ECOLOGICAL THREATS TO HUMAN SURVIVAL; AN EVOLUTIONARY PERSPECTIVE

by

SOHEIL SHAPOURI

(Under the Direction of Leonard L. Martin)

## ABSTRACT

Predation, natural disasters, and infectious diseases have endangered Homo Sapiens throughout its evolution, and adaptations to these ecological threats have impacted our emotions, cognitions, and behaviors. In three different studies, we investigated these threats from an evolutionary perspective. In Study 1 we systematically reviewed the literature that has compared phylogenetic and ontogenetic threats. The results show that while ancient and modern threats differ, this difference might not be in the direction predicted by biological preparedness. Moreover, natural and technological disasters have been absent from these studies. Study 2, compared emotional responses to natural and technological disasters and indicated that although natural disasters kill more people, cause more injuries, and cost more financial damage, technological disasters are rated as more unpleasant. Study 3 reviewed theories that consider ecological factors (natural disasters, climate, infectious diseases, etc.) as drivers of collectivism. The results show that parasite stress theory, which proposes pathogenic stress as a strong driver of collectivism provides a better evolutionary explanation regarding the ultimate causes of collectivism and is backed by empirical support but has many methodological issues that should

be addressed. These studies' implications and future directions researchers can take to advance evolutionary understanding of ecological threats are discussed.

INDEX WORDS: biological preparedness, natural disasters, parasite stress, evolutionary psychology

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# DEDICATION

To me who never gives up.

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# CHAPTER 1

## INTRODUCTION AND LITERATURE REVIEW

Carl Sagan's renowned quote succinctly encapsulates the essence of life on Earth for nearly all species: “Extinction is the rule, survival is the exception.” Threats come from everywhere. Thus, any species that wants to survive must exhibit adaptations that enable detection, reaction, and coping efficiently with threats. Homo Sapiens is not an exception, and its survival has been tied to efficient detection and response to ecological threats it faces. However, two sources of threats, predation and infectious disease, have captured evolutionary scholars’ attention more than other dangers, as they have the greatest effects on human evolution.

The earliest influential evolutionary theories were those that addressed predation. The high prevalence of animal phobia worldwide (Wardenaar et al., 2017) and inadequacies of behavioral explanations (McNally, 2016) resulted in the proposition of biological preparedness by Martin Seligman (Seligman, 1971) who basically argued that while phobias of ancient objects (e.g., spiders) are common, fears of modern objects (e.g., pajama phobia) are rare if they ever exist. So, we are biologically prepared and evolutionarily wired to be afraid of objects that were threatening to our hunter-gatherers’ ancestors. Later, a more sophisticated version of biological preparedness was proposed by Öhman & Mineka (2001) who combined cognitive neuroscience findings (i.e., the importance of the Amygdala in fear learning) and evolutionary ideas (i.e., biological preparedness) to propose fear module theory. Their general idea was that recurrent threats like predation have equipped humans with a threat detection system with the centrality of

the Amygdala that helps us with fast detection, quick learning, and automatic response to dangers.

In the next few decades, these theories guided research not only in evolutionary psychology but also in related fields like cognitive neuroscience, developmental psychology, and clinical fields. For example, brain imaging studies were conducted to find archaic threat detection systems (Paradiso et al, 1999) proposed by fear module theory. The importance of predatory animals emphasized by these theories was taken into account when researchers created standardized affective stimuli sets like GAPED (Dan-Glauser & Scherer, 2011). Based on the importance of predatory animals outlined by evolutionary theories almost all standardized affective stimuli datasets contain pictures of snakes and spiders. Even developmental psychologists who put more emphasis on environmental factors and proximate causes of behaviors widely accepted these theories as explanations of the ultimate causes of fear in children (LoBue & Adolph, 2019).

Predation, though, was not the only ecological threat that gained the attention of evolutionary psychologists. Infectious diseases have probably killed more humans than violent conflicts, natural disasters, and non-infectious diseases combined (Inhorn & Brown, 1990). Considering the significance of this selection pressure, it comes as no surprise that infection has stimulated theoretical and empirical work in evolutionary community.

Of the earliest efforts to explain the role of infectious disease in human evolution are studies conducted by Corey Fincher, Randy Thornhill, Damian Murray, and Mark Schaller. The link that these pioneers made between pathogenic stress and collectivism (Fincher et al., 2008) was later expanded as parasite stress theory of sociality and values (Thornhill & Fincher, 2014) which tries to explain cross-cultural variations as a result of pathogen prevalence. The general

idea behind parasite stress is that characteristics of collectivism, like xenophobia, can reduce the possibility of exposure to pathogens which our bodies have not developed immunity against them.

Similar to the idea of biological preparedness, parasite stress theory had a tremendous impact on research both within evolutionary psychology and in wider community of social and behavioral sciences. In the past two decades, prevalence of parasitic infection has been used to explain cross-national differences in economic institutions (Nikolaev & Salahodjaev, 2017), governmental restrictions (Conway et al., 2017), and individual-level openness to experience (Schaller & Murray, 2008). Moreover, it has played an important role in driving psychological research during recent pandemics including Swine Flu (Hamamura & Park, 2010), Ebola (Kim et al., 2016), and COVID-19 (Ma, 2022). More interestingly, harboring skepticism regarding the statistical validity of parasite stress findings has sparked fervent discussions about the independence of data points in cross-cultural research (Bromham et al., 2018; Claessens & Atkinson, 2022).

In summary, the theories of biological preparedness and parasite stress have made significant contributions to our comprehension of human responses to fear-inducing and disgust-evoking stimuli associated with threats. Nevertheless, numerous unanswered questions persist, methodological concerns demand attention, and the need to elucidate contradictory findings remains paramount.

The biological preparedness idea was so appealing that soon after its advent it became the driver of research on fear and phobia but surprisingly the efforts to summarize and synthesize this line of research are rare. One of the most important predictions of biological preparedness, for example, is that humans have stronger, more negative, and faster reactions to threats of

ancient worlds (e.g., predatory animals) than modern threatening objects. Dozens of studies have investigated this hypothesis with fear conditioning (e.g., Luck et al., 2020), illusory correlation bias (e.g., Muris et al., 2007), attention bias (e.g., Zsido et al., 2019), and brain imaging methods (e.g., Zhang & Guo, 2019) but there is not even a single study to give us a big picture of what has been done so far, whether the idea is supported by empirical research or not and what needs to be done in future.

A persistent challenge affecting research in psychology stems from its predominant reliance on theoretical frameworks. While recent developments in the utilization of big data and the advancement of machine learning algorithms are altering the landscape of knowledge generation (Egger & Yu, 2022), the majority of psychological investigations continue to be shaped by predictions derived from influential theories. Until data-driven methodologies can relax the constraints imposed by theory-driven research (Jack et al., 2018), for example by reducing the dependency on anecdotal yet influential observations, psychology will remain tethered to theory-driven research.

One of the observations that skewed early evolutionary theories of fear and phobia was the frequent occurrence of specific phobias, particularly animal phobias, within clinical samples (Marks, 1970). Both the biological preparedness and fear module explanations relied on characteristics of clinical samples to make conclusions about human nature. To further clarify the problem, it is important to note that Öhman and Mineka's logic (2001) was that recurrent threats of our evolutionary past shaped the fear module but among all possible threats that could have been chosen, they assumed snakes are prototypes of ancient threats (Öhman, 1986). Snakes have been a source of threat during evolution of mammals (Falótico et al, 2018) as they frequently

cause injuries and death even among contemporary hunter-gatherers (Headland & Greene, 2011) but arguing that they are prototypes of ancient threats needs more substantial evidence.

The advent of weaponry likely diminished the selection pressure imposed by predation (Thornhill & Fincher, 2014). However, ecological threats, such as deforestation (Stanley, 1992) and climate change (Behrensmeyer, 2006), played significant roles throughout our evolutionary history and continue to influence human adaptations (Pisor and Jones, 2021). The genus Homo has repeatedly confronted challenges such as volcanic activities (Levin, 2015), droughts (Scholz et al., 2007), and extreme fluctuations in wetness and aridity (Trauth et al., 2007). Natural disasters are acknowledged as catalysts for cultural evolution (Grattan & Torrence, 2003). Therefore, it is reasonable to posit that adaptations to natural disasters are, at the very least, equally likely if not more plausible than adaptations to predation. But the focus on predatory animals by preparedness and fear module has overshadowed the importance of natural disasters in fear research.

Much like the impact of biological preparedness and fear module theories on the study of fear, the parasite stress theory has similarly shaped research in the realm of cross-cultural investigations of national cultures, especially collectivism. However, the popularity of parasite stress has caused at least two problems that are overlooked. First, there are other theories of collectivism that try to explain cross-cultural variations based on ecological factors. For example, climato-economic theory (Van de Vliert, 2013) attributes collectivism to climate demand and its interaction with economic resources and has received empirical support but the popularity of parasite stress has overshadowed these efforts without necessarily providing stronger empirical evidence. The scientific literature lacks a review of these efforts, a big picture that can guide future evolutionary, cross-cultural research.

We designed three empirical and theoretical studies to address the above-mentioned issues.

The first study is a systematic review that aims to summarize research on comparisons between phylogenetic and ontogenetic threats. As discussed earlier, one of the predictions of fear module theory is faster, stronger, and more resistance in response to ancient threats than modern threats. To what extent empirical research actually supports this idea is not clear and hence that is the primary goal of this study. The second goal is providing a summary of literature to identify gaps that should be filled by future research in studying fear.

The second study is an empirical investigation of fear-relevant threats based on the insights provided by the first study. Study 2 aims to use a refined version of the evolutionary psychology framework to advance the field by introducing a new set of stimuli, natural and technological disasters. It can be seen as the first step toward integrating evolutionary psychology and risk sciences for a better understating of pressing issues such as climate change. Study 3 reviews four theories about the origin of collectivism. It compares evolutionary modernization theory (Inglehart, 2017), rice versus wheat theory (Talhelm, 2020), climato-economic theory (Van de Vliert, 2013), and parasite stress theory (Thornhill & Fincher, 2014) in terms of ultimate and proximate causes of collectivism they focus on. It also examines empirical evidence that has been provided during the past decade to support parasite stress theory with a focus on methodological issues in measuring parasitic stress and handling non-independent data.

# CHAPTER 2

## Snakes vs. Guns: a Systematic Review of Comparisons Between Phylogenetic and Ontogenetic Threats[1]

[1] Shapouri, S., & Martin, L. L. (2022). Snakes vs. guns: a systematic review of comparisons between phylogenetic and ontogenetic threats. *Adaptive Human Behavior and Physiology, 8*, 131-155. [Reprinted here with permission of publisher]

Abstract

Objectives: The potential differences between phylogenetic threats (e.g., snakes) and ontogenetic threats (e.g., guns) can have a wide-ranging impact on a variety of theoretical and practical issues, from etiology of specific phobias to stimulus selection in psychophysiological studies, yet this line of research has not been systematically reviewed.

Methods: We summarize and synthesize findings from fear conditioning, illusory correlation, attention bias, and neuroimaging studies that have compared these two types of threats to human survival.

Results: While a few brain imaging studies reveal preliminary evidence for different brain networks involved in the processing of phylogenetic and ontogenetic threats, attention bias studies tentatively show faster reaction time for modern threats, illusory correlation bias is evident for both types of threats, and fear conditioning studies are far from conclusive.

Conclusions: The results of behavioral experiments, especially attention bias research, pose a challenge to established theories like biological preparedness and fear module, as they show faster reaction time to modern threats, which is the opposite of what some evolutionary theories predict. We discuss the findings in terms of other theories that might explain the same results and conclude with potential future directions.

*Keywords*: Phylogenetic threats, Ontogenetic threats, Fear module, Biological Preparedness

Chapter 3

# Affective Responses to Natural and Technological Disasters; An Evolutionary Perspective[2]

[2] Shapouri, S., Martin, L. L., & Arhami, O. (2023). Affective Responses to Natural and Technological Disasters; An Evolutionary Perspective. *Adaptive Human Behavior and Physiology*, *9*, 308-322. [Reprinted here with permission of publisher]

Abstract

Objectives: Anecdotal reports indicate more severe psychological distress following technological catastrophes in comparison to natural disasters. Previous research also suggests a more negative evaluation of the outcomes of disasters if they are manmade. On the other hand, evolutionary neuroscience shows differential neural processing of ancient and modern threats.

Method: Building upon this literature, we probed valence and arousal ratings of stimuli depicting natural and technological disasters in several standardized affective stimuli datasets used in neuroscience and psychological research.

Results: Our results show that while technological disasters are rated as slightly less arousing than natural disasters they are rated as significantly more unpleasant.

Conclusion: It seems the evolutionary age of disasters is one of the factors that affect emotional experiences evoked by these threats and can impact our evaluations of catastrophes. We discuss how evolutionary psychology might explain our findings and help us to better understand the biological and learned roots of our biases in risk perception.

# Chapter 4

## Of Germs and Culture; Parasite Stress as the Origin of Individualism-Collectivism[3]

[3] Shapouri, S. (2023). Of germs and culture; parasite stress as the origin of individualism-collectivism. *Evolutionary Psychological Science, 9*(1), 82-89. [Reprinted here with permission of publisher]

Abstract

Among four proposed origins of individualism-collectivism, modernization theory, rice versus wheat theory, climato-economic theory, and pathogen stress theory, the latter has gained more attention in cross-cultural and evolutionary psychology. Since the parasite stress theory of values and sociality makes a connection between infectious diseases and cultural orientations, it gained even more popularity during the COVID pandemic. But despite extensive research on parasite stress theory, it is not still clear what kind of infectious disease contributes more to the emergence of cultures, what are the possible mechanisms through which pathogenic threat gives rise to cultural systems, and how parasite stress might affect vertical vs. horizontal dimensions of individualism-collectivism. This review summarizes and integrates major findings of parasite stress theory related to individualism-collectivism and its closely related variables and discusses future directions that researchers can take to answer the remaining questions.

*Keywords:* Evolutionary psychology, Natural disasters, Technological disasters, Affective stimuli · Risk perception

# CHAPTER 5

# GENERAL DISCUSSION

Three studies investigated humans' responses to different ecological threats: predatory animals, natural and technological disasters, and infectious diseases. The results show that evolutionary psychology can provide a broad theoretical framework to conduct research on the impacts of ecological threats on human cognition and social behavior. This framework has been strongly influential in directing research in cognitive neuroscience and cross-cultural psychology. At the same time, accepting evolutionary explanations at face value, especially more famous theories, without carefully considering empirical research that support them has narrowed the focus of research in some areas, has sometimes resulted in prevalent misconceptions, and ignorance of empirical evidence in other areas. The three studies described here can shed light on some of these problems and can help us to move the field froward. Below I discuss the findings and implications of these studies along with the future directions that researchers can take to advance our understanding of ecological threats.

Study 1 (Shapouri & Martin, 2022) systematically reviewed papers that have compared ancient and modern threats. The hypotheses of the majority of these studies were based on biological preparedness and fear module theories which, based on the methods they use, predict stronger, faster, or more resistance to extinction for ancient threats than modern threats. Our results revealed some interesting patterns:

First, the general idea of biological preparedness and fear module theories are supported by brain imaging studies (e.g., Cao et al, 2014; Fang et al., 2016; Dhum et al., 2017). A common

pattern found in fMRI studies is stronger cortical activity when participants are exposed to modern threats and heightened subcortical activity when they are shown threatening ancient stimuli.

Second, unlike predictions of evolutionary theories most attention bias studies, fear conditioning, and illusory correlation bias domains do not support faster, stronger, and more biased reactions toward ancient threats (Shapouri & Martin, 2021). Some attention bias studies even show faster reaction time for modern dangers (e.g., Brown et al., 2010; Zsido et al, 2019).

Third, besides a few exceptions, research in this area has entirely focused on predatory animals as prototypes of ancient threats and guns as prototypes of modern threats. As mentioned earlier, although adaptive responses to recurrent threats to humans' survival during its evolution was the idea behind fear module theory, other frequent ecological threats like natural disasters have been ignored in this line of research. So, future research can consider these events to investigate biological preparedness with new stimuli. Moreover, these investigations need not to be in the direction of influential theories as these theories have constantly failed to provide correct predictions regarding the direction of difference between phylogenetic and ontogenetic stimuli.

The findings of Study 1 provided the basis for designing a study to test the differences between phylogenetic and ontogenetic threats with a new set of stimuli and generating hypotheses in the opposite direction of previous research.

On the one hand as study 1 shows it is warranted to assume neural processing of ancient and modern threats are different. On the other hand, several studies in risk sciences literature have highlighted differences in risk perception between natural and technological catastrophes. Anecdotal evidence suggests that technological disasters may have more enduring psychological

impacts compared to natural disasters (Baum et al., 1983). Additionally, research indicates a greater perceived need for public intervention in manmade hazards than in natural risks (Brun, 1992), and negative outcomes of disasters are viewed more severely when attributed to technological causes (Siegrist & Sütterlin, 2014).

In sum, evolutionary psychology research has documented the differences between ancient and modern threats and risk science literature shows biased risk perception in favor of modern disasters. As risk perception is influenced by emotional reactions to dangers, we can hypothesize more negative emotional reactions to technological disasters than modern disasters. This hypothesis was tested in study 2 by using standardized affective stimuli ratings.

Our results (Shapouri et al., 2023) showed significantly more negative valence and slightly lower arousal ratings of modern disasters in comparison to ancient disasters. The most important aspect of these findings is that the pattern found here matches neuroimaging studies of valence and arousal as well as ancient and modern threats. Highly arousing emotional experiences increase the activity of subcortical regions (e.g., amygdala, thalamus, and hippocampus) and unpleasant stimuli (lower in valence) heighten the activity of neocortical regions (Colibazzi et al., 2010); a pattern similar to subcortical-neocortical activation in response to ancient-modern dichotomy.

In sum, this study showed the usefulness of evolutionary psychology framework in the study of natural and technological disasters and provided the first empirical evidence regarding affective responses to ancient and modern disasters. The results of this study can be seen as the preliminary explanation about inaction against climate-change related disasters from an evolutionary perspective.

There are at least two possible ways to further support the idea proposed by this study. The first one is rejecting the idea that the pattern found here can be attributed to casualties caused by disasters. As epidemiological data shows natural disasters kill more people, cause more injuries, and cost more financial damage we can argue that the results are not due to the more severe consequences of technological disasters. However, a more appropriate method of handling this confound is to measure the severity of disasters that are used as stimuli of the study. The second one is providing neuroimaging evidence that the subcortical-neocortical activation pattern in response to natural-technological disasters that we proposed is the mechanism by which these threats might provoke differential emotional reactions.

If we have evolutionary adaptations to natural disasters as study 2 in this project and other studies (e.g., Katsampouris et al., 2022) show, can these adaptations affect our social behavior? In other words, can natural disasters shape our relationships with others? At least two studies have investigated this question but have reached different conclusions. In a study of 33 nations, Gelfand and her colleagues (2011) found that tight nations experience more natural disasters. But in a study of collectivism and natural disaster risk, Oishi and Kashima (2017) showed that natural disasters cannot predict collectivism when other ecological factors like national wealth, parasite stress, and climate harshness were controlled for. Of course, contradictory results are not uncommon, but what is surprising is the fact that despite the prevalence of natural disasters, research on the effects of these extreme events on national cultures is scarce. A review of the literature (Shapouri, 2023) might provide some explanations.

First, as mentioned before, a theory-driven field like psychology relies on theoretical frameworks to investigate factors that shape national cultures. There are currently four prominent theories of collectivism as one of the most important aspects of national cultures: modernization

(Hamamura, 2012), rice vs. wheat (Talhelm et al., 2014), climato-economic (Van de Vliert et al., 2013), and parasite stress theory (Fincher et al., 2008). Each of these theories has its own strengths and weaknesses and has some empirical support. The problem is that most often than not researchers select a few variables based on a particular theory. As ecological factors are typically correlated (Bromham et al., 2018), it is not surprising that most studies find a significant correlation between their variables of interest and collectivism. What is currently missing is the investigation of a comprehensive list of ecological factors to determine what factors explain more cross-cultural variations.

Second, evolutionary cross-cultural research in the past few decades has utilized measures of national cultures that at best represent a small portion of world cultures. Empirical studies of parasite stress theory typically use measures of collectivism like Hofstede that covers about one third of the world. So, depending on which cultures are included in the study we might reach a totally different conclusion. For example, the correlation between serotonin transporter functional polymorphism (5-HTTLRP) and collectivism (Chiao & Blizinsky, 2010) might disappear once sub-Saharan African countries (high in collectivism but low in the prevalence of short allele of 5-HTTLRP) are included in the sample (Minkov et al., 2015).

Third, as parasite stress theory provides better explanations regarding ultimate causes of collectivism, and it can also direct research during pandemics it has gained more popularity in recent years. At the same time, this popularity has made it a natural target of critics who are concerned with methodological issues in cross-cultural research (e.g., Bromham et al., 2018; Claessens & Atkinson, 2022). The overarching theme of these critics is the non-independence of countries (also known as Galton's problem). While there is little doubt that independence of cultures cannot be assumed, the method of dealing with the problem is not as straightforward as

many critics of parasite stress theory suggest. Multilevel modeling, which is considered as the solution for Galton's problem, has a shortcoming of valid statistical inferences if the number of data points within each category of grouping variable is low. Moreover, although there are some evidence that the possible relationship between parasite stress (and possibly other ecological factors) and collectivism is not linear (Zhang, 2018), most studies still use linear multilevel regression to investigate parasite stress theory.

There are at least three ways to drastically improve methodologies used in evolutionary cross-cultural research. First, considering ever-growing publicly available data provided by governmental agencies, research institute, and open-science practices, it is necessary to conduct explanatory data analysis to determine the most important factors affecting national cultures instead of subjectively select a handful of variables based on a particular theory. Second, evolutionary cross-cultural research should strive to provide measures of national cultures like Global Collectivism Index (Pelham et al., 2022) that covers almost all cultures of the world not just more developed countries. Finally, machine learning algorithms like random forests are constantly revised to meet the needs of data analysis. These algorithms are more flexible methods of dealing with nonlinearity of predictors and outcomes, small sample sizes, and hierarchical structure of the data. Utilizations of these methods in big datasets that include comprehensive lists of possible drivers of national cultures can drastically change the direction of future research by identifying variables that have not been considered in previous theories, ranking variable importance in explaining cross-cultural variations, and patterns that cannot be detected by hypothesis significance testing procedures.

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