and analyses of research reported herein

Student Murray—with oversight and assistance from supervisor Schaller—was primarily responsible for the identification and design of this Ph.D. research program, which represents an extension of an earlier research program developed by supervisor Schaller. Murray was the lead investigator and was responsible for all data collected. All statistical analyses were performed primarily by Murray, with oversight and assistance from Schaller.

Publications arising from, and relative contributions to, individual research chapters

The results reported in Chapter Two are now published: Murray, D. R., Jones, D. N., & Schaller, M. (2013). Perceived threat of infectious disease and its implications for sexual attitudes. *Personality and Individual Differences, 54*, 103-108. Student Murray created the study design, was responsible for overseeing execution of the experiment, and spearheaded data analysis, manuscript writing, and journal correspondence. Co-author Jones helped with study design. Co-author Schaller assisted in study design, data analysis, and revising the manuscript for publication. This study (along with the study reported in Chapter Three) was approved by the UBC Behavioral Research Ethics Board (Project Titles: "Who are you attracted to?" "How do you evaluate people?" BREB # H07-02573).

The results reported in Chapter Three are now published: Murray, D. R., & Schaller, M. (2012). Threat(s) and conformity deconstructed: Perceived threat of infectious disease and its implications for conformist attitudes and behavior. *European Journal of Social Psychology, 42*, 180-188. Student Murray created the study design, was responsible for overseeing execution of the experiment, and spearheaded data analysis, manuscript writing, and journal correspondence. Co-author Schaller assisted in study design, data analysis, and revising the manuscript.

The results reported in Chapter Four are now published: Murray, D. R., & Schaller, M. (2010). Historical prevalence of disease within 230 geopolitical regions: A tool for investigating origins of culture. *Journal of Cross-Cultural Psychology, 41*, 99-108. Student Murray obtained the archival materials needed for this work, and was solely responsible for creating all disease codes. Murray also spearheaded manuscript writing and journal correspondence. Co-author Schaller assisted in data presentation, and revising the manuscript.

The results reported in Chapter Five have been accepted for publication: Murray, D. R., Schaller, M., & Suedfeld, P. (in press). Pathogens and Politics: Further Evidence that Parasite Prevalence Predicts Authoritarianism. *PLoS ONE.* Student Murray obtained the published materials needed for this work, performed all statistical analyses, and was responsible for manuscript writing and journal correspondence. Co-author Schaller assisted in revising the manuscript. Co-author Suedfeld assisted in theory-building and in revising the manuscript.

The results reported in Chapter Six have been submitted for publication: Murray, D. R. (under review). Direct and indirect implications of pathogen prevalence for scientific and technological innovation.

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For my Family

CHAPTER ONE

General Introduction

"Infectious diseases have likely claimed more lives than all wars, non-infectious diseases, and natural disasters taken together. In the face of such attack by microscopic invaders, human populations have been forced to adapt to infectious agents on the levels of both genes and culture."

Inhorn & Brown, 1990 (p. 89)

I'll begin this work with a quick personal anecdote, before jumping into the real scholarly stuff.

I have always been somewhat of a maverick. Although I understand the inherent value of rules and norms, they don't seem to exert the psychological "pull" on me like they do on many other people. During my childhood, my lax attitude towards rules and normative proscriptions sometimes landed me in trouble—both punitive and physical in nature. My disregard for teachers' gentle-yet-persistent requests to stop talking led me to spend far more hours in detention than I think was healthy; my disregard for "out-of-bounds" markers would get me lost whilst skiing, and would sometimes get me stitches whilst biking; my disregard for norms regarding not sharing with sick classmates would get me the flu (or so my mother claims). But my independently-minded behavior also brought benefits. Deviating from marked trails has led me to some of my favourite skiing and hiking; even today when I cook, my favourite dishes have arisen from experimentation and deviation from original recipes.

This maverick-like attitude came with me when I traveled through Southeast Asia—for the most part. In the first leg of my journey through Thailand and Vietnam I felt like myself, psychologically speaking. However, once I entered Cambodia my attitudes and behavior seemed to change. For the first time I always wore sunscreen and a hat like my guidebook recommended; I consistently obeyed "No Entry" signs when exploring the temples of Angkor; I was hypervigilant in asking locals before I photographed anything.

Why did this sudden change occur? Why in Cambodia? Although my memory may bias somewhat, I believe now that my temporary dispositional change was at least partly due to the warnings that I received as I first walked into the country. Included with the Visa I received at the border was a piece of paper, on which the English read, "IN CAMBODIA YOU MAY BE EXPOSED TO DANGEROUS INFECTIOUS DISEASES. SEEK IMMEDIATE MEDICAL ATTENTION IF YOU HAVE SYMPTOMS OF ILLNESS." My guidebook confirmed this fact: Traveling through Cambodia carried with it a higher risk of exposure to pathogens than traveling through any neighbouring countries.

Disease-relevant messages such as these of course lead people to be more vigilant in preventative behaviors. But could these warnings have been sufficient to change my attitudes and behavior, even in domains seemingly irrelevant to disease? Maybe. A growing body of research demonstrates that the impact of disease threat is far more potent and expansive than once thought. The threat posed by infectious disease has implications not just for domains pertaining specifically to health; rather, it has far reaching consequences for basic cognition, attitudes, behavioral dispositions, and the emergence of cross-cultural differences. But before jumping into the meat of this thesis, it's worth taking a look at the deep history shared between humans and parasites.

1.1 Disease Threat and Adaptive Behavior

The ancestral tale of the battle between parasites and their hosts is an epic that stretches back to the origins of multicellular life itself—parasites have posed a threat to the welfare of the ancestors of modern humans for nearly a billion years (Zimmer, 2001). In human populations disease has likely represented the largest threat to survival throughout history; in populations lacking sophisticated medical systems infectious diseases are one of the most common causes of death even today (Gurven & Kaplan, 2007; Inhorn & Brown, 1990).

Humans have evolved several defense mechanisms aimed at mitigating the ubiquitous threat posed by infectious disease. One such set of mechanisms comprises the physiological immune system. At a basic level, this system operates by detecting invading parasites in the body, notifying the appropriate antibodies, and activating the appropriate physiological response. Although this highly sophisticated system is generally effective, it suffers from at least three shortcomings. First, this cascade of defenses only becomes operative *after* infection; pathogens may wreak significant damage during even this short latency period. Second, this system is more effective at eliminating pathogens with which it has already been in contact; the immune system lacks the specific antibodies required for novel pathogens, which further increases the latency time between detection and elimination. Third, these physiological defenses are costly. Immunological responses to bacterial infections, for example, typically involve an increase in body heat (experienced as fever), which potentiates immune responses and creates a suboptimal environment for the invading pathogen (e.g. Nesse & Williams, 1995). This fever response comes at great energetic cost: A 13 percent increase in metabolic activity is required to increase human body temperature by just 1^o Celsius (Dantzer, Kent, Bluthe, & Kelley, 1991). Immunological responses such as fever not only consume substantial caloric energy (which otherwise could be allocated to sustain other important physiological systems), they can also be temporarily physically debilitating.

Along with the physiological immune system, humans (and other animals) are equipped with a type of *behavioral* (or, more accurately, psychological) immune system. This system serves as a first line of defense against pathogens, and in doing so decreases the frequency of costly activation of the behavioral immune system. This psychologically-based immune system operates by detecting potential disease-connoting cues within the local environment and responding with a cascade of cognitive, affective, and behavioral reactions designed to facilitate avoidance of pathogens (Schaller, 2011).

Behavioral disease avoidance is well-documented in non-human animal species within the biological sciences literature. Behavioral parasitic avoidance exists within even the most phylogenetically distant faunal taxa: The nematode *C. Elegans,* for example, can discriminate between innocuous and pathogenic bacteria and actively avoids the latter (Schulenburg & Muller, 2004). Avoidance behaviors may be directed against pathogenic substances (such as feces, e.g. Michel, 1955) as well as potentially infectious group members. Social Caribbean spiny lobsters discriminately avoid conspecifics suffering from viral infections (Behringer, Butler, & Shields, 2006); bullfrog tadpoles detect chemically-transduced cues signaling parasitic infection in other tadpoles, and respond by selectively swimming away from the infected conspecifics (Kiesecker, Skelly, Beard, & Preisser, 1999). Phylogenetically closer to home, chimps ostracize and react with unusually aggressive displays towards other group members that have become infected with polio (Goodall, 1986). Freeland (1976) notes that disease has been one of the most important ecological influences in the evolution of primate behavior, given its role in debilitating illness, congenital malformations, and significant infant and juvenile mortality in free-living primates.

Despite the well-documented link between pathogens in the biological sciences, the role that parasites play in shaping human psychology and behavior was largely ignored until only recently. Even at the turn of the century, Kurzban and Leary (2001) observed, “although parasites may play a critical role in the evolutionary process, they have received little attention in terms of their power to drive human psychological adaptations” (p. 197).

1.2 Social Implications of the Behavioral Immune System

Research pertaining to the specific hypotheses addressed in the research chapters will be covered in more detail at the outset of each chapter. However, an overview of some of the work documenting the effects of the behavioral immune system will serve here as a good primer. Most of the early research on the implications of disease threat for interpersonal behavior focused upon stigmatization and prejudice. The general logic underpinning these investigations was that interpersonal interactions are associated with the risk of disease transmission; many contemporary diseases are spread primarily through social contact. Such diseases have burgeoned in the last 11,000 years due to the human shift from low-density, nomadic lifestyles to higher-density, more sedentary lifestyles (e.g. Wolfe, Dunavon, & Diamond, 2007). Of course, interacting with certain types of people is riskier than others—pathogenically speaking—and the logical hypothesis that follows is that people should stigmatize or avoid people displaying cues that might connote the threat of disease.

Indeed, individuals stigmatize and avoid others who display obvious symptoms of illness (Crandall & Moriarty, 1995). However, the behavioral immune system is also biased towards false alarms. Error Management Theory (Haselton & Buss, 2000) suggests why this should be the case: The costs of a false rejection (incorrectly assuming an infectious person to be healthy) are much greater than a false alarm (incorrectly assuming a healthy person infectious). Whereas the costs of the latter can amount to the temporary loss of a social contact, the cost of the former is exposure to potentially harmful or debilitating pathogens (e.g. Haselton & Nettle, 2006). This hypersensitivity to disease cues leads to stigmatization or avoidance of individuals who pose no risk of disease transmission whatsoever, yet display cues that are heuristically associated with disease threat. Individuals with noninfectious morphological anomalies, for example, activate avoidant responses (Zebrowitz & Montpare, 2006). Similarly, individuals with physical disabilities and obese individuals are implicitly associated with disease (Park, Schaller, & Crandall, 2007; Park, Schaller, & Faulkner, 2003).

Another broad category of people who have historically represented disease threat are strangers, or outgroup members more generally. The human adaptive immune system produces antibodies primarily against pathogens with which it has had previous contact, such as the pathogens present in low levels in group members or the local environment. Therefore, contact with unfamiliar outgroups brings increased risk of exposure to pathogens for which the body has no natural defenses (Diamond, 1999). This adaptive immunity is highly localized: Even adjacent villages can have highly variable immune defenses to specific strains of parasites (e.g. Miller et al., 2007). The upshot is that individuals displaying cues that connote outgroup status may be implicitly associated with higher threat of contagion.

Although outgroups may have historically represented a threat of contagion, contact with outgroups has numerous social, economic, and coalitional benefits too. Cost/benefit logic predicts that ethnocentrism should be highest when the benefits of outgroup contact are likely to be outweighed by the potential pathogenic costs—that is, xenophobia and ethnocentrism should be highest when real or perceived pathogenic threat is highest. Multiple lines of research, which are especially relevant to the research reported in Chapter Five, now show this to be the case. Individuals who are more chronically worried about pathogen transmission endorse more xenophobic attitudes towards foreign, but not familiar, ethnic outgroups (across four studies; Faulkner, Schaller, Park, & Duncan, 2004). Similarly, ethnocentrism increases as a function of perceived vulnerability to disease and disgust sensitivity (across two studies; Navarette & Fessler, 2006). Furthermore, an experimental manipulation of pathogen threat (via slideshows with pictures of rashes, mucous, and puss) decreased endorsement for immigration from unfamiliar foreign countries relative to an affectively neutral prime, and led individuals to allocate relatively more hypothetical aid to ethnically similar—rather than ethnically foreign—groups (Faulkner et al., 2004).

Ethnocentrism is also correlated with actual variation in immune function. Pregnant women are most vulnerable to pathogens in their first trimester of pregnancy, when they undergo severe immunosuppression in order to prevent their body from rejecting the new fetus. This period of pathogenic vulnerability is concurrently when women score highest in measures of ethnocentrism (Navarette, Fessler, & Eng, 2007).

Along with ethnocentrism, disease threat is associated with social conservatism more generally (social conservatism here is defined as any sort of value system that emphasizes adherence to social norms, social exclusivity, and tradition, e.g. Altemeyer, 1988; these elements of social conservatism will be explored further in Chapters Three, Five, and Six). Such value systems thus have elements of conformity, ethnocentrism, and xenophobia and may be reflected across a wide range of individual beliefs. Sensitivity to disease cues (e.g. the ease with which a person feels “disgust”) is associated with right-wing authoritarianiam (Terrizzi, Shook, & Ventis, 2010), and with political conservatism (Inbar, Pizarro, & Bloom, 2009).

Attitudes towards homosexuals—a specific value reflective of social conservatism—appear to be especially strongly related to sensitivity to disease. Using both explicit and implicit measures has revealed that higher disgust sensitivity predicts anti-homosexual prejudice (Inbar, Pizarro, Knobe, & Bloom, 2009; Olatunji, 2008; Terrizzi et al., 2010). These associations are also evident in measures assessing basic personality: Individuals higher in either germ aversion or disgust sensitivity also score lower on the self-reported Big Five personality trait Openness (Druschel & Sherman, 1999; Duncan et al., 2009)—the personality trait most closely associated with non-normative and creative attitudes.

1.3 Cross-Cultural Implications of the Behavioral Immune System

Another body of work documents the implications of disease threat at a much larger level of analysis: at the level of culture. Just as perceived disease threat produces individual-level variation in attitudes and behavior, so can ecological variation in real disease threat produce reliable cross-cultural variation in cultural practices, norms, and value systems. These differences appear to arise in response to the variable cost/benefit tradeoffs across different regions. Cross-cultural variation in extraversion offers a good example. Extraversion is associated with many benefits: More highly extraverted individuals report higher levels of happiness, are more effective leaders, and enjoy more opportunities for sexual reproduction (Berry & Miller, 2001; Silverthorne, 2001). However, being highly extraverted also carries with it a higher risk of being exposed to disease-causing pathogens (Nettle, 2005). These benefits of extraversion are more likely to outweigh the disease-related costs under ecological conditions in which these costs are relatively minimal: In places characterized by low levels of interpersonally transmitted pathogens. Conversely, in areas characterized by high pathogen prevalence, the disease-related costs of extraversion may outweigh its benefits. This cost/benefit analysis suggests that regional variation in pathogen prevalence should be inversely related to population-level variation in extraversion, and this is exactly what cross-cultural investigations show (Schaller & Murray, 2008).

Several other research programs are revealing that regional variation in disease threat is associated with a wide array of psychological cross-cultural differences. (Deciphering the causality of these relationships isn't always easy—an issue that is considered further in Chapter Four). Many of these differences lie within two broad realms: In attitudes and behaviors pertaining to mating and sexuality, and in attitudes and behaviors pertaining to socially conservative values.

Disease threat and cross-cultural variation in sexuality

Disease threat and sexuality are considered in detail Chapter Two. The threat posed by infectious disease has implications for sexual behavior and mate choice for at least two reasons.

The first reason that disease threat influences sexuality pertains to mate choice. Several physical and facial characteristics are indicative of a person's inherent immunological profile, or their ability to fight and resist pathogens. Such features include a clear, blemish-free complexion, averageness of facial features, and bilateral or facial symmetry (e.g. Moller, 1997; Thornhill & Gangestad, 1993). Given that immunity is heritable (as are behaviors that mitigate pathogen transmission), a "good genes" model of mate preferences posits that disease-free individuals and individuals showing signs of a robust immune system should be considered more attractive mates. Indeed, clear complexions, symmetry and average facial features are universally physically attractive characteristics (Moller, 1997; Mealey, Bridgstock, & Townsend, 1999; Rhodes, Proffitt, Grady, & Sumich, 1998; Thornhill & Gangestad, 1999; Thornhill & Grammar, 1994).

A logical cost/benefit analysis predicts that characteristics connoting strong pathogen resistance should be especially beneficial in a mate—and therefore more strongly preferred—in environments where disease threat is especially high, and this is what research shows. Historical disease prevalence positively predicts the value placed on physical attractiveness across cultures (Gangestad & Buss, 1993). Similarly, masculinized male faces (another indicator of a strong immunological profile) are more strongly preferred in areas where pathogen threat is higher (DeBruine, Jones, Crawford, Welling, & Little, 2010).

A second reason disease threat should have implications for sexuality is that sexual contact entails intimate interpersonal contact, which increases the risk of exposure to novel pathogens. Indeed, many pathogens are spread exclusively through sexual contact, and the more sexually unrestricted a person is, the more they put themselves at risk for contracting diseases. Therefore, where pathogen prevalence is higher, the costs of unrestricted sexuality are more likely to outweigh the reproductive or social benefits, whereas in places characterized by lower pathogen prevalence the benefits are more likely to outweigh the costs. This logic leads to the hypothesis that greater pathogen prevalence predicts more sociosexually restricted attitudes. Utilizing results from a cross-national sexuality survey (the Sociosexual Orientation Inventory, Gangestad & Simpson, 1991) given to over 48,000 individuals in 48 countries, this is exactly what Schaller and Murray (2008) found. Further analyses revealed that this relationship was stronger for men than for women (*r*'s -.62 and -.27 respectively). This relationship between disease threat and unrestricted sexuality is explored at the individual level of analysis in Chapter Two.

Disease threat and cross-cultural variation in social conservatism

Just as perceived disease threat has implications for individual differences in social conservatism, actual disease threat has implications for cross-cultural differences in social conservatism. Some potential implications of this disease-related conservatism are considered in Chapters Five and Six. One way these differences manifest is in variation in measures of xenophobia end ethnocentrism. Pathogen prevalence is positively correlated with the percentage of people in a country who indicate that they would not want “people of a different race” as neighbors (Schaller & Murray, 2010). High pathogen prevalence also negatively predicts frequency of contact and assimilation between ethnic groups (Fincher & Thornhill, 2008a,b).

Schaller and Murray (2008) found obliquely related results examining socially conservative personality traits. The Big Five trait Openness to Experience—which is partly characterized by non-normative attitudes and behaviors—was negatively predicted by historical pathogen prevalence across three separate cross-national personality surveys.

Other related studies have investigated variation in individualism and collectivism—value constructs which have been subjected to more rigorous scientific inquiry than any other, and may ultimately prove to represent one of the key dimensions for capturing cultural variation (Heine, 2008). Relative to individualist value systems, collectivist systems emphasize conformity to group norms, tradition, and rigid ingroup/outgroup boundaries (e.g. Gelfand, Nishii, & Raver, 2006), which are all values that inhibit pathogen transmission. The hypothesis that follows, then, is that collectivism should be positively predicted by disease threat.

Fincher, Thornhill, Murray and Schaller (2008) tested the hypothesis that disease threat negatively predicts individualism and positively predicts collectivism. Results clearly supported the hypothesis: historical disease prevalence negatively predicted two measures of individualism (*r*’s = -.69 and -.71) and positively predicted two measures of collectivism (*r*’s = .63 and .73, *p*’s < .001). These relationships were robust when controlling for economic development and other potential causes of cultural differences in collectivism. Further, *historical* disease prevalence more strongly predicted these four outcome measures than did a contemporary measure of disease prevalence.

Investigations focusing on a specific facet collectivism—conformity pressure—have found convergent results. Murray and colleagues (2011) recently conducted four tests designed investigate whether regional differences in pathogen prevalence predict worldwide geographic differences in conformity, and in tolerance for nonconformity. Results revealed that the historical prevalence of pathogens correlated significantly positively with behavioral conformity effect sizes and the value placed on obedience (*r*'s = .49 and .48), and significantly negatively with personality variation and the percentage of left-handers (*r*'s = -.52 and -.73). This relationship exists between disease prevalence and institutional conformity pressure as well: Fincher, Thornhill, and Aran (2009) found that disease prevalence positively predicted restrictions on civil rights and liberties, and negatively predicted democratization. This relationship between disease prevalence and political systems is further investigated in Chapter Five. Further, results pertaining to the specific relationship between disease threat and conformity on the individual level of analysis are reported in Chapter Three.

1.4 Questions Unaddressed by Previous Work

Many key questions remain unaddressed within the growing literature on the implications of disease threat for attitudes, behavior, and culture. At the time of their conception and development, the empirical studies reported in this thesis were designed to address several of these key unanswered questions (the work that has followed these studies will be discussed in Chapter Seven).

One key question pertains to causal mechanisms, and equivalence across units of analysis. Despite the literature documenting the relationship between cultural variation in disease threat and cultural variation in sexual and conformist attitudes, no studies prior to those reported here have investigated this relationship using people, rather than whole cultures, as units of analysis. Several different causal mechanisms can account for cross-cultural variation (e.g. epigenetic, cultural transmission), and the existence of cross-cultural variation in response to disease threat does not logically entail individual variation in response to disease threat. The studies in Chapters Two and Three test whether such facultative individual variation exists, and represent the first studies to experimentally test whether *temporary* disease salience can cause ephemeral shifts in attitudes and behaviors pertaining to sexuality and conformity.

A second key question pertains to the broader societal implications of cross-cultural psychological variation. Although recent cross-cultural work documents relationships between disease threat and numerous attitudinal and interpersonal variables, the downstream society-wide and institutional *consequences* of this psychosocial variation remains largely uninvestigated. By testing models that incorporate both institutional and psychological variables, Chapters Five and Six begin to address this question.

A third key question pertains to the inferential limitations that arise when studying relationships that employ modern nation states as units of analysis. Countries can hardly be considered independent entities, and this non-independence can artificially inflate (or even create) relationships in cross-cultural investigations. Studies in Chapter Five begin to address this issue for the recently-documented relationship between disease prevalence and political systems. Further, for many cross-cultural relationships the directionality is unclear—how can we know that disease prevalence is a cause, rather than a consequence, of these numerous variables of interest? Experimental studies such as those in Chapters Two and Three can sometimes address this question; alternatively, Chapter Four provides a tool that helps to partly mitigate this inferential limitation for non-experimental analyses at the cultural level of analysis.

Addressing these broad research questions requires methodological and analytical tools that employ both individuals as well as entire cultures as units of analysis. The research in this thesis opens with two investigations employing the former, and follows with three investigations employing the latter.

1.5 Overview of this Thesis

Chapter Two focuses specifically on sexual attitudes, and reports a study which investigates the impact of perceived disease threat on these attitudes. (This chapter is adapted from a published article: Murray, D. R., Jones, D. N., & Schaller, M. [2013]. Perceived threat of infectious disease and its implications for sexual attitudes. *Personality and Individual Differences, 54,* 103-108). Experimental results reveal that when the threat of disease is made temporarily salient, participants high in dispositional worry about disease report more restrictive sexual attitudes on several different measures. Subsequent analyses reveal that these effects emerge most clearly and strongly for women. Participants higher in trait germ aversion also report a less promiscuous sexual history.

Chapter Three reports a study which specifically investigates the impact of perceived disease threat on conformist attitudes and behaviors. (This chapter is adapted from a published article: Murray, D. R., & Schaller, M. [2012]. Threat(s) and conformity deconstructed: Perceived threat of infectious disease and its implications for conformist attitudes and behavior. *European Journal of Social Psychology, 42,* 180-188). Results in this chapter reveal a two-pronged impact of perceived disease threat on four separate measures of conformity: first, participants showed higher conformist attitudes and behaviors when the threat of disease was experimentally made salient; when a non-disease threat was made salient, participants showed no higher levels of conformity than those in an affectively neutral condition. Second, participants higher in trait germ aversion tended to endorse more conformist attitudes; this effect was statistically independent of chronic worry about harm in general. Trait-like perceived disease threat and temporarily-salient disease threat did not interact to produce effects.

Chapter Four introduces the methodology involved in investigating the impact of historical disease prevalence on contemporary cross-cultural differences, and provides a broad overview of the issues and limitations inherent in these types of investigations. (This chapter is adapted from a published article: Murray, D. R., & Schaller, M. [2010]. Historical prevalence of disease within 230 geopolitical regions: A tool for investigating origins of culture. *Journal of Cross-Cultural Psychology, 41,* 99-108). Measuring historical disease prevalence around the world is no easy task. This chapter opens with a report on how a historical disease index was created for each country around the world, and how this disease index predicts cross-cultural differences in the same types of psychological variables that are associated with perceived threat of disease at the individual level of analysis. For example, this historical disease index negatively predicts female sociosexuality, negatively predicts trait Openness to Experience, and negatively predicts levels of democratization. This index represents the key independent variable used in the investigations reported in Chapters Five and Six.

Armed with this disease index, Chapter Five explores how cross-cultural differences in authoritarianism are predicted by regional variation in disease prevalence. (This chapter is adapted from a published article: Murray, D. R., Schaller, M., & Suedfeld, P. [2013]. Pathogens and Politics: Further Evidence that Parasite Prevalence Predicts Authoritarianism. *Plos One, 8,* e62275). Previous work has documented a positive link between pathogen prevalence and authoritarianism among nation states (Fincher et al., 2009); however, inferential issues and alternative explanations arising from these country-level analyses such as these remain unaddressed Results demonstrate that average authoritarian personality scores within a country are positively predicted by historical levels of infectious disease. Further, average F-scale authoritarianism scores largely mediate the relationships between disease prevalence and political measures of authoritarianism that have been reported in previous research. An alternative mediational model (wherein political authoritarianism mediates the relationship between disease prevalence and F-scale authoritarianism) is less consistent with the data. These results complement results from Chapters Two and Three suggesting that disease threat has implications for individual psychology, and that individual psychologies drive broader societal differences. Specifically, the results suggest that authoritarian personalities drive authoritarian political systems, rather than vice versa. Study Two in this chapter shows that historical disease prevalence predicts eleven of twelve markers of authoritarian-like measures in the Standard

Cross-Cultural Sample. This represents the first study to address the parasite-stress model of authoritarianism using more traditional, small-scale cultures as units of analysis.

Chapter Six investigates another potential societal implication of disease threat's influence on individual psychosocial functioning. Specifically, it tests how cross-national differences in scientific and technological innovation are predicted by variation in disease prevalence. (This chapter is adapted from an article recently submitted for publication: Murray, D. R. [under review]. Direct and indirect implications of pathogen prevalence for scientific and technological innovation. *Journal of Cross-Cultural Psychology*). Disease prevalence, of course, negatively affects wealth, productivity, and educational attainment—all variables which predict innovation. However, results of this study reveal that higher disease threat uniquely predicts lower innovative output even when controlling for the effects of these demographic variables. Mediational analyses show that collectivist values mediate the relationship between disease threat and innovation—that is, values that emphasize traditionalism, conformity, and ingroup cohesion. This is the first study to suggest that disease threat may impact innovation through two routes: Through negatively impacting wealth and productivity, as well as through a more psychological route of impacting values and dispositions that encourage conformity and inhibit creativity.

The concluding chapter details some of the subsequent work that this thesis work has led to, and explores some of the deeper questions that begin to be addressed by this body of work. For example, by which—and by how many—mechanisms might disease exact its influence on human psychology? The individual-level studies in Chapters Two and Three suggest some sort of neurocognitive mechanism, whereby people detect cues that connote the threat of disease within their immediate environments, and respond to these cues with an appropriate disease-buffering attitudinal or behavioral response. However, if this neurocognitive mechanism singly accounted for the causal effects of disease threat, why is it that the cross-cultural differences discussed in Chapters Four, Five, and Six are better predicted by *historical* rather than contemporary indices of pathogen threat? Such a time lag suggests the presence of another mechanism: These cultural differences could be due to differential patterns of cultural transmission; they could be epigenetic; they may even be partly genetic. This chapter ends with a brief look and which important questions remain to be answered, and how this work adds to our understanding of human sociality and how it sheds light on possible avenues for social and cultural change.

CHAPTER TWO

Perceived Threat of Infectious Disease and Its Implications for Sexual Attitudes[1]

While casual sex with multiple partners may be objectionable to some people, it is the only way to swing for others. Recently, the National Health and Social Life Survey (NHSLS) found that whereas a large proportion of men and women labelled themselves as "comfortable monogamists," another significant proportion characterized themselves as being at the opposite end of the spectrum—as "enthusiastic polygamists" (Laumann & Michael, 1994). These preferences tend to be relatively stable across time, and are often empirically assessed as trait-like individual differences (Jackson & Kirkpatrick, 2007; Simpson & Gangestad, 1991). But these attitudes can also vary *within* many individuals. Attitudes pertaining to sexual promiscuity change across the lifespan (Pfeiffer, Verwoerdt, & Davis, 1972). These attitudes may also undergo more ephemeral changes, in response to immediate environmental contexts and cues. This chapter investigates the hypothesis that sexual attitudes are influenced by the perceived threat of infectious disease.

Preferences Pertaining to Promiscuity

Much of the research exploring the influences on sexual attitudes has focused on the kinds of causal variables that are typically predictive of stable individual differences. Behavioral genetics research has revealed links between polymorphic variation on the DRD4 dopamine receptor gene and variation in individual's sexual attitudes (Zion et al., 2006), including attitudes regarding promiscuity and infidelity (Garcia et al., 2010). Other programs of research have

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[1] This chapter has been adapted from Murray, D. R., Jones, D. N., & Schaller, M. (2013). Perceived threat of infectious disease and its implications for sexual attitudes. *Personality and Individual Differences, 54,* 103-108. It has been modified to fit the format of this thesis.

focused upon early life experiences that may influence sociosexual attitudes later in life. For instance, one line of inquiry reveals that religious involvement during adolescence predicts less permissive sexual attitudes during adulthood (Thornton & Camburn, 1989). Another line of inquiry documents relations between childhood family dynamics and later sexual attitudes (Hetherington, 1972). This work reveals, for example, that women especially are likely to develop more sexually permissive attitudes if they grew up in single-parent households (Kinnaird & Gerrard, 1986; Miller & Bingham, 1989; Newcomer & Udry, 1987).

Relatively stable cognitive structures, however, such as traits and attitudes, may undergo short-term fluctuations. Recently, a body of research has emerged showing that women's sexual preferences and behaviors vary predictably in response to the hormonal fluctuations over the course of the ovulatory cycle. During the part of the ovulatory cycle in which the risk of conception is highest, women show greater interest in extradydic sexual relationships, and in short-term sexual encounters more generally (e.g. Gangestad, Thornhill, & Garver, 2002; Haselton & Gangestad, 2006; Pillsworth & Haselton, 2006).

These findings linking environmental factors to sexual attitudes are particularly relevant to this research chapter, which investigates the impact of the perceived threat of infectious disease and its implications for attitudes toward sexual promiscuity. The results reported in this chapter address three questions: (1) Are mating styles predicted by chronic individual differences in perceived vulnerability to disease? (2) Does this relationship differ depending on the temporary salience of disease transmission? And (3) does this relationship differ between men and women?

Perceived Threat of Disease and its Implications for Attitudes and Behavior

As discussed in Chapter One, there has recently emerged a literature on the subjective perception of threat posed by infectious diseases and its implications for affect, cognition, and behavior (Curtis, de Barra, & Aunger, 2011; Oaten, Stevenson, & Case, 2009; Schaller & Park, 2011). Trait-like differences exist in the extent to which individuals perceive themselves as vulnerable to disease transmission—as indicated by individuals' self-assessments of immunocompetence, the extent to which they avoid situations associated with germ-transmission, and in the extent to which they experience a disgust response when presented with such situations (Duncan, Schaller, & Park, 2009; Haidt, McCauley, & Rozin, 1994; Tybur, Lieberman, & Griskevicius, 2009). These individual differences are correlated with a variety of traits and attitudes implying behavioral caution and attitudinal conservatism.

These relations can be understood as reflecting tradeoffs in an implicit cost-benefit analysis. Any particular behavioral disposition can have functional benefits, but may have disease-relevant costs as well. The ratio of benefits to costs varies depending upon the magnitude of the threat posed by pathogen infection. Extraversion provides an illustrative example. Extraverted behavior is associated with social benefits (e.g., greater opportunities for social support); but, by exposing individuals to a larger number of people (who may be carriers of infectious diseases), extraversion is also associated with a higher risk of pathogen infection (Hamrick, Cohen, & Rodriguez, 2002; Nettle, 2005). The perceived magnitude of these costs is implicitly exaggerated for individuals who chronically perceive pathogens to pose a greater threat. To the extent that behavioral dispositions are responsive to an implicit benefit/cost analysis, it follows that extraversion is likely to be lower among individuals who are chronically more germ-averse—and that is exactly what empirical results reveal (Duncan et al., 2009).

These predictive effects of chronic individual differences are complemented by—and sometimes moderated by—the effects of contextual cues that make the threat of disease transmission temporarily salient. Under experimental conditions in which the possibility of disease transmission is temporarily salient, people report lower levels of extraversion (Mortensen, Becker, Ackerman, Neuberg, & Kenrick, 2010), and higher levels of political conservatism (Helzer & Pizarro, 2011). In addition, chronic individual differences in perceived vulnerability to disease predict specific kinds of behavioral dispositions more strongly under conditions in which the threat of disease transmission is temporarily salient (Duncan & Schaller, 2009; Mortensen et al., 2010). These person-by-situation interactions are consistent with additional findings (e.g., Schaller, Park, & Mueller, 2003) suggesting that individual differences in sensitivities to specific kinds of threats may predict functionally relevant attitudes especially strongly under conditions in which cues connoting that particular kind of threat are perceptually salient.

The cost/benefit logic that links disease threat to extraversion and other behavioral attitudes can also be applied within the specific domain of sexual behavior. There can be adaptive benefits associated with promiscuous sexual behavior, but unrestricted sexual behavior also has disease-specific costs. Sexual activity entails intimate interpersonal contact and thus carries with it a risk of disease transmission; indeed, many infections are transmitted almost exclusively through sexual contact. Consequently, unrestricted sexual behavior is associated with increased risk of contracting infectious diseases (Halperin & Epstein, 2004; Morris & Kretzschmar, 1997). The perceived magnitude of this cost is likely to be implicitly exaggerated among people who feel more vulnerable to disease transmission. It follows that individuals who feel more vulnerable to disease will be less inclined toward promiscuous short-term mating, and instead favour a long-term mating strategy (which implies relatively fewer lifetime sexual partners).

Preliminary evidence is consistent with this hypothesis. Duncan et al. (2009) reported correlations between two subscales of a Perceived Vulnerability to Disease questionnaire (PVD) and a Sociosexual Orientation Inventory (SOI; Simpson & Gangestad, 1991). Results revealed a weak correlation between SOI and PVD-Perceived Infectability (*r* = - .14) and a stronger correlation between SOI and PVD-Germ Aversion (*r* = -.28). A limitation of these results, however, is that the SOI questionnaire employed by Duncan et al. (2009) treated long- and short-term mating styles as opposite ends of a unidimensional continuum. Mating styles may be more accurately considered as conceptually distinct, context-contingent strategies (Gangestad & Simpson, 2000). Consistent with this conjecture are results showing that long- and short-term mating are somewhat orthogonal, and can be measured as distinct constructs (Jackson & Kirkpatrick, 2007). It remains to be tested whether individual differences in perceived vulnerability to disease primarily predicts attitudes specific to long-term mating, short-term mating, or both.

Another question that remains unanswered is whether any predictive effects of these individual differences might be moderated by the specific context within which mating orientations are assessed. Mortensen et al. (2010) found that it was primarily under conditions in which infectious disease was highly salient that chronically higher levels of perceived vulnerability to disease predicted lower levels of extraversion and openness to experience. Such a person-by-situation interaction may predict reported sexual attitudes as well.

Also unknown is whether there might be sex differences in the magnitude of relations between disease threat and attitudes toward long- and short-term mating. Men tend to be approach-oriented in the domain of sexual behavior, whereas women are more risk-averse (Haselton & Buss, 2000). One well-documented implication is that, compared to women, men are generally more attitudinally inclined toward short-term mating behavior (Schmitt, 2005). A less obvious implication is that, compared to men, women may be more sensitive to information implying increased costs associated with promiscuity—including the increased risk of disease-transmission. Due to the resource-costly higher minimum parental investment required by women relative to men, the costs of sexual promiscuity are more likely to outweigh the benefits for women in a wider variety of contexts. This implies the possibility that any relation between disease threat and mating orientation may be observed more strongly among women.

Some prior evidence is obliquely consistent with such a sex difference: In an analysis of nation-level mean values of pathogen prevalence and sexual attitudes, Schaller and Murray (2008) reported that in nations characterized by higher levels of disease-causing pathogens, people reported attitudes endorsing more restricted (i.e., less promiscuous) sexual behavior, and this effect emerged most strongly in the prediction of female attitudes. However, these results focused on ecological variation in pathogen prevalence (rather than perceived vulnerability to pathogens) predicting nation-level (rather than individual) sexual attitudes; no prior results have evaluated whether the hypothesized effects of perceived disease threat on short- and long-term mating attitudes might differ between the sexes.

Overview of the Present Investigation

Below we report the results from analyses on data obtained from young adults. All participants completed measures designed to assess perceived vulnerability to disease, as well as a revised version of the SOI, which independently assesses long- and short-term mating orientation. In addition, shortly before completing the revised SOI questionnaire, some participants were exposed to an experimental procedure designed to make the threat of disease temporarily salient. The experimental manipulation allowed us to test whether relations between PVD subscales and mating orientations were moderated by the temporary perceptual salience of the threat posed by disease transmission.

Two distinct versions of the disease threat manipulation were employed across two separate samples. We combined results across these two samples, and conducted primary analyses on the combined dataset. We did so for three main reasons. First, although procedurally different, the two manipulations were designed to serve a conceptually identical function. Second, other experiments employing these manipulations have shown that they do produce conceptually identical effects on common outcome variables (outcome variables that will be discussed in Chapter Three). Third, by combining data across the two samples, we increased statistical power to detect sex differences and to test for effects within each sex separately. Statistical power was of special concern here because there was a relative paucity of men in the population from which we sampled. We conducted preliminary statistical analyses (reported below) to ensure that the effects observed across the two samples were indeed comparable.

2.1 Method

Participants

Participants were 411 undergraduate students (298 women 113 men) from the University of British Columbia (mean age 20.37, SD = 3.36). The sample was ethnically diverse (242 participants reported Asian ethnic origin, 136 reported European origin, and 33 reported other ethnic origins). Participants completed the procedures either singly or in small groups.

Individual Differences in Perceived Vulnerability to Disease

Participants completed a set of questionnaires assessing demographic information and several other measures unrelated to the current investigation. Included was a 15-item questionnaire assessing individual differences in perceived vulnerability to disease (PVD; Duncan, et al., 2009). Eight items measured individuals' avoidant response to situations that imply high likelihood of pathogen transmission (e.g. “I don’t like to write with a pencil someone else has obviously chewed on”); these 8 items comprise a Germ Aversion subscale (PVD-GA; Cronbach’s Alpha = .76). An additional 7 items measured individuals' self-perceived susceptibility to infectious diseases (e.g., "In general, I am very susceptible to colds, flu, and other infectious diseases"); these 7 items comprise a Perceived Infectability subscale (PVD-PI; Cronbach’s Alpha = .91). These subscales were only weakly correlated ($r = .12$, $p = .01$). Preliminary analyses revealed weak and non-significant relations between PVD-PI and the primary outcome measures (results consistent with the weak relation between PVD-PI and SOI reported by Duncan et al., 2009, and consistent with PVD-PI’s lack of association with other psychological variables that are associated with PVD-GA). Consequently, PVD-PI is not considered further; analyses reported below focus just on the Germ-Aversion subscale (PVD-GA).

Experimental Manipulation of Disease Salience

Across 2 separate samples, 2 different versions of an experimental manipulation were employed. In one sample, 305 participants (225 women, 80 men) looked at 8 color photographs; the photographs differed across 3 experimental conditions (this manipulation was adapted from Schaller, Miller, Gervais, Yager, & Chen, 2010). In the Disease Threat condition, participants looked at photographs depicting people with obvious morphological or behavioral symptoms of infectious disease (e.g., skin lesions, sneezing). In the Other Threats Control condition, participants looked at photographs depicting people brandishing guns, most of which were aimed directly at perceivers. In the No Threat Control condition, participants looked at photographs depicting household furniture. Participants were asked to look at each photograph for approximately 5 seconds, and were instructed to attend closely to each photograph.

In the second sample, 106 participants (73 women, 33 men) recalled and described specific kinds of experiences, which differed across 3 experimental conditions. In the Disease Threat condition, participants recollected a time when they felt vulnerable to infectious disease. In the Other Threats Control condition, participants recollected a time when they feared for their physical safety. In the No Threat Control condition, participants recollected the activities that they had engaged in during the previous day. In all three experimental conditions, experimenters elicited detailed descriptions by prompting participants with questions from a common list (e.g. “What emotions were you feeling during this situation?”). All participants spent approximately 3 to 5 minutes engaged in detailed recollection and description of the specific experience.

Before combining data across the samples, we conducted preliminary Analyses of Variance on the primary outcome measures. These ANOVAs included the two different samples as a factor (along with experimental condition and participant sex). Results revealed no main effects or interaction effects associated with the two different samples (all *p*'s > .13). Thus, in addition to the conceptual and statistical rationales for combining data across the two versions of the manipulation, there also emerged no compelling empirical basis to treat the two samples separately. For the primary analyses reported below, we combined results into a single dataset.

Long-Term and Short-Term Mating Orientation, and Future Sexual Promiscuity

Shortly after the experimental manipulation, participants completed the revised Sociosexual Orientation Inventory (Jackson & Kirkpatrick, 2007). Ten items assessed Long Term Mating Orientation (LTMO; sample item: “I would like to have a romantic relationship that lasts forever”; Cronbach's alpha = .80). Ten additional items assessed Short-Term Mating Orientation (STMO; sample item: "I can easily imagine myself being comfortable and enjoying 'casual' sex with different partners"; Cronbach's alpha = .85). Participants responded to these items by indicating their agreement on 7-point rating scales. Higher LTMO scores indicate more positive attitudes toward long-term mating; Higher STMO scores indicate more positive attitudes toward short-term mating behavior. LTMO and STMO were negatively correlated, $r = -.37$, $p < .001$.

The revised SOI questionnaire also included an additional single item assessing behavioral inclination toward future sexual promiscuity: Participants were asked to provide a numerical answer to the question, “With how many partners do you foresee having sexual intercourse during the next five years?” Responses to this question included one extreme outlier (over 9 standard deviations higher than the mean); this value was truncated to the next highest response. (The revised SOI questionnaire also includes 3 items assessing past sexual promiscuity, and a single item assessing frequency of sexual fantasy. Given our focus on attitudes toward mating behavior in the present and future, we do not include these measures in the analyses reported below. However, past sexual promiscuity was negatively correlated with Germ Aversion among women, $r = -.30$, $p < .001$; this effect was weaker among men, $r = -.16$, $p = .097$.)

2.2 Results

Table 2.1 (on p. 34) shows means and standard deviations for the three primary dependent measures in each condition, for both men and women. Consistent with previous research (e.g. Faulkner et al., 2004), preliminary analyses revealed no meaningful differences between the two control conditions on the primary dependent variables, either for the entire sample or for males and female separately (*t*'s < 1.44, *p*'s > .15). Therefore, in order to simplify further analyses, we combined the two control conditions into a single Combined Control condition.

Results on LTMO, STMO, and Future Sexual Promiscuity were analyzed with 3 separate regression analyses, the results of which are summarized in Table 2.2 (p. 35). Each regression analysis included 6 predictor variables: Chronic germ aversion (participant's score on the PVD-GA subscale); experimental condition (the Disease Threat condition was coded as 1, and the Combined Control condition was coded as -1); participant sex (female was coded as 1 and male was coded as -1), and 3 variables representing each of the 2-way interactions. (Three preliminary analyses also included an additional predictor variable representing the 3-way interaction between PVD-GA, experimental condition, and sex. Results revealed no significant 3-way interaction on any of the outcome variables [β's < .07, *p*'s > .21]; therefore, the three-way interaction term was dropped from analyses reported in Table 2.2).

Participant sex was a significant predictor of STMO and Future Sexual Promiscuity, indicating that women were less inclined toward short-term mating and preferred relatively fewer future sexual partners. Sex did not significantly predict LTMO, *p* = .09. Of greater conceptual interest, PVD-GA was significantly inversely related to STMO and Future Sexual Promiscuity: More highly germ-averse individuals had lower STMO scores and desired fewer future sexual partners. The relation between PVD-GA and LTMO was nonsignificant (*p* = .09).

The experimental manipulation had a main effect only on future sexual promiscuity. Surprisingly, participants in the Disease Threat condition indicated a preference for relatively more future sexual partners (2.46 vs. 1.85, *p* = .03). However, this main effect was qualified by a 2-way interaction between Experimental Condition and Sex. Follow-up analyses revealed that this unexpected effect of the experimental manipulation emerged only among men: Men indicated a preference for more future sexual partners in the Disease Threat condition compared to the Combined Control condition (3.79 vs. 2.15, *p* = .03); among women, no such effect occurred (M's were 1.96 and 1.73 in the Disease Threat and Combined Control conditions, respectively, *p* = .38).

Two-way interactions between PVD-GA and Experimental Condition emerged on all three measures of sociosexual attitudes (*p*'s ≤ .06). (To ascertain whether these 2-way interaction effects might be specific to just one version of the experimental manipulation, we conducted follow-up regression analyses in which we included a predictor variable representing the 3-way interaction between PVD-GA, experimental condition, and sample. On none of the 3 outcome measures was the 3-way interaction significant, *p*'s > .45. The PVD-GA x Experimental Condition interactions do not appear to be qualified by procedural differences in the experimental manipulation.) To illuminate the nature of these 2-way interactions, we examined the predictive effects of PVD-GA within the Disease Threat and Combined Control conditions separately. These correlations are summarized at the top of Table 2.3 (p. 36). The negative relation between PVD-GA and STMO was evident across both conditions, but was stronger in the Disease Threat condition. Furthermore, only in the Disease Threat condition did PVD-GA negatively predict future sexual promiscuity and positively predict LTMO.

As noted above, these 2-way interactions were *not* qualified by any statistically significant 3-way interactions involving participant sex. However, while there is no compelling basis to conclude that observed effects were stronger for one sex than another, the absence of significant 3-way interactions also does not logically imply that the effects were equivalent across sexes. It is potentially informative to examine within-condition correlations for men and women separately. These correlations are presented in Table 2.3 (p. 36). Among women, PVD-GA significantly predicted all three dependent variables in the Disease Threat condition (the effect on LTMO was somewhat weaker than the effects on STMO and Future Sexual Promiscuity), and for all three dependent variables this effect was stronger than in the Combined Control condition. Among men, only weak (statistically nonsignificant) correlations emerged, even in the Disease Threat condition. These results imply that the effects found in the full sample are attributable primarily to female responses.

2.3 Discussion

The findings in this chapter make at least two novel conceptual contributions. First, these results usefully extend previous findings linking individual differences in germ aversion to overall mating orientation (Duncan et al., 2009). Whereas previous research failed to address the conceptual distinction between short-term and long-term mating, these new results reveal that germ aversion influences attitudes regarding *both* long-term and short-term mating relationships, with additional implications for future sexual promiscuity. Second, these results reveal that these predictive effects of chronic germ aversion emerge more strongly under conditions in which the threat posed by infectious diseases is perceptually salient. These moderating effects of disease salience cannot be attributed to anxiety or fearfulness in general; when conceptually distinct disease-irrelevant threats were made salient, the predictive effects of germ aversion on sociosexual attitudes were no different than those observed in an affectively neutral control condition.

It is also worth noting that these effects emerged clearly only among women. This statement should not be misinterpreted. These results alone cannot compel any confident conclusion about sex differences in the effects of germ aversion on sociosexual attitudes. But these results do suggest that inferences about relations between germ aversion and sociosexual attitudes might best be limited to the one sex within which those relations clearly emerge.

This sex-specific conclusion is conceptually consistent with previous research linking ecological context to cross-cultural differences in mating orientation: Worldwide ecological variation in pathogen prevalence is negatively correlated with sociosexually "unrestricted" attitudes, but it was only for female attitudes this correlation clearly emerged (Schaller & Murray, 2008). There are many plausible causal mechanisms that can produce population-level outcomes such as these (which will be considered at length in Chapter Seven). The fact that we observed a conceptually similar pattern of results in this current study suggests the possibility that the worldwide cross-cultural differences may result, in part, from processes operating primarily at a psychological level of analysis.

Future research might also consider the epidemiological implications of our results. The spread of sexually-transmitted infections depends on the geometric properties of the social networks through which those infections are transmitted, and these network properties depend on individuals' decisions to have, or not have, sexual relations with specific individuals. To the extent that subjective concerns with pathogen transmission influence these decisions—as our results imply—there may be predictable and important implications for epidemiology and public health.

Table 2.1. Means (and standard deviations) on attitudes pertaining to promiscuity, broken down by experimental condition and by participant sex.

Dependent Variable	Experimental Condition					
	Disease Threat		Other Threats Control		Neutral Control	
	Male	Female	Male	Female	Male	Female
Short-term mating orientation	4.31 (1.37)	2.98 (1.69)	4.22 (1.57)	2.86 (1.29)	4.15 (1.81)	2.87 (1.55)
Long-term mating orientation	5.65 (0.90)	5.93 (0.97)	5.82 (0.91)	6.00 (0.68)	5.88 (0.80)	5.84 (0.95)
Sexual partners foreseen in next 5 years	3.78 (5.26)	1.96 (2.40)	2.62 (2.47)	1.74 (1.69)	1.77 (2.36)	1.73 (2.03)
N	43	108	32	89	38	101

Table 2.2. Results of multiple regression analyses assessing the extent to which sociosexual attitudes are predicted by PVD-Germ Aversion, Experimental Condition, and Sex.

	Dependent Variables					
Predictor Variables	Short-Term Mating Orientation		Future Sexual Promiscuity		Long-Term Mating Orientation	
	β	*p*	*β*	*p*	*β*	*p*
PVD-Germ Aversion	-.19	.001	-.15	.008	.10	.09
Experimental Condition	.03	.53	.17	.002	-.05	.37
Sex	-.35	<.001	-.19	<.001	.09	.09
PVD-Germ Aversion X Experimental Condition	-.09	.06	-.12	.02	.10	.04
PVD-Germ Aversion X Sex	-.06	.24	.01	.81	.00	.96
Experimental Condition X Sex	-.01	.91	-.14	.02	.06	.26

Table 2.3. Correlations between PVD-Germ Aversion and measures of sociosexual attitudes, separately within the Disease Threat and the Combined Control condition.

	Dependent Variables					
	Short-Term Mating Orientation		Future Sexual Promiscuity		Long-Term Mating Orientation	
	r	*p*	*r*	*p*	*r*	*p*
Full Sample (N = 411)						
Disease Threat (n = 151)	-.31	<.001	-.21	.008	.20	.01
Combined Control (n = 260)	-.17	.006	-.05	.41	.00	.96
Women (n = 298)						
Disease Threat(n = 108)	-.37	<.001	-.34	<.001	.25	.01
Combined Control (n = 190)	-.17	.02	-.02	.83	-.03	.64
Men (n = 113)						
Disease Threat(n = 43)	-.20	.19	-.10	.53	.06	.72
Combined Control (n = 70)	-.05	.67	-.10	.41	.08	.53

CHAPTER THREE

Perceived Threat of Infectious Disease and Its Implications for Conformist Attitudes and Behavior[2]

The hypothesized link between sexual behavior and disease risk discussed in the last chapter was relatively intuitive; most people are aware of the fact that sexual behavior brings with it the possibility of exposure to infectious disease. But what about nonconformist behavior? Although the link between conformity and disease threat may be less intuitive, it is equally logically compelling. This chapter discusses why (and how) disease threat has implications for conformist attitudes and behavior.

Similar to sexuality, conformity is a ubiquitous part of social life, and the psychology of conformity manifests in many different guises. Children are expected to conform to the directives of parents, teachers and other authority figures, and are often punished if they don't. As adults too, people are expected to adopt the beliefs and behavioral norms of their social groups, and may be socially rejected if they don't (e.g. Festinger, Gerard, Hymovitch, Kelley, & Raven, 1952; Festinger & Thibault, 1951; Schacter, 1951). Indeed, failures to conform to enduring group or cultural norms (e.g., incest taboos) are often viewed by others not merely as an embarrassing social *faux pas*, but as a contemptible moral transgression as well.

The prevalence of conformity in social life can be understood as a consequence of the fact that, although conformity can be costly (it inhibits innovation), it can be beneficial too. Many social norms provide a basis for predictable interaction and efficient decision-making; the collective benefits associated with sociality require some level of conformity to those norms. In

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[2] This chapter has been adapted from Murray, D. R., & Schaller, M. (2012). Threat(s) and conformity deconstructed: Perceived threat of infectious disease and its implications for conformist attitudes and behavior. *European Journal of Social Psychology, 42*, 180-188. It has been modified to fit the format of this thesis.

addition, many norms provide buffers against specific risks and hazards. (Norms regarding reciprocity reduce the likelihood of being cheated in exchange relationships; norms regarding interactions with other animals reduce the likelihood of predation; norms regarding hygiene and food preparation inhibit the spread of infectious diseases, and so forth.) Normative transgressions not only put transgressors at risk, they may also increase risks to others in the local population. Given these benefits of conformity, there may have evolved fundamental psychological tendencies that dispose people toward conformity (Henrich & Boyd, 1998; Henrich & Gil-White, 2001). Consistent with this analysis, empirical research reveals that individuals are guided by heuristic processes that incline them to adopt the attitudes of popular majorities, to obey the advice of authorities, to maintain the *status quo*, and to respond aversely to those who don't (Asch, 1956; Cialdini & Goldstein, 2004; Eidelman & Crandall, 2009; Jost & Hunyady, 2005; Kruglanski, Pierro, Mannetti, & De Grada, 2006; Milgram, 1974; Sechrist & Stangor, 2001; Wheatley & Haidt, 2005).

This natural tendency toward conformity is variable across both persons and situations. Many different variables influence conformist attitudes and behaviors (Cialdini & Goldstein, 2004; Hogg, 2010). Of particular relevance here is the perception of threat. Given that many norms provide beneficial buffers against risks and hazards, it follows that individuals may show especially strong conformist tendencies under conditions in which they feel especially vulnerable to risks and hazards. Abundant evidence supports this analysis. Right-wing authoritarianism (which is defined substantially by socially conservative attitudes and adherence to the status quo) correlates positively with individual differences in the belief that the world is a dangerous place (Altemeyer, 1988) and is increased under threatening circumstances (Feldman & Stenner, 1997; Sales, 1973). Experimental manipulations that facilitate accessibility of danger- or death-related thoughts lead to increased conformity to majority opinion (Renkema, Stapel, & Van Yperen, 2008; Griskevicius, Goldstein, Mortensen, Cialdini, & Kenrick, 2006).

Does the Threat of Infectious Disease Exert a Unique Impact on Conformity?

Threat is broad and non-specific construct. Qualitatively different kinds of threats influence human health and welfare, and these distinct kinds of threat elicit distinct neurochemical, affective, cognitive, and behavioral responses, (e.g., Cottrell & Neuberg, 2005; Neuberg, Kenrick, & Schaller, 2011; Plutchik, 1980). Previous research linking threat to conformity has not attended closely to these distinctions. It remains unknown whether different forms of threat have psychologically distinct implications for conformity. However, there are several reasons to suspect that threat of infectious disease may exert a unique – and perhaps especially potent – influence on conformity.

One reason pertains to the antiquity and ubiquity of disease. Disease-causing parasites have been present within human populations throughout history and, as discussed in Chapter 1, have imposed powerful selective pressures on the evolution of human physiology and behavior (Wolfe et al., 2007; Zuk, 2007), and these diseases have likely claimed more lives than all wars, non-infectious diseases, and natural disasters combined (e.g. Inhorn & Brown, 1990). A second reason pertains to the mysteriousness of infectious disease. Unlike most other threats to human welfare (e.g., intergroup violence, predation by larger mammals), most disease-causing parasites are invisible. Prior to recent scientific advances (the microscope, germ theory, pharmacology) the causes of infectious disease, and means of mitigating their transmission, were inaccessible to logical analysis. Disease control therefore depended substantially on the development of behavioral norms that reduced the risk of infection, and on semi-superstitious adherence to those norms; this remains evident in contemporary foraging societies that have no access to modern healthcare, wherein most social norms operate as prescriptions to avoid illness in some way (Fabrega, 1997).

If indeed social norms historically served an essential rule in blunting the powerful threat posed by infectious diseases, it follows that the perceived threat of infectious disease may exert a similarly powerful influence on conformist attitudes and behaviors. If so, this influence may be psychologically distinct from effects associated with other threats to human welfare.

Several bodies of evidence are somewhat relevant to this hypothesis, including research on disgust -- the emotional experience most closely connected to the perceived risk of disease transmission (Oaten et al., 2009; Curtis et al., 2011). The arousal of disgust leads to greater contempt in response to counter-normative behavior (e.g., Wheatley & Haidt, 2005); individuals who are more chronically sensitive to disgust recommend more lengthy sentences for criminals (Jones & Fitness, 2008). However, disgust is not specific to disease threat (it serves as a signal of other kinds of threats as well; Rozin, Haidt, & Fincher, 2009); consequently, these results do not bear directly on the current hypothesis. Additional evidence has emerged from the cross-national studies discussed earlier showing that ecological variation in pathogen prevalence predicts societal variation in collectivistic value systems and societal conformity pressure (Fincher et al., 2008; Murray & Schaller, 2010; Murray et al., 2011).

In sum, while various bodies of evidence are obliquely relevant, there is no extant evidence that directly tests the hypothesis that perceived threat of infectious disease influences individuals' conformist attitudes and behavior (and that this effect is distinct from the influence of other threats to individuals' welfare).

If such an effect exists, an additional question arises: Just how specific might this effect be to particular domains of normative behavior? The effect of disgust on moral judgments has been found across a variety of behavioral domains, some of which have no clear implications for disease transmission (e.g., shoplifting; Wheatley & Haidt, 2005). Similarly, collectivistic value systems have pervasive implications across behavioral domains (Fincher et al., 2008). It is plausible that disease threat may trigger conformist attitudes that are expressed broadly, even in domains of normative behavior that serve no obvious disease-buffering function. Nevertheless, if indeed the psychology of conformity serves as a functional defense against the threat of pathogen transmission, it is also plausible that the effect of disease threat on conformist attitudes may be especially pronounced within specific behavioral domains (such as food preparation and personal hygiene) that have especially clear implications for pathogen transmission. No prior research has tested this subsidiary hypothesis.

Overview of the Present Investigation

We employed two methodological strategies to examine the effects of disease threat on conformist attitudes and behavior. One strategy focused on individual differences. We assessed chronic individual differences in *perceived vulnerability to disease* (Duncan et al., 2009), and tested whether individuals who felt more chronically vulnerable to infectious disease also exhibited more strongly conformist attitudes and behavior. Importantly, we also tested whether these predicted correlations remained when statistically controlling for individual differences in concerns pertaining to other (disease-irrelevant) threats. This allowed us to test whether perceived vulnerability to disease exerted a statistically unique effect in predicting conformity.

The second strategy employed the inferential rigor of experimental methods. We tested whether the experimentally-manipulated salience of infectious disease led to stronger conformist attitudes and behavior. Importantly, we included a control condition in which other threats (non-relevant to infectious disease) were made salient. This allowed us to test whether the salience of infectious disease exerted an especially potent influence on conformity.

All participants completed a set of dependent measures that assessed (a) self-reported conformist attitudes, (b) liking for people with conformist personality traits, (c) valuation of obedience, and (d) behavioral conformity to majority opinion. These measures did not distinguish between different domains of normative behavior, and so cannot test the subsidiary hypothesis that disease threat may trigger conformist attitudes most strongly within specific behavioral domains. However, before data collection was completed, we added two measures specifically designed to test this additional hypothesis. Therefore, a subset of participants also completed measures that assessed evaluative responses to people who either (a) violated norms or (b) conformed to normative pressure, in behavioral domains that either were highly relevant to disease-transmission (e.g., food preparation) or were not (e.g., motor vehicle operation). Results on these additional measures provide preliminary evidence bearing on the subsidiary hypothesis.

3.1 Method

Participants

Participants were 217 undergraduate students (172 women, 45 men; mean age 20.2 years) at the University of British Columbia. They volunteered to earn extra credit in undergraduate psychology courses. Participants were randomly assigned to one of three experimental conditions (Disease Threat, Other Threats, Neutral). Because the Disease Threat and Other

Threats conditions (and the comparison between them) were of special inferential interest, the random assignment algorithm was designed to assign a higher percentage of participants to these two conditions, relative to the Neutral condition; N's in each condition were 82, 74, and 61, respectively.

Experimental Manipulation of Disease Salience

The experimenter asked each participant a series of questions designed to elicit recollection and verbal description of circumstances from the participant's past. The specific nature of these recollected circumstances varied across experimental conditions. In the *Disease Threat* condition, participants discussed a time when they felt vulnerable to germs or disease. In the *Other Threats* condition, participants discussed a time when they feared for their physical safety. In the *Neutral* condition, participants discussed the activities that they had engaged in during the previous day.

In all conditions, experimenters elicited detailed descriptions of participants' thoughts and feelings by prompting participants with questions from a common list (e.g. "What emotions were you feeling during this situation?"). All participants spent approximately 3 - 5 minutes engaged in detailed verbal recollection and description of the intended set of circumstances. In order to ensure a continuing psychological effect of the manipulation throughout the duration the experimental session, participants were asked to recall the same event again, approximately 10 minutes later, in the context of completing the dependent variables (described below). Specifically, participants were asked to describe, in writing, "the event/events that you discussed with the experimenter a few moments ago" and "the emotions and physical reactions... that you had in response to these events."

Participants’ written recollections provided the basis for a manipulation check. A naive coder (who was blind to participants' experimental condition and also entirely unaware of the objectives the experiment) read a subset of participants' written responses (N = 95). The coder rated the extent to which the described events would make a person feel anxious, afraid, and disgusted, and also rated the extent to which the situation appeared “to pose some sort of threat.” (All ratings were on 7-point scales.) The manipulation appeared to work. Very little affect was elicited in the Neutral condition (on all 4 ratings, M's < 2.5). The Disease Threat condition elicited recollections that were rated more highly on "disgusted" (M = 4.57, SD = 1.43) than on "afraid" (M = 3.63, SD = 1.56), p < .001; whereas the Other Threats condition elicited recollections that were rated more highly on “afraid” (M = 4.83, SD = 1.26) than on “disgusted” (M = 1.27, SD = 1.03), p < .001. Importantly, there were no meaningful differences between the two threat conditions in the extent to which they elicited a sense of threat or anxiety: On ratings of threat, M's were 4.23 (SD = 1.25) and 4.54 (SD = 1.23) in the Disease Threat and Other Threats conditions, respectively; on ratings of “anxious,” M's were 4.97 (SD = 1.19) and 5.12 (SD = 1.14) in the Disease Threat and Other Threats conditions, respectively.

Primary Dependent Measures

Behavioral Conformity with Majority Opinion. Participants were presented with a potential scenario in which their university might change the numerical scale on which course grades are reported on student transcripts, and were asked to indicate whether they agreed or disagreed with this potential change by putting a penny (provided by the experimenter) into one of two clear plastic cups, labelled “AGREE” or “DISAGREE”. One of the cups already contained 3 pennies, and the other already contained 25 pennies -- indicating a substantial majority opinion offered collectively by prior participants. (In fact, the pennies were placed in the cups by the experimenter prior to participant's arrival; the apparent majority preference for “AGREE” or “DISAGREE” was counterbalanced.) Conformity was indicated by whether participants placed their penny in the cup containing the majority of existing pennies.

Liking for People with Conformist Traits. Participants were presented with brief descriptions of nine same-sex individuals, and were asked to rate how much they would like to have each person as a friend. Three of these nine descriptions comprised our dependent variable of interest. One description explicitly connoted a conformist disposition (described as conventional and traditional), and two descriptions connoted nonconformist dispositions (one described as untraditional and original, and the other as artistic and creative). Ratings were made on 7-point scales (higher values indicated greater liking). After reverse-scoring ratings for the two non-conformists, the mean of these three ratings was computed to create a single index indicating liking for people with conformist traits.

Valuation of Obedience. Participants were asked to assign monetary values to different personal qualities that children can be encouraged to learn. They were provided a hypothetical budget of $100 and instructed to allocate specific dollar amounts from this budget to each of seven specific qualities, as a means of indicating how much “I would like to encourage my children” to possess each quality. (The seven qualities listed were: Hard-working, Financially wealthy, Independent, Open-minded, Determined/Motivated, Religious, and Obedient). Our analyses focused on dollar values assigned to the trait “Obedient.” (In 6 cases, participants' total did not add to $100. For these 6 participants, we computed the dollars allocated to obedience as the proportion [out of 100] relative to the total dollar amount allocated across all 7 qualities).

Self-Reported Conformist Attitudes. Participants completed a questionnaire -- developed by the authors for the purposes of this study -- that included 6 statements endorsing conformist attitudes (e.g., “Breaking social norms can have harmful, unintended consequences”). Participants indicated the extent to which they agreed with each statement on a 6-point rating scale (1 = strongly disagree, 6 = strongly agree). A measure of self-reported conformist attitudes was computed as the mean rating across these items. (Principal components analysis of the 6 items yielded a clear one-factor solution, with only one eigenvalue > 1, accounting for 44% of variance; Cronbach’s alpha = .77.)

Ancillary Variables Assessing Domain-Specific Differences in Conformist Reactions

Part-way through the study, two additional measures were added, each of which was designed to assess the extent to which participants exhibited more conformist responses in disease-relevant (compared to non-relevant) domains of normative behavior. Therefore, a subset of 92 participants (75 women, 17 men) completed these two additional measures.

Difference in Perceived Severity of Normative Transgressions. Participants were presented with 12 scenarios in which individuals transgressed against a social norm. Five scenarios described transgressions that were overtly relevant to pathogen transmission (e.g. a butcher changes the date of expired meat to sell it as new meat; a hotel maid fails to disinfect a hotel room but reports that she has). The remaining scenarios described transgressions in disease-irrelevant domains of behavior (e.g. a bus driver drives with an expired license; a mechanic installs a car part that he knows to be unsafe). Participants rated the seriousness of each transgression on a 9-point scale (1 = not at all serious, 9 = extremely serious). We subtracted the mean rating of non-relevant transgressions from the mean rating of disease-relevant transgressions, to compute a single index measuring the domain-specific difference in perceived severity of normative transgressions.

Difference in Perceived Correctness of Conformist Choices. Participants were presented with 6 scenarios in which individuals chose to conform to majority opinion rather than following their own intuitions. Three of these scenarios described conformist behavior in disease-relevant domains (e.g., a woman in a public restroom conforms to collective pressure to spend extra time washing her hands, despite her desire to conserve water). Three other scenarios described conformist behavior in disease-irrelevant domains (e.g., a woman conforms to collective pressure to choose a particular topic for a group project, even though she thinks it's a poor choice). On 9-point scales, participants rated the extent to which each individual took the right course of action (1 = completely the wrong course of action, 9 = completely the right course of action). We subtracted mean ratings for non-relevant scenarios from the mean ratings for disease-relevant scenarios, to create a single index measuring the domain-specific difference in perceived correctness of conformist choices.

Individual Difference Measures Pertaining to Threat

All participants completed an additional set of questionnaires that assessed chronic personality traits and demographic information. Included were two individual difference measures of particular relevance.

Perceived Vulnerability to Disease. Participants completed a 15-item questionnaire assessing Perceived Vulnerability to Disease (PVD; Duncan et al., 2009). The questionnaire has two subscales. An 8-item "Germ Aversion" subscale (PVD-GA) measures individuals' discomfort in situations that imply high likelihood of pathogen transmission (e.g. "I don't like to write with a pencil someone else has obviously chewed on”). A 7-item "Perceived Infectability" subscale (PVD-PI) measures individuals' explicit beliefs that they are susceptible to contracting infectious diseases (e.g. “I am more likely than the people around me to catch an infectious disease”). Psychometric analyses indicate good internal reliability of both subscales (for PVD-GA Cronbach’s alpha = .75; for PVD-PI Cronbach’s alpha = .89); the subscales are only moderately correlated ($r = .29$, $p < .01$), and typically predict different psychological outcomes. These measures were assessed on a 7-point scale, where 1 = “Strongly Disagree,” and 7 = Strongly Agree Previous research suggests that the Germ Aversion subscale may be more predictive of variables obliquely related to conformity (e.g. it is positively associated with Need for Structure, and is negatively associated with the personality trait Openness to Experience; Duncan et al., 2009).

Belief in a Dangerous World. Participants completed the 12-item Belief in a Dangerous World questionnaire (BDW; Altemeyer, 1988), which assesses concerns about other (disease-irrelevant) threats to human welfare. (Example items: “There are many dangerous people in our society who will attack someone out of pure meanness, for no reason at all”; “Every day, as our society becomes more lawless and bestial, a person's chances of being robbed, assaulted, and even murdered go up and up.” These concerns were measured on a 7-point scale, where 1 = “Strongly Disagree,” and 7 = Strongly Agree) Previous research indicates good internal reliability, and good predictive validity as well (e.g. Altemeyer, 1988; Schaller, Park, & Mueller, 2003).

3.2 Results

Predictive Effects of Perceived Vulnerability to Disease

Table 3.1 (p. 58) presents zero-order correlations involving Perceived Vulnerability to Disease (PVD), Belief in a Dangerous World (BDW) and the four primary dependent measures individually. These results indicate no meaningful effects of Perceived Infectability (PVD-PI), but there were statistically significant predictive implications of Germ-Aversion (PVD-GA) on 3 of the 4 individual independent variables. People who were more chronically germ-averse reported stronger conformist attitudes, greater liking for people with conformist traits, and a higher monetary value on obedience (r's = .40, .16, and .24, respectively; p's< .05). The four primary dependent measures were all positively intercorrelated; consequently, we computed an aggregate conformity score for each participant by standardizing values on each measure (conversion to z-scores) and then computing the mean z-score across the four measures. PVD-GA correlated positively with this aggregate conformity index ($r = .35$, $p < .001$). Because the PVD and BDW questionnaires were administered to participants at the end of the experimental session, we were attentive to the possibility that responses on the questionnaires might be affected by the manipulation. BDW was not (BDW scores were statistically equivalent across conditions, p's > .20). PVD-GA scores were significantly higher in the Disease Threat condition than in the Other Threats condition, $p = .04$ (but were not higher than in the Neutral condition, $p > .40$). Therefore, in order to ensure that the correlation and regression results involving PVD-GA are statistically independent of the effects of the experimental manipulation, we performed additional correlation and regression analyses that statistically controlled for experimental condition. The results of these additional analyses were virtually identical (in terms of effect sizes and p-values) to those reported above.

Do these relations persist even when statistically controlling for BDW (which also correlated significantly with 3 of the 4 primary dependent measures, and with the aggregate conformity index)? We conducted separate regression analyses on the aggregate conformity index and on each of the 4 individual dependent measures, with PVD-GA and BDW entered simultaneously as predictor variables. Results of these analyses are summarized in Table 3.2 (p. 59). Notably, the unique effect of PVD-GA was significant for 2 of the 4 primary measures, and near-significant for a third. (By comparison, the unique effect of BDW was significant for 1 measure, and near-significant for two others.) An additional regression analysis revealed that PVD-GA was a significant unique predictor of the aggregate conformity index ($\beta = .26$, $p < .001$), as was BDW ($\beta = .25$, $p < .001$).

Is the predictive effect of PVD-GA especially pronounced in behavioral domains that are more pertinent to pathogen transmission? PVD-GA correlated positively with the two ancillary difference-score measures assessing the extent to which perceived severity of normative transgression and the perceived correctness of conformist choices are stronger in disease-relevant domains compared to non-relevant domains of normative behavior: r's = .18 and .21, p's = .092 and .044, respectively. (Correlations between BDW and these two measures were -.13 and .11; both p's > .20). We conducted regression analyses on each difference-score measure, with PVD-GA and BDW entered simultaneously as predictor variables. Results of these two regression analyses are summarized in Table 3.3 (p. 60). Results reveal that, when controlling for BDW, PVD-GA is a significant predictor of a tendency to judge normative transgressions more severely in disease-relevant domains, and a marginally significant predictor of a tendency to more strongly endorse conformist choices in disease-relevant domains.

Impact of the Disease Salience Manipulation

Did the experimental manipulation exert a causal influence on conformist attitudes and behavior? In order to first test whether experimental condition accounted for a significant portion of variance across measures, the four primary conformity measures (behavioral conformity, liking for people with conformist traits, valuation of obedience, self-reported conformist attitudes) were included as dependent variables in a multivariate analysis of variance (MANOVA), with experimental condition (Disease Threat, Other Threats, Neutral) as the independent variable. The multivariate test was significant, exact $F(2, 212) = 2.01$, $p = .043$, revealing an overall influence of the manipulation across the four measures. Univariate ANOVAs on each of the four dependent variables revealed a significant effect of condition on behavioral conformity, $F(2, 214) = 4.84$, $p = .009$, a near-significant effect on liking for people with conformist traits, $F(2,214) = 2.77$, $p = .06$. (The univariate ANOVAs on conformist attitudes and valuation of obedience were non-significant, *p*'s = .12 and .13 respectively).

These omnibus *F* tests were followed by a set of 3 planned contrasts which compared the means in each of the three experimental conditions. Table 3.4 (p. 61) presents means, standard deviations, and results of the pairwise contrasts on all 4 primary dependent measures. Of particular inferential interest are the pairwise contrasts on the two measures for which the omnibus univariate F test was either significant (behavioral conformity) or near-significant (liking for people with conformist traits). Behavioral conformity was highest in the Disease Threat condition; this mean was significantly higher than in the Neutral condition, and near-significantly higher than in the Other Threats condition. Liking for people with conformist traits was also highest in the Disease Threat; this mean was near-significantly higher than in the Neutral condition, and significantly higher than in the Other Threats condition. On neither of these measures did the difference between the Other Threats and Neutral conditions approach significance.

Additional pairwise contrasts also compared mean values of the aggregate conformity index. (A one-way ANOVA revealed a significant effect of experimental condition on this index, $F(2,214) = 6.16$, $p = .002$). Results revealed that the mean aggregate conformity score in the Disease Threat condition was significantly higher than in the Neutral condition ($t = 3.20$, $p = .002$), and also higher than in the Other Threats condition ($t = 2.73$, $p = .007$). (The mean aggregate conformity score was higher in the Other Threats condition than in the Neutral condition, but this difference did not approach statistically significance, $t = .60$, $p = .55$.)

To test the subsidiary hypothesis, we examined responses on the two difference-score measures assessing the extent to which conformist attitudes are exhibited more strongly in disease-relevant domains of normative behavior. Across all participants who completed these measures, mean values on both measures were significantly greater than 0 (both *t*'s > 10, *p*'s < .001), indicating that normative transgressions were generally perceived to be more severe in disease-relevant domains, and that conformist choices were generally perceived to be more correct in disease-relevant domains. Were these domain-specific differences greater under conditions of disease threat? Table 3.5 (p. 62) summarizes the impact of the experimental manipulation on both difference-score measures, and also summarizes the results of 3 planned pairwise contrasts. Mean values on both indices were highest in the Disease Threat condition, but a statistically significant difference between experimental conditions emerged only on the measure of domain-specific differences in perceived severity of normative transgressions: Compared to participants in the Neutral condition, participants in the Disease Threat condition showed an especially strong tendency to judge normative transgressions to be more severe in behavioral domains with clear implications for pathogen transmission (*p* = .008).

3.3 Discussion

Individual differences in perceived vulnerability to disease predicted conformist attitudes; this effect was largely independent of concerns pertaining to threats non-relevant to disease. These correlational results are corroborated by experimental results: When the threat of infectious disease was temporarily salient, people expressed greater liking for people with conformist traits and exhibited higher levels of behavioral conformity; no comparable increase in conformist attitudes and behavior followed from temporarily salience of threats that were non-relevant to disease. These results support the hypothesis that the perceived threat of infectious disease exerts an especially potent (and perhaps psychologically unique) influence on individuals' conformist attitudes and behavior.

Additional results provided some evidence that the positive relation between disease threat and conformist attitudes may emerge especially strongly in contexts that have potentially pathogenic consequences. These results offer preliminary support for the subsidiary hypothesis that the effects of disease threat on conformity may be particularly pronounced in domains of normative behavior that are especially pertinent to disease transmission.

It is important to note that, given the nature of the experimental manipulation, the experimenter was not blind to participant's experimental condition. However, for two reasons, this methodological limitation seems unlikely to undermine the validity of the results. First, only one of the primary dependent measures involved any meaningful interaction between experimenter and participant; all other measures were questionnaire-based, with instructions provided in written form on paper rather than through interaction with the experimenter. This substantially eliminated opportunities for the experiment to influence participant responses. Second, the between-condition results (showing greater conformity in the Disease Threat condition) are conceptually replicated by results involving individual-difference measures (showing that PVD-GA uniquely predicted conformity). The latter finding cannot have been influenced by experimenter's knowledge of participant's condition. No explanation based on the experimenter knowledge can offer a complete alternative account of the results of this study.

While the overall pattern of results is fairly consistent, there was some variability in effects across different methods and measures. For instance, analyses of individual differences revealed statistically significant effects of belief in a dangerous world (BDW) on conformist measures, but there was no significant increase in conformity in the Other Threats condition compared to the Neutral condition. The former finding conceptually replicates previous research linking threat to conformity (and extends it by showing that this effect of non-disease-relevant threat is statistically distinct from the effects of disease-relevant threat), but the latter non-effect fails to replicate previous experimental findings (e.g., Griskevicius et al., 2006). There are several possible methodological reasons for this non-replication. First, our experiment employed a different experimental manipulation to arouse disease-irrelevant threat. While the manipulation check indicated that the manipulation was successful in arousing threat-relevant emotions, it may have been less motivationally potent than procedures used in previous experiments. Another methodological difference between our experiment and previous experiments lies in the measures used to assess conformity. Both Griskevicius et al. (2006) and Renkema et al. (2008) reported results showing that non-disease-relevant threats produce increased conformity, but both employed a very specific kind of outcome measure: The extent to which participants agreed with other people's opinions in their self-reported subjective liking of artistic images. Our measures were different, and more diverse. (In our experiment, only one of four primary dependent measures assessed behavioral conformity to others' opinions. It is perhaps worth noting that it was only on this measure that the mean difference between Other Threats and Neutral conditions even approached statistical significance.)

Another apparent inconsistency lies in the finding that the disease salience manipulation had a substantial (and significant) effect on the measure of behavioral conformity, but individual differences in Germ Aversion did not. This is perhaps unsurprising. Personality traits most strongly predict outcomes aggregated across multiple responses in multiple situations, and are less effective in predicting single behavioral responses in specific contexts (Epstein, 1983).

There was also some inconsistency in effects on the two measures assessing domain-specificity in conformist attitudes: The disease salience manipulation had a stronger effect on the measure assessing responses to normative transgression than on the measure assessing responses to conformist choices. This may reflect the fact that, compared to norm-consistent behavior, normative transgressions are evaluated more negatively; consequently, they are more psychologically potent and more likely to produce differentiated responses (Rozin & Royzman, 2001).

Implications and Future Directions

The results underscore the importance of treating threat not as a single scientific construct, but instead as a category of psychologically distinct constructs, each with potentially unique implications. This perspective fits with that of Amoebic Self Theory (Burris & Rempel, 2010), and has also proven productive in research on the psychology of prejudice: different threats predict psychologically distinct forms of prejudice (Cottrell & Neuberg, 2005; Neuberg et al., 2011). More generally, different forms of threat may produce psychologically distinct effects on many phenomena pertaining to social cognition and social behavior. Only recently has there emerged a body of work documenting the unique impact of disease threat on psychological responses (Schaller & Park, 2011). Most of this research has focused on social cognition (e.g., person perception and prejudice; Ackerman, Becker, Mortensen, Sasaki, Neuberg, & Kenrick, 2009; Duncan & Schaller, 2009; Faulkner et al., 2004; Park, Schaller, & Crandall, 2007). Our results offer some of the first empirical evidence that disease threat has implications for attitudes and social influence as well.

Just as disease threat may exert unique effects on conformist attitudes, disease threat may also exert unique effects on the cognitive biases that are psychologically consistent with these attitudes (Eidelman & Crandall, 2009; Jost, Glaser, Kruglanski, & Sulloway, 2003). For example, recent research reveals that people treat the mere existence of something (e.g., a policy) as evidence of its goodness (Eidelman & Crandall, 2009). Extrapolating from our results, one might speculate that this "existence bias" will be exaggerated under conditions of disease threat, and that this exaggeration may occur especially when the existing policy is perceived as having immediate implications for pathogen transmission.

An individual's perception of vulnerability to infection need not be calibrated to that individual's actual vulnerability to infection. Our experimental manipulation focused on perception, not reality. Another avenue for future research is to examine the consequences of differences in actual immunocompetence. Previous research reveals that decreased immunocompetence is associated with increased disgust sensitivity and also increased ethnocentrism (Navarette, et al., 2007). It is possible that individuals who are temporarily immunosuppressed (because of pregnancy, medication, etc.) may also be temporarily more disposed toward conformist attitudes and behaviors. As immunocompetence changes across the lifespan, these changes may have attitudinal consequences as well.

There may also be consequences that reverberate throughout entire populations. A disease epidemic, or even the perceived threat of an epidemic (such as the H1N1 outbreak of 2009), may lead to temporarily higher levels of conformity within populations, and may dispose individuals within those populations to respond more harshly to normative transgressions (perhaps especially in domains with immediate implications for infection). By the same reasoning, societal investments in public health (e.g., vaccination programs, disease eradication programs, and other public policies that reduce vulnerability -- or perceptions of vulnerability -- to the threat posed by infectious diseases) may result in a populace that is not only healthier, but also less beholden to the existing status quo.

Table 3.1. Correlations between individual difference variables and primary dependent variables.

	1	2	3	4	5	6	7
1. PVD - Germ Aversion	-						
2. PVD - Perceived Infectability	.29**	-					
3. Belief in a Dangerous World	.34**	.14*	-				
4. Self-Reported Conformist Attitudes	.40**	.10	.46**	-			
5. Liking for People with Conformist Traits	.16*	-.05	.16*	.38**	-		
6. Valuation of Obedience	.24**	.06	.19**	.43**	.19**	-	
7. Behavioral Conformity with Majority Opinion	.10	.09	.06	.19**	.17*	.10	-

Note: ** p < .01, * p < .05, N = 217.

Table 3.2. Results of multiple regression analyses assessing the extent to which each primary dependent variable was uniquely predicted by Germ Aversion (PVD-GA) and Belief in a Dangerous World (BDW).

	PVD-GA		BDW	
Dependent variable	*β*	*p*	*β*	*p*
Self-Reported Conformist Attitudes	.28	<.001	.37	<.001
Liking for People with Conformist Traits	.12	.089	.12	.085
Valuation of Obedience	.20	.005	.12	.084
Behavioral Conformity with Majority Opinion	.09	.222	.02	.655

Note: N = 217.

Table 3.3. Results of multiple regression analyses assessing the extent to which Germ Aversion (PVD-GA) and Belief in a Dangerous World (BDW) uniquely predicted difference-scores assessing the tendency to exhibit more conformist responses in disease-relevant (compared to non-relevant) domains of normative behavior.

Domain-specific Differences in:	PVD-GA		BDW	
	β	*p*	*β*	*p*
Perceived Severity of Normative Transgressions	.31	.009	-.28	.019
Perceived Correctness of Conformist Choices	.21	.083	.01	.953

Note: N = 92.

Table 3.4. Means (and standard deviations) on the four primary dependent variables in each of the three experimental conditions, along with p-values for the corresponding planned pairwise contrasts between these means.

	Experimental Conditions			Planned Contrasts		
Dependent Variable	Disease Threat	Other Threats	Neutral	Disease Threat vs. Neutral	Disease Threat vs. Other threats	Other Threat vs. Neutral
Self-Reported Conformist Attitudes	3.34 (0.83)	3.10 (0.89)	3.11 (0.78)	p = .108	p = .076	p = .939
Liking for People With Conformist Traits	3.62 (0.99)	3.31 (0.93)	3.34 (0.86)	p = .082	p = .034	p = .789
Valuation of Obedience	9.71 (7.90)	8.25 (5.62)	7.59 (5.15)	p = .054	p = .162	p = .561
Behavioral Conformity to Majority Opinion	0.67 (0.47)	0.53 (0.50)	0.42 (0.50)	p = .003	p = .069	p = .196
N	82	74	61			

Note: The *p*-values reported in this table correspond to two-tailed tests of null hypotheses.

Table 3.5. Means (and standard deviations) on difference-scores assessing the tendency to exhibit more conformist responses in disease-relevant (compared to non-relevant) domains of normative behavior.

	Experimental Conditions			Planned Contrasts		
Domain-specific Differences in:	Disease Threat	Other Threats	Neutral	Disease Threat vs. Neutral	Disease Threat vs. Other Threats	Other Threats vs. Neutral
Perceived Severity of Normative Transgressions	1.67 (1.01)	1.33 (1.07)	0.91 (0.89)	*p* = .008	*p* = .162	*p* = .123
Perceived Correctness of Conformist Choices	1.58 (1.31)	1.43 (1.24)	1.32 (1.48)	*p* = .464	*p* = .617	*p* = .756
N	30	39	23			

CHAPTER FOUR

Historical Prevalence of Infectious Diseases within 230 Regions: Creating a Tool for Investigating the Origins of Culture[3]

The individual-level investigations in Chapters Two and Three benefit from certain pragmatic and inferential luxuries. Pragmatically, these investigations required data from only a few hundred individuals—data that is fairly easily obtained from student populations. A subset of results from these investigations are inferentially uncomplicated as well: Laboratory studies such as these allow for rigorous control of environmental conditions, which in turn allows researchers to confidently infer that differences between conditions are due to experimental manipulations, and not due to extemporaneous variables. Participants in these studies can further be assumed to be relatively statistically independent of one another (in the sense that they do not influence each other's responses in the laboratory, at least), which further bolsters the inferential power of these laboratory investigations.

Cross-cultural investigations are not afforded these pragmatic or inferential niceties. Cross-cultural enquiries into complex psychological phenomena usually require gathering data from hundreds or thousands of individuals in dozens of cultures simply to obtain enough statistical power to detect meaningful differences or to test hypotheses. Even if a researcher overcomes this pragmatic data-collection gauntlet, the ability to confidently draw conclusions from cross-cultural data is constrained. Unlike random assignment in laboratory studies, people cannot be randomly assigned to cultures; environmental conditions cannot be experimentally manipulated between

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[3] This chapter has been adapted from Murray, D. R., & Schaller, M. (2010). Historical prevalence of disease within 230 geopolitical regions: A tool for investigating origins of culture. *Journal of Cross-Cultural Psychology, 41,* 99-108. It has been modified to fit the format of this thesis.

cultures; even *defining* which cultures should be considered functional units of analysis can be a challenge.

Despite the fact that cross-cultural investigations cannot employ controlled experiments, however, several methodological and analytical tools exist that can provide insights into possible causal relationships lurking in cross-cultural data. Such large-scale investigations are necessary in order to begin to uncover some of the causes of the emergence of contemporary cross-cultural differences. But it's no easy task. This chapter describes the first step in this type of cross-cultural investigation: Creating a tool that reliably and accurately represents the historical prevalence of disease in dozens of cultures around the world.

Human Cultural Variability

Human cultures differ along many psychological dimensions, including basic perceptual capacities, personality profiles, and complex value systems. These cultural differences and their implications can be studied productively, regardless of whether cultures are defined according to ethnographic methods (e.g., differences between isolated small-scale societies), or according to contemporary geopolitical boundaries (e.g., differences between people living in different countries). Now that the presence of cultural differences is well established, it is important to understand how and why those cultural differences may have emerged in the first place. Many speculative answers have been provided, along with a burgeoning empirical literature as well (Cohen, 2001; Gangestad, Haselton, & Buss, 2006; Kitayama, Ishii, Imada, Takamura, & Ramaswamy, 2006; Uskul, Kitayama, & Nisbett, 2008). Of course, one body of evidence suggests that regional variation in the prevalence of infectious diseases have played an important role in the origin of many different kinds of cross-cultural differences. Analyses of small-scale societies implicate disease prevalence as a predictor of cross-cultural differences in mating structures and parenting practices (Low, 1990; Quinlan, 2007). Other studies have defined cultures according to contemporary geopolitical boundaries, and have found that disease prevalence predicts cross-cultural differences in culinary practices (Sherman & Billing, 1999), mate preferences (Gangestad & Buss, 1993; Gangestad, Haselton, & Buss, 2006), and personality traits such as extraversion and openness to experience (Schaller & Murray, 2008). Indeed, cultural diversity itself is predicted by the prevalence of infectious diseases within an ecological region (Fincher & Thornhill, 2008a, 2008b).

Exactly *why* does disease prevalence have implications for these cultural outcomes? Similar to the earlier logic of how perceived disease threat influences the perceived cost/benefit ratio of specific behaviors, does *actual* variation in disease threat influence the relative costs and benefits of many behaviors and practices. For example, the use of culinary spices can be costly (e.g., because their cultivation consumes resources that could otherwise be devoted to more nutritional foodstuffs); but spices are also powerful antibiotics and so confer health benefits accordingly. The benefits of spices are especially likely to outweigh their costs under conditions in which bacterial infestation of food is especially problematic (Sherman & Billing, 1999). Thus, spices are more likely to be used in regions with relatively higher prevalence of infectious diseases. Similar cost/benefit analyses have been employed to predict and explain relations between disease prevalence and other cross-cultural differences, such as extraversion (discussed in Chapter 1). It is worth noting that this cost/benefit approach does not imply that individuals rationally weigh the costs and benefits associated with all of these behaviours when choosing how to act; rather, cultural values that favour beneficial behaviours in a region over time will tend to proliferate compared to those that favour more costly behaviours.

The predictive effects of disease prevalence emerge even when statistically controlling for a variety of other variables that are correlated with disease prevalence and that also might be expected to independently predict particular cross-cultural differences. For example, regional differences in disease prevalence predicted cross-cultural differences in personality even when controlling for a series of variables that included absolute latitude, temperature, life expectancy, and GDP per capita (Schaller & Murray, 2008). Similarly, disease prevalence predicted cross-cultural differences in mate preferences and in individualism / collectivism even when controlling for plausible confounds (Fincher et al., 2008; Gangestad et al., 2006). Emerging from this body of research is the intriguing possibility that ecological variation in the prevalence of infectious diseases has implications for the origins of many different kinds of cross-cultural differences.

Several of these studies (Fincher et al., 2008; Schaller & Murray, 2008) compared the extent to which contemporary cross-cultural differences were predicted by contemporary disease prevalence, which is indicated by current epidemiological databases, versus historical disease prevalence, which was estimated by medical atlases published many decades ago. Results reveal that the historical prevalence of infectious diseases is the stronger predictor. These findings implicate disease prevalence as a cause, rather than a consequence, of contemporary cross-cultural differences; also, they highlight the scientific utility that will be served if researchers have access to a reliable, valid, and comprehensive index of historical disease prevalence. An index pertaining specifically to 186 small-scale societies is widely available to researchers within the Standard Cross-Cultural Sample dataset (Murdock & White, 1969, 2006), but its utility is limited to analyses of the ethnographic record. No comparable comprehensive index is available to researchers whose cross-cultural inquiries require comparisons between countries and other contemporary geopolitical entities. Here, we provide just such a measure.

Employing methods adapted from previous inquiries (in which disease prevalence indices were computed for limited samples of geopolitical entities; Fincher et al., 2008; Gangestad & Buss, 1993), we assessed the historical prevalence of infectious diseases in 230 geopolitical regions worldwide.

4.1 Methods and Results

Gangestad and Buss (1993) employed old epidemiological atlases to rate the prevalence of 7 different kinds of disease-causing pathogens, and combined these estimates into a single measure indicating the historical prevalence of pathogens in each of 29 countries. More recently, we used a similar procedure to rate the prevalence of 9 infectious diseases in each of 100 geopolitical regions (71 of these regions were included in analyses reported by Schaller & Murray, 2008; 97 of these regions were included in analyses reported by Fincher et al., 2008). We extended that procedure (and rated anew even those regions that had been the focus of prior investigations) in an attempt to assess the prevalence of those 9 diseases within a comprehensive set of geopolitical regions worldwide. The majority of these regions are nations (e.g., Albania, Zimbabwe); others are territories or protectorates (e.g., Falkland Islands, New Caledonia) or culturally distinct regions within a nation (e.g., Hawaii, Hong Kong).

The 9 diseases coded were: leishmania, schitsoma, trypanosoma, leprosy, malaria, typhus, filaria, dengue, and tuberculosis. Epidemiological atlases were used to estimate the prevalence of each of these nine diseases in each region. For eight of these diseases (all but tuberculosis), prevalence of each disease was based primarily upon epidemiological maps provided in Rodenwaldt and Bader's (1952-1961) *World-Atlas of Epidemic Diseases* and in Simmons, Whayne, Anderson, and Horack's (1944) *Global Epidemiology*. A 4-point coding scheme was employed: 0 = *completely absent or never reported,* 1 = *rarely reported* (e.g. infrequent cases are reported, but the disease does not pose a recurrent problem), 2 = *sporadically or moderately reported* (e.g. the disease poses a recurrent problem, but not at severe or epidemic levels), 3 = *present at severe levels or epidemic levels at least once.* In the rare cases in which these two epidemiological sources provided contradictory information, priority was placed on data provided by the older source (Simmons et al., 1944). In cases in which the relevant maps were unavailable (this was especially true for leprosy) or insufficiently detailed (this was especially true for many of the Pacific island nations), prevalence ratings were informed also by verbal summaries found in Simmons et al. (1944). The prevalence of tuberculosis was based upon a map contained in the National Geographic Society's *Atlas of the World* (2005), which provided incidence information in each region for every 100,000 people. Prevalence of tuberculosis was coded according to a 3-point scheme: 1 = *3-49,* 2 = *50-99,* 3 = *100 or more.*

For 160 geopolitical regions, we were able to estimate the prevalence of all 9 diseases. The remaining regions of the world largely lacked adequate historical data for the prevalence of tuberculosis and leprosy. Therefore, we also computed a 7-item index, which encompasses 224 regions. In a handful of rare cases (six), a region lacked data for malaria as well; therefore, we computed a 6-item index as well. The specific six-item index values are only reported for the 6 countries that lack a 7-item measure, in the interest of space. However, all analyses were performed with the 6-item measure as well and are included below. Thus, for 230 distinct geopolitical regions, we were able to compute one or more disease prevalence indices, based on the prevalence of 6 or more distinct infectious diseases. (This set of 230 geopolitical regions includes nations and territories from each of the six major world cultural regions identified by Murdock, 1949. The number of coded geopolitical regions within each of these major regions is as follows: Africa = 57, Insular Pacific = 30, North America = 30, South America = 20, Eastern Eurasia = 27, Western Eurasia = 66.)

To ensure that our different disease prevalence indices were computed on a common scale of measurement, all 9 disease prevalence ratings were standardized by converting them to *z*-scores. Each overall disease prevalence index was then computed as the mean of z-scores of the items included in the index. Thus, for each overall index (whether based on 6, 7, or 9 items), the mean is approximately 0; positive scores indicate disease prevalence that is higher than the mean, and negative scores indicate disease prevalence that is lower than the mean. Table 4.2 (p. 76) lists each of these disease prevalence scores for each of the 230 geopolitical regions.

There is abundant evidence that pathogenic diseases are generally more prevalent in the tropics compared to more temperate zones (Epstein, 1999; Guernier, Hochberg, & Guégan, 2004). Consistent with this fact, the 9 disease prevalence ratings were all positively correlated, and all composite indices are internally reliable. As would be expected, the 9-item index shows the highest internal reliability: Cronbach's alpha = .84, and for the 7-item index, alpha = .75, and for the 6-item index, alpha = .70.

The reliability and validity of each index can also be assessed by examining correlations of each index with the disease prevalence index computed by Gangestad and Buss (1993), who used a similar rating procedure to estimate the overall historical prevalence of 7 diseases in 29 countries. Gangestad and Buss's index correlates very highly with all three of the indices we computed: *r*'s range from .87 to .90. In addition, the indices are highly correlated with a measure of *contemporary* parasite prevalence (computed for 225 of these geopolitical regions from epidemiological data obtained in 2007; Fincher & Thornhill, 2008a): *r*'s range from .81 to .84. It is also worth noting these three indices are highly intercorrelated: the correlations between the 6-, 7-, and 9-item indices are all equal to or greater than .97.

We examined the extent to which each of these five indices predicted cross-cultural differences that have previously been linked to the historical prevalence of infectious diseases. Fincher et al. (2008) reported strong correlations between a computationally similar 9-item disease prevalence index and four different regional indicators of individualism or collectivism (absolute values of these *r*'s ranged from .63 to .73; N's ranged from 58 to 70). Schaller and Murray (2008) reported negative correlations (*r*'s = -.51 and -.44) between a 9-item disease prevalence index and multi-sample composite indicators of two personality traits (extraversion, openness to experience) across 38 regions. Schaller and Murray (2008) also reported a negative correlation (*r* = -.62) between this index and female sociosexuality assessed across 48 regions. (In all cases, these correlations remained statistically significant even when controlling for plausible confounding variables.) For comparison, Table 4.1 (p. 75) reports correlations indicating the association between each of these cross-cultural outcome variables and each of the three disease prevalence indices computed here. As these results reveal, each of these three disease prevalence indices produces results that replicate those reported previously. The 9-item index typically produces the strongest correlations (producing values that are virtually identical to those reported in previous studies). But even the 6-item index produces correlations that are only trivially different in magnitude.

In addition, we examined the extent to which these three indices predicted several additional cross-cultural differences that have previously been predicted by somewhat different indicators of disease prevalence. Sherman and Billing (1999) reported a significant positive correlation between mean annual temperature (which served as a proxy for the prevalence of pathogens) and the extent to which spices are used in food preparation (*r* = .57; N = 34). Thornhill, Fincher, and Aran (2009) reported that a measure of *contemporary* pathogen prevalence correlated positively with restrictions placed on political rights and civil liberties (*r* = .45; N = 192) and negatively with an index of democratization (*r* = -.52, N = 170; both correlations remained significant when controlling for additional confounding variables). For comparison, Table 4.1 (p. 75) reports correlations revealing the association between each of these cross-cultural outcome variables and each of the three indices of historical disease prevalence computed here. The notable finding is that our three indices of historical disease prevalence predict the cross-cultural outcomes at least as strongly (and in some cases, *more* strongly) than the measures employed in the original studies.

The overall implication of these results is that these indices of historical disease prevalence are useful for investigating cross-cultural differences. The 9-item index is the most highly reliable and generally offers the greatest utility for predicting cross-cultural differences. (E.g., the 9-item index typically produces the strongest correlations, such as those indicated in Table 4.1 (p. 75), which remain significant even when controlling for confounding variables identified in previous studies on the topic). Only a small amount of predictive power is lost even if one must use one of the other scores (based on fewer items) to estimate disease prevalence within a region.

Of important note is that disease prevalence “predicting” cross-cultural differences is not equivalent to disease prevalence explaining these differences. Even though these correlations remain robust when controlling for confounding variables, causal conclusions cannot be made.

4.2 Discussion

It is no easy task to develop a reliable and valid index indicating the historical prevalence of infectious diseases in a particular region. For many regions, relevant data is scant. The authors of the epidemiological sources employed here (e.g. Simmons et al., 1944) explicitly acknowledge the difficulties of precisely estimating disease prevalence rates within specific regions. Despite these measurement issues, composite indices of historical disease prevalence can be created that are both reliable and also highly associated with cross-cultural differences. Previous studies have computed such indices for relatively limited samples of geopolitical regions (e.g., Fincher et al., 2008; Gangestad & Buss, 1993; Schaller & Murray, 2008). This chapter provides indices for a comprehensive set of geopolitical regions around the world.

Many inquiries into the origins of cross-cultural differences are likely to focus on data obtained from within the 160 regions for which it was possible to estimate the prevalence of 9 different diseases. For such inquiries, the 9-item index appears to offer the best available measure of historical disease prevalence. For researchers whose dataset includes additional geopolitical regions (those for which data on one or more of the specific diseases was unavailable), it may be more appropriate to employ the 7-item index (and, in some rare cases, employ the few 6-item measures). These indices too have acceptable levels of reliability, considerable predictive utility, and (although less ideal than the 9-item index) can still provide a very effective tool for testing hypotheses about disease prevalence and the emergence of cross-cultural differences.

Any researcher employing one of these indices to predict cross-cultural differences is advised to also assess, and consider the causal implications of, additional variables that may correlate highly with disease prevalence. Many specific cross-cultural differences are correlated with latitude and associated meteorological variables, as well as with economic variables and other aspects of the local social ecology (e.g., Cohen, 2001; Kashima & Kashima, 2003; Uskul et al., 2008; Van de Vliert, 2009; Van de Vliert, Schwartz, Huismans, Hofstede, & Daan, 1999). Disease prevalence is correlated with many of these variables (Schaller & Murray, 2008). Therefore, compelling conclusions about the effects of disease prevalence on cultural differences can be drawn only if the effects of disease prevalence persist even after controlling for these potential confounds (e.g., Fincher & Thornhill, 2008a, 2008b; Fincher et al., 2008; Gangestad et al., 2006; Schaller & Murray, 2008).

The reverse is true as well. Any researcher wishing to rigorously test the predictive effects of other variables on cross-cultural outcomes would be wise to account for the effects of disease prevalence. Case in point: Cross-cultural differences in sociosexuality are predicted by average life expectancy (Schmitt, 2005); but this effect essentially disappears when controlling for disease prevalence (which is a stronger predictor of sociosexuality; Schaller & Murray, 2008). Similarly, across cultures there is a correlation between individualistic value systems and mean levels of extraversion (Hofstede & McCrae, 2004); but this effect too disappears when statistically controlling for disease prevalence (which is uniquely associated with both individualism and extraversion; Fincher et al., 2008; Schaller & Murray, 2008). The predictive effects of economic wealth (e.g. GDP) on cultural differences also tend to be sharply reduced – although do not always disappear entirely – when controlling for disease prevalence (Fincher et al., 2008; Schaller & Murray, 2008).

These indices of disease prevalence should also prove useful to researchers who attempt to articulate the complex causal relations between multiple ecological variables that predict cross-cultural differences. For example, although simple regression analyses reveal that both disease prevalence and GDP are uniquely related to cross-cultural differences in individualism/collectivism (Fincher et al., 2008), these variables are likely to be causally linked in more complex ways than previously identified. Given the profound implications that disease prevalence has on regional economic outcomes (e.g., Sachs & Malaney, 2002), for instance, the unique direct effects of economic wealth may actually reflect an additional indirect effect of disease prevalence. Similarly, given the profound implications that meteorological conditions have for the survival and transmission of disease-causing pathogens (Epstein, 1999; Guernier et al., 2004), disease prevalence may be a conceptually important mediating variable that helps to explain the many important relations that exist between climate and cultural practices (Van de Vliert, 2009). The correlations in Table 4.1, therefore, are not intended to reflect stand-alone results; rather, these relationships should raise more scientific questions than they should answer. Thus, not only does a comprehensive index of historical disease prevalence provide an essential empirical tool to researchers testing hypotheses about the cultural consequences of disease, it also provides a useful tool to researchers who wish to inquire more deeply into the specific causal mechanisms through which ecological variables contribute to cross-cultural differences.

Table 4.1. Correlations between 9-, 7-, and 6-item disease prevalence scores and specific cross-cultural outcome variables that have been linked to disease prevalence in previously published work.

	Index of Historical Disease Prevalence		
Cross-Cultural Outcome Variable	9-item	7-item	6-item
Individualism (Hofstede, 2001)	-.68	-.65	-.63
Individualism (Suh et al., 1998)	-.70	-.63	-.61
Collectivism (Gelfand et al, 2004)	.68	.68	.67
Collectivism (Kashima & Kashima, 1998)	.62	.61	.59
Extraversion	-.51	-.46	-.50
Openness to Experience	-.43	-.37	-.36
Female Sociosexuality	-.60	-.59	-.57
Use of Spices in Food Preparation	.58	.58	.59
Restriction of Rights and Civil Liberties	.55	.50	.47
Democratization	-.65	-.57	-.53

Note: All *r*'s are statistically significant, $p < .05$. See text for references to previously published work on cross-cultural outcome variables, and refer to those prior publications for complete details on samples and methods used to assess outcome variables.

Table 4.2. Indices of Historical Disease Prevalence for Each of 230 Geopolitical Regions

Region	9-item	7-item
Afghanistan	.23	.15
Albania	- .25	.03
Algeria	.47	.63
Andorra	-1.08	-1.05
Angola	.95	.93
Anguilla	---	- .27
Antigua	---	- .27
Argentina	- .12	.03
Armenia	.10	.15
Aruba	---	-.28
Australia	-.25	-.14
Austria	-.77	-.65
Azerbaijan	.33	.29
Azores	---	-.73*
Bahamas	---	-.51
Bahrain	.10	.15
Bangladesh	.62	.66
Barbados	---	-.15
Belarus	-.75	-.78
Belgium	-1.00	-.78
Belize	---	.28
Benin	.93	1.07
Bermuda	---	-.63
Bhutan	.44	.27
Bolivia	.34	.30
Bosnia & Herzegovina	.00	.03
Botswana	.41	.39
Brazil	.93	1.06
Brunei	-.01	.00
Bulgaria	-.35	-.10
Burkina Faso	1.16	1.19
Burundi	1.06	1.07
Cambodia	.45	.28
Cameroon	1.17	1.20
Canada	-1.31	-1.18
Canary Islands	---	-.23
Cape Verde	---	-.26
Cayman Islands	---	-.65
Central African Rep.	1.16	1.19
Chad	1.04	1.04
Chile	-.45	-.22
China (P.R.C.)	1.03	1.03
Christmas Island	---	-1.04*
Colombia	.27	.53
Comoros	---	-.25
Congo, Dem. Rep.	.97	.95
Congo, Rep.	1.16	1.19
Cook Islands	---	-.93
Costa Rica	.12	.18
Cote d'Ivoire	1.06	1.06
Croatia	-.44	-.38
Cuba	---	.00
Cyprus	-.34	-.25

Region	9-item	7-item
Czech Republic	-.87	-.78
Denmark	-.98	-.91
Djibouti	.49	.50
Dominica	---	-.02
Dominican Rep.	---	-.13
East Timor	.24	.01
Ecuador	.34	.30
Egypt	.44	.76
El Salvador	.30	.42
England	-1.01	-.78
Equatorial Guinea	.96	.93
Eritrea	.52	.37
Estonia	-.62	-.78
Ethiopia	.71	.77
Falkland Islands	---	-1.18
Fiji	-.07	-.39
Finland	-.75	-.78
France	-.46	-.40
French Guiana	---	.92
French Polynesia	---	-.67
Gabon	1.04	1.19
Gambia	.94	.92
Georgia	.10	.16
Germany	-.87	-.78
Ghana	1.16	1.19
Gibraltar	---	-.50
Greece	.08	.29
Greenland	---	-1.18
Grenada	---	-.53
Guadeloupe	---	-.15
Guam	-.17	-.52
Guatemala	.42	.56
Guinea	1.06	1.06
Guinea-Bissau	1.06	1.06
Guyana	---	.64
Haiti	---	-.01
Hawaii	---	-.52
Honduras	---	.16
Hong Kong	.27	.37
Hungary	-1.00	-.78
Iceland	-1.19	-1.18
India	.94	.91
Indonesia	.63	.51
Iran	-.15	-.16
Iraq	.54	.40
Ireland	-.45	-.23
Israel	.52	.53
Italy	.16	.40
Jamaica	.18	.25
Japan	.43	.25
Jordan	.16	.39
Kazakhstan	---	-.38
Kenya	.95	.92
Kiribati	---	-.53
Korea, North	.12	-.14
Korea, South	-.11	-.28
Kuwait	-.34	-.25
Kyrgyzstan	---	-.38
Laos	.45	.28

Region	9-item	7-item
Latvia	-.62	-.78
Lebanon	.36	.65
Lesotho	.01	-.13
Liberia	.73	.80
Libya	.04	.24
Liechtenstein	-1.08	-1.05
Lithuania	-.75	-.78
Luxembourg	-1.11	-.91
Macau	.10	-.01
Macedonia	-.25	.03
Madagascar	.63	.51
Malawi	.73	.64
Malaysia	.50	.51
Maldives	---	-.90*
Mali	1.04	1.04
Malta	-.41	-.50
Marshall Islands	---	-.25
Martinique	---	.24
Mauritania	.31	.26
Mauritius	---	.11
Mexico	.28	.56
Micronesia	---	-.11
Moldova	-.31	-.37
Monaco	-.77	-.65
Mongolia	---	-.78
Montserrat	---	-.02
Morocco	.59	.62
Mozambique	.83	.93
Myanmar (Burma)	.64	.53
Namibia	-.09	-.25
Nauru	---	-.80
Nepal	.14	-.12
Netherlands	-.87	-.78
Netherlands Antilles	---	-.28
New Caledonia	---	-.53
New Zealand	-.98	-.91
Nicaragua	---	.16
Niger	.51	.52
Nigeria	1.16	1.19
Niue	---	-.93
Norfolk Island	---	-1.04*
Northern Ireland	-.87	-.78
Northern Mariana Isl.	---	-.52
Norway	-.85	-.91
Oman	-.14	.00
Pakistan	.02	-.12
Palau	---	-.38
Panama	.09	.31
Papua New Guinea	---	.15
Paraguay	---	.17
Peru	.23	.16
Philippines	.50	.51
Pitcairn Islands	---	-1.18
Poland	-.87	-.78
Portugal	.47	.63
Puerto Rico	.07	.12
Qatar	---	-.25
Reunion	---	-.25
Romania	-.18	-.37

Region	9-item	7-item
Russia	-.39	-.64
Rwanda	1.05	1.05
St. Helena	---	-1.04*
St. Kitts	---	-.15
St. Lucia	---	-.15
St. Vincent	---	-.28
Samoa	---	-.41
Samoa (U.S.)	---	-.41
San Marino	-.46	-.25
Sao Tome & Principe	---	-.19
Saudi Arabia	.04	.24
Scotland	-1.31	-1.18
Senegal	.72	.78
Serbia	-.23	-.11
Seychelles	---	-.63
Sierra Leone	.94	.92
Singapore	.31	.26
Slovakia	-1.00	-.78
Slovenia	-.87	-.78
Solomon Islands	---	-.12
Somalia	.61	.64
South Africa	.11	.00
Spain	-.05	.13
Sri Lanka	.64	.52
Sudan	1.00	1.15
Surinam	.63	.67
Swaziland	.08	.13
Sweden	-.98	-.91
Switzerland	-1.08	-1.05
Syria	.30	.41
Taiwan	.30	.25
Tajikistan	---	.02
Tanzania	.75	.66
Thailand	.64	.52
Togo	1.16	1.19
Tokelau	---	-.93
Tonga	---	-.67
Trinidad	-.03	-.01
Tunisia	.81	.90
Turkey	.16	.40
Turkmenistan	.00	.02
Turks & Caicos Isl.	---	-.39
Tuvalu	---	-.93
Uganda	1.05	1.05
Ukraine	-.40	-.64
United Arab Emirates	-.45	-.39
United States Amer.	-.89	-.64
Uruguay	.39	.53
Uzbekistan	-.44	-.37
Vanuatu	---	-.13
Venezuela	.48	.80
Vietnam	.61	.64
Virgin Isl. (Brit.)	---	-.27
Virgin Isl. (U.S.)	---	-.15
Wake Island	---	-1.04*
Western Sahara	---	-.26
Yemen	.41	.23
Zambia	.64	.52
Zimbabwe	.64	.53

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* Indicates a 6-item index

CHAPTER FIVE

Pathogens and Politics: Exploring the Relationships between Parasite Prevalence and Authoritarianism[4]

The historical disease index created in Chapter 4 provides a valuable tool for investigating the origins of cultural differences. This methodological tool has since been employed in investigating the origins of cross-cultural variation in attitudes, personality, and value systems. Since its inception, the index created in Chapter 4 has inspired creation of a similar methodological tool designed to assess disease prevalence and investigate cultural differences in more traditional societies (see Cashdan & Steele, 2013). Using both of these indices, this chapter reports cross-cultural results from two studies that investigate the predictive effects of historical disease prevalence on authoritarian attitudes and authoritarian political systems, both in modern nation states and in traditional societies.

Authoritarianism and Disease Prevalence across Cultures

Systems of governance differ widely, and one important dimension on which they vary is authoritarianism. In contrast to liberal democratic forms of governance (characterized by popular participation in the political process, and by protection of individual civil rights and ideological freedoms), authoritarian governance is defined by highly concentrated power structures that repress dissent and emphasize submission to authority, social conformity, and hostility towards outgroups (Adorno, Frenkel-Brunswick, Levinson, & Sanford, 1950; Altemeyer, 1996). Why is governance in some states and societies more authoritarian than in

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others? Economic variables—including the overall availability of economic resources and the manner in which those resources are distributed—provide partial answers to that question (Acemoglu & Robinson, 2005; Haber & Menaldo, 2011; Perry & Robertson, 2002; Vanhanen, 2003). Ecological variables may play a role as well. As the last chapter revealed, societal variability in authoritarian governance may result, in part, from variability in the prevalence of disease-causing parasites (Thornhill et al., 2009). Although results from several initial studies support this "parasite stress" hypothesis of authoritarian governance (Thornhill et al., 2009; Thornhill, Fincher, Murray, & Schaller, 2010), alternative explanations for those results remain unaddressed. This chapter reports results from two investigations designed to test the parasite stress hypothesis and to address inferential limitations of previous studies.

Why might there be a causal link between the prevalence of infectious diseases in the local ecology and an authoritarian system of governance? The hypothesis follows cost/benefit logic similar to that which specifies relationships between disease threat and other cross-cultural variables: Several defining characteristics of authoritarian political systems (such as institutionalized emphasis on social conformity, intolerance of dissent, and ethnocentrism) have implications for the spread of infectious disease. Because many disease-causing parasites are invisible, and their actions mysterious, disease control has historically depended substantially on adherence to ritualized behavioral practices that reduced infection risk (e.g. Fabrega, 1997). Individuals who openly dissented from, or simply failed to conform to, these behavioral traditions therefore posed a health threat to self and others. Thus, while there can be societal costs associated with a collective behavioral tendency towards authoritarianism (e.g., inhibition of technological innovation), there are disease-specific benefits too (presuming that a greater proportion of these behavioral traditions serve to mitigate, rather than propagate, the spread of disease).

This logical analysis has implications for predictable variation in individuals’ attitudes and values, and for worldwide societal differences too. At a psychological level of analysis, results from Chapter Three revealed that the subjective perception of infection risk causes individuals to be more conformist, and to prefer conformity and obedience in others. Other studies similarly reveal that perceived disease risk leads individuals to respond more negatively toward others who fail to conform, and to endorse more conservative socio-political attitudes (Helzer & Pizarro, 2011; Inbar et al., 2009; Jones & Fitness, 2008). At a societal level of analysis, in countries and cultures characterized by historically higher prevalence of parasitic diseases, people exhibit lower levels of dispositional openness to new things, are more likely to conform to majority opinion, and more strongly endorse cultural values that emphasize group loyalty, obedience, and respect for authority (Cashdan & Steele, 2013; Fincher et al., 2008; Murray et al., 2011; Schaller & Murray, 2008). In addition to their intolerance of nonconformity, authoritarian political systems are also characterized by nepotism and ethnocentrism (Vestal, 1999), which have also been empirically linked to the threat of disease.

To the extent that institutionalized forms of governance reflect the attitudes and values of the individuals who populate the local ecology, these lines of research have implications for predicting worldwide variability in authoritarian governance: In places where parasitic diseases have posed greater stress on human health and welfare, authoritarian forms of governance may be especially likely to emerge and to persist over time.

Thornhill and colleagues (2009) empirically tested this parasite stress hypothesis, using modern geopolitical entities (e.g., countries) as units of analysis. The hypothesis was tested on four different measures of democratization and/or authoritarianism, using a parasite stress measure derived from a modern epidemiological database. Consistent evidence was observed across all measures: Higher levels of parasite stress were associated with less democratic, more highly authoritarian political systems (N's > 192, absolute r's > .45, p's < .001). These relationships remained statistically significant when statistically controlling for measures of economic development and economic inequality (as assessed by a country's GDP per capita and GINI coefficient respectively). The analyses from Chapter Four revealed that country-level differences in authoritarian governance were even more strongly predicted by a measure of *historical* (rather than modern-day) parasite prevalence—a finding consistent with the hypothesis that authoritarian governance is a consequence (rather than a cause) of parasite stress.

However, nontrivial inferential issues arise from the use of contemporary nation-states as units of analysis (Nettle, 2009). Until these issues are addressed empirically, it is difficult to draw confident conclusions about the relationship between parasite stress and authoritarian governance.

One issue pertains to the history of European colonization, and its consequences. When countries colonize other geographic regions, they often impose their own political and economic institutions onto those regions; those institutions may persist even after those regions attain independence. It has been argued that ecological variables (such as the prevalence of infectious diseases) predict societal outcomes primarily because of their influence on particular patterns of colonial settlement, such that European colonial powers were more likely to establish long-lasting democratic political systems and economic institutions in regions characterized by lower incidences of infectious diseases (Acemoglu, Robinson, & Johnson, 2001; Easterly & Levine, 2003). This represents a very different causal process than that implied by the parasite stress hypothesis.

We conducted two separate investigations, using two different empirical strategies, to address this inferential issue and thus to more rigorously test the hypothesized relation between parasite stress and authoritarian governance.

The first study extends some of the analyses of disease prevalence and authoritarianism reported in Chapter Four. The alternative explanation—differential colonial establishment of political institutions—is tested by examining relations not only between disease prevalence and state-level authoritarianism evident in government institutions, but also by examining the relation between those variables and authoritarian attitudes expressed by individuals who populate the country. The colonial-establishment-of-institutions explanation implies a direct causal influence of disease prevalence on state-level authoritarian governance, which may in turn have downstream consequences for individual-level authoritarian attitudes. Conversely, the parasite stress hypothesis implies a more direct causal influence of disease prevalence on individuals' authoritarian attitudes, which in turn would be expected to have a consequent influence on state-level systems of government. In statistical analytic terms, the alternative explanation implies an indirect relation between disease prevalence and individuals' authoritarian attitudes that is statistically mediated by authoritarian governance, whereas the parasite stress hypothesis implies an indirect relation between disease prevalence and authoritarian governance that is statistically mediated by individuals' authoritarian attitudes.

In addition to testing the alternative explanation, the results of this study also have implications for our understanding of individual-level authoritarian attitudes as they relate to societal outcomes. Research on "the authoritarian personality" of individuals indicates some relation between politically entrenched authoritarian systems of governance and individually expressed authoritarian personality traits, as such governments and individuals have in common their emphasis on adherence to conventional values, repression of dissent, and devotion to order and hierarchy (Adorno et al., 1950, Altemeyer, 1996; Meloen, 1996). But the direction of causality is unclear: To what extent does the correlation reflect the influence of government institutions on individuals' personalities, versus the influence of individuals' personalities on systems of governance? By introducing an additional variable into the analysis, and testing statistical mediation, our results may contribute toward some resolution to this question.

The second study further addresses alternative explanations based on European colonialism by testing the parasite stress hypothesis on a sample of more traditional societies documented within the Standard Cross-Cultural Sample (Murdock & White, 1969). The Standard Cross-Cultural Sample (SCCS) consists of 186 worldwide cultural populations, many of which are small-scale aboriginal societies. Cashdan and Steele (2013) employed the SCCS dataset to test several other hypothesized consequences of disease prevalence that had previously been tested only with cross-national comparisons; their results provided important substantiation for the relationship between disease prevalence and collectivist values—especially those values pertaining to adherence to group norms. We employed the same strategy to provide an empirically complementary test of the hypothesis that ecological variation in disease prevalence predicts societal variation in authoritarian governance.

Drawing on an extensive ethnographic database, the cultures that comprise the SCCS are described by hundreds of numerically coded variables gathered by dozens of different ethnographers—including multiple variables pertaining to systems of governance (Ross, 1983). These variables, in conjunction with two indicators of disease prevalence (Cashdan & Steele, 2013; Low, 1988), allow a statistically rigorous test of the relation between parasite stress and authoritarian governance in small-scale societies. Additional variables assess the prevalence of conceptually distinct threats to human welfare within these societies (e.g., famine, warfare). This allowed us to test the unique predictive effects of parasite stress, while statistically controlling for any effects associated with these other threats.

5.1 Study One: Method

Analyses were conducted on 31 countries for which empirical data were available for the variables of primary conceptual interest: (a) authoritarian governance, (b) individual authoritarianism, and (c) historical prevalence of disease-causing parasites.

Authoritarian Governance

We employed four variables that are either directly or inversely indicative of authoritarian governance; previous analyses reveal that all four variables are predicted by measures of parasite stress (Thornhill et al., 2009).

Two measures were obtained from www.freedomhouse.org which, for all countries, provides numerical values indicating (1) governmental restrictions on individuals' political rights and (2) governmental restrictions on individuals' civil liberties. Both scores are represented on 7-point scales, with higher values indicating more severe governmental restrictions on individuals' rights and civil liberties. We employed scores pertaining to the year 2007.

A third measure (obtained from www.heritage.org) assesses the extent to which the law protects the rights of individuals to own and accrue private property. Country level scores were represented on a 100-point scale, with higher values representing greater legal protection for individuals' property rights (indicative of a lower level of authoritarian governance). We employed scores from the years 2004-2008.

The fourth measure was Vanhanen’s (2003) index of democracy for the years 1999-2001. This index was derived from two components of a democratic governance system—competition and participation in the electoral process—which were weighted equally in computation of the overall democracy index. Higher values indicate higher levels of democratization (and lower levels of authoritarian governance) within each country.

Individual Authoritarianism

Adorno and colleagues (1950) developed a questionnaire—the "F Scale"—to assess individual differences in traits and attitudes that define the authoritarian personality (e.g., conventionalism, authoritarian submission, authoritarian aggression, ethnocentrism). This scale has been validated in both Western and non-Western cultures (e.g. Kool & Ray, 1983). Meloen (1996) compiled results obtained from over 30,000 individuals worldwide who completed the F Scale, and reported mean standardized F Scale scores for individuals living within each of 31 countries. Meloen reported separate mean F Scale scores for student and non-student samples within each country. Although mean F Scale scores were different across these two types of samples (non-student means were generally higher), these two scores were almost perfectly correlated across the 31 countries ($r > .99$), and so virtually identical results emerge regardless of which set of scores is used as an indicator of individuals' authoritarian personality. In the analyses reported below, we employed mean F Scale scores obtained from non-student samples.

Prevalence of Disease-Causing Parasites

Historical disease prevalence was assessed using the index developed in Chapter Four. Nine-item scores were used for a country if they were available; if a nine-item score for a country was not available, its seven-item score was used.

Control Variables

Country-level variables other than disease prevalence may also predict authoritarianism, and it is important that these variables be accounted for statistically in order to test the unique predictive effects of disease prevalence. In our analyses, we included four such variables. (Given that these variables are ostensibly predictors—rather than consequences—of authoritarianism, we attempted to obtain measures that predated data collection on the primary authoritarianism measures, while still retaining accurate data for as many countries as possible.)

GDP per capita. Previous research indicates that authoritarian governance is associated with low levels of economic development (e.g. Perry & Robertson, 2002). As a measure of economic development, we used the World Bank's (www.data.worldbank.org) country-level scores of GDP per capita data for the year 1980.

Wealth Inequality. Inequitable distribution of wealth predicts variation in democratic versus authoritarian governance (Vanhanen, 2003). As a measure of wealth inequality we used GINI coefficients obtained from CIA World Factbook (www.cia.gov). (A GINI coefficient of zero indicates total wealth equality within a country; a coefficient of one indicates maximal inequality.) The dates of these GINI scores ranged from 1991-1996.

Education. Meloen (1996) found that authoritarianism was inversely related to the mean level of education within a country. As a measure of this construct, we used the United Nations Education Index scores (obtained from www.hdr.undp.org) for the year 1990.

Life Expectancy Residual. In addition to the specific threat posed by infectious diseases, other threats to human welfare have also been found to be predictive of individuals' authoritarian personality and related attitudes (e.g. Altemeyer, 1988; Cohrs, Kielmann, Maes, & Moschner, 2005; Feldman & Stenner, 1997; Sales, 1973). We employed a method used in previous cross-national investigations (Fincher et al., 2008) to create an index that indirectly assessed disease-*ir*relevant threats: We regressed average life expectancy (obtained for the year 1990, from www.hdr.undp.org) on the index of disease prevalence and saved the residuals. These life expectancy residuals represent variation in life expectancy that cannot be predicted by variation in disease prevalence, and thus is indicative of various other threats to human welfare.

5.2 Study One: Results and Discussion

Preliminary analyses revealed that pathogen prevalence strongly predicted all four measures of authoritarian governance (r’s ranged from .47 to .67 in absolute value, all p’s < .01). These results replicate the previous findings from Chapter Four and from Thornhill and colleagues (2009) on the smaller subset of countries included in our analyses.

Additional results (summarized in Table 5.1, p. 102) revealed that individuals' authoritarianism scores were also strongly predicted by pathogen prevalence, $r = .65$ ($p < .001$). Individual authoritarianism was also predicted by GDP per capita, GINI, Education, and Life Expectancy Residual (r's ranged from .36 to .68 in absolute value, all p's < .05).

In order to test unique effects on individuals' authoritarian scores, pathogen prevalence and the four control variables were entered simultaneously as predictors into a regression equation, with individual authoritarianism as the dependent variable. Results revealed that the predictive effects of the control variables were all statistically nonsignificant (absolute values of β's < .32, p's > .10), but that—despite relatively low statistical power—there was a significant unique effect of pathogen prevalence, $\beta = .73$ ($p = .04$). (The partial correlation coefficient between pathogen prevalence and authoritarian scores when controlling for these four control variables was $r = .48$, $p = .04$). This result is conceptually consistent with previous research linking pathogen prevalence uniquely to other conformist attitudes and personality traits (Murray et al., 2011; Schaller & Murray, 2008).

The key question is whether the relation between pathogen prevalence and authoritarian governance is mediated by individual-level authoritarianism. To address this question, we employed a bootstrapping procedure recommended by Preacher and Hayes (2004). We determined path coefficients by regression analyses, and determined indirect effects and their 95 percent confidence intervals based upon 10,000 nonparametric bootstrapped samples. Results of all 4 mediation tests indicated that the relation between pathogen prevalence and authoritarian governance was significantly mediated by individual authoritarianism, with none of the bootstrapped confidence intervals containing zero. The mediated effect accounted for 77% of the total effect of pathogen prevalence on political rights (Unstandardized regression coefficients [*B*'s] between pathogen prevalence and political rights = .29/1.28 after/before mediation), for 63% of the total effect on civil liberties (*B*'s = .50/1.38 after/before mediation), for 60% of the total effect on democracy (*B*'s = -3.45/-8.60 after/before mediation, and for 37% of the effect on property rights (*B*'s = -16.00/-25.56 after/before mediation). Of the 4 measures of authoritarian governance, only for the measure of property rights did the direct effect of pathogen prevalence remain significant when statistically controlling for individual authoritarianism ($\beta = -.48$, $p = .02$); for the remaining three measures of authoritarian governance, the direct effect of pathogen prevalence was reduced to nonsignificance (absolute values of β's < .23, p's > .20).

For the sake of comparison, we performed another set of bootstrapping analyses that tested an alternative mediational model that specified authoritarian governance as the mediator between pathogen prevalence and individual Authoritarianism. This alternative model was not as well supported by the data. Across the four analyses, the mediated effect accounted for between 31-48% of the total effect of pathogen prevalence on individual authoritarianism. The direct effect of pathogen prevalence on individual Authoritarianism remained significant in every analysis, even when controlling for state-level authoritarian governance, (*p*’s ranged from .005 - .04).

These mediation results suggest that the ecological prevalence of infectious diseases predicts the individual authoritarian personalities of people living within that ecological region, and these individual-level dispositions in turn give rise to (and sustain) authoritarian systems of governance. These results are consistent with the logical implications of the parasite stress hypothesis, and are inconsistent with an alternative explanation suggesting that the correlation between disease prevalence and authoritarianism is based solely on colonial establishment of state-level institutions.

5.3 Study Two: Method

Analyses were conducted on 90 cultural populations described within the Standard Cross Cultural Sample (SCCS; Murdock & White, 1969), for which empirical data were available for the variables of primary conceptual interest: (a) authoritarian governance, and (b) historical prevalence of infectious disease.

Authoritarian Governance

Drawing on ethnographic observations, Ross (1983) coded 42 numerical variables assessing aspects of political life in 90 societies within the SCCS. Factor analytic results reported by Ross revealed that 12 of these variables loaded highly on a common underlying factor, which Ross called "concentration of political power"—a defining feature of authoritarian political systems. These variables are: Political role differentiation, Basis of local community leadership selection, Perceptions of political leaders' power (as seen by society), Checks on leaders' power, Removal of leaders who are incompetent or disliked, Leaders' exercise of authority, Operation of decision making bodies, Extensiveness of adult participation in community decisions, Litigation/use of third parties for binding decisions, Formal sanctions and enforcement for community decisions, Prevalence of enforcement specialists (e.g. police, tax collectors), and Level of taxation paid to local community (SCCS variable numbers 756, 758, 759, 761, 762, 763, 764, 766, 772, 776, 777, 784). Due to society-specific missing (or insufficiently precise) data, *N*'s for these variables range from 77 to 90.

We employed all 12 of these variables as indicators of authoritarian governance. As originally coded, greater authoritarianism (i.e., greater concentration of political power) was indicated by lower numerical values on 11 of the 12 variables (all except SCCS variable #766, Extensiveness of adult participation in community decisions). For our analyses, we reverse-coded those 11 items so that, for all 12 variables, higher values represented higher levels of authoritarian governance. (Following the recoding, all 12 variables were positively intercorrelated; *r*'s ranged from .26 to .77, with median *r* = .54.) We then created a single composite index by standardizing the 12 variables (converting them to z-scores), and computing the mean of these *z*-scores. This 12-item index (Cronbach's alpha = .94) served as the primary measure of authoritarian governance.

Prevalence of Disease-Causing Parasites

We conducted parallel sets of analyses employing two different measures of parasite prevalence. One measure was developed by Cashdan and Steele (2013), based upon the historical prevalence of ten disease-causing pathogens. These authors employed the same source materials employed in Chapter 4, and assigned a historical pathogen prevalence score to each of the 186 SCCS societies based upon local conditions (within 200 km) of each society. The specific pathogens coded were leishmanias, trypanosomes, malaria, schistosomes, filariae, dengue, typhus, leprosy, spirochetes, and plague. (Cashdan and Steele generated new codings for 8 of the 10 pathogens; data for the remaining two pathogens—leprosy and spirochetes—were obtained from previously published work [Low, 1988].) This measure was internally reliable, Cronbach's alpha = .81.

The second measure was an index of "total pathogen stress" (SCCS variable #1260) developed previously by Low (1988), who drew upon similar source materials but coded fewer categories of parasitic diseases. This index is based on the overall extent to which 7 specific kinds of infectious diseases were present within the region occupied by each society. Across all 186 societies in the SCCS dataset, this 7-item index has Cronbach's alpha = .77.

The two above indices are highly correlated, *r* = .87 (*p* < .001).

Control Variables

Given previous evidence that authoritarianism may be associated with lack of valued resources or by other threats to human welfare (e.g., Henriksen, 2001; Mathews, 1989; Wilson, 1968), we also included 3 additional measures in our analyses.

Malnutrition. The SCCS dataset includes 3 variables that assess regular shortages in nutritional resources of the sort that predict chronic malnutrition: ordinary malnutrition, short-term starvation, and seasonal starvation (SCCS variable #'s 1261 – 1263; Dirks, 1993). Each variable is coded on a 4-point scale. We created a single index by first converting the 3 variables to z-scores, and then computing the mean of these *z*-scores (for the 3-item scale, Cronbach’s alpha = .63).

Famine. The SCCS dataset includes 4 variables that indicate the prevalence of acute famines: occurrence, severity, persistence, and recurrence of famine (SCCS variable #'s 1265, 1267, 1268 and 1269; Dirks, 1993). Each variable is coded on a 4-point scale. We created a single index assessing threat of famine by first converting the 4 variables to z-scores, and then computing the mean of these *z*-scores (for the 4-item scale, Cronbach’s alpha = .90). (The malnutrition and famine variables are related, but differ in several important aspects. As defined by these variables, malnutrition is characterized by regular caloric deficiency but is rarely characterized by mortality; in contrast, famine is characterized by significant mortality. Malnutrition is a relatively predictable and chronic state of affairs and so rarely creates alarm within a society; in contrast, famine is an unpredictable and acute event characterized by marked disruptions in community life).

Warfare. The SCCS dataset includes separate variables pertaining to the frequency of internal warfare and the frequency of external warfare (SCCS variable #'s 773 and 774; Ross, 1983). Each variable is coded on a 4-point scale. We created a single index assessing threat of warfare by first converting these 2 variables to z-scores, and then computing the mean of these *z*-scores (for the 2-item scale, Cronbach's alpha = .45.)

5.4 Study Two: Results and Discussion

Table 5.2 (p. 103) presents zero-order correlations between variables. Both parasite stress measures were positive predictors of authoritarian governance (*r*'s = .42 and .29, *p*'s < .01). In addition, the threat of famine also correlated positively with authoritarian governance (*r* = .26, *p* = .01). Neither malnutrition nor warfare was significantly associated with authoritarian governance. (In an additional analysis, we aggregated society-level values within each of the 6 world regions identified by Murdock (1949), and thus computed composite measures of pathogen prevalence (Cashdan & Steele, 2013) and authoritarian governance for each of these six culturally-independent world regions. The correlation between these region-level composite variables provides an ancillary test of the parasite stress hypothesis. This correlation was strongly positive, *r*(6) = .67, *p* = .14.)

We conducted follow-up multiple regression analyses to test whether parasite stress uniquely predicted authoritarian governance, even when controlling for additional threats. In one analysis, the set of predictors included the 3 control variables (famine, malnutrition, and warfare) along with Cashdan and Steele's measure of historical pathogen prevalence. Results revealed that both pathogen prevalence and the threat of famine were unique predictors of authoritarian governance (β's = .47 and .36, respectively; *p*'s < .001). In a conceptually identical analysis the predictors included the 3 control variables along with Low's (1988) measure of total pathogen stress. The results were inferentially identical: Pathogen stress and the threat of famine were unique predictors of authoritarian governance (β's = .36 and .34 respectively; *p*'s < .005).

We also performed separate multiple regression analyses on each of the 12 individual variables that comprised the index of authoritarian governance (the 12 variables that Ross [1993] identified as indicators of "concentration of political power"). Predictor variables in each analysis included the 3 control variables (famine, malnutrition, and warfare) along with Cashdan and Steele's (2013) measure of historical pathogen prevalence. (Virtually identical results were obtained in separate analyses that instead included Low's [1988] measure of pathogen stress.) Results are summarized in Table 5.3 (p. 104), and reveal that pathogen prevalence uniquely predicted 11 of the 12 variables: Higher levels of pathogen prevalence were associated with ethnographic observations indicating more authoritarian systems of governance. In addition, famine uniquely predicted 8 of the 12 variables, such that greater threat of famine was associated with greater authoritarianism. Malnutrition uniquely predicted 1 of the 12 variables (greater malnutrition was associated with the perception of leaders as *less* powerful). Warfare did not uniquely predict any of these variables.

Overall, these results support the parasite stress hypothesis, with both the authoritarian composite measure and all but one of its twelve constituent parts producing convergent results. These results also suggest that the prevalence of a disease-irrelevant threat—famine—may also uniquely encourage authoritarian political governance, which is consistent with past research that links other threats to authoritarianism (e.g. Feldman & Stenner, 1997; Sales, 1973).

5.5 General Discussion

Results from both studies in this chapter provide empirical substantiation for the hypothesis that societal differences in authoritarian governance may result, in part, from ecological variation in the prevalence of disease-causing parasites. Study 1 was designed to address one specific alternative explanation for a previously documented relation between parasite stress and contemporary nation-level markers of authoritarianism (Thornhill et al., 2009). Results revealed that the relation between parasite prevalence and authoritarian governance was mediated by individual authoritarianism—a result that is consistent with the parasite stress hypothesis, and inconsistent with an alternative explanation based solely on the colonial spread of political and economic institutions. These results do not challenge the important role of colonial history in explaining contemporary nation-level differences in political and economic outcomes (e.g. Acemoglu et al., 2001; Easterly & Levine, 2003); the results simply indicate that a colonial-spread-of-institutions process cannot provide a complete explanation for the relation between parasite prevalence and authoritarianism.

Study 2 was designed to provide a complementary analysis in a sample of traditional small-scale societies. Results revealed that parasite prevalence predicted the level of authoritarian governance across a diverse sample of 90 small-scale societies within the Standard Cross Cultural Sample (SCCS). These results provide further, empirically independent evidence of the hypothesized relation between parasite stress and authoritarian governance.

The magnitude of the statistical relationships between parasite prevalence and authoritarian governance differed across the two studies: These relations were more modest in the sample of small-scale societies than in the sample of modern geopolitical regions. (Similar differences in magnitude are evident in empirical results linking pathogen stress to collectivist values [Cashdan & Steele, 2013; Fincher et al., 2008]). Why might this be? One possibility is that, when using contemporary nation states as units of analysis, the relationship is more likely to be spuriously inflated (due, for instance, to conceptually independent processes such as those involved in European colonialism). Another possibility is that, when using the SCCS dataset, the relationship is more likely to be artificially attenuated (due to the measurement error that almost certainly attends any attempt to turn ethnographers' qualitative observations into numerical codings). These considerations suggest caution in drawing any conclusions about actual effect sizes, and attest further to the value of using multiple methods (and multiple samples) to test functional hypotheses of cross-cultural differences.

In addition to parasite prevalence, Study 2 also assessed several additional, conceptually distinct forms of threat to human welfare: malnutrition, famine, and warfare. Results revealed that both parasite prevalence and famine uniquely predicted variability in authoritarian governance. These results suggest that the societal implications of parasite stress (and the societal implications of famine) are distinct from the implications of other variables that might also affect individual fitness and mortality. This conclusion is consistent also with psychological evidence showing that, while other threats can also influence individuals' conformist and ethnocentric attitudes, the perceived threat of infectious disease has effects that are empirically unique and, often, especially powerful (Faulkner et al., 2004; Murray & Schaller, 2012; Wu & Chang, 2012).

The finding that the threat of famine predicts authoritarian governance in small-scale societies is also convergent with psychological research showing that individual-level authoritarianism is generally higher during times of resource scarcity (e.g. Doty, Peterson, & Winter, 1991; Sales, 1973). Two other threats to human welfare (malnutrition and warfare) had negligible relations with authoritarian governance in small-scale societies. Malnutrition may fail to exact any substantial societal-based influence due to its chronic and enduring nature (whereas famines are acute, and therefore more threat-like). The null result for warfare is perhaps more surprising, given the prevailing belief that authoritarian governments are more likely to go to war (e.g. Gaddis, 1997). This null result may simply be due to scale. The war-like nature of authoritarian regimes has typically been ascribed to large nation states; the same principles may not apply small-scale societies of the sort represented in the SCCS.

Although these empirical results provide evidence that ecological variation in parasite stress (as well as famine) uniquely predicts societal-level differences in authoritarian governance, these results cannot address deeper questions about the specific underlying processes through which this relation may have emerged. Although the pattern of results is consistent with previous research in the psychological sciences that documents specific cognitive and behavioral changes that occur when individuals perceive that they are vulnerable to infectious diseases, additional mechanisms may also plausibly explain the same societal outcomes (Schaller & Murray, 2011, 2012). Nor can these kinds of results distinguish whether the unique effects of parasite stress and famine reflect the operation of a single underlying mechanism that responds to any kind of stressor or threat, or whether these two effects reflect the complementary operation of multiple mechanisms that are each functionally attuned to different forms of threat. A simple appeal to parsimony favors the former interpretation. However, considerable evidence at an individual level of analysis—including the experimental results from Chapter 3 that reveal unique effects of different threats on attitudes relevant to authoritarianism—suggests the latter.

Although one cannot confidently draw inferences about individual-level processes from population-level data, the results of Study 1 may have other implications at the psychological level of analysis. It has been suggested that an authoritarian personality serves a self-protective function (e.g. Jugert & Duckitt, 2009). Consequently, rather than being a stable trait, individuals' authoritarian tendencies may temporarily increase when threats are psychologically salient (Cohrs & Ibler, 2009; Hetherington & Weiler, 2009; Lavine, Lodge, & Frietas, 2005; Thórisdóttir and Jost, 2011). Our results provide novel evidence of a relationship between a conceptually distinct form of threat—the threat of infectious disease—and individuals' authoritarian tendencies. This relationship is consistent with a wide range of additional evidence indicating that individuals are sensitive to disease-connoting cues within their immediate environment, and respond to these cues with functionally adaptive shifts in cognition and behavior (Schaller, 2011; Schaller & Park, 2011).

These results have further implications for understanding the direction of the presumed causal relation between individual-level authoritarian attitudes and state-level authoritarian governance. Are people who live within authoritarian states more likely to adopt authoritarian attitudes? Or are people who hold authoritarian attitudes more likely to give rise to authoritarian governments? By including an additional variable (parasite prevalence), and using mediation analyses to test the direct and indirect implications of this variable, Study 1 addressed these questions in a novel manner. Results suggest that, consistent with some lines of speculation (e.g. Lavine et al., 2005), individual-level authoritarianism shapes political systems, rather than political systems shaping individual attitudes (although, of course, neither causal path necessarily operates at the exclusion of the other).

In addition to their conceptual implications, these results may also have useful implications for predicting the collateral consequences of health-related public policies. If indeed parasite stress has unique causal implications for authoritarian governance, then disease-eradication programs may not only have direct consequences for human health, they may also have indirect consequences for individual rights, civil liberties, and political freedoms (Thornhill and colleagues (2009) noted that the democratic transitions in North America and Europe were preceded by dramatic reductions in the prevalence of infectious disease). There may also be implications for reduced for increased levels of creativity, innovation, and open-mindedness more generally. Chapter 6 investigates the potential implications of disease threat for creativity and innovation more directly.

Table 5.1. Results from analyses on 31 countries (Study 1): Correlations between mean individual F-scale scores, historical pathogen prevalence, and other country-level variables.

	1	2	3	4	5
1. Mean F-scale scores	--				
2. Pathogen Prevalence	.65**	--			
3. Education Index	-.60**	-.73**	--		
4. GDP per Capita	-.68**	-.77**	.77**	--	
5. Wealth Inequality (GINI)	.51**	-.60**	-.42*	-.57**	--
6. Life Expectancy (Residual)	.36*	.00	-.41*	-.38	.26

Note: ** *p* < .01, * *p* < .05, N = 31.

Table 5.2. Results from analyses on the Standard Cross Cultural Sample (Study 2): Zero-order correlations between 12-item index of authoritarian governance, two measures of parasite stress, and three measures assessing other threats to health and welfare.

	1	2	3	4	5
1. Authoritarian governance	--				
2. Pathogen prevalence (C&S)	.42**	--			
3. Pathogen stress (L)	.29**	.87**	--		
4. Famine	.26*	-.10	-.06	--	
5. Malnutrition	.05	-.01	-.07	.35**	--
6. Warfare	-.11	-.16	-.30**	-.17	-.09

Note: ** *p* < .01, * *p* < .05. "Pathogen prevalence (C&S)" refers to Cashdan & Steele’s [15] index of historical pathogen prevalence; "Pathogen stress (L)" refers to Low's [36] index of total pathogen stress.

Table 5.3. Results from analyses on the Standard Cross Cultural Sample (Study 2): Standardized regression coefficients (β's) identifying unique predictive effects of threats due to pathogens, famine, malnutrition and warfare on indicators of authoritarian governance.

SCCS Variable		Pathogens	Famine	Malnutrition	Warfare
#756:	Political role differentiation	.33**	.37**	-.21	-.06
#758:	Leadership selection basis	.11	.20	-.12	-.11
#759:	Perceptions of leader's power	.40**	.44**	-.25*	-.06
#761:	Checks on leader's power	.31**	.30*	-.13	-.07
#762:	Removal of bad leaders	.33**	.33**	-.02	.05
#763:	Leader's exercise of authority	.48**	.24*	-.09	.09
#764:	Depth of decision making bodies	.35**	.23*	-.09	.02
#766:	Collective decision making	.33**	.16	-.10	.00
#772:	Litigation for binding decisions	.46**	.28*	-.16	.05
#776:	Formal enforcement of decisions	.43**	.45**	-.06	.08
#777:	Prevalence of enforcement specialists	.40**	.17	-.06	.01
#784:	Prevalence of taxation	.34**	.22*	-.01	.01

Note: ** $p < .01$, * $p < .05$. All variables were (re-)coded such that higher values indicate greater concentration of political power (i.e., higher levels of authoritarian governance).

CHAPTER SIX

Direct and Indirect Implications of Pathogen Prevalence for Scientific and Technological Innovation[5]

The frequency of technological and scientific breakthroughs varies greatly between countries and cultures. Whereas Denmark has produced over thirty Nobel laureates per million citizens since the prizes have been awarded, Italy has produced just over one per million. Such variation is evident in other measures of innovation as well: whereas South Korea is granted almost 800 international patents per million citizens per year, Singapore is granted only about eight. The origin of these differences is still unclear; exactly *why* might some cultures develop so much more innovative prowess than others?

Several political and demographic variables, such as those discussed in Chapter Five, likely account for much of the cross-cultural variation in innovative output. Not surprisingly, countries with relatively high educational attainment (and cultures which place a high value on education more generally) produce greater innovative output (Herbig & Dunphy, 1998; Lee, 1990; Mokyr, 1991). Similarly, average wealth and economic development more generally predict subsequent innovative output, largely due to greater expenditures on education and research & development (e.g. Beteille, 1977; Lee, Florida, & Acs, 2004). Several scholars have also speculated that large, dense populations are conducive to innovation. According to this perspective, cities function as creative "sinks" which concentrate human capital and diverse perspectives, which stimulate creative synthesis of ideas and subsequent innovative thinking (Jacobs, 1961; Lucas, 1988; Thompson, 1965).

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[5] This chapter has been adapted from Murray, D. R. (under review). Direct and indirect implications of pathogen prevalence for scientific and technological innovation. *Journal of Cross-Cultural Psychology.* It has been modified to fit the format of this thesis.

The study in this chapter complements these demographic perspectives on innovative variation, and investigates whether cross-cultural differences in innovation are due, at least in part, to varying levels of infectious disease. This hypothesis is logically informed by the fact that cultural values that partly serve to mitigate disease transmission—traditionalism, conformity, and xenophobia—are also cultural values that may inhibit creativity and innovation (e.g. Mokyr, 1991; Rothwell & Wissema, 1986).

Disease Threat and Innovation

Chapters One and Three discussed the theoretical underpinnings and the suite of research documenting the effects of disease threat on both conformity and xenophobia. The previous chapter showed that these effects are evident in political attitudes as well: Higher disease prevalence predicts higher dispositional authoritarianism within a country, and more institutional restrictions on political and individual freedoms. Although the above findings highlight the fact that regional variation in disease prevalence may partly account for cultural differences in numerous constructs pertaining to conformity and xenophobia, what has received less attention are the consequences of this variation. How might this disease-caused psychological variation manifest in downstream cultural differences?

One such set of outcomes that may be impacted by disease threat are variables pertaining to technological and scientific innovation. Key psychological variables conducive to innovation and invention include low traditionalism, low conformity, and low wariness of outsiders (Herbig & Dunphy 1998)—variables that are all negatively predicted by disease prevalence. This leads to the logical hypothesis that higher threat of infectious disease within a local ecology should negatively predict inventive and innovative outputs.

These variables—traditionalism, conformity, and xenophobia—are three of the major dimensions upon which the distinction between collectivist and individualist societies are based. Whereas collectivistic societies tend to be characterized by values emphasizing traditionalism, conformity to group norms, and wariness of outsiders, more individualistic societies are generally place lower value on tradition and conformity, and have a looser boundary that separates the coalitional ingroup from outgroup (Cukur, De Gusman, & Carlo, 2004; Gelfand, Bhawuk, Nishii, & Bechtold, 2004; Oishi, Schimmack, Diener, & Suh, 1998; Sagiv & Schwartz, 1995). Several scholars have noted the strong positive relationship between individualism (versus collectivism) and innovation across cultures, and most speculate that the values encapsulated by individualism are a cause, rather than a consequence, of higher innovation and invention (Barnett, 1953; Beitelle, 1977; Herbig & Miller, 1991; Shane, 1992; but for an alternative interpretation see Hofstede, 2001). Therefore, the negative relationship between disease prevalence and innovation may be mediated by variation in collectivism and individualism.

Of course, disease prevalence shares relationships with other variables that influence innovation. Bidirectional relationships exist between disease prevalence and several demographic variables that influence innovation: Greater wealth and education decrease disease burden through greater access to, and proficiency of, medical systems; conversely, higher disease prevalence decreases average wealth, healthy life expectancy, and value placed on education within a country (Bloom & Canning, 2000; Gallup & Sachs, 2001; Sachs & Malaney, 2002)—all demographic features which negatively predict innovation across cultures. Therefore, examining whether disease prevalence predicts innovation independently of the effects of wealth, education, and healthy life expectancy provides an especially rigorous test of whether the psychological effects of disease prevalence uniquely account, at least in part, for cultural variation in innovation.

Overview of the present study

Despite the relatively large literature exploring the cultural antecedents of innovation, no study to date has rigorously explored the influence of disease prevalence—be this influence direct or indirect—on innovative output. Innovation and invention can be defined and measured in several different ways. Therefore, five separate measures designed to assess a country's innovative output are employed in this chapter. These measures include innovation in academics and science, technology, and business. The first analyses investigate uncorrected relationships between innovation measures, disease prevalence, and other purported causes of cross-cultural variation in innovation. Further analyses investigate the unique predictive effects of disease prevalence on innovation when controlling for other key causal variables. Final analyses test whether variation in cultural values systems mediates the effects of disease prevalence on innovation. Overall, these analyses test the two complementary hypotheses that 1) higher threat of disease negatively affects innovation, independently of disease threat's implications for wealth, health, and education, and 2) These impacts of disease prevalence on innovation are mediated by variation in individualism/collectivism.

6.1 Method

For all central analyses, geopolitical regions served as the units of analysis. The majority of these regions were countries, but the sample also included several culturally distinct regions or territories within a country (e.g. Hong Kong). Although geopolitical borders are not perfectly analogous to cultural borders, much evidence indicates that geopolitical entities serve as useful proxies for societal cultures (e.g. Schwartz, 2004).

Five different measures of innovation were employed for the current investigation.

Nobel Prize laureates. Nobel Prize laureates per capita were assessed for each country (data obtained from www.nobelprize.org/nobel_prizes). This measure included all prizes awarded to the end of 2012, in all six award categories (chemistry, literature, physiology or medicine, physics, peace, and economic sciences).[6] In total, awards have been awarded to individuals from 72 countries (countries with no laureates were not included in this measure). Rates per 10 million citizens range from .03 to 123.32. This set of scores was extremely positively skewed and was thus normalized via log transformation for the current analyses.

Global Innovation Index. A country's Global Innovation Index for 2012 is comprised of seven indicators (e.g. business sophistication, knowledge and technology outputs, creative outputs), and scores are available for 141 countries worldwide. These scores range from 16.8 to 68.2, with higher scores indicating more innovative outputs. These data were obtained from www.globalinnovationindex.org.

Technological Achievement Index. The Technological Achievement Index consists of eight indicators which assess technology creation, diffusion of innovations, and human skills. An index score is available for 68 countries worldwide, and these unitless scores range from .07 to .74. These data were obtained from the UN's human development report, and can be accessed at http://hdr.undp.org/en/reports/global/hdr2002/.

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[6] It might be argued that Nobel prizes for Peace and Literature do not appropriately represent academic innovation. Therefore, identical analyses were also performed using a measure of Nobel laureates winning only scientific prizes (in chemistry, medicine, physics, and economics). This measure correlated very highly with the total Nobel laureate measure (*r* = .97) and produced inferentially identical results to those reported in Tables 6.1-6.3.

Innovative capacity. In the Global Competiveness Report, the World Economic Forum measures innovative capacity in each of 144 countries by assessing responses from business executives on the following question: “In your country, how do companies obtain technology?” Responses are recorded on a 7-point scale, with higher scores indicating higher innovative capacity (1 = exclusively from imitating foreign companies, 7 = by conducting formal research and pioneering their own new products and processes). These scores were obtained for the year 2012, which range from 1.8 to 5.9. These data were obtained from http://www.weforum.org/issues/global-competitiveness.

Patent applications. The World Intellectual Property Organization reports the number of patent applications per country, per million residents. Patent data for 2010-2011 were available for 91 countries, with rates ranging from 1-7072 applications per million residents. These data were extremely positively skewed and were thus normalized via log transformation. Data were obtained from www.wipo.int/ipstats/en/statistics/patents.

Total Innovation Score. The above five measures were all positively correlated, *r*’s = .42-.93, and a Principal Components Analysis revealed a clear one-component solution, with this component accounting for 85% of the total variance. Each country's total Innovation Score for was created by transforming each of the above 5 measures to *z*-scores, and calculating the mean of these standardized scores. All available data was used in the computation of this score, but due to country-specific missing data, a country's total innovation score was not always comprised of all five measures. It total, Innovation scores were available for 161 countries.

Historical Disease Prevalence

Historical disease prevalence was assessed using the index developed in Chapter Four. Nine-item scores were used for a country if they were available; if a nine-item score for a country was not available, its seven-item score was used.

Collectivism/Individualism

Chapter Four reported country-level results documenting the impact of disease-causing pathogens on collectivism/individualism. These analyses employed two measures assessing collectivism (from Gelfand et al., 2004; Kashima & Kashima, 1998), and two measures assessing individualism (from Hofstede, 2001; Suh, Diener, Oishi, & Triandis, 1998; see Fincher at al. [2008] for a detailed description of these variables). These latter two variables were reverse-scored, and all four variables were then converted to *z*-scores and averaged to create a composite Collectivism score for each country. These collectivism scores were available for 95 countries (due to society-specific missing data, not all scores were based upon all four measures).

Human Development

Education, wealth, and healthy life expectancy all impact a country's innovative capacity. These variables are each assessed in the UN's yearly Human Development Report (obtained from http://hdr.undp.org/en/statistics/hdi), which reports country-level scores of human development based upon four indicators: Average wealth, mean years of schooling, expected years of schooling, and life expectancy at birth. The current analyses used country scores from the 2011 report, which contains scores for 185 countries.

Population Structure

Several scholars have speculated that cities serve to foster innovation, given that they function to concentrate human capital, which in turn stimulates creativity and generates innovative thinking (e.g. Jacobs, 1961; Lucas, 1988). Data on the percentage of a country's population living in urban areas for all geopolitical regions were obtained from the UN's World Urbanization Prospects report for the year 2003 (from www.nationmaster.com).

Additional Analyses: World Regions

Although countries serve as useful proxies for separate cultures, they may not represent ecologically or statistically independent units of analysis. This nonindependence may artificially inflate the magnitude of the relationships reported in the country-level analyses. Therefore, it can be informative to perform complementary tests using different units of analysis. In order to complement the country-level analyses above, the relationships between disease and innovation were investigated using Murdock's (1949) world regions as units of analysis. These region-level values were computed by calculating the mean of all of the country-level values in each world region. Although these ancillary analyses are constrained by very low statistical power (N = 6), obtaining correlation coefficients that parallel those found in the country-level analyses can provide additional evidence that pathogen prevalence has implications for Innovation.

6.2 Results

The conceptual hypothesis predicts a negative relationship between pathogen prevalence and innovation. Zero-order correlations between Historical pathogen prevalence and each of the indicators of innovation are summarized in Table 6.1 (p. 119). As predicted, Pathogen

Prevalence was significantly negatively correlated with the aggregate Innovation score, $r = -.69$, $p < .0001$. Pathogen prevalence was also significantly negatively correlated with each of the five markers of innovation, r's $\leq -.49$, p's $< .0001$. Human development was positively correlated with each measure of Innovation, r's $\geq .62$, p's $< .0001$, as was proportion of population living in cities, r's $\geq .37$, p's $< .001$.

Complementary tests examined the relationship between Pathogen Prevalence and innovation using six world regions as the units of analysis. These tests produced results similar to those obtained at the country level. Even with this small sample size Pathogen Prevalence was significantly associated with the total Innovation score, $r = .95$, $p = .004$. Replicating results obtained at the country level, Pathogen Prevalence was similarly highly associated with each of the five innovation measures individually, r's $> .74$, p's $< .09$.

A multiple regression analysis investigated the simultaneous unique predictive effects of Pathogen Prevalence, Human Development, and Proportion of population living in cities on Innovation. Although these three predictors overlapped substantially, results revealed that pathogen prevalence uniquely predicted Innovation aggregate scores, $\beta = -.29$, $p < .001$, as did Human Development, $\beta = .57$, $p < .001$. Proportion of a country's population living in cities did not uniquely predict Innovation, $p > .50$. Further regression analyses investigated the unique effects of these three variables in predicting each of the five constituent innovation measures individually. Results of these analyses are reported in Table 6.2 (p. 120). As can be seen from the table, Pathogen Prevalence uniquely predicted four of the five innovation variables (all but Innovative Capacity), p's $\leq .002$. Human Development significantly uniquely predicted all five innovation variables, p's $< .05$. Proportion living in cities significantly uniquely predicted one of the five measures (Patent applications per capita, $p = .01$); however, this predictive effect was opposite to what would be predicted by previous scholarship, with a higher proportion living in cities *negatively* predicting number of patent applications when controlling for pathogen prevalence and human development.

Finally, mediation analyses investigated whether variation in individualism/collectivism mediated the relationship between Pathogen Prevalence and innovation scores. Path coefficients were determined by regression analyses, and indirect effects and their 95 percent confidence intervals were determined via the SPSS bootstrapping procedure recommended by Preacher and Hayes (2004), based upon 10,000 bootstrapped samples. Results of these mediation analyses are summarized in Table 6.3 (p. 121). Across all six analyses, none of the confidence intervals for these mediated effects contained zero, indicating that collectivism significantly mediated the effects of Pathogen Prevalence on innovation in each model. In five of these six analyses the direct effect remained significant ($p < .05$; only in the model predicting Innovative Capacity was the direct effect of Pathogen Prevalence nonsignificant), suggesting that the impact of disease prevalence on innovation is not fully accounted for by the indirect effect of collectivism.

6.3 Discussion

The results in this chapter can be summarized as follows: Historical pathogen prevalence predicts cross-cultural differences in scientific and technological innovation. This predictive effect is independent of other purported causes of innovation, such as healthy life expectancy, average wealth, education, and population structure. That pathogen prevalence remained significant when controlling for these markers of human development provides especially strong evidence of pathogen prevalence’s effects on innovation, given that these human development variables are causally influenced by pathogen prevalence as well (and, not surprisingly, human development also strongly predicted innovative outputs). This pattern of results emerged for a composite measure of innovation comprised of diverse measures of innovation, and also emerged for all but one of these innovation variables when analyzing them individually.

A few limitations of this study deserve note. First, while the models and conceptual hypotheses are clearly causal, these data are necessarily correlational. Although the fact that the disease prevalence measure temporally precedes the outcome measures in these analyses is consistent with the causal explanation, the inferential issues discussed at the outset of Chapter Four remain: Cross-cultural investigations of this type cannot be experimental in nature, as individuals cannot be randomly assigned to cultural groups. A second consideration with these results is that they are derived from data that use nation states as independent units of analysis. Although countries can serve as useful proxies for societal cultures in contemporary cross-cultural investigations (see Schwartz, 2004), neighboring countries can hardly be considered functionally independent. This statistical non-independence can spuriously inflate the magnitude of relationships between variables in cross-cultural analyses; therefore, the magnitude of the relationships between innovation and disease prevalence (as well as between innovation and its other predictors) may be attenuated due to this non-independence. However, the zero-order relationship between disease prevalence and innovation was actually *larger* at the more-independent world region level of analysis—a pattern of results that suggests this conceptual relationship is not simply statistical artifact. Further, several previously documented relationships between disease prevalence and psychological outcomes using countries as units of analysis—including the relationship between disease and collectivism—have now been replicated in investigations employing traditional, small scale societies (see Chapter Five, and Cashdan &

Steele, in press). Such convergent results provide further reassurance that these country-level results are not spurious statistical artifacts.

These results make at least two novel contributions. First, they demonstrate that the impact of disease threat on attitudes and personality may have downstream consequences for domains well beyond those pertaining to individual psychosocial functioning; disease threat may have implications for a culture’s propensity towards creative outputs, Nobel-prize worthy scientific research, and technological innovation. Second, the current set of results suggests that disease threat may influence innovative outputs via two distinct pathways: through its effects on demographic variables such as economic development, education, and healthy life expectancy, as well as through influencing attitudes towards new ideas, conformity, and outgroups.

Mediational results suggest that one psychological mechanism through which disease threat impacts innovation is through cultural value systems—specifically, through values that are associated with individualism or collectivism. These results are consistent with previously-documented relationships between higher individualist values within a culture (which encourage nonconformity and non-traditionalism) and innovation. The current results highlight how disease threat affects the costs of cultural values and behavioral dispositions, and that these effects have downstream consequences for other cultural outcomes. These results complement those in the previous chapter showing that pathogen prevalence influences individual authoritarian attitudes, and that these attitudes have downstream consequences for authoritarian political systems. This chapter demonstrates how varying costs and benefits across cultures may have a different type of downstream consequence: Although values emphasizing traditionalist and conformist dispositions may mitigate the threat of infectious disease (which may be especially important in high-disease ecologies), these characteristics also incur the cost of fewer opportunities for creativity and innovation.

The results in this chapter suggest that disease prevalence is a unique predictor of innovation; however, disease is not the only ecological factor influencing variables that affect innovation, nor is it likely that disease operates independently of these other ecological influences to produce cultural outcomes. Several other compelling explanations for the origins of related cultural differences have recently been put forth. Van de Vliert (e.g. 2006), for example, provides data showing that the interaction between climate and wealth affect several variables pertaining to human freedoms. Similarly, Varnum (2012) reports data suggesting that both frontier settlement patterns and pathogen prevalence predict patterns of nonconformist voting. Alternatively, Hackman and Hruschka (in press) suggest that variation in life-history strategies may account for regional variation in value systems. These different explanations need not operate at the exclusion of one another, and they may each operate at different explanatory levels of analysis. Single-factor explanations of cultural differences are at best short-sighted, and at worst a hindrance to scientific progress; the next step in research investigating the origins of cross-cultural differences will be to test increasingly complex causal models as more exhaustive and reliable data become available.

These results add to the growing body of research demonstrating that the threat posed by infectious disease is responsible, at least in part, for cross-cultural variation in attitudes, cultural value systems, intergroup relations, and contemporary political systems. Together with the current results, this emerging literature highlights the fact that widespread disease eradication and vaccination programs may have implications that extend well beyond the impacts on physical health and well being. The current results suggest that such health programs may have implications for conformist and xenophobic attitudes, which in turn may have downstream implications for technological and scientific innovation. These social and economic benefits of lowering the prevalence of infectious disease may eventually deserve consideration when weighing health policy decisions as these ancillary benefits become clearer.

Table 6.1: Zero-order correlations between Historical Pathogen Prevalence, Human Development, Proportion of population living in cities, and Innovation scores.

	Pathogen Prevalence	Human Development	Proportion In Cities
Pathogen Prevalence	-		
Human Development	.73	-	
Proportion living in cities	-.45	.71	-
Innovation Score (Total)	-.69	.77	.56
Nobel laureates	-.75	.63	.55
Global Innovation Index	-.70	.84	.67
Technological Achievement	-.73	.90	.66
Innovative Capacity	-.49	.62	.47
Patent Applications	-.61	.76	.37

Note: all p's < .001

Table 6.2: Results of multiple regression analyses identifying unique predictive effects of Historical Pathogen prevalence, Human Development, and Proportion of population living in cities on indicators of Innovation.

Innovation Indicator	Historical Pathogen Prevalence		Human Development Index		Proportion In Cities	
	β	p	β	p	β	p
Total Innovation Score	-.29	<.001	.57	<.001	-.03	.68
Nobel laureates (log transformed)	-.49	<.001	.35	.02	.01	.96
Global Innovation Index	-.23	.002	.61	<.001	.05	.51
Technological Achievement	-.21	.008	.73	<.001	.01	.89
Innovative Capacity	-.10	.37	.53	<.001	.02	.88
Patent Applications (log transformed)	-.26	.002	.75	<.001	-.21	.01

Note: Two-tailed *p*-values

Table 6.3. Standardized path coefficients, bootstrapped mediated effects, and confidence intervals for the indirect effects of Collectivism on Innovation. (n's = number of countries available for each model).

	Standardized Path Coefficients				Mediated effect and Confidence Intervals		
Dependent Variable	α	β	τ	τ'	BMED	95%L	95%U
Total Innovation Score ($n = 95$)	.66**	-.52**	-.70**	-.36**	-.34	-.47	-.24
Nobel Laureates ($n = 61$)	.68**	-.40**	-.80**	-.53**	-.27	-.43	-.15
Global Innovation Index ($n = 91$)	.68**	-.50**	-.68**	-.34**	-.34	-.48	-.22
Technological Achievement ($n = 57$)	.72**	-.53**	-.70**	-.32*	-.38	-.59	-.18
Innovative Capacity ($n = 91$)	.67**	-.63**	-.48**	-.06	-.42	-.59	-.29
Patent Applications ($n = 70$)	.71**	-.46**	-.60**	-.27^{+}	-.33	-.55	-.17

Note: α = path from Pathogen Prevalence to Collectivism, β = path from Collectivism to DV, τ = unmediated path from Pathogen prevalence to DV (within set of countries used for given model), τ' = direct effect of Pathogen prevalence on DV after accounting for mediated effect, BMED = bootstrapped mediated effect

$^{+}$ $p < .05$; *$p < .01$; **$p < .001$

CHAPTER SEVEN

Conclusion: Implications, Limitations, and Future Directions

The results from this set of studies can be summarized as follows: The threat of disease—be this threat real or perceived—is associated with 1) neurocognitive, context-dependent attitudinal and behavioral changes, 2) relatively stable dispositional differences, and 3) contemporary cross-cultural differences.

Experimental results from Chapters Two and Three demonstrate that temporary disease salience leads people towards higher behavioral and attitudinal conformity and more restrictive sexual attitudes. These effects appear to be unique to the threat of disease; temporary salience of non-disease threats produced results that were statistically equivalent to affectively neutral conditions. These results add to a growing body of work showing that ephemeral changes in the perceived threat of disease lead to facultative shifts in attitudes, behaviors, and cognitions.

Chapters Five and Six—using an important methodological tool created in Chapter Four—showed that regional variation in disease threat is associated with diverse measures of authoritarian governance and dispositional tendencies, and with several measures of scientific and technological innovation. These relationships cannot be accounted for by other possible causes of these cultural differences. These results add to the growing body of work implicating disease threat in contemporary cross-cultural differences; further, these results demonstrate that the cross-cultural variation in attitudes and dispositions (which has been captured by previous cross-cultural investigations) can manifest in significant downstream consequences.

In addition to adding to the growing literature on the psychological and societal implications of disease threat, these studies add to the literatures which map the diverse factors that impact conformity and sexuality. A rich literature documents the numerous factors that influence conformity, such as group size and group cohesiveness (Latane, 1981), the ambiguity of the situation (Sherif, 1936), or even manipulating romantic motives (Griskevicius et al., 2006). A similarly diverse—albeit more recent—literature documents the numerous factors that influence sexuality, such as family structure during childhood (e.g. Miller & Bingham, 1989), hormonal fluctuations during ovulation (e.g. Haselton & Gangestad, 2006), or even metropolitan gender ratios (e.g. Baumeister & Vohs, 2004). The work reported in this thesis adds to both of these literatures by demonstrating that an endemic ecological variable—the threat of infectious disease—can exert both ephemeral and chronic influences on conformity and sexuality.

7.1 Recent Work on the Psychological Implications of Pathogen Threat

Given that the studies reported here were theoretically developed and performed well before publication of this thesis, some of the specific literature reviews (which provided background for the then-novel questions that these studies addressed) are already somewhat antiquated. Happily, this is simply a sign of a burgeoning field of research. Several conceptually-related studies have been performed since—and many have been informed by—the research reported here. Most pertinently, the link between disease threat and conformity (reported in Chapter Three and in Murray & Schaller, 2012) has been conceptually replicated across two studies in a sample of participants living in East Asia, using different measures of conformity (Wu & Chang, 2012). Another recent study has shown that an experimentally manipulating disease threat via an olfactory cue (smelling a fecal odorant, “Liquid Ass”) resulted in participants reporting greater intention to engage in safe sex practices (Tybur, Bryan, Magnan, &

Caldwell Hooper, 2011)—a result conceptually compatible with those reported in Chapter 2 (and in Murray et al., 2013).

Other programs of work have further demonstrated the link between pathogen threat and facets of social conservatism. A recent follow-up investigation investigating political conservatism (employing a very large sample, N = 31,045) has replicated the relationship between disgust sensitivity and political conservatism, and found that the relationship was largely driven by concern about pathogenic contamination (rather than moral or death disgust; Inbar, Pizarro, Iyer, & Haidt, 2012). Evidence now exists that disgust sensitivity is associated with religious conservatism (Terrizzi, Shook, & Ventis, 2012). Individual differences in vertical collectivism (which is partly characterized by importance of tradition and hierarchy) are also predicted by disgust sensitivity (Clay, Terrizzi, & Shook, 2012). Further, physiological disgust reactions appear to be linked to political conservatism independently of self-reported disgust reactions: One study found that higher skin-conductance in response to viewing disgusting images predicted a more conservative political orientation (Smith, Oxley, Hibbing, Alford, & Hibbing, 2011). Interestingly, these involuntary physiological disgust reactions predicted political orientation independently of self-reported disgust sensitivity. Other recent investigations suggest that these attitudes are situationally malleable: Participants in both a public and laboratory setting reported more politically conservative attitudes if they were given a reminder of physical cleansing (Helzer & Pizarro, 2011). For a recent meta-analysis examining the effects of perceived disease threat and social conservatism, see Terrizzi, Shook, and McDaniel (2013).

Other recent work further adds to the growing literature implicating pathogen prevalence in the emergence of contemporary regional differences. Varnum (2012) found that disease prevalence negatively predicted levels of nonconformist third-party voting in the United States.

Another investigation examined the possibility that pathogen prevalence predicts "binding" moral values. Such moral values concern group loyalty, purity, and respect for authority (as opposed to individualizing moral values). Van Leeuwen, Park, Koenig, and Graham (2012) tested this hypothesis on data obtained from over 120,000 people in 147 countries. Results revealed that historical pathogen prevalence was a significant predictor of binding moral values, but not of individualizing moral values. As with previous investigations, historical pathogen prevalence was a stronger predictor of these cultural outcomes than was contemporary pathogen prevalence—a pattern consistent with the causal hypothesis.

7.2 Potential Mechanisms by which Disease Threat Influences Cultural Differences in Attitudes, Behavior, and Cognition

That disease induces temporary psychological shifts such as those reported in Chapters Two and Three does not imply that the mechanism through which disease impacts attitudes, behavior, and culture is *only* facultative. Correlational results within chapters two and three also show that conformity and sexual attitudes (and past behaviors) are predicted by a more stable characteristic: Dispositional worry about disease transmission. These results too are consistent with previous research documenting relationships between trait-like worry about disease transmission and numerous psychosocial variables (e.g. Duncan et al., 2009; Inbar et al., 2009; Terrizi et al., 2012; Tybur et al., 2009). Taken together with the better predictive ability of historical (versus contemporary) pathogen prevalence in cross-cultural investigations, this pattern of results suggests that facultative shifts provide only part of the answer to the question of *how* disease threat exacts its influence on stable individual and cultural differences. Other causal processes must be at play as well.

There are at least three other mechanisms by which disease might exert a causal influence on cultural variability. One such causal process is social or cultural transmission. More than any other animal, humans have extensive cognitive capacities that allow them to learn adaptive behavior efficiently based upon environmental feedback, to communicate this information effectively to others, and to similarly learn or copy other's behavior based upon their trial-and-error experiences. Such selective communication of adaptive information and behavioral proscriptions is one way in which cultural norms develop; by this logic, then, different cultural norms will develop in response to different ecological pressures. Such selective communication need not operate at the level of entire cultures; different families may selectively instill different norms and communicate different information to offspring due to different social or environmental niches, due to different life histories, or due to innumerable other sets of variables unique to one family but not others.

Social and cultural transmission processes provide a compelling means through which disease might influence individual-level and cultural outcomes. Humans are a hopelessly cultural species, and social transmission provides a relatively quick means for adapting to a wide range of ecologies and environmental changes. An explanation based upon wholly cultural or social processes is also compatible with evidence documenting rapid-but-not-overnight changes in cultural values (i.e., changes observed over the course of a generation or two) associated with immigrant populations who migrate from countries characterized by high pathogen prevalence to countries with substantially lower pathogen prevalence (e.g., Hardyck, Petrinovich, & Goldman, 1976). Humans are also equipped with cognitive tools and biases which are compatible with a cultural transmission explanation, such as perceptual hypervigilance to cues connoting the presence of threat, selective communication about threat, and social learning of avoidant responses to threat (Cook & Mineka, 1990; Hornick, Risenhoover, & Gunnar, 1987; Öhman, Flykt, & Esteves 2001; Schaller & Conway, 1999; Schaller, Faulkner, Park, Neuberg, & Kenrick, 2004; Schupp, Öhman, Junghofer, Weike, Stockburger, & Hamm, 2004). However, of this literature documenting hypersensitivity to threat, there are only a few that suggest hypervigilance to disease-connoting cues in particular (e.g., Ackerman et al., 2009; Miller & Maner, 2012). Further, there is no empirical work that directly tests the hypothesis that cultural transmission processes might mediate any of the observed relationships between pathogen prevalence and cultural characteristics. While logically compelling, the role that social and cultural transmission processes play in shaping individual and cultural differences require further direct investigation.

An epigenetic process is another candidate through which disease threat might influence psychobehavioral outcomes, wherein differential environmental inputs lead to selective expression of certain genes. Gene expression is profoundly influenced—typically in functionally adaptive ways—by the ecological circumstances within which an individual organism develops.

Applying this epigenetic logic to pathogen threat is straightforward: Under developmental circumstances characterized by higher pathogen threat (real or perceived), genes associated with cautious personality traits (e.g., sexual restrictiveness, conformist attitudes, wariness of outsiders) are relatively more likely to be expressed during development, and to exert a greater influence on individuals' eventual dispositional tendencies. This context-contingent epigenetic process results, inevitably, in regional and individual variation in attitudes, values, and personality traits. The plausibility of this epigenetic explanation is supported by a considerable body of evidence documenting gene by environment interactions in predicting human cognition and behavior (e.g., Cole, 2009). It is further supported by an extensive literature in the biological sciences bearing on the evolutionary advantages associated with phenotypic plasticity, and the innumerable ways phenotypic plasticity manifests in the natural world (e.g. Ridley, 2003).

Among many mammal species these epigenetic processes begin before birth, with developing fetuses obtaining information about postnatal environments via chemical cues obtained through the placenta; these cues influence gene expression in ways that promote the development of adaptive phenotypic responses (Gluckman & Hanson, 2005). Among meadow voles, for example, the placental transfer of melatonin (a chemical signal diagnostic of the length of the day) signals to the fetus which season to "expect"; as a developmental consequence, infants are born with thicker coats as winter (rather than summer) approaches (Lee & Zucker, 1988).

Development may be similarly influenced by the placental transfer of chemical signals that are produced maternally when mothers are exposed to pathogens. These chemical signals include corticosteroids and other hormones associated with stress and immune response. In research with non-human mammals, prenatal exposure to maternal corticosteroids has been linked to dispositional tendencies later in life, including lower levels of sexual aggression, reduced social interaction, and less exploratory behaviors in novel environments (Takahashi, Haglin, & Kalin, 1992; see Edwards & Burnham, 2001, for review). In one particularly notable study with mice, pregnant dams who were exposed to pathogen-infected conspecifics produced higher levels of corticosterone and produced offspring who, upon reaching adulthood, were meeker and less socially aggressive than controls (Curno, Behnke, McElligot, Reader, & Barnard, 2009). Analogously, among humans, pregnant mothers treated with a stress hormone (dexamethasone) gave birth to children who at age five, compared to controls, were relatively shier and less sociable (Trautman, Meyer-Bahlburg, Postelnek, & New, 1995).

These developmental results neatly parallel the current findings—and others—linking pathogen prevalence to more restrictive sexual and normative attitudes and behaviors, and thus give some credence to an explanation based upon the effects of pathogen prevalence on genetic expression. However, this evidence is indirect at best; more compelling tests of this explanation must focus more specifically on human development, and must consider a fuller range of the attitudes, traits, and behaviors that have been linked to pathogen prevalence.

Finally, it is worth considering a genetic evolutionary process, whereby alleles that predispose individuals to specific kinds of traits and values are differentially likely to proliferate under different kinds of ecological circumstances. Such a process is germane mostly to explanations for cultural—rather than individual—differences. Such a mechanism works as follows: Just as alleles promoting post-weaning production of lactase have been differentially selected for (and consequently have become relatively more common) within pastoral populations that domesticate milk-producing animals (Durham, 1991), alleles promoting conformity, traditionalism, or restrictive sexuality may have been differentially selected for (and become relatively more common) within populations characterized by higher levels of pathogen prevalence.

The genetic evolution explanation is consistent with findings showing that historical pathogen prevalence predicts cultural outcomes more strongly than contemporary pathogen prevalence. Its plausibility is supported by evidence that attitudes, traits, and values are at least moderately heritable. For example, the Big Five personality traits have substantial heritability coefficients (Henderson, 1982; Jang, Livesely, & Vemon, 1996; Pederson, 1993), and there is also more direct evidence of genetic influence on behavioral tendencies towards traditionalism, xenophobia, and conformity (Bouchard & McGue, 2003). The plausibility of such a process is further supported by evidence of relatively rapid evolution of different gene frequencies within populations inhabiting ecologies that differ in pathogenic threat (Williamson, Hubisz, Clark, Payseur, Bustamante, & Nielson, 2007).

In order to be truly compelling, the genetic evolution explanation must be tested directly against empirical data pertaining to sets of specific genetic polymorphisms that (a) are statistically associated with specific kinds of dispositional tendencies, and (b) exist in at different frequencies within different cultural populations. A few such candidates are now being given consideration. One such candidate is polymorphic variation on the DRD4 dopamine receptor gene. The long version of this polymorphism has been linked to novelty-seeking behaviors, financial risk taking, and sexual promiscuity and infidelity (Bailey, Breidenthal, Jorgensen, McCracken, & Fairbanks, 2007; Dreber et al., 2009; Garcia, MacKillop, Aller, Merriwether, Wilson, & Lum, 2010; Schinka et al., 2002), and frequencies of this allele in different populations vary widely throughout the world (Chen et al., 1999). Another promising candidate is the 5-HTTLPR polymorphic region of the SLC6A4 serotonin transporter gene. The short allele version of this polymorphism has been associated with a variety of cautious and avoidant behavioral tendencies (e.g., Beevers, Gibb, McGeary, & Miller, 2007; Munafo, Clark, & Flint, 2005), and the relative frequencies of short versus long 5-HTTLPR alleles vary substantially across different populations (Gelernter, Kranzler, & Cubells, 1997).

However, there has been little rigorous research addressing the possibility that these gene frequencies might help to account for the relationships between pathogen prevalence and cultural outcomes. In one of the first studies to address this question, Chiao and Blizinksy (2010) reported that, across several dozen countries worldwide, the relative frequency of short 5-HTTLPR alleles is strongly positively associated with country-level values of collectivism.

Moreover, the frequency of short 5-HTTLPR alleles is also positively associated with country-level values of pathogen prevalence and significantly mediates the relationship between pathogen prevalence and collectivism. These results provide the first empirical evidence that gives credence to a gene-frequency explanation for the effects of pathogen prevalence on cultural outcomes.

Regardless of evidence such as this, genetic evolution can provide, at best, only a partial explanation. Genetic evolution certainly cannot account for changes in cultural values that often occur over the course of just one or two generations. For example, compared to populations in East Asia, left-handedness occurs more frequently among populations of East Asian immigrants to North America (Hardyck et al., 1976). Further, unlike physiological immunocompetence, which is highly heritable (De Craen et al., 2005), sensitivity to disease cues is only minimally heritable (Rozin & Millman, 1987). Therefore, a genetic process at best can only work in tandem with epigenetic, social, or facultative processes to account for the effects of pathogen prevalence on cultural variation. (see Schaller & Murray, 2011, 2012 for further discussions on the merits of each potential mechanism).

7.3 Fitting the Effects of Pathogen Prevalence with other Ecological Variables

Although results from these cross-cultural investigations indicate that pathogen prevalence exerts a unique predictive effect on the emergence of a number of cultural differences, disease threat is clearly not the only factor that influences the emergence of these differences. Other causal variables have been offered to explain some of these contemporary cross-cultural differences. One such explanation for cultural differences in variables related to conformity involves patterns of migration and voluntary settlement; this perspective holds that individuals who chose to migrate from established settlements are more likely to be characterized by traditionalist or conformist dispositions (Kitayama & Bowman, 2010; Kitayama et al., 2006). Another more intricate alternative perspective—climate-economic theory—suggests that poor cultures inhabiting more climatically “demanding” ecologies should develop norms that restrict freedoms, whereas rich cultures inhabiting climatically demanding ecologies should develop norms that encourage freedoms, and cultures inhabiting temperate climates should develop norms that lie somewhere between these endpoints, regardless of wealth (Van de Vliert, 2009). Each of these explanations need not operate at the exclusion of others. In fact, as the explanatory validity and precision of these causal variables grows, single-factor explanations of culture such as these may come to appear myopic. Parasite stress and climate-economic theories, for example, may fit together nicely: Much of the relationship between thermal demands and restrictions on freedoms in poor countries may be mediated by pathogen prevalence (Murray, in press). Another recent result suggest that patterns of voluntary settlement and pathogen prevalence may work in tandem to predict nonconformist voting in the United States (Varnum, 2012). Very few ecological and demographic variables operate in isolation; the next step in this research will involve testing increasingly complex structural models of the interrelationships between causal ecological variables and their impact on the evolution of cultural differences.

7.4 Consequences of the Changing Landscape of Disease Threat

It is fitting to close this thesis by considering—in light of the research presented here—just what might be the consequences of worldwide changes in pathogen prevalence. The threat posed by infectious disease has changed dramatically in just a few generations. Whereas the three leading causes of death in the United States were infectious diseases in 1900 (pneumonia, tuberculosis, and gastrointestinal infections), the top *nine* leading causes today are all non-infectious (Jones, Podolsky, & Greene, 2012). This decrease in the burden of infectious disease throughout the 20th century in the United States was conveniently paired with concurrent increases in sexual liberation, decreases in restrictions on civil rights, and an alarming increase in the rate at which technology develops. Of course, at this point any supposed relationship between these changes is mere speculation; truly rigorous tests of posited causal relationships between changing level of disease threat and social changes will require sophisticated analytical tools (such as time-series analyses) as well as voluminous datasets (which may or may not be sufficiently precise or exhaustive). These studies too will suffer from inferential limitations if considered in isolation; however, they will add to the increasingly methodologically-diverse literature which evaluates hypotheses pertaining to the relationship between disease threat and psychology.

Longitudinal-type studies may also provide insight into the question of the causal mechanisms through which disease threat exacts its influence on these variables. Each of the four potential mechanisms discussed above entails a somewhat different time lag for which disease might produce appreciable effects on these psychological variables. Evidence for a purely facultative mechanism, of course, would be seeing almost immediate psychosocial changes in response to a change in disease threat. Evidence for an epigenetic mechanism would be a time lag of about one generation. Evidence for a genetic mechanism would be a lag of several generations. A social or cultural transmission mechanism could operate with a lag of anywhere between a few generations and—given the rapid diffusion within modern communication networks—a few years.

Regardless of *when* or *how* these changes might occur the broad upshot remains the same: Should the theories tested in this thesis be valid, changes in global disease burden *will* have implications that extend far beyond those for physical health. Several recently implemented vaccination and disease eradication programs will provide fruitful data with which to further investigate these ideas. Perhaps India's new free drug program will lead Indians to endorse a more unrestricted sexuality; perhaps increasing access to medical care in China will lead to lower adherence to Chinese cultural norms; perhaps malaria eradication programs in Africa will decrease its preponderance of despotic political regimes. Be these changes positive or negative, time (and further research) will tell.

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