Essays on Evolution, Social Behavior and Climate Change

by

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Abstract

Inequality, collective action, and adapting climatic variability are all central adaptive problems that shaped the evolution of our species' sociality. Equally so, because of the internal logical structure of these challenges, each of these problems also sits at the heart of climate change. However, there has been little attempt to bridge climate change research with the evolutionary foundations of social behavior and historical change. This thesis helps build that bridge through an analysis of the evolutionary foundations of inequality aversion, leadership in collective action and how the process of adapting to climate shocks has influenced socio-political history. Using a modified dictator game, our first study explores the ontogenetic impacts that severe climate shocks have on preferences for inequality aversion. We find that acute exposure to droughts, during youth, is correlated with a greater tendency towards enviousness and spite. In our second study, we use public goods games with a leader, to test the conditions under which people are willing to accept centralized leadership. Our analysis shows that two fundamental conditions must be met for people to recognize leaders; (a) the perception of a coordination challenge and (b) high levels of mutual interest between leaders and followers. Finally, in our third paper, we explore how the process of cultural adaptation to droughts has influenced the historical development of traditional societies. We find that when the adaptive capacity of a community is stressed, people search out new strategies which then create a dynamism and uncertainty that allows for large scale macro changes to take place. Overall these studies are part of a growing body of research that applies evolutionary principles to problems related to climate change, in the hope that our knowledge can help provide solutions for our generations and those yet born.

Preface

This dissertation is an Original intellectual product of the author, Jeffrey Andrews. The fieldwork and experiments reported in Chapters 2-4 was approved by the University of Alberta Research Ethics Board, "Drought, Inequality, and Egalitarianism", No. Pro00045483, 4/8/14

To those who never reproduced but should have.

“Look deep into nature, and then you will understand everything better"
- Albert Einstien

"The universal order and the personal order are nothing but different expressions and manifestations of a common underlying principle."
- Marcus Aurelius

"Thus, from the war of nature, from famine and death, the most exalted object which we are capable of conceiving, namely, the production of the higher animals, directly follows. There is grandeur in this view of life, with its several powers, having been originally breathed into a few forms or into one; and that, whilst this planet has gone cycling on according to the fixed law of gravity, from so simple a beginning endless forms most beautiful and most wonderful have been, and are being, evolved."
-Charles Darwin

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Introduction

1.1 Introduction

There is a great irony in the fact that evolution, the process that sits at the heart of all life, complexity and change, may be the same force that condemns our species to its greatest follies. The evolved neurological traits that allow humans to harness the power of fossil fuels, to cheat Malthusian dynamics and to build the complex social structures that hold together modern civilization are the result of our unique capacities for cooperation and culture (Bowels and Gintis, 2011; Boyd and Richerson 1986; Nowak, 2006; Tomasello, 1999). However, the far-reaching consequences of these significant accomplishments are global warming, overpopulation and the potential for environmental collapse. Together these are some of the chief threats to our current way of life. This paradox is the grand tragedy of modern human existence; that the traits that give rise to our dynamism and success–the ambition and the cooperation, the innovation and the traditions, the rationality and the emotions–have all combined to create a tribalistic, culturally dependent, morally conflicted, myopic great ape.

Culture, the adaptive ability to transmit and retain information with high fidelity through language, (Boyd and Richerson 1986; Jablonka, Lamb, and Zeligowski, 2014; Tomasello, 1999) has endowed our species with the capacity to grow food to feed billions, create cities to house millions and build transportation networks that link the world together. Yet, it is precisely these scientific and cultural achievements that are the driving forces behind environmental degradation and climate change. Paradoxically, while our cultural capacity gave rise to these problems, the same ability to generate information will also provide solutions.

Nevertheless, the only reason why we can put our scientific advancements into practice to such a scale that we can restructure the face of the planet is because of a suite of prosocial dispositions that allows us to reap the benefits of cooperation on levels unparalleled amongst animals (Alexander, 1987; Nowak, 2006). Unfortunately, the evolutionary logic of cooperation is a double-edged sword, because cohesion at lower scales is typically built by the threat of group based competition at higher levels (Price 1970; Maynard-Smith and

Szathmary, 1997; Okasha, 2006). This fundamental principle enables our economies and societies to function with great efficiency, but, for better or worse, these same cooperative tendencies can also heighten our parochial, tribalistic nature, and fuel intergroup conflict and political gridlock.

Quixotically, though, there is hope that by understanding how evolutionary principles have shaped human social behavior and thus social change, that this knowledge can help us solve the same problems that evolution has created. This thesis investigates how three of the most prevalent problems in our species' evolutionary history are equally central to our current challenges with climate change. The overarching goal is to demonstrate that an evolutionary understanding of social behavior and historical change is fundamental and necessary for the social sciences and our struggles with climate change.

In our first study, we seek to uncover how environmental factors related to natural disasters, interact with our evolutionary heritage to influence how people think about economic inequality. Our focus is motivated by the fact that rising rates of inequality now pose serious challenges for societies across the world (Piketty 2014). These rising rates of inequality affect climate change because, below the high-level political negotiations, lurk global economic inequalities that have produced, both significant vested interests in sustaining high carbon economies, and tangible vulnerabilities amongst those least responsible. With this context in mind, we wish to understand how droughts will impact the neurological development of how people respond to economic inequality. Using a modified dictator game, we analyze the long-term influences that droughts have on the development of peoples' preferences for economic redistribution and fairness.

Second, we seek to understand the essential nature of group decision making in collective action dilemmas. Specifically, what are the conditions under which individuals are willing to accept leaders with strong, autocratic powers. Consider that at the core of climate change mitigation is the collective action problems of attempting to establish an international legal framework to mitigate GHG emissions. In order to aid our understanding, we explore the most basic conditions under which evolution would select for individuals who would willingly give up their personal autonomy to a single entity to solve collective action dilemmas.

Finally, we shift from studying how evolution has sculpted our neurological processes and social behavior, to analyze how the evolutionary process creates change more generally. In our fourth chapter, we look at how micro-level adaptations to droughts produce macro-scale change. As it stands, climate change will result in more frequent and severe droughts (Parry et al, 2007), and currently over 25% of the worlds population has already suffered the direct effects of drought (DARA, 2012). The response to these changing conditions currently involves rising food prices, economic shocks, stressed social security nets, migration, and violent conflict. However, due to the unpredictable nature of the complex web of interrelated causal processes that links climatological processes to individual behavior and to social structure, we have a poor idea of how climate change and adaptation will affect

broader socio-political outcomes. To address this problem, our third study evaluates how, throughout history, in traditional subsistence societies, the process of adapting to droughts has generated the necessary conditions for large-scale socio-political transitions.

1.2 The Social Sciences, Evolution and Epistemology

What is striking about the academic literature on climate change, is that despite the amount of ink that has spilled, little consideration has been given to the evolutionary foundations of the behavior that underlies it. Unfortunately, this is because, even though the evolutionary sciences are fundamentally tied to social behavior, evolutionary thinking has typically been met by a bulwark of antagonism within the social sciences. While there are various explanations for this (Wilson, 1999), we believe that it is principally predicated on a epistemological rift between the natural and many of the social sciences. In short, with the rise of post-modernism, post-structuralism, many of the social sciences became entrenched in a epistemological critique of scientific knowledge, and a push to have the axiomatic principles disciplines, like sociology, to be independently of evolutionary theory and the natural sciences more broadly (Sokal and Brickmont, 1998).

Amongst the primary charges leveled against evolutionary theory and its application to humans is that (Goldman, 2006; Sokal Brickmont, 1998; Wilson, 1999): (a) due to the inherent power structures and cultural biases within society, claims about the objectivity of human nature are actually ideological utterances reflecting political interests and culturally dominant narratives; (b) that the scientific worldview does not have a more accurate view of reality than other systems of knowledge; (c) the reductionist principles of the natural sciences cannot help us elucidate social life because of the 'intangible complexity' of culture and individual idiosyncrasies. While each of these claims possess a seed of truth, the overextension of their logic has led to a tautological solipsism and the assumption that natural scientists are naïve to the biases that infuse social life and the pursuit of knowledge.

Arguably, the birth of this epistemological rift was given life by the founding fathers of the social sciences. In the 19th century, as anthropology, sociology, economics and political science began to carve out distinct disciplinary boundaries, much effort was placed on delineating formal areas of analysis (e.g., Durkheim, 2010). This territoriality functioned to separate each discipline from one another and from the natural sciences more generally. As such, the core theoretical propositions that guided the formation of each of the disciplines were neither coordinated amongst each other, nor with the developing biological sciences. This history led to divergent evolutionary trajectories between the new fields, and there was little common ground to root them. This intellectual development was unlike the progress of the natural sciences where the basic laws of physics allowed for the various branches to grow in relative concert and consilience.[1]

[1] Despite my derision of the intellectual history of the social sciences, the divergent pathways taken by the various disciplines would appear to be a natural evolutionary process.

As the 20th century proceeded, the differences in theoretical orientation and the competition for prestige between disciplines led to bitter ideological disputes. Predictably, as with most inter-group conflicts, the debates turned political, which strengthened both inter-group boundaries and commitments to, often untenable, central axiomatic principles. The result was calls from all sides that the theoretical paradigms of rival disciplines were politically, rather than academically motivated (Bourdieu, 1984). At times, these accusations were correct; the most obvious example being the incorrect application of evolutionary theory to Social Darwinism and 1960's functionalism (see Parsons and Jones, 1960). These disputes and false starts further entrenched the epistemological and axiomatic differences between the disciplines. However, this conflict also hamstrung the development of an objective basis for the social sciences rooted in first principles, ultimatley tied to evolution and the rest of the natural sciences more broadly.

During the 1960s and 1970s, the theoretical discordance with the social sciences became paired with an emerging post-colonial attempt to assert the validity of non-scientific systems of knowledge. The 'deconstruction' of the scientific method led many to posit that science merely reflected the biases of Western intellectual development and aimed to reinforce existing social power structures (Foucault, 1970; Bourdieu, 1988). Then, without the possibility of objective knowledge, nor scientific axioms, many of the social sciences reoriented themselves to subjective interpretations, 'textual analysis,' and deconstruction as their primary methodological tools. For many academics, the focus of these methodologies was intuitively welcomed because they validated personal experience in a way that was previously unheard of in academia.

However, this emphasis on subjective realities and 'texts' is particularly dangerous for two reasons. First, the focus on subjectivity, and the indeterminacy of language/truth drew many academics attention away from large-scale practical problems such as climate change.[2] Second, over the past 40 years, psychologists have been documenting an ever-growing list of psychological biases that paint a condemning view of subjective rationalizations as a set of self-confirming, weak attempts at moral self-justification (Haidt, 2001; Kahneman, 2011). It is precisely because our minds are so prone to such fallacies that demonstrates exactly why replicable, testable methods with strong theoretical orientations, which are ultimately tied to physical reality, are of the utmost importance in the study of human behavior.

Nevertheless, a resolute suspicion amongst many social scientists remains against the scientific enterprise as a whole. This doubt is partially due to a skepticism of the ability of scientific methods to uncover reality with any greater clarity than that found in other systems of knowing. However, the history of the 20th century demostrates the power of the scientific method. Consider that near the end of World War II, two atomic bombs were dropped on Japan. These weapons were created because our scientific knowledge of the fundamental constituent's of the sub-atomic world was sufficient to produce almost enough

[2]It was once remarked to me in this department by a senior academic, that 'w*hile we do not believe in a scientific world view*, we must used it to understand climate change.'

energy to destroy a modern city with a single warhead. Throughout the 20th and 21st century, scientific advances have populated our world with computers, GMO's, DNA tests, space stations, neutrino detectors, etc. The scientific method does, *on average*, produce a privileged view of reality, but this is because it is a *method* that involves debate, contention, doubt and replication. It is by demanding that all claims to knowledge are formulated into hypotheses and tested against a physical and external reality, that the scientific method gains its power.

Even when it is granted that a scientific worldview has a privileged view of the natural world, many still doubt the contribution that the biological sciences can make to understanding social life. This is because culture is often thought to be the primary, if not the sole determinant of behavior. However, the functioning of culture; the symbols and the interpretation of them, is wholly dependent on basal biological processes – a fact that is often neglected (See Pinker, 2003). To account for how a mind can store information, process symbols, transmit complex ideas and create culture, *without* neurological processes and genetic expression, requires that the standard social science model posit some metaphysical injunction to account for this disconnect.

This disconnect between the functioning of physical reality and the operation of social life sits at the heart of the third primary criticism of the scientific method, the *rejection of reductionism*. That is, the belief that a purely reductionist worldview, based on atoms, molecules, hormones, neurons, etc., cannot account for emergent meta-level properties such as subjective consciousness, social reality, and culture (Durkheim, 2012; Nagel, 1974).

However, if one accepts the most basic causal axiom, *causal determinism*, that everything has a cause that preceded it – then it must be strictly true that all behavior must ultimately be linked to the movement of atoms. Outside of some measurement uncertainties in quantum mechanics, there are no significant challenges to causal determinism. Therefore, it would follow that consciousness and social life must be a by-product of orderly lower level physical operations. Where the real intellectual challenge lies, is in accounting for how to move from causal processes at lower levels to behavior at higher levels.

Formally, most of the disbelief that causal determinism can lead to emergent complexity does not rest with the logical coherency that links physical laws to emergent psycho-social processes. Instead, it is because humans lack the cognitive processing power to perceive, comprehend and represent the interrelated causal processes interacting across vastly different spatial and temporal scales.

This inability exists for a good reason, our minds did not evolve to process information about the intricate functioning of the universe or to perform sophisticated logic based calculations, but instead our minds are built for survival and reproduction. As such, we cannot map reality in one-to-one fashion. Our processing and representational abilities cannot naturally link millions of years of genetic selection to neurological structures, to action potentials, to the subjective experience of reality, nor to the interaction of billions of people

across the globe.[3]

Instead, what are readily available to our perceptions' are newspapers, magazine covers, nightly news, music, art, and movies. As such much social theorizing focuses on these immediate sources of cultural causation (eg. Zizek, 1989). The result is a circular, horizontal explanatory framework, where culture both causes and is the product of behavior. Most of the social sciences have existed comfortably for nearly a century without reference to the true basic causal structures that operate at lower levels of functional organization. Intellectually this approach is weak because it simply ignores biology and evolution and therefore forgets what the eye cannot see.

1.3 Evolution and Social Behavior

Encouragingly, over the past 25 years, we can observe an emerging consensus amongst some evolutionary biologists, anthropologists, economists, psychologists and neuroscientists as to the evolutionary foundations of humans' social behavior (Tooby and Cosmides, 1992; Pinker, 1999; Wilson and Wilson, 2007; Boyd and Richerson, 1986; Alexander, 1987; Bowels and Gintis, 2011; Lieberman, 2013). The most fundamental proposition of this framework is that the principles of evolutionary change; variation, selection, and retention, does not just affect the evolution of physical traits, but over the course of the past 3.7 billion years, evolution has also been sculpting organism's social behavior as well. Evolution has selected for social traits because social interactions amongst conspecifics are one of the most basic aspects of almost every individuals' organisms life. Living in social groups produces a consistent set of adaptive problems that affect reproduction and survival (Silk, 2007). These include coordination problems, cooperation dilemmas, conflicts for resources, mating, and parental investment. Heritable adaptive traits that conferred an evolutionary advantage in these domains have been selected for and have been under cycling and evolving throughout populations for millions of years.

Central to evolutionary explanations of social behavior, is the fact that there are two fundamental levels of causation that account for why a trait is selected for and how it functions (Mayr, 1993; Laland et al, 2011).

1.3.1 Ultimate Causes of Social Behavior

Ultimate causation accounts for the evolutionary benefits in reproduction and survival that a trait confers and the necessary conditions (environmental or social) for the trait to confer that advantage. The most fundamental proposition that must hold true for any ultimate evolutionary explanation is that the trait under question must promote the spread of the gene(s) that underlies it expression. That is, for a trait to be an evolutionarily stable strategy, it must perform at least as well as, or better than all other traits in the population

[3] Without the aid of simplified simulations

(Maynard-Smith and Price, 1973). If the trait is deleterious to reproduction and survival, that is, it is strictly dominated by other traits in the population, then *ceteris paribus* it will be selected out of the population, and the characteristic or behavior will disappear.[4]

The simplicity of this statement hides a central fact about evolution; genes and traits do not exist in isolation. Instead, they are carried in chromosomes, organelles, bodies and social groups, and these 'vehicles' do not always have perfectly aligned interests. The fact that 'interests' are not always precisely aligned across all functional levels of organization means that traits can evolve which are beneficial at one level but deleterious to another. To illustrate, consider the genes responsible for cancer. These genes promote the unchecked spread of malignant cells throughout an organism and in doing so, those genes increase in relative frequency *within* a particular individual. The cancerous cells thrive and have extremely high levels of fitness within an individual. However, the tumor decreases an individual's reproductive success and therefore is deleterious at individual and group levels.[5]

The difference of scale demonstrates that what is adaptive at one level of organization may be maladaptive at another. The same principle applies to social behavior as well, that different social traits, such as altruism or spite, produce different effects at different scales.[6] This example demonstrates the core concept of multi-level selection; evolution and selection can operate simultaneously at different levels of the biological hierarchy (Okasha, 2006; Maynard Smith and Szathmary, 1996). The relative strength of selection pressures operating at each level of organization is what ultimately determines the success of a trait. This axiom has fundamental importance for the evolution of social behavior, because if over generations, the environment necessitates the functioning of groups, then traits which suppress selfish tendencies, and promote cooperation/altruism, can flourish (Sober and Wilson, 1999) and vice versa. Darwin noted during the 19th century:

> 'When two tribes of primeval man, living in the same country, came into competition, if (other circumstances being equal) the one tribe included a great number of courageous, sympathetic and faithful members, who were always ready to warn each other of danger, to aid and defend each other, this tribe would succeed better and conquer the other. [...] A tribe rich in the above qualities would spread and be victorious over other tribes: but in turn overcome by some other tribe still more highly endowed. [...] and this would be natural selection (Darwin 1871/2004, p. 155)'

Despite this observation, Darwin was acutely aware of the problem that selfish individ-

[4] This basic fact explains why altruism is an evolutionary conundrum, because it is costly to the individual, so it needs other mechanisms to explain its prevalence (Nowak, 2005).

[5] The fact that cancer has remained a part of our species genetic makeup is likely due to the fact that most cancers only begin to manifest after prime reproductive ages, when the impact on individual fitness is less significant.

[6] This very premise is that same idea that underlies the basic structure of the prisoner's dilemma. But in evolution, whether cooperation or defection will evolve is a product of the strength of selection operating at different scales.

uals within any group would outperform altruistic members within the group – thus, the evolution of social behavior must be understood as a tug-of-war between selection pressures at the individual and collective level (Wilson and Wilson 2006).

Groups have been fundamental to the survival of our ancestors (Dunbar, 1998). The long roots of our social heritage has resulted in the selection for traits that help humans function cohesively in social groups (Sober and Wilson, 1999; Nowak, 2006). These include altruism, empathy, inequality aversion, and a host of behaviors related to collective action and coordination. However, the correlation between individual and group success is not perfect. Instead, human life is full of competing interests operating at different scales; from children putting themselves before their families to nations pursing CO^2 intensive economies to the detriment of the planet.

On a grand scale, Maynard Smith and Szathmary (1996) have documented a series of systematic changes that happen to biological systems when they complete a transition towards a higher level of complexity, such as from single-celled to multicellular life. First, the ability of independent agents (at lower levels) to survive and reproduce becomes perfectly correlated with the success of functionally higher levels of organization. When this process takes place, those agents lose their ability to survive outside of these larger structures. Subsequently, to aid in collective functioning at new higher levels, competition at the lower levels is highly regulated and suppressed by system-wide feedbacks and checks. For human groups, neither of these conditions are entirely fulfilled, as we are not perfectly adapted to groups nor, completely individualistic. Thus Stearns (2007) has suggested that our species is stuck somewhere in the middle of the transition from being an individual to a group oriented species.

1.3.2 Proximate Causes of Social Behavior

Proximate causes, on the other hand, account for the flesh and blood of how the characteristic operates. In short, it describes the functional biology of the trait. How does it develop and grow and how does the trait respond to environmental pressures? What is the exact nature of neurological structure and what cognitive mechanisms and information processing heuristics that allow it to function? And finally, what kind of stimuli is the system sensitive to, and how in turn does it produce behavior?

For these selection pressures to telegraph their effects into social behavior, they have to rely on genetic networks that build neurological systems, which in turn produces behavior. Here, one of the simplest ways that evolution affects behavior is through prepared associations (Seligman, 1970). That is, evolution has selected for some stimuli/behavioral pairings that are easier to learn than others because of their important consequences for fitness. For example, due to the lag in evolutionary selection, people living in modern cities are far more likely to be killed by cigarette smoke, cars, and electricity than snakes or spiders, but yet still develop intense phobias against reptiles and insects and not against the threats of

modernity.

However, prepared associations only represent one small way in which evolution has sculpted the proximate causes of human behavior. The evidence now suggests that the brains of all organisms are composed of a vast number of functional, and semi-isolated cognitive modules (Tooby and Cosmides 1992; Pinker 1999; Kurzban 2011). These networks evolved to solve reoccurring adaptive problems within ancestral environments, such as social exchange, foraging, threat detection, mate selection, coalition formation, etc. The modules are often highly flexible to environmental conditions and allow for a comprehensive range of expression in response to cultural context. Roughly speaking, the modules provide a template that can be *recalibrated over the course of ontogeny*, and new modules can be created in a bricolage fashion which have no direct ancestral antecedents – such as ones dealing with literacy and mathematics (Heyes, 2012).

Life history theory predicts that the particular phylogenetic history and current ecology of the organism should result in a different emphasis on each of the three separate information input systems that affect the calibration of these modules. These information inputs that affect socio-cogntive modules include: 1) genetic preprogramming, 2) developmental calibration, and 3) 'on the fly' flexibility for novel situations (Kaplan, Hill, Lancaster, and Hurtado, 2000). Humans, who have extended periods of adolescent development with a high degree of neural plasticity that aids in the acquisition of cultural knowledge (Boyd and Richerson 1985, 2006), may have a significant proportion of their behavioral 'fine tuning' done in the first 25 years of their life. This flexibility is what accounts for the high degree of cultural variation found within the human species (eg. Markus and Kitayama, 1991).

The fact that different functional modules compose our cognitive process means that the mind is a specialized but malleable system and, not a domain-general information processing machine. This is because a general all-purpose computational device would simply be outcompeted by any device that was specialized early on to solve specific reoccurring problems over the life course (Pinker 1999). The reason why specificity reigns over generality, is because of the information processing constraints imposed on a domain-general system, which is not calibrated to distinguish between forms of stimuli that carry fitness-relevant information and those which do not. Any system that could provide linkages between relevant fitness stimuli and specific adaptive behavioral programs would have a significant advantage over a domain general/unspecified system, especially when there are recurring and predictable fitness challenges the species faces. As such, a large body of literature has developed that shows that many of the biases and heuristics that cause deviations from rationality are the by-product of functional cognitive modules that evolved to processes explicitly social information (Cosmides and Tooby 1992, Pinker, 1999, Kurzban, 2012, Dunbar, 1996).

Currently, there is substantial evidence to doubt that most human behavior and motivation is the product of effortful, purposeful, internally narrated rational action. Instead,

behavioral scientists have shown that it relies more heavily on emotions and intuitions (Haidt, 2012; Kahneman, 2011; Le Doux, 1998). Modern psychologists and neuroscientists have begun to catalog the operation of our cognitive processes into two primary neurological systems, simply called system one and system two (Kahneman 2011, Haidt 2012). System one, which is roughly based in the limbic-cortical pathways, and accounts for fast, intuitive, emotionally based motivations and decision making. More so, our understanding of the effect that hormonal systems such as the HPA, and oxytocin has on social bonding suggests that they are long-term endocrinological determinates of social behavior as well (Elliot and Gray, 2009). System one is evolutionarily ancient, and because most our behavior is entirely automatic, this system may, in fact, be the true 'great captain' of our lives.

System two, on the other hand, is often associated with rational, conscious, effortful deliberation. It is much slower, uses more energy than system one, and despite our lauding applause of it, it is still subject to many errors and biases. It is by no means free from information constraints imposed by individual learning/ignorance, cultural transmission, and neurological processing. System two is believed to be relatively new on the evolutionary time scale, probably appearing with the advent of language (Tomasello, 2014), and thus it is unsurprising that our neurological systems have not placed full behavioral control within systems one because a well-designed intuitive system is already in place. With this framework in place we now turn to the specific evolutionary challenges that are the focus of this thesis.

1.4 Evolution and Climate Change

1.4.1 Inequality Aversion and Climate Change

Let us first consider the question of inequality. At its most basic level, the fundamental adaptive problem that sits at the heart of inequality is about the distribution of resources amongst individuals (Peterson et al, 2013). Who has what, and how willing are individuals to invest effort in changing or maintaining the current distribution of resources? For most species, because cooperation and sharing is limited to close family and a few reciprocating partners, this problem typically takes the form of conflicts and contests over resources (Williams, 1966). Thus, these interactions typically assume the structure of an 'asymmetrical war of attrition' where individuals signal and fight with each other over a resource (Maynard-Smith, 1982). Here, any asymmetries in formidability allow stronger individuals to appropiate and defend resources. In turn, because animals typically wish to avoid full blown violent conflicts, these contests generate social hierarchies that establish preferential (but not exclusive) access to resources and the diffrential access to resources causes significant skews in reproductive success.

On a proximate level, the result of this selection is that individuals possess a host of behavioral and information processing systems related to social comparison, dominance,

submission, status, coalitions, and costly signaling. The neurological machinery involved in each of these processes is dedicated to promoting individuals to try and maximize their payoffs in these contests given their social and physical formidability and the existence of other relevant social and environmental cues.

It is often argued in evolutionary models that the most significant environmental factor influencing decisions whether to fight or share resources, has to do with the variability of the resource itself (Andras, Lazarus, and Gilbert, 2007; Kameda, Takezawa, Tindale, and Smith, 2002). The prediction is that the human mind has an evolved neural architecture allowing subjects to assess resource unpredictability, and adjust sharing and competition accordingly.

The proposed rationale for the proximate egalitarianism that underlie food sharing, which is ubiquitous among hunter-gatherers may, in fact, be a kind of resource pooling adaptation that aims to smooth the consumption of highly variable resources like protein (Kaplan, Gurven, Hill, and Hurtado, 2005). Because hunters have a high rate of failure, (only about 3% of hunts result in success), and as humans have high metabolic requirements (especially children), food sharing may have evolved as a collective risk pooling strategy to deal with high variance returns in limited, but highly valued resources. So alas the question becomes, what impact does climate shocks, like droughts have on individual's preference for the distribution of resources within their groups – do shocks make people more 'group oriented' and altruistic or would they make individuals more selfish?

1.4.2 Collective Action, Leadership and Climate Change

Our second area of concern is the evolutionary systems involved in leadership, collective action and coordination. A coordination challenge is an interaction whereby individuals can all gain mutually, but only if all participants make consistent decisions with respect to each other (Pancheco, 2009). Thus, coordination problems, whether they are social dilemmas or not, represent a fundamentally different evolutionary problem than economic redistribution because it involves group decison making processes. Such challenges are not strictly about the distribution of resources within a group, but instead, involve group decision-making processes that require all individuals to act in concert.

Large-scale cooperative dilemmas are typically modeled using n-person prisoner dilemmas, where each individual has a temptation to defect. Yet, when individual interests are well aligned these kinds of games can shift to become a pure coordination challenge (Skyrms, 2004). So while the most common evolutionary explanations of large-scale cooperation and collective action typically rely on altruistic punishment, group selection, and/or norms, it is clear that leadership and group decision-making apparatus are also fundamental to securing coordination (Van Vugt et al, 2008). In more basic language, authority, power and leader/follower dynamics are deeply entwined with large scale cooperation and coordination.

From an evolutionary perspective, leadership is adaptive, under some conditions, be-

cause it can provide a efficent mechanism to ensure group coordination (Ruve and Wilke, 1984; Van Vugt, et al, 2008). The evolution of traits that support leadership involves not just leaders themselves but also neurocognitive processes that aid in followership. Being a follower presents a serious adaptive problem to individuals because it involves voluntarily giving up a portion of their autonomy in decision making, and this can expose followers to exploitation.

Therefore, it is likely that humans possess a suite of neurocognitive computational programs that are geared towards both identifying situations when leadership is necessary, and to help determine who should be trusted as leaders (Smith, et al, 2015). We predict that these neurological systems are highly sensitive to information that indicates (a) the presence of a coordination challenge and (b) the degree of congruence between the follower's interest and that of the potential leader – because high congruence predicts a low threat of exploitation.[7]

1.4.3 Niche Construction, Emergence and Climate Change

Finally, on a broad scale, evolution is about more than understanding how natural selection has shaped the mind, because evolutionary processes take place in real time and in real natural ecologies. Thus, evolution also fundamentally involves the interaction between organisms and their environments reciprocally shaping each other. The physical (non-social) world creates the underlying conditions and adaptive challenges to which all organisms must respond to reproduce and survive.

This reciprocal relationship means that natural ecologies/habitats fundamentally shape social life and vis versa. For example, our once solitary proto-primate ancestors evolved to live in groups after the adaptive radiation of mammals, following the extinction of the dinosaurs. This transition is thought to have given rise to social groups because during that transition all primates, except prosimians, adopted a diurnal lifestyle, which significantly heightened the threat of predation; to which primates sought protection in the safety of numbers (Van Schaik, 1983; Shultz et al, 2011). More recently, it has been proposed that the origins of culture and language are tied to the rapid adaptations needed to survive the climatic uncertainties during the late Pleistocene (Richerson and Boyd; 2000).

Significantly, by adapting to their environments, organisms fundamentally change their own ecological and social worlds. As such they modify the kind and logical structure, of adaptive problems that their offspring inherit. In a way, this process creates self-induced natural selection, where the current selection pressures are the result of past adaptation. This process is called 'niche construction' and it means that species do not just inherit the genes of their ancestors, but their environments as well (Odling-Smee, Laland, and Feldman, 2003)

[7] There is likely a third criterion, the competence/quality of information possessed by a leader, prestige, but we do not test for it in this thesis.

The reciprocal process of adaptation affecting environments and thus changing selection pressure is typically slow for most species, as the rate of genetic change is measured on the order of generations. For humans, who have evolved language and culture over the past ~500,000-200,000 years, (Tomasello, 2014) the rate with which we have been able to adapt to our environments has increased by orders of magnitude (Perrault, 2012). By increasing the rate of evolution, culture has created a process whereby humans have begun rapidly reshaping their social and ecological environments at an unprecedented rate and with vast unintended consequences. As such, we are increasingly introducing novel evolutionary challenges on scales our species has never faced.

1.5 The Organization of the Thesis

While the subject matter of this thesis roughly lies within the realm of questions covered by traditional sociological inquiry, with its focus on inequality, group decision making and adaptation/social change, the theoretical underpinnings and methodological orientation is decidedly not sociological. Truthfully, this thesis's lack of disciplinary coherency does not concern the writer. Sociology has a few options, it can change and begin the painful transition towards the natural sciences and integration with the other social sciences that are already moving in that direction, or face a future of diminishing academic prestige. Therefore, the methods and theories used in this thesis are derived from the evolutionary social sciences but are applied to social problems central to sociology.

The thesis is organized in a way that each paper addresses a different scale of interaction between evolution, social life, and climate change. The first paper is concerned with the individual-level impact that climatological shocks have on the development of peoples' preferences for economic redistribution and fairness. Using modified dictator games and survey research, we test to see whether the severity of exposure to droughts, during critical developmental periods (0-25 years of age) impacts how people redistribute money to members of their own in-groups and members of out-groups. We find that individuals who are severely affected by shocks in their youth are more envious and spiteful than their unaffected counterparts. Our objective is to understand how the crisis, trauma, and existential threats imposed by extreme weather events shape the social preferences that shape social structures.

The second paper analyzes meso-level group dynamics and focuses on how individual behavioral dispositions affect the process of group decision making. Specifically, we investigate the conditions under which people are willing to accept voluntarily power and authority. By combining the results from our dictator games with the results from a modified public goods game (with leaders), we study the impact that individuals' 'other-regarding' preferences have on their willingness to vote for a leader to solve group level social dilemmas. The goal is to understand why, under some conditions, people readily accept leaders in group ventures and in other situations people resist them fervently. We find that both

economic egalitarians and individuals who expect that their community members are more trustworthy are each more willing to vote for leaders.

The final paper studies how both individuals, and group-level behavior influence macro-level social processes. By combining qualitative research with the literature on economic development, we review the range of adaptive strategies that people use to cope with droughts. We then combine these results with an analysis of historical and archeological data on how droughts affected past societies socio-political structures. This framework then allows us to explore how these acute adaptation strategies create emergent social structures and affect the long-term development of social systems. The goal of chapter 4 is to provide a historical framework to contextualize the potential paths that our current climate dilemma can take. We find that by stressing a societies adaptive capacity drought cause people to search out new adaptive strategies.

Chapter 2

The Long-Term Effects of Climate Shocks on 'Other-Regarding' Preferences: Inequality Aversion and Spite

> 'A group of villagers working out in the feilds found a lamp buried in the dirt. It spoke to them and offered each one a single wish. Joyous, the first said 'I have always wanted to be beautiful' – and so it was. Gleaming with envy the next in line looked over and said, 'make me more beautiful than him' – and so it was. Being a jealous sort, this continued through the whole group until it came to the last. She was smiling and said 'I want you to make them all ugly.'

2.1 Introduction

That individuals are not *just* self-interested is now well-established in economics (Roth *et al.*, 1991; Fehr and Gächter, 2000). People care about fairness, reciprocity, and sometimes altruism. In addition, when individual allocations are made to a group of people, each person will not only care about her own allocation but will also consider their relative standing in the group (Fehr and Schmidt, 1999; Bolton and Ockenfells, 2002). While inequality aversion may vary across cultures, it is both widespread and universal (Henrich et al., 2001).

Given the universality of "other-regarding" preferences, costly social behaviors like altruism and spite have often been cast in an evolutionary setting (Boyd et al., 2003). In order to explain generalized pro-social behavior, common conceptual models use small hunter-gatherer communities that are subject to exogenous shocks which threatens their existence.[1] In these circumstances, altruistic sharing or helping, may allow members of the group to withstand these shocks and survive but will put the giver at risk. In an evolutionary setting, altruistic behavior can be rationalized by the fact that even though the individual

[1] These are normally thought of in the context of tribal wars and inter-group competition.

bears a (fitness) cost in helping, they may receive benefits from this gesture through future inclusive fitness gains, reciprocation, or through other mechanisms such as the survival of community members who are vital to their own survival. As such, under a wide range of conditions, individuals in groups can evolve altruistic preferences in their genetic make-up (Nowak, 2006).

The case of spiteful behavior is arguably more involved than altruistic gestures. Spiteful behavior toward individuals refusing to cooperate will insure that defection becomes less attractive. Even though an individual may bear the cost of being spiteful, the group will benefit from this (altruistic) anti-social behavior (Fehr and Gächter, 2000; Masclet et al., 2003). Under this view, a spiteful act can be construed as an altruistic act aimed at keeping shirkers on their toes. On the other hand, Stuart West and Andy Gardner (2010) show that in an environment characterized by resource scarcity, non-cooperative spiteful behavior can also represent a direct 'defense mechanism' through which an individual is committed to behave more aggressively, to secure a higher *fraction* of the group's resource for herself or her kin-group (West and Gardner, 2010). Under this view, spite is an *competitive* phenomenon not *specifically* meant to increase cooperation within the group.[2]

However, irrespective of the exact underlying motivation for spite, for these explanations to work they require that, when shocks occur more often, say because of climate instability, preferences toward inequality aversion and spite should *somehow* become more pronounced within the group.[3] Arguably, climate shocks involving droughts seem to be good candidates to study the impact of 'stressors' on individual's social preferences. Indeed, these natural events are often followed by periods of food restrictions and during these moments, a more pronounced inequality aversion (IA) and spite can help to encourage food sharing and discourage defection. Alternatively, when shocks are extremely harsh, an aversion to disadvantageous inequality and a spiteful behavior can also help an individual to secure a higher portion of the available resources by reducing others' access.

Understanding the long term relationship between climate shocks (together with their associated trauma) and preferences for inequality aversion and spite is the main theme of this paper. In this study we use both surveys and behavioral experiments in three populations of subsistence level farmers in Tanzania to provide evidence that severe exposure to droughts during critical developmental periods (between birth and 25 years of age) can permanently calibrate an individual's social preferences for inequality aversion and spite. Therefore, our study is the first to our knowledge that is able to demonstrate that there is consistent and permanent effect from climate events on the development of other regarding preferences.

An emerging stream of research has begun to address whether natural disasters can affect peoples' social preferences in the short term, but so far the findings are inconclusive.

[2] This distinction is important since indiscriminate spite actions will not (often) foster cooperation and, hence, will be Pareto inferior.

[3] In the coming section on "developmental Canalization," we will discuss the exact transmission mechanism between the harshness of the environment and the pro-social nature of the individual.

Despite a variety of effects demonstrated, such as changes in risk taking (Eckel, El-Gamal and Wilson, 2009), trust (Cassar, Healy, and von Kessler, 2011), and altruism (Castillo and Carter, 2011), there is no established consensus as to why these effects take place. While some studies show behavioral effects that last for many years, research on economic shocks in the US indicates that the effects of shocks on social preferences during adulthood tends to be temporary (Hatemi, 2013). People revert back to their pre-shock preferences over the long run. In contrast, a recent study by Michal Bauer and colleagues (2013) found that, cross culturally, exposure during childhood to war is associated with increases in both inequality aversion and parochialism into adulthood. More precisely, subjects affected by wars, years later, were more willing to forgo their own allocation in order to reduce *both* advantageous and disadvantageous inequality within their group.

While wars can be perceived as a threat that is *external* to the group, droughts (and the food scarcity that results) represent a stressor that, from the individuals perspective, exacerbates social tensions *within* the group. Taken together, these considerations beg the question as to whether droughts experienced during critical developmental periods can have distinct or similar enduring effect on social preferences that spans a lifetime.

In an influential article, Ernst Fehr and Klaus Schmidt develop a formal model of inequality aversion whose objective is to account for the strong behavioral evidence that humans are indeed averse to some forms of inequality. In their framework, an individual receives a direct utility from her allocation but suffers a negative utility when her allocation is strictly lower than that of the average of the other players and, to a lesser extent, when her allocation is superior to that of the average of the rest of the group. In their model, individual's incentives to become spiteful lie in the magnitude of the parameter describing their distaste for disadvantageous inequality (see also Fehr, Hoff and Kshetramade, 2008).[4] In essence, an important contribution of our paper is to uncover a crucial long-term determinant of the strength of inequality aversion. More precisely, we show that trauma induced by severe climatic shocks can permanently bias individuals toward a stronger aversion to disadvantageous inequality. Moreover, we show that this aversion is directed towards members of their own community, and leads them to make more spiteful allocation choices towards the in-group. However, unlike Bauer and colleagues (2013) for wars, we show that this effect is *one-sided* in the sense that affected individuals do not become more averse to advantageous inequality; it therefore results in Pareto inferior outcomes.[5]

To study the impact of drought induced trauma on inequality aversion, it was *necessary* to document the history of each of our players. Thus, our work uses a combination of

[4]Similarly, Gary Bolton and Axel Ockenfells develop an operational model of other-regarding preferences in which a player receives a non-pecuniary loss when her allocation differs from the average allocation received by other players. In their setting, the relative importance of this loss (as compared to the direct pecuniary gain) can be captured by a parameter measuring the strength attached by the individual to the difference in allocation.

[5]More precisely, subjects severely exposed 'climate stressors' tend to reject a monetary allocation that "grow the pie" (i.e. one that gives strictly more to them and their in-group game partner) *if* this allocation results in them having (strictly) less than their in-group partner.

experimental games and survey research to begin to fill these gaps in our existing knowledge. More precisely, we constructed a 'severity index' to measure people's exposure to traumas related to extreme drought events. This index captures how severely participants have been affected by droughts over their lifetime and is corroborated with extensive oral histories.[6]

The standard in the literature in early life stress research is to rely on potentially subjective reporting by participants because, it is *precisely* that subjective experience that calibrates future behavioral responses. While our survey relies on factual questions rather than impressions or feelings, our measure of the intensity of a trauma (obtained through the participant's report) is combined with game experiments. This procedure might thus be subject to endogeneity issues. A participant's description of their trauma may have some subjectivity imbedded in it, even if reporting choices are actually designed to be factual and thus minimize any sort of systematic distortion. Therefore, it is impossible to rule out that our intensity of exposure measure and the report that is made on it might be affected by the very social preferences that our games measure. To check the robustness of our findings, we construct an additional index in which participants cannot inflate or deflate their exposure with weather-related trauma. We simply use the age at which the worst shock was incurred. This anodyne single piece of information allows us to mostly replicate the results obtained with our more rich (yet perhaps more subjective) measures of weather-related trauma.[7]

Overall our experimental set-up is simple and was originally devised to study inequality aversion in chimpanzees but has more recently been adapted to humans (Fehr, Bernhard, and Rockenbach, 2008; Silk et al., 2005). The modified dictator games we use allow us to capture a wide range of behavioral profiles, from inequality aversion, altruism and spite using real (substantial) incentives.

As emphasized earlier, the effect of trauma on social preferences that we uncover are long term effects. Yet, pointing to a plausible causality between a subject's current behavior and events that took place in her life, say 20 years ago needs to be carefully argued. Therefore, in the next section we review the recent experimental evidence on both IA and spiteful behavior, their neurological mechanisms, and the developmental canalization of these traits to show that causality between trauma and disadvantageous inequality aversion is more than likely.

Our focus on the neurological and developmental literature is crucial, because it emphasizes that inequality aversion and spite are controlled by real physical neurological systems that are subject to a developmental calibration. On top of that, the emerging evidence

[6] As described by Chuang and Schechter (2015), there is a recent literature on the impact of natural disasters and conflicts on risk and social preferences. However, the authors also note that this literature gives very contrasted results "with no signs of converging to one consistent set of results". Perhaps an important contribution of our study is to stress the importance of documenting *when* shocks were incured by subjects. As shown in our result section, failure to control for the subject shocks' history yields unconclusive results as far as social preferences like inequality aversion and spite are concerned.

[7] More precisely, in our population we show that the other-regarding preferences of our participants can be inferred with relative precision if we know *when* their worst weather-related year happened. In this robustness check, note that the threshold of the *25th birthday* plays (again) a crucial role.

from developmental studies provides a mechanistic pathway that can account for our findings. Section 3 describes our sample, explains our experimental procedures, and presents our basic results. Section 4 proposes several alternatives interpretation of our results and show why they can indeed be discarded. Finally, section 5 concludes and discusses several possible avenues for future research.

2.2 Theoretical Considerations and Literature Review

2.2.1 Inequality Aversion and Spite

While humans and other animals (Range et al., 2009; Price and Brosnan, 2012) display an aversion to inequality, the evidence points to the conclusion that an aversion to self-disadvantageous inequality (DI) is both an older and stronger evolutionary force than its more altruistic counterpart (an aversion to self-advantageous inequality (AI)) (e.g., Loewenstein, Thompson, and Bazerman, 1989). In evolutionary systems, the combination of limited resources, rapid population growth and iterated payoff based replication means that evolutionary dynamics are far closer to models exploring market share competition than anything else (i.e. profit maximization). The result is that under most evolutionary conditions, success approaches a zero-sum game, *making relative payoffs matter*.[8] Therefore the cognitive systems that are used to evaluate payoffs must include a population or 'local competitive environment' reference point that allows individuals to track both advantageous and disadvantageous inequality.

The universality of DI aversion is confirmed by cross cultural research (e.g., Hager, Oud, and Schunk, 2012). These species wide behaviors are motivated by two main neuropsychological mechanisms. First, *envy*, which is a universal human motivation that functions both as an alarm system that directs attention towards relative payoffs and as a motivational apparatus that regulates energy and time allocations towards intraspecific competition (Hill and Buss, 2008). Second, on a cognitive level, there are suggestions in the research that humans may possess a bias that influences our perception of competition to mistakenly assume that most interactions are inherently zero-sum (Różycka-Tran, Boski, and Wojciszke, 2015; Meegan, 2010).[9] This zero-sum bias would, in turn, lead our cognitive evaluation of payoffs to place more weight on relative payoffs which in turn can motivate DI aversion as opposed to strict maximization.

Spite is fundamentally linked to the ultimate and proximate causes of DI aversion. Spite is the willingness to pay a cost to harm someone else when there are no immediate gains. Because of spite's cost and its lack of apparent benefits, it is much like altruism, an evolutionary 'anomaly' that requires specific mechanisms to evolve. Although William D.

[8] As does competition.

[9] On the other hand, an aversion to self-advantageous inequality is not motivated by basic emotions such as envy. Instead an aversion to AI presumably is motivated by the fear of spite and hostilities. Similarly acquiescence, tolerated scrounging, and the inculcation of justice norms and humility are behaviors consistent with aversion to AI.

Hamilton originally proposed that spite would constitute a weak evolutionary force, it is now recognized that the conditions under which spite can evolve are considerably broad. Mechanisms that promote the evolution of spite include negative relatedness (Hamilton, 1970), negative assortment (Lehmann, Feldman, and Rousset, 2009), highly localized competition (Gardner and West, 2004), and fairness considerations (Forber and Smead, 2014). Animal studies demonstrate spiteful behavior for a wide range of species including wasps (Gardner et al. 2007), bacteria (Riley and Wertz, 2002), and sticklebacks (FitzGerald, 1992).[10]

The primary psychological mechanism motivating spite is *schadenfreude*; the joyful sensation felt at someone else's pain (Caitlin Powell, Richard Smith, and David Schurtz, 2008). Unfortunately, our understanding of spite in humans is complicated by the fact that spite can fulfill two distinct, yet related functions in social behavior. First, spite can be used as a competitive strategy used to reduce DI, in competition between kin groups, and as a credible signal to deter challenges. On the other hand, spite can also be part of a broader set of cooperative strategies used as a punishment to deter defection, enforce social norms and secure egalitarian outcomes, all of which participate in the collective functioning of groups.

2.2.2 Allocation Processes, Disadvantageous Inequality Aversion and Spite

Perhaps the single most important insight into the nature of DI aversion and spite is that the magnitude of their expression is directly related to how initial inequalities are created in the first place. For example, are the inequalities created through random forces, such as unpredictable weather events/rolling a dice, or instead are they due to intrinsic characteristics or behavior of the individuals involved, such as skill and/or effort? In their now classic study, Elizabeth Hoffman and Matthew Spitzer show that in dictator and ultimatum games, if the first mover advantage is acquired randomly, individuals are more willing to redistribute their winnings, and reject unfair offers than if it is decided by skill (Hoffman and Spitzer, 1985). These findings are supported by research on the public perception of redistributive policies; individuals are more accepting of inequalities when they correspond to the amount of effort invested. On the flip side of the coin, people are more willing to support redistribution policies when inequalities are produced through random forces (Petersen et al., 2012). On a mechanistic level, neurological studies find that reward systems in the brain are significantly more sensitive to gains and losses when effort is involved (Hernandez Lallement et al., 2014) and that the willingness to play spiteful strategies to reduce DI is negatively correlated with the effort invested (Cappelen et al., 2014). This connection is important for us because climate shocks can create both acute and prolonged inequalities through processes akin to random allocations (Bowles, Smith, and Borgerhoff, 2010). In essence natural disasters and the fortune and failures they produce are randomly

[10] Yet, there remains a debate as to whether our closest ancestors, chimpanzees, show spite or merely self-interest (Jensen, Call, and Tomasello, 2007).

distributed and have very little do with skill and/or effort. Therefore the frequency and intensity of shocks may influence the development of an emerging sense of fairness through this pathway.

The fact that the behavioral system - related to ownership, fairness, and IA responds to whether the allocation of resources is the result of random events *or* skill/effort may sit at the heart of the evolutionary puzzle of why humans have such elaborate sense of fairness. Evolutionary anthropologists have long suspected that our egalitarian ethos may have evolved to its current state in the context of sharing critical, yet scarce resource like meat among our hunter gatherer ancestors (Kaplan et al., 2005). Amongst hunter gatherers, hunting success is highly variable, and in order to smooth the consumption of meat, hunters are required to share their gains with unrelated camp members as part of a social insurance network. Therefore, when returns on critical economic activity are highly variable (i.e. lottery winnings/hunting or farming returns during climatic instability), this insecurity may trigger a strong aversion to DI. This, in turn, motivates behaviors such as scrounging, and a sense of entitlement to the windfall gains of others, as well as motivating spite to enforce egalitarian allocations (Marlowe et al., 2010; Kameda et al., 2010).

2.2.3 Developmental Canalization

For our purpose, it is also important to recognize that, like most behavioral systems, the expression of DI aversion will be affected by early life events. Developmental canalization is the adaptive response of a genotype to environmental conditions present during critical developmental periods. The developing animal integrates information from its environment into its genetic expression and produces an adult phenotype that is better adapted to existing social and ecological conditions. The canalization process is not random - existing pathways are the result of a natural selection on the variety of canalization pathways present in ancestral populations. If IA has some kind of genetic component, which behavioral genetics, and our phylogenetic heritage suggest it does, then the development of sub traits like an aversion to DI, and spite should equally be sensitive to environmental stimuli during critical developmental periods (Bell, Schermer, and Vernon, 2009). The important question though is; what kind of stimuli are these behavioral systems sensitive to? Why would environmental shocks affect DI aversion and spite? Is this due to intense zero-sum competition over critical resources during shocks, or is it because the random nature of shocks creates inequalities that inform an emerging sense of fairness?

The developmental origin of spite and DI aversion has two potential sources.

The first, suggested by Simone Shamay-Tsoory, Dorin Ahronberg-Kirschenbaum, and Nirit Bauminger-Zviely (2014), is that it develops in the context of competition over scarce resources and, thus, is fundamentally about the *scale of competition and selection.* Arguably, the earliest form of competition for most animals is amongst siblings for parental resources such as attention and food. Examples of rivalry and murder amongst siblings are common

in the wild and includes competition between baby eaglets and pelicans (Cash and Evans, 1986) and between shark embryos (Joung and Hsu, 2005). Competition amongst close kin is disfavored in the context of broader social interactions among non-relatives. But, when the scope of social contact is limited to zero-sum competition amongst a few siblings for critical parental resources, then costly behaviors such as an aversion to DI and spite can be favored in so far as they can guarantee high relative fitness payoffs.

This theory on the development of spite and envy is built on competition for critical resources during early development. In turn, it predicts that the temporary, highly localized zero-sum competition induced by climate shocks[11] can create a situation where costly strategies are favored in order to maintain relatively high returns while depriving competitors of access. If crisis events are frequent and intense, then the associated trauma from food shortages and highly localized competition can increase a persons aversion to DI, simply because of the importance of an immediate relative advantage over nearby competitors. As a result, DI can become perceived as a greater threat and the neurological system that monitors potential threats will become more sensitive to unequal allocations and will dedicate more energy and resources towards avoiding them. This prediction is consistent with a multilevel selection approach, as during climate shocks the scale of competition is reduced to the individual level, rather than during war where selection is on groups.

Independently of intense competition, spite and an aversion to DI can develop in the context of an emerging, generalized sense of fairness (Boehm, 1999). As noted above, DI aversion and spite develops as a set of preferences that are sensitive to the allocation and distribution of resources and inequalities. The evolutionary rationale for this hypothesis is that the human sense of fairness, evolved in order to smooth consumption irregularities of critical, yet highly variable resources, like meat (Kaplan et al., 2005). If droughts and other random weather shocks signal inconsistent economic returns, then this information would calibrate the developing sense of fairness to become more averse to DI and encourage spitefulness in order to secure cooperative sharing, and reduce inequality.

Research into the ontogeny of fairness now shows that a concern about the distribution of resources develops very early as an integrated part of emerging social emotions, and cognition. A recent study by Alessandra Geraci and Luca Surian, shows that infants as early as 16 months do prefer egalitarian outcomes to unequal ones (Geraci and Surian, 2011). This early developmental trajectory is confirmed by Vanessa LoBue and her colleagues who report that even three years old children react negatively to disadvantageous inequality (LoBue et al., 2011). In a series of studies using methods very similar to our own, Ernst Fehr, Helen Bernhard, and Bettina Rockenbach show that envious and spiteful intentions are present in children as young as 3-4 but declines over later development (Fehr, Bernhard, and Rockenbach, 2008). While a follow up study on adolescents showed that during adolescence, individuals become more envious, and less spiteful towards in-group members (Fehr, Glatzle-

[11] such as competition for limited food during a drought.

Rutzler, and Sutter, 2013).[12] However, to the best of our knowledge, no other work than Bauer et al. (2013) on the impact of war on egalitarian preferences has shown what kind of developmental experiences can shape the calibration of social preferences.

2.2.4 Neurological and Developmental Studies

Neurological studies on IA and spite have the advantage that they can pinpoint the involvement of exact neural structures and strongly suggest deterministic causal mechanisms. In general, DI aversion is associated with evolutionary old limbic-cortico pathways that involve the ventral striatum, the insula, the anterior cingulate cortex (ACC), the amygdala, and the orbital-prefrontal cortex. While the function and connections of these neurological systems may be unknown to many of our readers, we include this review because it is critical to understand that the neurological systems involved in thinking about inequality aversion are physical realities. They are composite networks of neurons in the brain which can be *permanently* altered through experience and genetic expression.

In the research done on western populations the focus on developmental adversity is unsurprisingly not about climate shocks and their associated trauma, but instead stress related to childhood abuse and maltreatment - nevertheless this research shows that there are real functional changes in neurological processes as the result of early life stress. If these effects are general enough then the early life trauma associated with climate shocks should result in those individuals who are severely affected having physical differences in their neural structure, and actually process information in a different way than the unaffected population. These changes can be particularly strong because systems involved in thinking about inequality are broadly characterized as system 1 processes, i.e. they are rapid, intuitive and usually outside of conscious control (Kahneman, 2011).

In brief, the neurological subsystem involved in processing and acting on information about inequality can broadly be construed as being composed of six parts that includes: 1. A system that values both relative and absolute payoffs 2. An assessment of how the payoff structure will not only affect the self, but also other members of the social group (i.e. empathetic considerations) 3. A threat detection mechanism that assesses how the allocation will affect fitness (i.e. will it result in a shift in the dominance hierarchies structure?) 4. A system that produces the subjective experience of pain or pleasure from the allocation's effect on both the self and others. 5. A system that motivates responses to adjust the allocation (i.e. spite) and 6. A system involved in assessing, regulating, and providing executive control over the intuitive responses (i.e., should a spiteful action be taken or is it too costly?) .

The *ventral striatum* (VS) is the central brain structure involved in processing and valu-

[12] An important note is that these studies differ from ours in the fact their envious choice, is not costly, the children are not having to pay a cost to be adverse to DI, this impacts their behavioral type of spiteful as it does not involve paying a cost.

ing rewards (Schultz, Tremblay, and Hollerman, 2000).[13] Activity in the ventral striatum does not simply assign value to absolute payoffs but is highly reactive to relative returns and social comparison (Fliessbach et al., 2007). Importantly, Klauss Fliessbach and colleagues finds that the VS is more responsive to relative, rather than absolute losses and is therefore highly involved in the valuation of DI (Fliessbach et al., 2012). In addition, the VS is linked to schadenfreude (Takahashi et al., 2009), paying to reduce inequality (Vostroknutov et al., 2012) and altruistic punishment (de Quervain et al., 2004). The implication is that the VS is involved in the cost/benefit calculations related to using aggression and spite to adjust inequalities and enforce cooperation. In short, the VS both places weight on the value of relative payoffs *and* produces the motivation to use costly strategies to adjust the allocation.

Decades of study on addictions show that repeated, *early life stress* (ELS) changes the way the VS processes rewards – which later in life produces vulnerabilities to addictions (Andersen and Teicher, 2009). While this research shows us that ELS can alter the development of the VS - exactly how these findings relate to inequality aversion is poorly established. Fortunately, a recent study looking at charitable giving amongst survivors of a magnitude 8.0 earthquake in China found that seriously affected individuals showed less activation in the VS in response to gains than losses - increasing loss aversion (Wei et al., 2013). This functional change in the VS illustrates a mechanism that adjusts the valuation of DI in response to shocks. Crucially though, because the VS is more sensitive to relative returns, its calibration *should be anchored by social comparisons with others.*

The anterior cingulate cortex (ACC), is unique to mammals and is associated with error detection and social emotions (Bush, Luu, and Posner, 2000) such as social bonding, exclusion, and parental attachment (Rotge et al., 2015). The ACC acts as an alarm system with two basic components, one that tracks threats to social bonds, and the other motivates behavioral responses to threatened relationships (Eisenberger and Lieberman, 2004). The ACC is activated in relation to unfair offers in ultimatum games (Sanfey et al., 2003), costly aggressive retaliation (Joseph et al. 2009), and schadenfreude (Takahashi et al., 2009). A few emerging studies show that ELS results in a reduction in the volume of the ACC resulting in neurotropic effects on moods disorders (Gerritsen et al., 2012). These findings suggest that the role the ACC plays in DI aversion is to track the threat to social relationships that a disadvantageous allocation represents, and then triggers social responses.

The amygdala, a central part of the limbic system, is involved in arousal, emotional salience, fear, vigilance, anxiety, and the regulation of the stress response.[14] Because of its association in responding to a disadvantageous inequality (Gospic et al., 2011), rejection in ultimatum games (Gospic et al., 2011), and paying to reduce DI (Yu et al., 2014), we strongly suspect that the amygdala involvement in DI aversion is in detecting the threat that DI poses, and triggering intuitive responses.

Developmental activity in the amygdala peaks in early life and then levels off during

[13] Including Money, Sex, Reputation and Drugs.

[14] For a full review of its functionality, see Elizabeth Phelps and Joseph LeDoux (2005).

adulthood (Guyer et al., 2008; Payne et al., 2010). The high level of activity during childhood is due to the vital process of learning about threats in the environment that takes place early in life. During these years ELS, is found to alter the structure and function of the amygdala (for a review, see Tottenham and Sheridan, 2009). The amygdala becomes more reactive to threats, and less effective at inhibiting emotional responses.

The insula is a limbic related cortex involved in the visceral experience of emotions (Damasio, 2008) and is also the primary neurological structure associated with processing physical and social pain (Eisenberger and Lieberman, 2004). There is a positive correlation between activation in the insula and rejections in ultimatum games (Sanfey et al. 2003), egalitarian behavior (Dawes et al., 2012), and moral/physical disgust (Phillips et al., 2007). Interestingly the insula is also associated with empathy. Tania Singer and her colleagues (2006) show that while the insula reacts to the observation of a partner receiving shocks after an ultimatum game, if the partner made an unfair offer in the game, the activation in the insula decreased (less empathetic pain) and activity in the VS increases (increased reward). These results suggest that the decrease in activation in the insula that follows unfair offers dampens empathetic responses to others pain, and make spite more appealing. Research on the effects of ELS on the insula, shows that this area and the related areas involved in emotional processing become enhanced in their centrality of the brain's neural network due to childhood adversity (Teicher et al., 2014).

In summary the literature indicates that shocks can have an impact on IA preferences by inducing structural changes on the underlying neural substructures. First, functional changes take place in the ventral striatum which affects how rewards are processed, making people more loss averse. At the same time that the reward system is being reorganized, the amygdala develops to become more reactive to potential threats (such as DI), and is less able to inhibit emotional reactions. The research on the ACC and Insula is in its infancy but suggests functional changes in the experience of pain, empathy and in mood disorders. Finally, we suspect that all of these changes interact with the well-known effects of ELS on the hypothalamic-pituitary-adrenal axis and stress response system (for a review see Lupien et al., 2009). The threat posed by DI triggers an elevated stress response that, remains in place for longer periods of time and, in turn, can motivate an aggressive and spiteful response.

Overall, a testable hypothesis from the developmental canalization review is that *Early Life Stress* calibrates neurological pathways to facilitate envious and spiteful behavior. Yet, as the literature demonstrates, these systems should be more responsive to relative rather than absolute returns because the mechanisms are fundamentally involved in social comparison. This means that, in a young age, individuals who are repetedly exposed to shocks that have a severe and marked impact on their lives, relative to others around them, should become more averse to disadvantageous inequality and subsequently more spiteful. In the next sections, this hypothesis is tested within the context of climatic shocks.

2.3 Methodology

2.3.1 Sample

The participants of this study are small scale subsistence farmers, from six villages across three ecologically *distinct* regions of Tanzania. We can broadly characterize the three regions by their rainfall patterns, the wet region is in Mvomero and has two villages, Kunke and Kidudwe with an average annual rainfall around 1135mm, the medium region, also in Mvomero has two villages, Wami Luhindo and Wami Sokoine, with annual rainfall averaging 831mm and finally the dry region is located in Kongwa, and the two villages are Ihanda, and Masenyeti in Kongwa with 589mm of annual precipitation. In each ecological zone, we have two sample villages that are no more than a 10 minutes motorbike ride apart. At least one village in each region is part of a larger, long term development research project that introduces dairy goats and new root crop varieties to farmers.

Farmers today still practice subsistence agriculture on farming plots of land with a median size of 6 acres. The crops that they grow vary from region to region. In the wet regions they mostly grow rice and maize, while in the drier region their main crops are maize, sorghum, and millet. Farming is still done with a hoe in hand, and labor is a major constraint on productive capacity. In the medium and dry region, farmers also practice small scale agro-pastoralism but herds are modest, averaging around 3 heads of cattle. Table I.I and table I.II below provides summary statistics for our overall sample and for each study region respectively.[15]

Table I.I - Summary Statistics

	Average	SD	Median
Age	43.5	13.7	42
Sex (Male)	60%	49%	1
Family Composition (total brothers and sisters)	6.6	3.7	6
Market Integration (% of calories purchased)	39%	25%	38%
Wealth (CAD)	$2385	$965	$2179
Annual Income (CAD)	$1783	$899	$665
Severity of Exposure	39.9	72.7	17
n=180			

[15] The variable wealth is a composite measure with three components: the value of the house, the value of land, and the value of the cattle. The construction of the variable "severity of exposure" is explained in subsection 3.2.

Table I.II - Summary Statistics by Region									
	Wet Region (Turiani)			*Medium Region (Wami)*			*Dry Region (Kongwa)*		
	Mean	SD	Median	Mean	SD	Median	Mean	SD	Median
Age	41	12	40	45	43	42	43	14	42
Sex	58%	50%	1	63%	49%	1	58%	50%	1
Family Composition	5.9	2.69	6	7.6	5.14	6	6.3	2.4	6
Market Integration	39%	18%	40%	54%	26%	55%	23%	20%	19%
Wealth (CAD)	$3023	$3124	$1995	$3608	$9381	$1498	$1280	$1821	$1709
Annual Income (CAD)	$1425	$1433	$968	$3316	$15163	$876	$524	$533	$316
Severity of Exposure	24	29	14	20	22	12	74	113	35
n=180. Each region has 60 participants spread across two villages, with 30 in each.									

All of the villages historically practiced some form of communal labor/sharing of basic resources. In recent years these norms have been deteriorating. In our long form interviews, farmers speculate that these changes are a result of an increasing integration into local labor markets. While community level sharing is deteriorating, clan and kinship networks are still strong. This is most visible in the physical layout of villages, as households are still arranged around traditional clan structures, with a small number of independent households circling a common court yard – separated from other clans.

Nevertheless, the modernization process has influenced farmers in a limited way. Major changes include improved housing, motorbikes, local dukas (stores), cell phones, and to a very limited extent electricity. Yet, despite these changes rural life still remains a matter of face-to-face interaction, strangers are a novelty, formal governmental support is extremely limited (in non-election years) and market access is severely limited. In fact, these limited changes make these populations suitable as a rough approximation of how ancestral peasant farming populations would have lived for the majority of the human agrarian history.

As shown in table II, our sample consists of 180 randomly selected participants from the six villages spanning the three selected ecological zones. Participants were randomly selected using village residence logs. Subjects were invited to participate in the study by an agricultural extension officer a week prior to the actual experiment date.

In a day session, selected participants from a particular village were gathered at a focal point of the village, usually a government building or a school. Participants were briefed about the games they would play (four mini dictator games) and the survey they would take part in. Once a participant finished playing the games and completed the survey, she or he was separated from the other participants in order to prevent collusion. After all games had been run in one village, we would run them the following day in the corresponding neighboring village in order to reduce the chances of information spreading about the nature of the experiment. On average, participants could earn the equivalent of one day wage labor (˜4000tsh) and received 1000 tsh as a show-up fee.

On the one hand, the standard procedure in the literature on early life stress research is to rely on subjective self-reporting and 'stories' told by subjects because, ultimately, it is

these experiences (and their trauma) that are going to calibrate behavioral responses. On the other hand, there is the legitimate concern that variation in the self-reported reactions to exposure measure may not be fully exogenous because it is not exclusively based on temporal variation in weather shocks.[16] Such a measure may also entail self-reported reactions to past shocks, which are endogenous because the actual reaction to the shock and the *decision to report on it* are choices that could be affected by the very preferences that our allocation games measure.

2.3.2 Severity Index

Our main hypothesis relies on the history of the participants and more precisely on their relative experience of severe weather shocks during childhood, adolescence and early adult life. Thus, documenting their history of climate-related trauma in an objective fashion was a concern for us.[17] To mitigate subjectivity in 'retrieving' participants' history, we constructed a survey with mostly closed-ended questions regarding well-defined factual events of the subjects' life.

In the survey we measured a broad range of variables related to both the *frequency of exposure* to droughts and the intensity stressor events associated with the shocks, which we collectively call *intensity of exposure*. Our first measure, *frequency of exposure,* include questions such as 'How many severe droughts have you experienced over your life that have seriously altered your normal seasonal cycle? When was the most severe drought that you have ever experienced? How many of these were before you were 25? How many droughts have you experienced in the past 10 years?' Our second group of questions, which compose our *intensity of exposure* metric, are more concerned with stressors experienced during these shocks. This metric captures a range of *exposure events* that a person would typically experience as part of a shock. We focus on factual conspicuous events such as: 'Have you/anyone in your household ever had to sell land as the result of a drought? Have you ever had to enter into debt as the result of a drought? Have you ever had to migrate to find work? Because of a drought, have you ever had to eat wild foods you would not normally? During a drought have you become sick? or know someone who has died?'[18] Thus, for any answer "yes" to one of these questions our basic intensity measure would grow by one unit. Note that given the (sometimes) traumatic nature of these life events, we opted to administer the survey *after* the games were played to avoid 'priming' the participants in a way or another.

In order to create a metric that could capture the effect that shocks have on early life

[16] In fact, the correlation between actual rainfall and temperature and a subject's actual experience is tenuous at best. In many circumstances, most young subjects have been shielded from the trauma induced by climatic shocks simply because their family could take some precautionary measures.

[17] For instance, a particular social preference of a subject may be associated with a decision to distort report over particular aspects of his/her life.

[18] Each question (i.e. have you entered into debt) in both the frequency of exposure and exposure events was asked for each shock type (droughts, floods, and infestations).

development, we begin by establishing the necessary properties that a successful metric for our purposes should display. First, the metric must quantify an individual's *relative* rather than absolute severity of exposure to droughts. This is because the neurological systems that underlie inequality aversion are fundamentally involved in social comparison and research has shown that these evaluation systems are more sensitive to relative rather than absolute returns (Fliessbach et al., 2012). Therefore, the impact that climate shocks may have on an individual's fairness preferences should be calibrated and anchored by the population average; This 'social anchor' provides a way for each individual to measure her own (relative) performance.

Second, the metric must be able to partition the effects of early life exposure from those of the later life exposure. This is necessary because it will make the early life and later life components comparable, and will allow us to study the relative impact of when exposure took place. As the neurological development litertature shows that neural plasticity severly declines after the age of 25 (Knudsen, 2004).

Third, the metric must have a way to simulate the greater potential impact that early life exposure has on the canalization of preferences. Therefore, a one-unit increase in the severity of exposure during critical developmental periods should have a greater impact on a person's overall score than a one-unit increase after the 25-year threshold. Finally, the greater weight that is attributed to early life exposure should be sensitive to how early in their life their most severe events took place.

To begin constructing our metric, we take the total number of droughts a person has experienced before the age of 25, d_{-25} and divide it by the sample average $\overline{d}_{-25}$. This will provide us with a relative measure of an individual's frequency of exposure before the age of 25. Then, in order to simulate the relative importance of early life exposure on developmental canalization, we multiply this value by B which captures how early in life a person experienced their most severe drought. B is equal to 1 if the most severe event happened after 25, 2 if between 25-21, 3 if between 16-20, 4 if between 11-15, 5 if between 5-10, and 6 if between 0-5. Our frequency index f_{-25} is thus defined as

$$f_{-25} = B\left(\frac{d_{-25}}{\overline{d}_{-25}} + 1\right) \tag{2.1}$$

In order to be able to contrast the effects of early life and later life, we construct a similar metric for later life that is the same in all respects, except that B is set equal to one. Again, we begin by taking the total number of droughts a person has experienced *after* 25, d_{+25} and divide this by the average number of droughts experienced after 25 (i.e. $\overline{d}_{+25}$). We get

$$f_{+25} = \left(\frac{d_{+25}}{\overline{d}_{+25}} + 1\right)$$

Next, we construct a subject's *relative intensity of exposure* that we denote by I_r. To obtain it we first sum together the total number of exposure events that a person has

experienced and form the score I_a. For instance, a person who reports having 1) received government aid 2) received help from family, and 3) entered into debt in response to a drought would obtain a score of 3. Likewise, a person who only reported 2 of those 3 instances would receive a score of 2.[19] This value ranges from 0-8. Note that since we are mainly interested by the subject's relative score, I_a is then divided by the population average $\overline{I_a}$ to obtain the relative intensity of exposure I_r.

$$I_r = I_a/\overline{I_a} \tag{2.2}$$

Finally, we need to incorporate both intensity of exposure *and* the existence of drought events *together* in the same index. by multiplying (2.1) and (2.2) together we are able to obtain S_{-25}, an individual's relative severity of exposure during critical developmental periods, that is

$$S_{-25} = f_{-25} * I_r \tag{2.3}$$

Likewise, the same index can be constructed using f_{+25} and we obtain

$$S_{+25} = \left(\frac{d_{+25}}{\overline{d}_{+25}} + 1\right) * I_r \tag{2.4}$$

To construct the full metric we simply add (2.3) to (2.4) to derive a person's relative lifetime *severity of exposure, S*. The overall metric obtained, $S = S_{-25} + S_{+25}$, satisfies all of the criteria laid out at the beginning of this section.

Admittedly, our overall measure of exposure is crude. In particular, one of its basic constituent, the *severity of exposure* index defined in (2.2), gives the *same* weight to all types of exposure events. With this in mind, we created several variations on this index where we attributed different weights to different *exposure events*. Putting different weights on different *exposure events* simply reflects the fact that events of higher magnitude will have a more profound impact on an individual's *intensity of exposure*. For instance, entering into debt is weighted higher than receiving gifts from friends and family, and having a friend or a family member die is weighted higher still.

A simple frequency analysis shows that our *severity of exposure* indexes have a Pareto like distribution - with the majority of subjects having low levels of exposure and far less are very severely affected.[20] In order to address the effect of outliers we conducted separate

[19] All exposure events are as follows. The question is "As a result of a drough, have you ever 1.received government Aid, 2. had to enter into debt 3. Temp wage labor 3. Family Aid 4. Liquidate Assets 5. Migrate 6. Eat Wild foods 7. Get sick/have family member get sick 8. Have family or friend die.

[20] While the reader might assume that the experience of droughts, floods, and infestations should be homogenous and correlated amongst farmers from a single community, we find significant variation and heterogeneity in exposure. One reason for this is that we are not measuring the physical shock, but instead the range of personal experience associated with that shock. This experience is affected by a variety of social, cultural, and economic factors that create heterogeneity. Moreover, in many of our regions there is high spatial variability in rainfall patterns, so that one farmer may experience a drought, while his neighbor does not - this is documented in 72 long form interviews.

analyses in which participants were grouped according to their 'severity percentile.' In our regression analysis, we choose to compare those who sat above the 85th percentile of exposure to the rest of the sample. Figure I.I below represents the distribution of our *severity of exposure* metric and shows that, while most people have not suffered from climate shocks, a minority has suffered severe and repeated early stress due to climate shocks.

Figure I.I - Distribution of *Severity of Exposure* scores across all regions

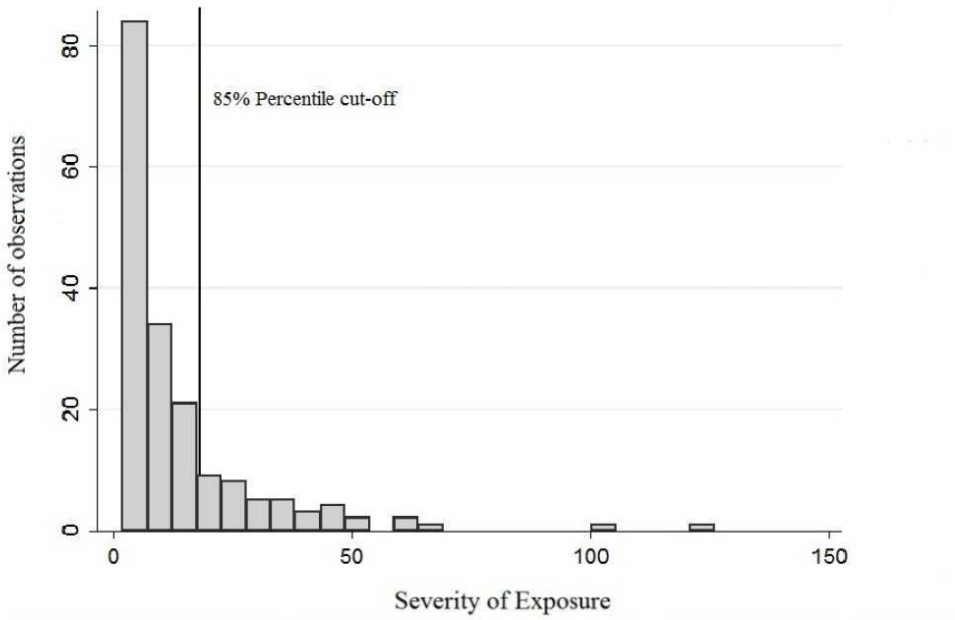


Figure I displays the distribution of our *Severity of Exposure* metric. This metric is composed of both the *intensity of exposure* and the *frequency of exposure* for individuals throughout their entire life, with a person's early life experience being weighted more heavily. To the right of the 85% cutoff are the individuals who are highly exposed.

As part of checking the robustness of our findings we have created mutliple metrics that are composed using diffrent methods for calculating severity. In all of our alternate metrics we vary how we interact *frequency of exposure* and *exposure events.* Additionally, we vary the way in which we scale the effect of early life expsoure. Each of these metrics demonstrate the same findings with only minor diffrences between them in their effect on prefernces (see below). The driving force behind the similarity between the alternate metrics is the fact that f_{-25} is driving the interaction between severity and preferences. Nevertheless, our prefered metric cannot simply be choosen on the fact that it correlates with prefrences, instead it must an externally valid measure of early life exposure.

In order to test the validity of our measurement tool we checked to see if each index predicted correlations between the severity of exposure and other variables that should be correlated with factors that would create either buffers *or* vulnerabilities to shocks. For example, a severity index that showed no correlation between an individuals' exposure and the number of social supports, wealth, or market integration, would have a low accuracy.

In our preferred index we find that being female ($p = 0.039$), the number of permanent household members ($p = 0.000$), the intensity of participation in community groups ($p = 0.001$), participation in agriculture ($p = 0.056$), a low market integration ($p = 0.049$) the number of children that a person has had die ($p = 0.052$), are all positively correlated with the severity of exposure to climate shocks. Variables that are negatively correlated with exposure (and therefore buffer the individual) are the total number of siblings ($p = 0.052$), the geographical closeness of social supports ($p = 0.007$), participating in a gifting network with friends ($p = 0.014$) and the number of community groups a person is a member of which can help during shocks ($p < 0.000$).[21] Interestingly neither wealth nor income are significantly related to our severity index. Instead almost all of our correlates are social variables which provide evidence of how strong a person's social network and insurance system is – indicating that functioning social relationships are indeed vital buffers.

2.3.3 Experimental Procedure

For our experiments we built on earlier protocols (Fehr, Bernhard, and Rockenbach, 2008; Silk et al., 2005) and ran four modified dictator games in which participants chose between two alternate allocations of money for themselves and for an anonymous partner. We focus on these *simple* allocation choice games, as opposed to more sophisticated cooperation games, mainly because we believe they will be fully understood by all our participants.[22] To illustrate how the games operate we will work through each game, beginning with the two costly games, where players can choose to be egalitarian, but at a cost to themselves. The results from the costly games are the most unambiguous.

In the *Sharing Game* participants had to choose between two cash allocations; \$10 for themselves and \$10 for their partner, (10,10), or \$15 dollars for themselves and \$5 for their partner, (15,5). The purpose of the Sharing Game is to have participants choose between an egalitarian outcome and a self-interested outcome – but where the egalitarian option comes at a cost. We use this game to measure the participants' willingness to pay to reduce self-advantageous inequality. In other words, if a participant chooses the egalitarian choice, she is actively paying a cost in order to benefit an anonymous partner. Clearly, no self-interested individual should do this.

In the *Envy Game*, the participant chooses between (10,10) and (13,18). In this game choosing the unequal option allows the participant to 'grow the pie' and increases the reward for both players while simultaneously placing herself at a relative disadvantage to their partner, thereby creating disadvantageous inequality. Therefore, by choosing (10,10)

[21] There is a positive correlation between severity and the number of community groups a person is part of, but a negative relationship between severity and participation in groups that can help during a crisis. These seemingly contradictory findings can be explained by people who become severely affected are actively searching out community groups as a buffer.

[22] In risk elicitation games played in rural Senegal, Charness and Visceiza (2015) show that, when confronted with relatively complex games, a large fraction of the subjects will not understand the games they involved in and, hence, make inconsistent choices.

the participant is incurring a cost to insure that the other player is not placed at a relative advantage. It is thus a measure of an aversion to self-disadvantageous inequality and no self-interested player should choose the egalitarian option.

In the costless games, participants are able to change their partner's payoff at no cost to themselves. For example in the *Generosity Game,* a participant is choosing between (10,10) and (10,15). She can increase her partner's payoff at no cost to herself, or choose an egalitarian option. Unlike in the Envy Game, in the Generosity Game the players are not foregoing an increase in their allocation if they choose the egalitarian option – therefore it measures the willingness to give when it comes at no cost to the self. In addition to measuring generosity, by combining the results from this game with their choice in the Envy Game, we can produce a stronger and more robust measure of an aversion to self-disadvantageous inequality (for example if they refuse to be generous (10,10) *and* they display envy (10,10) – then we will say that the subject is *strongly* averse to self-disadvantageous inequality).

The *Harm Game* is a costless version of the Sharing Game. At no cost to themselves, participants decrease their partner's payoff. Here, the choice is between (10,10) and (10,5). As above, we can combine these results with those from the Sharing Game to get a stronger measure of an aversion to advantageous inequality, (if players choose (10,10) in both games then they are unwilling to place themselves above their partner and are strongly averse to self-advantageous inequality).

2.3.4 Treatments

In order to test whether extreme weather events can shape parochial cooperative tendencies it is necessary to differentiate between in-group *and* out-group effects. Before playing the games, participants in our study were randomly assigned to either an in-group or an out-group condition. The *anonymous* in-group partner always came from the same village as the participant – in the anonymous out-group condition; participants were paired with a partner from another village in our sample sites.

2.3.5 Social Norms

To be able to isolate developmental effects we needed a tool to control for cultural norms. While we can partially control for cultural norms through community and village level dummy variables, we opted to also construct a variable that captures our participants expectations of what they believed a 'typical member' of their community would choose in each of the four games. The idea is that by measuring expectations we can account for people perceptions of social norms.

Thus, after each participant had completed the four real games but *before* they had been paid out, they were asked to go through each game again, but this time reporting what they 'thought, a typical member of their community would pick'. From this question,

we are able to partially isolate behaviors that are performed because of expectations (i.e., "it is just what we do") from behaviors that originate from idiosyncratic motivations.

2.4 Results

In all of our games and behavioral types we have a binary choice therefore we use a logit model for our analysis. To begin with, we analyzed the choices from each game separately. First, we found that in the Sharing, and Harm games there is no correlation between players choices and the severity of exposure to climate shocks in either the in-group or out-group treatment. In the Envy Game there is a significant negative correlation between the severity of exposure and choosing the non-envious allocation (13,18) in the *in-group treatment only* (Logit: $p = 0.023, r = 0.035, n = 95$). Additionally, in the Generosity game there is a negative correlation between severity of exposure and choosing the generous choice (10,15) in the *in-group treatment only* (Logit: $p = 0.056, r = 0.027, n = 95$). These results provides the first evidence that people who are severely affected by shocks are more averse to disadvantageous inequality.

Moving on to our primary analysis; we combine the choices each participant made in the four games to create a composite choice matrix that can measure more complex forms of behavior. Our composite choice variables measures six behavioral types: 1) Selfishness 2) Spite 3) Generosity/Altruism 4) Aversion to self-disadvantageous inequality 5) Aversion to self-advantageous inequality 6) Egalitarianism. This classification is represented in table I.III below.

Table I.III - Behavioral Choice Matrix

	Percent of sample	*Sharing Game* (15, 5 or 10, 10)	*Envy Game* (13, 18 or 10, 10)	*Generosity Game* (10, 15 or 10, 10)	*Harm Game* (10, 5 or 10, 10)
Selfish	45%	15, 5	13, 18		
Weak Altruism	19%	10, 10	13, 18		
Strong Altruism	9%	10, 10	13, 18	10, 15	10, 10
Weak Spite	22%	15, 5	10, 10		
Strong Spite	10%	15, 5	10, 10	10, 10	10, 5
Aversion to DI	31%		10, 10	10, 10	
Aversion to AI	28%	10, 10			10, 10
Egalitarianism	12%	10, 10	10, 10		

Note: Percentages do not add to 100% because not all categories are mutually exclusive

When considering inequality aversion, a total of 31% of our participants display a strong aversion to self-disadvantageous inequality and 28% display a costly aversion to advantageous inequality. These percentages are similar to other cross cultural rates found in countries as dispersed as Germany and Borneo (Hager, Oud, and Schunk, 2012).

We define an aversion to self-disadvantageous inequality as when a person never chooses an allocation that increases their partner's payoff above their own, even if that comes at a cost. Therefore a DI averse individual will choose (10, 10) in the Generous Game as opposed

to (10,15) and will choose (10, 10) in the Envy Game, instead of (13,18). Thus, they are incurring a cost to maintain egalitarianism. In the in-group condition, our logit regression analysis reported in table I.IV shows a significant positive relationship between the severity of past exposure and an aversion to self-disadvantageous inequality.

Table I.IV – The Impact of Severity of Exposure on an Aversion to Disadvantageous Inequality

	DI Aversion	Social Norms	DI Aversion with full control	DI Aversion with 85th Percent.	DI 85th with full control	DI Aversion with full control
Treatment	In-group					Out-group
Severity of Exposure	0.04**	0.04**	0.07***			0.002
	(0.01)	(0.01)	(0.01)			(0.03)
85th Percentile				1.87***	2.38***	
				(0.68)	(0.86)	
Social Norms		1.07	0.66		0.79	1.27**
		(6.89)	(0.81)		(0.75)	(0.61)
Age			-0.05		-0.03	-0.01
			(0.03)		(0.03)	(0.02)
Sex			1.65		0.847	0.15
			(1.03)		(1.08)	(0.65)
Wealth			1.31e-08		1.52e-08	2.29e-07
			(5.78e-08)		(6.23e-08)	(1.56e-07)
Income			-1.38e-07		-9.90e-08	2.22e-07
			(1.57e-07)		(1.49e-07)	(8.85e-08)
Family Composition (# of brothers/sisters)			0.317**		0.248*	0.21
			(0.14)		(0.15)	(0.15)
Market Integration (% calories purchased)			-0.709		0.31	-0.89
			(1.49)		(1.30)	(0.65)
Kongwa (Regional Dummy)			-0.957		0.004	0.80
			(0.99)		(0.86)	(0.80)
Wami (Regional Dummy)			-0.57		-0.6	-0.39
			(1.5)		(1.55)	(0.84)
Constant	-2.41***	-2.97***	-3.842**	-2.16***	-3.76**	-1.61
	(0.47)	(0.7)	(1.85)	(0.40)	(1.69)	(1.34)
Observations	82	82	82	82	82	75
Pseudo R^2	0.12	0.15	0.34	0.11	0.26	0.16

Standard deviation in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

In the basic model, the likelihood of our subject's behavior displaying aversion to self-disadvantageous inequality is impacted by the severity of her exposure to climate stressors. This relationship is significant (logit: $p = 0.004$, $n = 82$).[23] When adding a control for social norms this relationship remains relativley constant significant (logit: $p = 0.003$, $n = 82$).

After including additional variables that control for age, sex, income, wealth, family composition, social norms and market integration, the strength of the relationship becomes more significant (logit: $p < 0.000$, $n = 82$) and much stronger.[24]

Focusing on the subjects who sit above the 85th percentile, it is confirmed that, in the in-group treatment, this condition is conducive to allocation choices displaying aversion to self-disadvantageous inequality. However, when we turn to the *out-group treatment* the

[23] The n is 82 rather than the 95 in the in group condition because individuals who are completely egalitarian are excluded.

[24] Note that the variable *number of siblings* is always a positive and significant driver of aversion to self-disadvantageous inequality. In a subsistence economy, an increase in the number of siblings increases the selection pressure in the in-group *at the household scale*. Therefore, in our economic context, it is expected (at least theoretically) that siblings should have an effect similar to the severity of exposure.

picture changes dramatically and any relationship between the severity 85th percentile and an aversion to DI disappears. Instead, social norms of behavior (regarding DI) become important when participants (exposed or not) are confronted to the out-group subjects.[25] Interestingly, we did not find any relationship between the severity of exposure and an aversion to *advantageous* inequality in any treatment. In addition, going from in-group to out-group treatment, we find that the frequency of 'envious choices' increasing from 22% to 50% (logit: $p = 0.005$, $n = 82$). This result is depicted in figure I.II.

Figure I.II - Percent of Subjectes Averse to DI by Treatment Group and Severity of Exposure

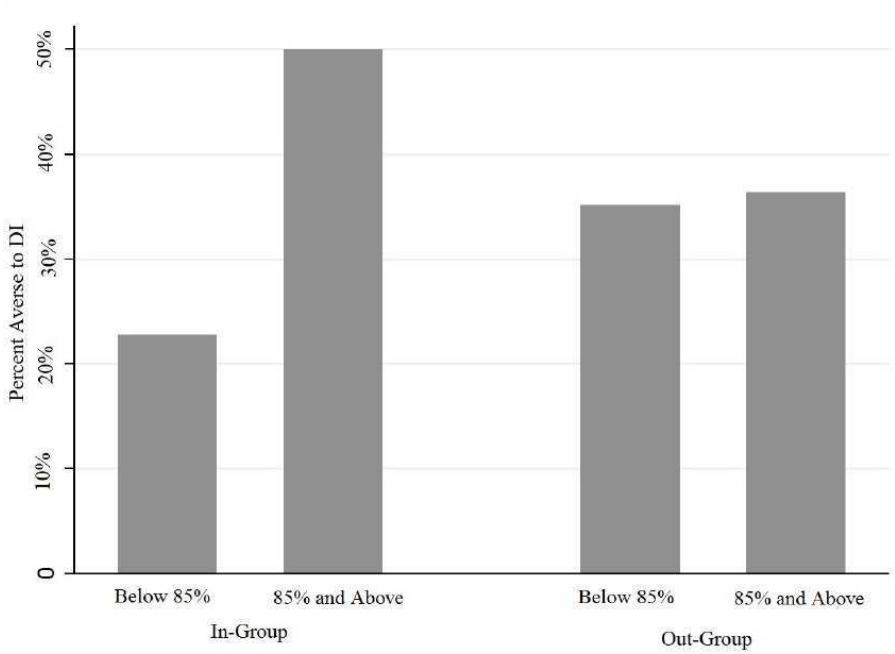


Figure II shows the percentage of subjects who are averse to self-disadvantageous inequality for those with the 85th percentile and those who are not, for both the in-group and the out-group treatments.

Does early exposure really matter? To tackle this question we ran regressions with S_{-25} and S_{+25} separately. When we consider only severity of exposure past the age of 25, the relationship decreases from being significant at $p < 0.001$ to $p < 0.10$ and the Pseudo R^2 from 0.053 to 0.022, indicating that the effect diminishes when shocks are experienced in adulthood. Unlike S_{+25}, regressions ran with S_{-25} were strong and significant. However, the significance and strength sharply declines (to $p > 0.10$) when we progressively deflate the weight of early exposure (i.e. when we progressively set B equal to 1 in (2.1)), showing that developmental canalization matters.

In our study, spiteful behavior amounts to paying a cost to reduce the payoff to the other player. In our most basic measure of spite, we operationalize it as the choices of

[25] We only present the regression with the 80th percentile for the out-group treatment. This is because all the previously run regressions (i.e., Basic, Social norms, Full control, and Index 2) yield the same result. That is, with the out-group, social norms related to DI becomes a significant driver of DI averse choices while the severity of exposure becomes insignificant.

(15,5) and (10,10) in the Sharing and Envy games respectively. 22% of players were spiteful and 13% were strongly spiteful (see below).[26] As reported in Table I.V, variables like age, sex, income, wealth, and market integration (% of calorie purchased) had no significant relationship to spiteful play.

Table I.V - The Impact of Severity of Exposure on Spite

	Spite	Social norms	Spite w. Controls	Spite w.85th %	Strong Spite	Strong Spite w. Control	Str. Spite w.85th %	Str. Spite w. Controls
	In-Group							*Out-Group*
Severity of exposure	0.026** (0.01)	0.026** (0.01)	0.038*** (0.02)		0.29** (0.01)	0.39** (0.02)		−0.07 (0.06)
85th percentile				1.5** (0.67)			2.12** (0.86)	
Social norms		0.561 (0.55)	0.607 (0.59)	0.67 (0.59)		−0.04 (1.35)	−0.07 (1.63)	−2.81 (1.02)
Age			−0.005 (0.02)	−0.03 (0.02)		−0.03 (0.03)	−0.019 (0.04)	0.01 (0.02)
Sex			0.22 (0.68)	−0.005 (0.65)		0.51 (1.0)	0.129 (1.23)	0.41 (0.8)
Wealth			$-1.6e-08$ $(3.5e-08)$	$-2.2e-08$ $(3.5e-08)$		$-4.8e-09$ $(4.5e-08)$	$1.0e-08$ $(5.6e-08)$	$2.6e-07$ $(1.6e-07)$
Income			$-1.4e-07$ $(1.2e-07)$	$-1.3e-07$ $(1.2e-07)$		$-1.0e-08$ $(1.6e-07)$	$-1.6e-08$ $(2.2e-08)$	$-2.6e-07$** $(5.6e-08)$
Family comp (Total sibs)			0.11 (0.08)	0.08 (0.07)		0.16 (0.07)	0.14 (1.45)	0.23 (0.24)
% calories (purhcased)			−0.73 (1.23)	−0.19 (1.27)		−0.09 (1.57)	0.19 (1.7)	−1.36 (1.74)
Kongwa (reg. dummy)			−0.98 (0.89)	−0.47 (0.76)		0.37 (1.18)	0.92 (1.16)	0.27 (0.96)
Wami (reg. dummy)			0.02 (0.81)	−0.053 (0.8)		0.31 (1.5)	0.47 1.79	−0.61 (1.49)
Constant	−1.901*** (0.325)	−2.11*** (0.451)	−2.33 (1.52)	−2.176 (1.41)	−3.32*** (0.59)	−4.10*** (1.51)	−4.759** (2.12)	−2.52 (1.79)
Observations	95	95	95	95	95	95	95	85
Pseudo R^2	0.05	0.06	0.14	0.11	0.09	0.21	0.20	0.29

Standard deviations in parentheses, $*p < 0.10$, $**p < 0.05$, $***p < 0.01$

Our analysis shows a significant positive correlation between spitefulness and the severity of exposure to weather shocks in the in-group treatment (Logit: $p = 0.015$, $n = 95$). After introducing controls for social norms, region, age, sex, income, wealth, market integration, and family composition both the strength and the significance values of the coefficient increase (logit: $p = 0.006$, $n = 95$). In line with our previous results on DI, there is no significant relationship between severity of shock and spite in the out-group condition (see last column). As with envy, when we limit our analysis to the severity of shocks that have happened after 25, the relationship disappears.

We checked the robustness of our results with different severity of exposure indexes that put weights on different exposure events (see above) and all tests show a significant positive relationship. To further confirm these findings, we tightened our definition of spite to include choosing (10,10) in the Generosity Game and (5,10) in the Harm Game, we call this *Strong Spite*. In this case, (Strong Spite w. Full control) the correlation between strong spite and severity of exposure becomes even stronger than our looser measure of

[26] These percentages are almost exactly the same as other studies on spite hinting at a strong genetic component; one Ukranian study found 10.5% to 25% people were spiteful depending on wheher their actions could be observed (Abbink and Benedikt, 2011) while another study in Namibia found this percentage to be 15% (Prediger, Vollan, and Hermman, 2013). In England, Zhang and Ortman (2013) found that between 28% and 15% percent were spiteful. While Bauer et al.'s research (2013) in Sierra Leone and Georgia found it to be between 15% in low treatment to 23.7% in the highest treatment.

spite (Logit: $p = 0.025$, $n = 95$) and still only remains present in the in-group condition. In order to understand who plays spite we subdivided our sample into 'severity percentiles' (see above). We have found that those in the 85% percentile are more likely to be spiteful, with an increase from 15% to 37% between the groups and again this is only true for the in-group condition. This result is reported in figure I.III.

Figure I.III - Percent of Spiteful Subjects by Treatment Group and Severity of Exposure

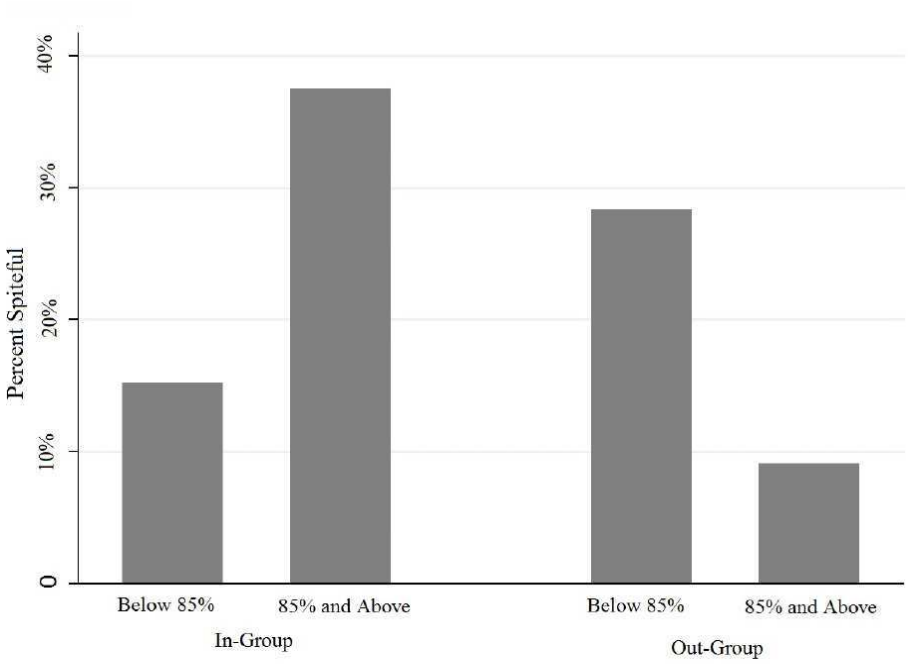


Figure III shows the percentage of subjects who are spiteful for those within the 85% percentile and those who are not, for both the in-group and the out-group treatments

To explore why players were choosing spite, we tested the likelihood of playing spite against a five question Likert scale that measures the subject's concern over local inequality. The scale includes questions such as, 'I think that the wealthy people in this community need to do more to help the poor' and 'I think that the difference in wealth between the wealthy and the poor is unfair in my community.' Here we have found a significant relationship between spiteful play and how concerned people are with local inequality (Logit: $p = 0.033$, $n = 180$).

Moving on, generous/altruistic players are those who actively work to maximize their partners payoff even when it is costly to themselves. They choose (13,18) in the Envy Game and (10,10) in the Sharing Game. This type represents 20% of the population. We find no correlation between, sex, age, family composition and generosity. Nor do we find any connection between generosity and severity of exposure in any of our treatments.

Next we wonder if shocks can make people more selfish. Selfish types, are homo-economicus, and work to maximize their own payoffs irrespective of other players – they do this by choosing (15,5) and (13,18) in the Sharing and Envy games respectively (the choices in the

costless games do not matter for the selfish category). Here we find no relationship between severity of shocks and selfishness in either test conditions. On the flip side of the coin, egalitarians choose (10,10) in all games, and we do not find any significant association with the severity of exposure in any of the treatments.

A reviewer raised a concern that there might be some level of endogeneity between people's perception of their experience with climate shocks (severity of exposure) and their choices in the behavioral game. For example, imagine that an individual is having a bad day, this may influence her to both over report their severity of exposure and cause her to play more spitefully in the games. In that case, past exposure and their trauma do not cause spiteful play. This is partly to address this concern regarding endogeneity that we developed our social norms variable. Recall that after each player made their four choices, the participant were asked what they thought a 'typical' member of their own community would choose in each game. Therefore, if there truly is an underlying endogenous factor that is causing both high reporting on our severity of exposure metric, as well as causing anti-social behavior in our games, then it is perfectly reasonable to suspect that this same endogenous characteristic would cause the subjects to expect anti-social behaviors in their expectations of others' behavior. For example, having a bad day would also result in person thinking that the members of their community are spiteful and envious as well. Having run a basic correlation shows us that this is in fact not the case, there is no significant relationship between severity of exposure and the expectations of other subjects choices in the game.

2.5 Further robustness checks and Discussion

Another concern for endogeneity relates to the objectivity of our measure for weather-related trauma. While it is based on factual reports, one could argue that the effects of exposure to early life trauma measured by our severity index are not entirely objective. More precisely, it is defensible to argue that these measures, which are partly based on self-reported reactions to past shocks, are not strictly exogenous and that the actual reaction to the shocks and the decision to report on it are choices that could be affected by the very preferences that our games are measuring. For instance, we could speculate that an individual who happens to be averse to disadvantageous inequality will also be inclined to systematically, say, inflate the severity of the drought effects that she endured during her life. Assuming this is true, then our severity index measure will then be inflated as well and we will infer a relationship between inequality aversion and a weather related trauma that is stronger than it is actually. The endogeneity issue raised by this plausible example has led us to develop a crude exposure index based on weather related trauma *endured* by our participants but one that can hardly be manipulated by our subject.[27]

[27] Relying on the weather data during the whole life of the participant would not be a satisfactory solution. During a drought, the correlation between actual rainfall and a person's actual experience would be tenuous

To document weather related traumas *without* attempting to 'measure' their intensity in any way *through* the participants' reports, we simply use the worst year for the shock endured by our participants. This simple metric is useful because it is systematic and cannot be manipulated. Thus, we ask the following simple question: can we 'predict' the other-regarding preferences of our participants by just using the year of their most severe weather event? As we shall see the answer to this question is a (qualified) *yes*. From the review of the developmental canalization literature as well as from the neurological and developmental studies (section 2.3 and 2.4), we know that when brains are affected at a young age, shocks will have an enduring effect that is even more pronounced the younger the subject was when the shock was incurred. However, this effect should vanish after they reach the age of 25. Using the age of the participant, we thus form an index taking value "1" when the shock is incurred between 20 and 25 years of age, value "2" when the shock is between 15 and 20 years, value "3" when it was incurred between between 10 and 15 years, etc. This metric that we call *shock-young years* produces a single value for each individual. To confirm that the age of the shock is crucial in the formation of social preferences, we also formed a 'reverse' index, called *shock-old years*, that takes value "1" each time a shock is incurred *after* 25 years old and "0" *before*. We then regressed each type of other-regarding preferences against these crude measures of shock controling for the age of our subject. Table VI below reports these regression results for disadvantageous inequality and spite:

Table I.VI - The Impact the Year of Shocks

	shock-young years (n=95)	*shock-old years (n=95)*
Disadvantageous Inequality		
shock-young years	0.248**	
	(0.117)	
shock-old years		0.051
		(0.072)
Age	0.001	-0.001
	(0.015)	(0.017)
Constant	-1.418*	-1.033
	(0.774)	(0.842)
Spite		
shock-young years	0.198*	
	(0.117)	
shock-old years		0.002
		(0.086)
Age	0.014	0.009
	(0.017)	(0.019)
Constant	-2.387***	-1.876**
	(0.905)	(0.905)

Standard deviations in parentheses. *$p<0.1$, **$p<0.05$, ***$p<0.01$

The results obtained in table VI are statistically significant but less strong than those obtained in the previous section. This is not surprising since they rely on a very thin (yet

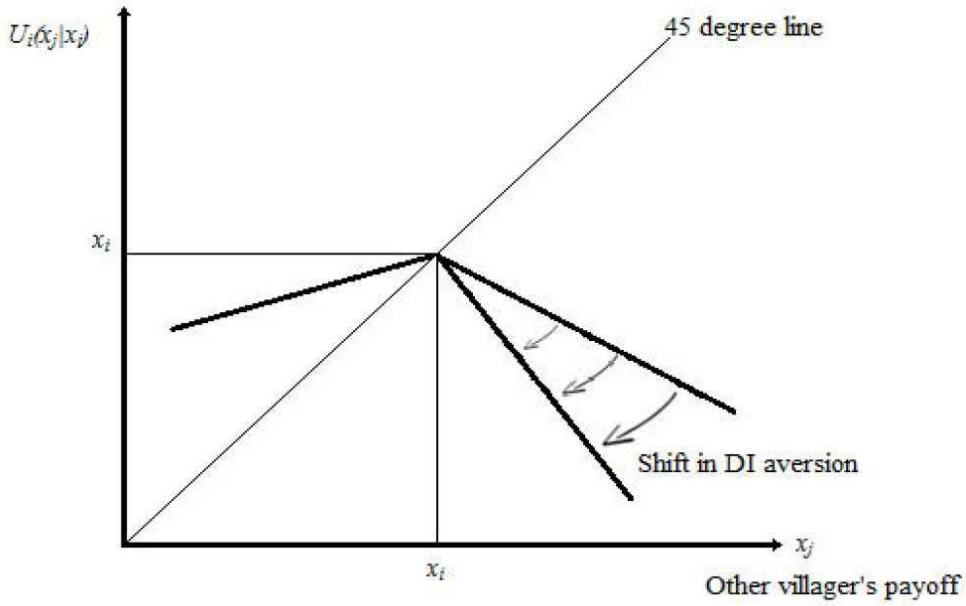
at best as many families have precautionary grain storage or are able to borrow money when drought happens, so that young individuals are often sheltered from the impact of weather events.

crucial) piece of information. More importantly, with this index our subject have hardly any opportunity to distort (consciously or unconsciously) this information. Interestingly, the index *shock-old years* yields no effect on other-regarding preferences choices of our game, confirming that adult other-regarding preferences are not impacted, at least *in the long-run,* by their worst year.

Overall, our results strongly suggest that there is a non-trivial long-term effect on social preferences that is due to the intensity and severity of climate shocks suffered during critical developmental periods. We find that, as the severity of exposure increases, people are more averse to self-disadvantageous inequality (envious), are more willing to pay a cost to harm other community members (spiteful), and subsequently are less generous. This relationship is only present in the in-group condition and is dependent on us accounting for the frequency of shocks experienced before 25 years of age. The fact that this effect spans three different ecological regions, and become universally stronger after we control for cultural and individual variables provides the first hint that this may be a species general developmental pathway.

In Fehr and Schmidt's original model on inequality aversion they propose a parameter that scales the strength of the aversion to DI, but they make no suggestion as to how that parameter would be derived. In an evolutionary framework, if DI aversion is an adaptive trait, then its expression could in principle be calibrated in response to environmental information. Indeed, what we have found is that the magnitude of DI aversion and subsequently spite is adjusted in response to the frequency and intensity of climate shocks during critical developmental periods. Using Fehr and Schmidt's original utility function, figure 4 illustrates exactly how a preference for AI aversion is modified in response to the exposure of climatic shocks.

Figure I.IV - Shift in IA Preferences due to the Experince of Climate Shocks During Development - Based on Fehr & Schmidt (1999)



Because this is the first time such a result has been found, the mechanistic connection that links climate shocks to envy and spite, may not be as clear we would like. For example, are we observing a form of developmental canalization or reaction norm? Some kind of conditioned learning? Or the preferential adoption of cultural norms? In order to disentangle the probable mechanisms and pathways that lay behind this relationship we propose a test between three different hypotheses. In brief, the three hypotheses are as follows, 'a frustration model' – where people who are severely harmed lash in out spitefully as a form of frustration and revenge. A 'cultural learning model' – where individuals in communities that have been severely affected by climate shocks preferentially develop and adopt norms around DI aversion and spite in order to sustain egalitarian sharing networks. And finally 'a developmental canalization model' – where repeated shocks affect brain development via altered stress pathways and senses of fairness.

Frustration Model: The connection between spite and climate shocks may be very simple; when people do not receive the help they expect in times of need, they may lash out in aggression against their community members as a form of punishment in order to promote future cooperation or merely out of frustration. In most traditional societies there is generally some form of social insurance mechanism in the form of reciprocal/community sharing which is used to buffer the effects of shocks. If a person has been significantly more severely affected by shocks than the average community member (i.e., having to sell large tracts of land, enter into indebtedness, migrate, etc.) then their hyper exposure may be the result of a failure in their insurance network or an active exclusion from such public goods.

If this failure is deliberate (i.e. people actively did not wish to help the affected individual),

the person may come to believe that others in their community are selfish or even spiteful. In response to this, the subject may attempt to coordinate her or his behavior with her or his beliefs about other members in their community; 'an eye for an eye'. If this was in fact the case, we would predict that individuals who are severely affected by weather shocks would come to think of members of their own community members as spiteful and selfish. Fortunately we were able to collect data on social norms and expectations as part of our experimental design.

In order to test the effect that shocks have on social norms (rather than strict individual preferences) we ran regressions that compared the subject's severity of exposure against our measure for social norms. Here we found no relationship between shocks and social norms relating to spitefulness (i.e. how spiteful a subject expect people from her community to be), selfishness or an aversion self-disadvantageous inequality. Therefore, because an individual's exposure level is not correlated with perceptions of maligned intentions of their in-group members, we rule out the hypothesis that spiteful behavior is the result of increased expectations of spite and selfishness.

On the other hand, several readers have commented that the causal link between spitefulness and the severity of exposure may be due to the fact that individuals who are spiteful are excluded from social sharing networks, and therefore are more severely affected. For example, behavioral genetics tells us that personality traits, which would include propensities for spitefulness and envy, are highly heritable (as evidenced by the high heritability of psychopathy).[28] Therefore, while growing up, spiteful households may be excluded from general sharing networks, while spiteful children in non-spiteful families maybe discriminated against by siblings and other adult caregivers and therefore suffer more stress from shocks. While we have little doubt that these sorts of endogenous factor may play a role, we suspect that this is not the complete case becasue there is a very strong positive correlation between spite and the total number of gifts a person has given and received in the last three months ($p = 0.001$, $n = 95$). This finding indicates that contrary to this counter explanation, people who are spiteful are actually highly integrated into sharing networks and this should buffer their total exposure to shocks.

Community Norms: A second hypothesis is that the envious and spiteful behavior is the result of the preferential adoption/development of community level norms which have evolved because they are effective at coping with shocks. Here, we have in mind a situation where egalitarian norms are favored in communities that have high exposure to shocks because it keeps people within sharing networks and prevents them from gaining too much wealth which may allow them to leave. Indeed, if a person becomes very wealthy, the benefits they derive from a sharing network diminish in relation to their relative advantage because they suffer less shocks and therefore receive less help. Yet, they are still coerced to

[28] For instance, using a twin design Cesarini et al. (2009) recently showed that preferences for risk taking and giving are heritable. While relatively new for economists, the fact that genes largely affect psychological phenotypes such as social attitudes has been noted by psychologists (Turkheimer, 2000; Chabris et al., 2015).

help others. This disproportionately causes wealthy individuals to leave the network, and results in a decrease of the insurance networks overall efficiency. Therefore, maintaining some critical number of people within the network is fundamental, and norms may develop that teach people to punish 'the nail that sticks out' in order to regulate wealth differentials and membership. Increases in envy and spite are then due to the preferential adoption of cultural norms that operates as an effective leveling mechanism that both enforces sharing and makes sure that more economically 'formidable' individuals cannot in fact leave the sharing network.

If this hypothesis is correct, we would predict that it should be consistent with at least two social behaviors. First, in our driest communities we would expect to find stronger sharing networks associated with climate shocks. Second, we would we expect the relationship between shocks and envy/spite to be at the community level and not at the individual level.

To test the first prediction, that insurance networks should be stronger in the drought prone community, we checked to see if there was a correlation between the frequency of gifting, and the community rainfall patterns. Contrary to this prediction, we found a negative relationship; that is, living in the driest, most drought and flood prone region is negatively associated with the practice of gifting ($p = 0.01$, $n = 180$). On top of this, receiving aid in times of crisis was not correlated with region either. Indeed, our qualitative research revealed that this negative relationship exists because the practice of informal insurance networks has fallen out of favor in the last ten years. Now, 'one for two' loans are common, where what is borrowed in times of crisis must be paid back at double the original value.

Second, we ran our models that tested for spite but with a dummy variable for the ecological region – in three out of the four models (where the severity index is being modified) the dummy variable was not significant. This suggests that the impact of shocks is limited to an independent *individual* level effect that must be explained by other means.

Stress, Random Allocations and Developmental Canalization: The third hypothesis is a developmental model that links the individual's experience of climate shocks during critical developmental periods to two main neurological systems that influence DI aversion and spite. First, the trauma and the acute reduction in the scale of competition induced by shocks, calibrates neurological substructures involved in threat processing and stress responses to increase DI aversion. Second, the frequency and intensity of shocks provide information about local resource variability and the sources of inequality which calibrates the individual's emerging sense of fairness. We propose that our results on DI aversion and spite are the product of the interaction between the canalized threat detection/stress system (that results because of the trauma), as well as the calibrated sense of fairness (that results from randomly distributed inequalities).

The hypothesis is as follows: when the exposure to extreme weather events is frequent and severe, the shocks trigger a functional restructuring of neural anatomy – particularly

the HPA axis which regulates stress responses, the amygdala which processes threats, as well as the insula, striatum and ACC which are all involved in processing information about inequality.[29] The stress induced by the indiscriminate nature of the climate shocks becomes associated with bouts of intense, highly localized competition, and in this situation disadvantageous inequality becomes potentially life-threatening. The outcome is an intensely negative association with DI because of its association with shocks and acute existential threats. At the same time that climate shocks are remolding the threat detection/stress response systems, the random nature of climatic shocks and the inequality that they create, calibrates the individual's emerging set of fairness preferences. In short, what we have is a stress response system that is strongly attuned to the threat posed by DI, as well as set of fairness preferences that are highly sensitive to randomly allocated inequalities - it is the combination of these two factors that result in the significant shift in DI aversion and spite that we observe.

Let us begin with the effect that the trauma and an increase in local competition (due to shocks) has on the stress and threat detection systems. First, our severity index indicates that most people have very low levels of exposure, while a relative few are harshly affected by climate shocks. Also, remember that it is (roughly) those within the top 20% who display an increased tendency towards DI aversion and spite. During development, the severely affected individuals frequently suffer from massive temporal disturbances to their food, existential and social security. At best their families are forced to sell land, migrate, and enter into debt and at worst they have to forage for wild foods, steal food and experience starvation conditions. The result is that the harsh conditions they experience are directly linked to their high levels of suffering, which is in contrast with to the rest of the population. Their stress response system is involved throughout the whole crisis, from coping with the disintegration of social support networks, to motivating migration in the face of hunger, and dealing with direct competition for limited resources. These prolonged and repeated shocks can have real physiological effects.[30]

In addition, the behavioral systems involved in fairness consideration are highly sensitive to the process that allocates inequalities in the first place (see above). When allocations are random, people are far more willing to adopt costly strategies to force egalitarian outcomes. While this predisposition may have evolved in the context of sharing critical yet highly variable resource, the exact neurological mechanisms controlling such behavior remain obscure. Nevertheless, the psychological motivations behind this fact appear to us as rather intuitive; when allocations are random those who come out on top are seen to 'not deserve it' because they did not 'work for it'. Indeed the mental system that keeps track of the allocation process is sensitive to the amount of skill and effort put into creating the inequality, not the

[29] Again, the fact that the most severely affected communities are also those who have a higher frequency of spiteful players is consistent with the calibration process taking place more often in these communities. Moreover, our field interviews reveal that, for an individual or a household, moving outside a community because of a shock is very costly and probably represents a last resort.

[30] These effects are described in subsection 2.3 and 2.4.

'amount of randomness' which is in essence a metaphysical claim. We suspect then that the 'fairness system' is calibrated during development by information about the amount of effort versus luck that contributes to resource allocations and inequality. People, who have experienced a large number of random shocks such as extreme weather events, would observe fortune and failure allocated in a manner that is largely independent of skill/effort. Therefore, they should express greater DI aversion, and an increased willingness to use spite to reduce these differences. The likely psychological result would be that inequalities born out of randomized processes would appear to be more unjust.[31]

This 'model' makes a number of interesting and somewhat counter intuitive predictions regarding social preferences such as inequality aversion. First, as we have already seen there should be a connection between the severity of exposure and both an aversion to disadvantageous inequality and spite because these behaviors are part of interconnected neurological systems. Second, this behavioral axis, should not simply be calibrated by socioeconomic status, but instead should be more sensitive to the frequency and intensity of shocks, because of both their random nature and the effects of acute stressor events. Third, because we predict that the calibration of DI is not simply due to the crisis and competition for resources, but that it also engages the developing sense fairness preferences - therefore we should expect some connection between behaviors like spite and fairness considerations.

As we have already seen in the results section, the experience of shocks during critical developmental periods is correlated with both disadvantageous inequality aversion and spite – illustrating that shocks have an effect on this general neurological system. Second, even after controlling for wealth and income there is still a significant relationship between exposure to shocks and spite. Therefore we know that it is not simply the fact that a person is located at the bottom of a socioeconomic hierarchy that is producing spite and envy, but that it has to do with the experience of early random shocks. In fact, there is *no detectable* relationship between income and wealth and spite at all. This finding may seem surprising as we expect that those who have been hit by early shocks should (statistically) be at an economic disadvantage. Yet, we also know that those who were subject to ELS are far more aggressive and eager to reduce DI that exist between themselves and the rest of their community. Finally, we find a positive correlation between verbal reports over the concerns of local inequality and a willingness to play spite. Therefore, we can extend the connection between spite, envy, and randomness, to include fairness considerations as well. With these three tests in place we are unable to reject this final hypothesis, but more cross cultural research is needed to confirm this explanation and establish a far more general connection.

[31] We also suspect that this psychological bias underpins principles of equity.

2.6 Final Considerations

To our knowledge our study is the first of its kind to show any relationship between the experience of climate shocks during critical developmental periods and social preferences in adulthood. This longer term association is important because unlike earlier studies that have demonstrated a short term effects – our research demonstrates that the severity and intensity of extreme weather can have behavioral consequences that span a lifetime. More research in other cultures is needed to confirm whether or not this is a consistent developmental effect or one that is culturally constrained. But if our findings are taken into account with the research in behavioral economics and neuroscience, it strongly suggests that the effect is in fact not isolated, but far more universal.

In a world that will experience more severe weather events these findings are a sobering reminder that the effects of climate change will not just consist in alterations to the physical environment but will also shape psychological and social preferences. Unfortunately our results do not suggest more altruism nor an aversion to advantageous inequality, instead that we can expect more spite and envy in severely affected areas around the world. In particular, if this 'calibration' takes place, spite and envy are likely to adversely affect development efforts aimed at correcting damages caused by weather events. While other research shows that climate shocks have a tendency to exacerbate existing levels of inequality (Dell, Jones, and Olken, 2008; Bowles, Alden Smith, and Borgerhoff, 2010), our results indicate that there is a counter-veiling psycho-social pressure that unconsciously shapes preferences to become less tolerant of inequalities. Crucially, while the real wealth inequalities are produced relatively immediately, the psychological aversion to inequality can take decades to manifest itself.[32] Ceteris paribus, if there is an increase in extreme weather and this results in both high levels of economic inequality and populations less willing to accept it, then we may predict an increase in sociopolitical instability. Therefore, even if 'stressors' due to climate change were to end tomorrow the effects of extreme weather events already experienced would not be visible for many decades. Also, while this kind of IA can enforce egalitarian outcomes, it can often result in economic sub-optimal equilibria because it impairs a community ability to cooperate effectively to address climate change adaptation and mitigation issues. From a development standpoint this means that actions to alleviate the effects of climate change have to be very conscious of the role of inequality.

It has been suggested by some theoretical biologists that harsh environments may have provided the necessary conditions to encourage the evolution of generalized group level altruism. Theoretical models suggest that harsh environments which impose a high cost of living can promote cooperation in the long run, but at the same time favoring short term selfishness and competitiveness (Paul Smaldino, Jeffrey Schank, and Richard McElreath, 2013). Here we were able to test whether climate shocks can, in a sense replace other

[32] In some way, our results show that, in a period of food crisis, there is (new) long term cost when immediate food aid does not reach the affected areas.

external threats such as wars in producing high levels of cooperation. Our evidence suggests that climate shocks do not facilitate altruism, but in fact encourage competitive tendencies such as aversion to DI, and spitefulness within communities. We suspect that these findings result because during war, the scale of selection is on the *group*, while during climate shocks, particularly ones like droughts, the scale of selection is on the *individual*.

It has not escaped our notice that our findings can perhaps go a long way in explaining why, after the origin of agriculture and sedentism high levels of socioeconomic inequalities began to emerge in human societies across the globe. This increase in economic inequality is generally associated with the elite control over land and other critical resources (Johnson and Earle 2000; Dow and Reed, 2013) that can be passed on intergenerationally (Bowles, Alden Smith, and Borgerhoff, 2010) and which has a higher rate of return than general economic growth (Piketty, 2014). While these explanations provide a basic economic mechanism for the transmission and accumulation of wealth what they do not describe is *how exactly humans overcame their egalitarian predispositions to allow for the unequal accumulation of wealth in the first place*. Spite, as we have seen, is a major leveling mechanism that can maintain high levels of egalitarianism through 'hammering the nail that stands up'. Therefore, it is not enough to posit simple economic mechanism that can allow for the accumulation of wealth but we also must be able to answer, why these early societies changed in their degree of tolerance for inequality. As we have seen, inequality aversion, and in particular envy and spite increase in response to harsh climates and uncertain returns, conditions that are similar to that which our hunter-gatherer ancestors would have experienced. As farming evolved and subsequently moved away from rainfed agriculture, the effect that climatic variation would have on immediate returns would be buffered by storage and irrigation. These innovations would smooth agricultural returns and damped nature's fickle fortune. As the frequency of climate stressors and the threat of starvation abated, then so too would levels of spite and envy. Lower levels of spite would then allow for the rise (and the tolerance) of social inequalities. When profits and wealth were no longer allocated by random environmental forces, then inequalities in wealth, power and prestige could attempt to be justified on the basis of exceptional skill and/or effort. It is only at this point that we suspect that the less fortunate began to tolerate rising rates of inequality - or perhaps more simply those who were richer became more justified in their belief that they earned their wealth and defended it more vigorously.

Chapter 3

"On what authority?" - On the Evolutionary Origins of Political Power and Anti-Authoritarianism

> "Of all men's miseries the bitterest is this: to know so much and to have control over nothing." - Herodotus

3.1 Introduction

Strictly, some political systems are more efficient than others because they use less time and resources to coordinate actors. A French General once claimed that he lost a battle during the French revolution because the *Garde Nationale* decided they should vote on whether to charge or not (Bertaud, 1988). Efficiency in political decision making often comes into conflict with peoples' perceptions of fairness, yet, why exactly some forms of politics are considered more fair than others is not immediately apparent.

When Aristotle said that man is a political animal he recognized our species is inherently cultural *and* biological. Like other animals, humans live in communities where individuals and coalitions vie for power and influence. Additionally, the ancients also knew that speech and verbal communication has endowed us with a degree of moral reasoning that allows for discourse on desirable forms of politics. This composite view of politics has lasted throughout most of western history. From St. Augustine to Hobbes the 'moral capacity' of humans was seen as being the result of natural tendencies, culture, rationality and a randomness that was ascribed to God. Nevertheless, in the 20th Century, reinforced by Durkheim, (1919) the stigmatization of Darwinian ideas in the post-War era led to the dominance of both cultural constructivism and rational actor models– as such scholarly discourse on politics lost its primal nature.

The assumption that political behavior is purely cultural or rational, however, has been challenged by mounting evidence from behavioral genetics (eg. Hatemi et. al. 2011),

evolutionary theory (Van Vugt, Hogan and Kaiser, 2008), neurobiology (Knutson et. al., 2006), and zoology (de Waal, 2007). Ultimately, beneath all of the sacralised rationality and culture sits an ape with a brain that has evolved over the course of hundreds of millions of years to become adapted to social and political life in small bands of somewhat related individuals (Chapais, 2009; Hill et al., 2011).

While it might be unclear to some scientists how biology influences political behavior and preferences, we argue that the clearest and most direct connection is to be found in our emotions. In short, emotions are psychosomatic motivational systems that guide behaviors towards adaptive outcomes in ancestral environments (Darwin, 1879; Le Doux, 1998; Damasio, 1996; Ekman 1987; Haidt, 2001; Tooby and Cosmides, 2008). Darwin (1859) began this tradition in *On the Origin of Species:*

> "...the senses and intuitions, the various emotions and faculties, such as love, memory, attention, curiosity, imitation, reason, etc., of which man boasts, may be found in an incipient, or even sometimes in a well-developed condition, in the lower animals."

At the core of all politics is the challenge of group decision-making – how is decision-making done and who is it done by? Because group life involves plenty of coordination challenges (ie. cohesive movement, mutual defense and trade) many species have evolved mechanisms for solving these kinds of problems (Van Vugt et. al., 2008), exploiting them (Byrne and Whiten, 1989; Buss, 2008), and resisting others' attempts to do so (Trivers, 1971). Fundamentally, the emotional force behind the ambition for status motivates many young adults to seek power, influence, dominance and belonging. In the process of doing so, emotions such as loyalty, betrayal, envy, suspicion, spite, love, trust, and anger guide the way.

Mounting evidence now suggests that even sophisticated political views are influenced by biological inheritance. For example, one study shows that genetic effects could account for the variance in preferences for: economic egalitarianism (48%), competition and business (41%) and ethnic and racial minorities (52%) (Bell, Shermer and Vernon, 2009; *but also see* Hatemi et. al., 2011). These studies do not imply that individuals are built with genetically pre-programed preferences, but instead that pre-existing biologically rooted tendencies, such as empathy, loyalty and aggression affect the probability of adopting one set of political beliefs over others. Simply, personality dispositions affect the likelihood that an individual will adopt one political belief over another (Boyd and Richerson, 2008). Consider, what then is the probability that a suspicious, distrusting, selfish individual is likely to want a large centralized government if they are not to rule it?

In this paper, we present the results of research that explores why some individuals prefer autocratic forms of decision making to more egalitarian systems. We do this through the use of two experimental games run in rural Tanzania. First, a modified dictator game

was used to measure 'other-regarding preferences.' Second, a modified public goods game with leader was used to measure preferences for political inequality. Long-form interviews supplemented these experiments. Initial results from studies conducted among Western populations suggest that a stable portion of the population favors decision-making systems that accord power to a single individual rather than having it dispersed over a large number of people (e.g., Ruve and Wilke, 1984; Samuelson, 1993; De Cremer, 2000). Despite that these autocrats are a minority, previous results suggest a positive correlation between heritable pro-social behavioral tendencies, and the willingness to vote for leaders to solve public goods challenges. Unfortunately, research has been limited to western populations and therefore do not exclude the possibility that these findings are culturally determined. To address this gap, we conducted a study in a non-WEIRD (western, educated, industrialize, rich, and democratic) population (subsistence scale farmers in Tanzania). To our knowledge, our research is the first of its kind to test experimentally for an aversion Political Inequality (PI) in a non-western population.

However, despite the fact that we are attempting to uncover underlying evolutionary impacts on political behavior, we begin with the premise that biological predilections must necessarily interact with culture in a sophisticated manner. In the evolutionary sciences, culture is seen as the transmission and inheritance of information through social learning mechanisms such as observation, imitation, and teaching (Boyd and Richerson, 1986; Tomasello, 2009). Unlike genetics, culture allows behaviors to be invented and transmitted over the course of years rather than generations (Perreault, 2012). While culture cannot completely rewrite humans' behavioral repertoire, it is capable of both calibrating instincts and emotions and can also create new behaviors. For example, culture can both regulate emotional expression through social norms, and it can create the ability to do calculus.

As such we adopt a dual inheritance theory: individuals have both a genetic and a cultural inheritance (Henrich and McElreath, 2003). What this means for politics is that humans possess an ancient emotionally-rooted set of behavioral tendencies that guide behavior in political realms. Also, we have culture - the accumulated writings, teachings, and norms particular to a group that proscribes how individuals should behave politically. To wit, other primates deal in politics by jockeying for political power while clinging to fragile coalitions; humans do the same but while one reads Locke and the other Burke.

Importantly, the set of cultural ideas present in a population is not random. Instead, it represents the historical accumulation of ideas constructed over thousands of years, and yet, crucially, is constrained by the nature of our cognitive and emotional capacities. Boyd and Richerson (1986/2008) have identified two key cognitive biases that affect the rates at which cultural ideas are adopted. *Context biases* pertain to who individuals learn information from – for example people preferentially learn cultural information from prestigious individuals. On the other hand, *content biase*s affect the probability of transmission based on the *information* encoded in the actual cultural idea, and how well that information in-

tegrates with pre-existing biological tendencies, and previously acquired beliefs. As such, cultural information about biological fitness, such as sex, violence and power, demands more attention and is more likely to be retained than information on, say, cabinetry.

Because of natural variation in populations, not all individuals will have the same content biases. For example, some men will be less prone to aggression than others, and this may lower their willingness to adopt hawkish political ideologies. This biological variation when paired with content biases will cause the frequency of cultural beliefs to be influenced by underlying biologically inherited preferences. There is a broad range of highly heritable dispositions that interact with the information content embedded in political norms and affect whether they are adopted or not. These dispositional or latent genetic effects include levels of trust, altruism, inequality aversion, envy, selfishness and even spite. Crucially, these biological tendencies provide *cognitive/emotional 'hooks'* that make it easier for certain cultural ideas to be retained and spread. Modern politicians are well aware of this and frequently attempt to exploit these hooks (eg. Salmon, 1998).

Likewise, culture manifests itself in politics. By encouraging the preferential adoption of particular beliefs, individuals can manipulate perceptions and beliefs to aid their attempts to gain power. For example, promoting the idea that foreigners are destroying both the social order and economy might enhance support for a politician who is tough on immigration. As Henrich (2009) notes, because political ideas can either increase an individual's fitness or make them vulnerable to exploitation, individuals likely have evaluation mechanisms to determine the veracity of political norms. One of the mechanisms by which people evaluate such norms is by determining the level of congruency between an actor's professed beliefs and his/her actions. For example, if the papacy professes that poverty is a virtue, but bishops and popes live in opulence, then one might conclude that that such norms aim to exploit their followers. Elaborate rituals and even asceticism often accompany politics because by incurring such a cost, politicians demonstrate a vivid signal that conveys their commitment to their espoused beliefs.

3.1.1 Definitions

Before fully considering the full evolutionary logic of how selection forces would have shaped perceptions of political fairness, we define here some key terms employed. *Politics* we define as the behaviors associated with individuals and coalitions attempting to gain and maintain influence over group decision making.[1] Note this definition focuses on the pursuit of decision-making power rather than strictly economic considerations such as the distribution of resources. *Power* is the ability to influence other individuals in the pursuit of goals. We adopt this broad definition of power over others that strictly focuses on the provisioning of rewards and punishments (see Keltner, Gruenfeld, and Cameron 2003) because we want our definition to account for the use of manipulation/deception.

[1] see de Waal (2007) for an ethological account of politics

To understand influence, assume that all individuals have a range of behavioral strategies that could be deployed in any particular situation with some intrinsic probability. *Influence* is the process of adjusting the otherwise independent chance that a particular strategy will be deployed by an individual. Our definitions of power and influence are much closer to those found in the traditional humanities and social sciences (see Foucault 1977), which views power as a (dynamic) attribute of systems, rather than strictly a static attribute possessed by individuals. We define *exploitation* as the use of power to influence others in a way that incurs a cost to them but a benefit to the person using the power.[2]

Political inequality (PI) refers to the distribution of political power within a group. In *autocratic* social systems such as dictatorships, autocracies or monarchies, one individual possess all decision-making power. In *politically egalitarian* systems such as a direct democracy, power is distributed evenly across all people. Intermediary systems would include representative democracies, which have radical equality in elections but much higher levels of political inequality involved in the practical running of a country. Theoretically, a scale like the Gini coefficient could be derived to index the distribution of political power within a society, but like the Gini coefficient, it would hide inner variation (Piketty, 2014).

Finally, we define *authority* as the use of power that is sanctioned by the group. The use of authority is delineated by existing norms, such as a religiously inspired caste system. *Anti-authoritarianism* refers to the rejection of the norms legitimizing political inequalities.

3.2 Theoretical Considerations and Literature Review

3.2.1 Evolutionary Foundations

Why would evolution have shaped preferences for political fairness? Let us first consider power and how it is typically used by animals. Both nature and history show that the capacity to assert power over others frequently leads to adverse outcomes for the less powerful including domination, slavery, rape, marital despotism, genocide, and economic oppression (Pinker, 2011).

At the most basal level, we suspect that all organisms have some form of adaptive resistance

[2] We suspect that part of the contentious history of the term exploitation comes from the fact that it was developed by Marx during the industrial revolution. Up until the industrial revolution, global economic growth was very low, around 0.01% per year (Piketty, 2014). This slow growth rate means that before the industrial revolution any change in the distribution of wealth could be attributed to individuals appropriating resources that formerly belonged to someone else - new wealth was rarely created. In pre-industrial societies, it would be very easy to identify exploitation because most interactions were zero-sum. The rapid creation of wealth in the industrial revolution created conditions for extensive non-zero interactions amongst individuals – this allowed for industrial capitalists to gain huge profit off of the labor provided by workers, while still marginally increasing their living standards over the long run. Unfortunately, there appears to be a cognitive bias that causes most individuals to perceive non-zero sum interactions as zero-sum interactions – probably because of the rarity of non-zero-sum interactions in our evolutionary history. This apparent inability to intuitively understand non-zero sum interactions (Meegan, 2010) means that when economic inequality increases it is assumed that it always does so because of exploitation. Note then that our definition of exploitation is separate from conventional definitions of fairness because an interaction can be unfair but not exploitative.

to others influencing their behaviour, and it is likely that this tendency is directly related to approach-avoidance. Non-domesticated animals (and children) tend to avoid strangers unless the animal in question is a big and hungry predator and the stranger is alone and vulnerable. Such a simple behavioral rule should exist because of the 'problem of unaligned interests' - in all organisms that do not share perfect relatedness, conflicts of interest are common because of competition for limited resources (Alexander, 1987). In the absence of mechanisms to promote cooperation, the use of influence or power would be a valuable competitive tactic, allowing individuals to exploit others to their own benefit (Buss, 2008). As such, individuals are sensitive to cues that indicate that another organism may have the capacity to influence their behavior, and under the right conditions this triggers vigilance, aversion, and even hostile reactions.[3]

Behavioral manipulation, influence, and exploitation is extremely common in nature and need not involve sophisticated social cognition. It can often happen through simple neurological 'bypasses,' for example:

> "...an ant falling victim to a parasitic fungus of the genus Cordyceps is manipulated in its behavior to facilitate dispersal of the fungus, thereby optimizing the parasite's chances of reproduction. To this end, Cordyceps fungi produce chemicals that alter the navigational sense of their ant hosts. It begins with the attachment of the spores of the fungus to the cuticle of the ant. The spores then germinate and break into the ant's body by diffusing through the tracheae. Fungal mycelia then grow by feeding on the host's organs, avoiding vital ones. The fungus then produces certain, yet unidentified, chemicals that cause the ant to climb to the top of a tree or plant and clamp its mandibles around a leaf or leafstalk to stay in place. When the fungus is ready to sporulate, it eventually feeds on the ant's brain and thus kills it. The fruiting bodies of the fungus then sprout out of the cuticle and release capsules filled with spores. The airborne capsules explode on their descent, spreading the spores over the surrounding area to infect other ants and thus start another cycle." (Libersat, Delago and Gal, 2009)

In humans, con-artists and politicians alike attempt to exploit such unsophisticated neurological triggers in order to gain trust and power. For example, by deploying terminology that indicates relatedness ('brother'), reciprocity ('friend'), and deference ('boss') scammers attempt increase the perception of mutual interest between themselves and the targeted dupe. As such, resistance and protest to political control are common. In chimpanzees, "wahoo"

[3] The evolutionary dynamics involved the use and resistance of power do not likely result in equilibrium for two reasons. First, as organisms adapt and evolve, this continually opens up new ways to gain influence and power, which individuals may not have a resistance too (see also the Red Queen effect). Second, as we will discuss below, because sometimes influence and power can be beneficial to both parties, individuals sometimes accept power as an adaptive strategy.

barks are produced in defiance of alphas attempting to exert political coercion (Boehm, 1999). Likewise, in humans' aversion to manipulation and political inequality underlies anti-authoritarian tendencies and forms the basis of dubious pathologies like Oppositional Defiance Disorder (ODD).

Psychologically, we propose that this anti-authoritarian tendency is composed of two separate emotions. Suspicion, the primary function of which is to evaluate the degree of mutual interest between the self and others, (Deutsch, 1960) is associated with distrust, approach-avoidance, threat detection, and vigilance. Suspicion both acts as an alarm system for distrust and alerts individuals to the potential of exploitation and manipulation. Regarding leadership, who would voluntarily accept authority under the suspicion of exploitation? Power exercised in the absence of mutual trust raises the potential for exploitation. Thus, those who have intrinsically lower levels of dispositional trust tend to be less accepting of political leadership (Smith et. al. 2007).

Neurologically, both testosterone (Archer, 2006) and arginine vasopressin (Carter, 2007) regulates the amount of energy that mammals, including humans, invest into competition. The fact that these hormones are sensitive to competition means they are calibrated by the degree or amount of mutual interest between individuals. Interestingly, research has shown that circulating levels of testosterone and vasopressin also predicts dispositional levels of distrust and suspicion (Riedl and Javor, 2011; Johnson and Breedlove, 2010; Bos et. al. 2010). Bos et al. (2010)conclude that "testosterone adaptively increases social vigilance in trusting individuals [in particular the naıve humans to better prepare them for competition over status and valued resources]." When individuals are in competition with each other, they have no reason to trust each other, and increase their vigilance and suspicion and in such situations are less likely to accept voluntarily political control.

Second, the unfavorable use of political power provokes anger. Anger is an emotion that is triggered when an individual suspect that a social partner does not value his/her own interest as much as they feel they should (Sell, Tooby and Cosmides, 2009). According to Sell et al.'s (2009) theory of Anger as Recalibration, the primary adaptive function of anger is an interpersonal negotiating tactic. Anger acts as a threat to forcefully recalibrate the weight that another individual places on the actor's welfare. In other words, if a person does not think they are treated fairly, this triggers moralistic anger (Trivers, 1971). Moralistic aggression can motivate one to incur punishment or withhold cooperation unless the other alters his or her behavior to a more favorable position. In politics, anger is provoked when individuals think group decision-making processes are exploiting them. As with competition and suspicion, testosterone is highly correlated with anger and aggression in humans, implying a deep connection between these two behavioral systems (Archer 2006).[4]

[4]This explains why public trust is so crucial for the success of politicians political campaigns.

3.2.2 The Evolutionary Adavantage of Political Inequality and Leadership

This instinctual resistance to power is complicated by the fact that under certain conditions political inequality is an invaluable tool for solving social dilemmas. Consider that all organisms who live in social groups, including bacteria, need to coordinate behavior for critical tasks like group movement (Conradt and List, 2007). In primates, maintaining cohesion is crucial because we possess few defenses against predation beyond strength in numbers and technology. The loss of cohesion during group movement results in each individual becoming more vulnerable to predation (Shultz et. al. 2011). Different species have different ways of solving these coordination problems; some adopt a system of voting for preferred direction, while in other species, leaders and first movers make decisions for the group (King, Johnson and Van Vugt, 2009).

Leadership and power are effective mechanisms for securing high levels of coordination among group members. Removing alphas from captive populations of chimpanzees results in an increase in internal conflicts, because the practice of policing, which is performed by alphas, is no longer available (Flack, de Waal and Krakauer, 2005; Von Rohr et. al., 2012). However, as Michael Tomasello (2014) notes, the range of collaborative enterprises available to our early ancestors was limited by their non-cooperative tendencies. As such, it was not until very recently in our evolutionary history that the potentials for coordination and cooperative enterprises began to multiply dramatically. As social life amongst early hominids became more complicated, the benefits that leadership could provide to groups increased. Interestingly, early antecedents of the domains in which leadership became invaluable to our species can still be observed in chimpanzee societies. For example, temporary positions of leadership emerge in the context of group hunting (Boesch, 2002), intergroup conflict (Gavrilets and Fortunato 2014), internal conflict resolution (de Waal, 2009) and policing (Von Rohr et. al., 2012).

As the potential benefits of leadership and differentials in political power increased, evolution would select for individuals who could capitalize on such situations. Practically, this means that individuals would become more attentive to cues that signaled conditions where leadership was desirable, and situations where exploitation was likely. Authority is most favorable in the presence of mutual interests because it can act as an inexpensive coordination mechanism for when people are working towards a common goal. Therefore, the willingness of individuals to accept political inequality should be calibrated by traditional mechanisms that signal cooperation, such as: relatedness, reciprocity, reputation, group selection, punishment, and norms.

Thus, the suspicion and anger that furnishes the resistance to political inequality is counteracted by the presence of trust (Smith et. al. 2007). Trust is a measure of how likely an individual suspects that someone else will take advantage of them (Coleman 1994).[5] The

[5] Trust is unlikely a purely continuous variable, but instead there is a threshold above which an individual

more trust, the less likely people expect exploitation. As such, individuals tend to cooperate with people whom they trust; for example, trust is higher among family members and friends than among random members of a population. The high levels of trust in families may help explain why many traditionally patriarchal family forms are stable despite their autocratic forms of decision making.

Neurologically, the primary correlate of trust is oxytocin. Interestingly, oxytocin is also associated with birth, lactation, approach behavior, social bonding, orgasms, economic egalitarianism, and general prosocial behavior but only towards in-group members (Kosfeld et. al., 2005; Baumgartner, 2008; De Dreu et. al. 2010). Behavioral genetics has demonstrated that the propensity to trust others is heritable (Cesarini, et. al. 2008), and genetics accounts for 15-20% variation in trust games – while unshared environment accounts for 68-72% of the variation.[6]

What is the connection between trust and political power? High levels of trust, whether the result of personality dispositions, interpersonal interactions, or larger cultural norms, provides a cue that an individual is unlikely to anticipate exploitation as the result of power differentials. Therefore, the presence of trust reduces the otherwise natural aversion to political inequality. This idea is central to modern leadership studies, which have identified trust as an essential component of successful leadership in organizations (e.g., Schannen, 2014).

In professional settings, trust is important because it allows employees and subordinates to have faith that leaders have their interests at heart (Dirks and Ferrin, 2002). At a global level, research has shown that trust is also negatively correlated with the degree of economic inequality within societies (Bjornskov, 2007). This is because trust tends to decrease as individuals assume that everyone else is 'out for themselves', and trust increases as mutual interests become more apparent.

Note that the implication of this is that in decision-making systems where there is complete political egalitarianism and each person represents their own self-interest, then there is no need for trust in politics. It is only when political inequalities emerge and individuals are endowed with decision-making authority that trust becomes essential for the functioning of hierarchies. It is likely that this is why societies with low levels of trust have dysfunctional institutions.

Finally, there is one major complication to this whole story, and it is that the ethnographic and archeological data on hunter-gatherers show that they often lack both material and political inequality (Kelly, 2013; Von Rueden et. al. 2014). This history means that since the spilt between the last common ancestor with chimpanzees, approximately 6-7mya, something happened in the hominid line that resulted in our ancestors transitioning from traditional despotic dominance hierarchies and leadership to an egalitarian structure (Boehm, 1999; 2012). However, research suggests further that while foraging societies are largely

is willing to trust someone, and below which they are unwilling to.

[6] Unshared environment refers to the effect that non-family environmental influence has on development.

egalitarian, leadership and political inequality still exist, albeit in a temporary, ad hoc form. Leadership is frequently described as, deliberative, brief, and highly constrained (von Rueden et al, 2014). Those who lead, lead because they are skilled in a particular task, hold high-quality information, and are prestigious (Cheng et al. 2013). They are not, as many treatments of politics would have us believe, individuals who translate material inequality into political authority backed by the threat of violence.

Across foraging societies, egalitarian and deliberative decision-making is enforced by a wide range of social leveling mechanisms that are used to constrain dominant tendencies, often found in young men who would attempt to become despotic leaders themselves. These leveling mechanisms range from teasing to ostracism, and even to assassination in some cases (Boehm, 1999; Kelly, 2013). In short, groups collectively sanction personality traits, such as ambition, that would lead individuals to attempt to consolidate political power. This sanctioning has caused some anthropologists to argue that foragers have a *reverse dominance hierarchy*, whereby individuals forgo their chances to become dominant to ensure that others will not become dominant over them (e.g., Boehm, 1999). Boehm suggests that the politically egalitarian tendencies found in hunter-gatherers form the basis of human preferences that predispose us towards resisting authority. As discussed later, this anti-authoritarian tendency might actually reflect lower levels of interpersonal trust amongst hunter-gatherers.

While some authors speak of our species' ambivalence towards power and authority (e.g., Boehm, 1999), our theory can make a series of robust, testable predictions about when political inequalities will be accepted. First, due to the ancient potential for exploitation, an aversion to political control should be more common than an acceptance of it. Second, an acceptance of political inequality should be calibrated by the degree of mutually perceived interests. Thus, individuals should only accept political authority in the presence of high levels of trust. This means that people with higher levels of dispositional, and interpersonal trust should be more willing to accept leadership and political inequality. Crucially, regardless of the levels of trust amongst individuals, if there is no coordination problem at hand, then there should be no need for leadership. Therefore, the acceptance PI should only take place if individuals perceive that they are facing a coordination challenge.

3.2.3 Experimental Literature

We will now turn to the insights on preferences for the distribution of political power offered by the experimental literature. Since the 1970's, social psychologists have been researching whether or not individuals derive disutility from violations of procedural justice (for a review see Bøggild and Peterson, 2015). The cross-cultural evidence suggests that humans appear to have a healthy aversion to procedural injustice. That is, individuals strongly dislike when established rules for decision making are violated. While at first glance, this evidence might seem to provide an answer to our question, unfortunately this research does not adequately

address whether or not humans derive disutility from *political inequality*.

Existing experimental studies on preferences for procedural justice do not actually measure individual preferences for the distribution of political power, but instead, estimate the disutility derived from violations of previously established norms regarding the process of political decision-making. That is, they measure how people react when established political norms are broken. The question of procedural justice is different from ours, because our concern is *not* with the process of *how* decisions are made and the rules governing them, but instead is about *who*, or more precisely *how many*, have the power to make those decisions.

Currently, only a few experimental studies come close to addressing whether or not individuals have consistent preferences for particular distributions of PI. The earliest studies were conducted by psychologists interested in the conditions under which individuals would prefer structural changes (introducing a leader/high political inequality) to solve a tragedy of commons/social dilemma. In a paradigmatic experiment, Ruve and Wilkes (1983) created a resource harvesting dilemma, in which a group of subjects started out with a fixed sum of communal resources that was replenished at a specific rate every round. In each round, the participants determined how many resources they wished to harvest. In making their choices, they had to balance two countervailing pressures one to maximize their returns and the other to avoid overharvesting the resource. Using bogus feedback, the researchers varied both the inequality of payoffs between harvesters, and whether the resource was being overharvested. After a single round of the game, they allowed the participants to change the mechanism by which the participants' harvesting rates were determined, by giving the subjects the chance to vote for a leader who could arbitrarily set rates of harvest for each subject. By allowing individuals to vote for leaders in a social dilemma, they could test for preferences for the distribution of political power.

Overall a full 36% of people within their sample voted for leaders. Analysis showed that subjects were significantly more willing to vote for a leader when there was high inequality between individual payoffs, and when the resource failed to be sustained. These results have subsequently been replicated multiple times with a similar proportion of people with preferences for leaders (eg. Samelson and Messick, 1986a; 1986b; Van Vugt et al, 2004). Early explanations for why people vote for leadership (and thus high political inequality) focused on the instrumental/strategic decisions made by individuals (Samuelson, 1993). It was assumed that when participants became unsatisfied with their material payoffs, they would opt for any kind of structural change in the game, such as introducing a leader, as part of a 'win-stay, lose-shift' strategy. However, continued analysis of experimental data showed that it was not only individuals unsatisfied with their payoffs who voted for a leader. Samuelson (1993) found that a sizeable portion (67%) of individuals who were *satisfied* with their returns voted *for* leaders regardless. Subsequently, he also found only a very weak link between individual harvesting behaviour–proclivities to self-interest–and likelihood to vote for a leader.

In light of the fact that strategic factors only weakly correlated with preferences for PI, researchers began to examine the impact that 'social values' have on preferences for leadership. The first systematic social value investigated was whether prosocial/cooperative individuals would have significantly different preferences for PI than selfish individuals. Using 'Social Values Orientation' metric, they found that *cooperators preferred leadership mechanisms considerably more than non-cooperators,* particularly when the resources were overharvested (Sameulson 1993; De Cremer 2000). Importantly, in these subsequent studies, the proportion of individuals willing to vote for a leader remained relatively constant with some 30-40% of individuals preferring leaders to acephalous forms of organization.

In all the studies cited above, analysis of individual preferences for PI was not the primary intention of the researchers. Instead, they aimed to discover the conditions under which individuals would accept structural changes in groups to solve social dilemmas. The only experimental study to our knowledge that directly tests for PI aversion was done in 2003 by Van Vugt et. al. In that study, participants played a modified, iterated public goods game, in which subjects were randomly assigned to one of three groups, all of which had different allocation mechanisms (ie. dictators, democratic leader, and laisse fair/acephalous system). At the end of each round, subjects were given the option to exit their group and join another. The results showed that the participants were significantly more likely to leave autocratic groups rather than democratic or acephalous groups. More so, the outcomes between the democratic and authoritarian groups were held stable - by doing so, the researchers were able to show that the choice to leave a group was not motivated by economic considerations. Consistent with earlier findings, 40% of subjects were willing to stay in the autocratic systems.

3.2.4 Critiques of the Experimental Literature

Unfortunately, although these studies provide valuable insights into the existence of preferences for PI, they all suffer from three limitations, that limit the ability to generalize from these findings. The first and most severe of these is that, without exception, all experimental studies were conducted in Western, Educated, Industrialised, Rich, Democratic (WEIRD) populations (Henrich, Heine and Norenzayan, 2010). As such, they cannot account for the extent to which the results are culturally derived or the result of deeper psychological predispositions. Adding to this complication is the fact that, in all of the studies sample populations were drawn from undergraduate psychology students – a decidedly unrepresentative sample. Research has shown that this sampling bias skews experimental results on a broad range of psychological variables (including fairness perceptions) (Henrich, Heine and Norenzayan, 2010). To correct this limitation, cross-cultural data must be collected in order to examine the range of stability and variation in these preferences across societies.

The second limitation is that experimental designs have not accounted for costs typically

associated with leadership and PI, the most pervasive of which is corruption.[7] In 2014, corruption was estimated to cost the global economy an estimated 5% of GDP or 2.6 trillion dollars (OECD, 2015). Without accounting for costs to political inequality like corruption, these experiments create no real decision tension. Instead, leadership mechanisms simply provide a free coordination mechanism with no trade-offs involved, and this aberration may skew the proportion of individuals willing to vote for a centralized decision-making mechanism. Our study introduces a mechanism for corruption into a standard public goods game and therefore corrects for this problem while still being able to hold expected outcomes stable.

The final limitation of these studies is that all those reviewed, with the exception of Van Vugt et al. (2003), fail to hold outcomes stable across differing levels of PI. By failing to hold outcomes stable, these studies are unable to show whether their subjects' preferences for PI are driven by economic considerations or a deeper set of preferences related to the distribution of political power. In other words, researchers never calculated the sub-game optimal equilibrium and therefore, were unable to determine how a perfectly rational individual would play the game. By failing to do so they are unable to determine whether or not the decision to vote for a leader or not is the result of a payoff-maximizing strategy or preferences related to political fairness. For this problem to be abated, the game must create a situation in which the option to vote for a leader would be a weakly dominant or neutral strategy. That is, there should be no payoff incentive/disincentive for voting for a leader. Once the economic incentives are removed, it should be possible to determine whether individuals have preferences for leadership structures that transcend economic considerations.

3.2.5 Research Questions and Hypotheses

Our primary research question is two-fold. First, what proportion of individuals favor political egalitarianism over autocratic forms decision-making in a non-western context? To explore this issue, we use a modified public goods game in which individuals can vote for a randomized leader. The leader can arbitrarily set the contributions made by the participants, and can 'pay themselves' out of the collective pot. Importantly, our experiment controls for both economic rationality, by holding expected outcomes stable between leadership conditions (see below), and for socio-cultural inculcation by using proxies such as political participation and education.

Our secondary research question pertains to whether underlying 'other-regarding preference'/social values influence the likelihood that an individual will accept autocratic forms of decision-making. For example, are economic egalitarians more politically egalitarian as well? To explore this question, we played a modified dictator game with our subjects, from which we can determine behavioral profiles such as spitefulness, altruism, selfishness and

[7] Which is a form of exploitation.

economic egalitarianism. We combine these results with the findings from the public goods game to study the effect that social dispositions have on political preferences.

As our theoretical outline predicts, individuals with pro-social orientations may tend to prefer leaders because they have higher intrinsic levels of trust, making them less wary of potential leaders. To capture the impact that levels of interpersonal trust has on perceptions of political fairness, we also analyze how our subjects' expectations of others' behavior (that is, do they think their community members are altruistic, egalitarian, selfish or spiteful) influence the likelihood that they accept leaders.

Hypothesis 1 – A preference for acephalous forms of decision-making will be more prevalent than preferences for autocratic forms of decision making. In our experiments, this means that less that 50% of individuals would be willing to accept high levels of political inequality. This hypothesis seeks to test the findings of Van Vugt et al. (2003) in a non-western, subsistence population. We suspect that the aversion to autocratic decision-making will be prevalent because over the course of our evolutionary history high levels of political inequality has been a reliable predictor of future exploitation. Therefore, high political inequality should trigger an intuitive aversion that should be robust, even after controlling for the socio-cultural inculcation of democratic norms.

Hypothesis 2a – Prosocial and cooperative individuals should be more willing to accept high levels of PI and vote for leadership structures. This hypothesis aims to test the findings of Samuelson (1996), and De Cremer (2000) that cooperative/prosocial individuals are significantly less averse to Political Inequality than self-interested individuals. We predict that a relationship may exist because cooperative individuals have intrinsically higher levels of dispositional trust and a concern with group outcomes/fairness. This, in turn, would reduce the otherwise natural aversion to political authority and allow individuals to gain from the coordination brought about by leadership.

Hypothesis 2b. – Of all the prosocial tendencies, egalitarians should be more likely to vote for a leader because it is *only* egalitarians who face a coordination challenge. Structurally, egalitarianism is unique because it requires that all individuals receive the same allocation and thus intrinsic to the preference's logic is a serious coordination problem. This is not true for people who are either averse to self-advantageous inequality or who are altruistic; their preferences can be achieved without the same restrictions and need for coordination.

Hypothesis 2c. – Individuals who have higher levels of interpersonal trust should be more willing to vote for leaders. We predict that they would be more willing to accept leaders because they *expect that leaders will not exploit them* and that instead they will act as a free coordination mechanism. While we do not have direct measures of trust, we do have people's reported expectations of other individual's behaviors in the modified dictator games. This operates as a sufficient proxy for trust because a person with high trust would assume that other individuals would be more altruistic and or egalitarian while an individual with little trust would suspect that others are selfish or spiteful.

Hypothesis 3. – The converse of Hypothesis 2a and 2c should be true as well: selfish individuals and individuals who perceive others as selfish, should be less willing to vote for a leader. We predict that this correlation exists because selfish individuals should have lower levels of trust, be more suspicious and be angered more easily by others attempting to direct their behavior because *they expect exploitation.*

3.3 Methodology

To address these hypotheses, we developed a studies with two separate but connected experiments and a formal household survey. First, we used a modified dictator game to determine social preferences. During the collection of this data, we administered an extensive survey to capture demographic, economic, and sociological variables. Second, as per standard protocol we waited two months then ran a modified public goods game where the participants had the ability to vote for a leader. Crucially, the two games were played with the same subjects to make possible comparisons between 'other-regarding preferences' and preferences for political inequality.

3.3.1 Sample

The participants of these studies are small-scale subsistence farmers, from six villages across three ecologically distinct regions of Tanzania. We can broadly characterize the three areas by their rainfall patterns: one is wet with average annual rainfall around 1135mm, another has medium rainfall with 831mm, and the third one is dry, with 589mm. In each ecological zone, we have two sample villages that are no more than a 10-minute motorbike ride apart. At least one village in each region is part of a larger, long-term development research project that introduces dairy goats and new root crop varieties to farmers.

Farmers in these regions practice subsistence agriculture on plots of land with a median size of 6 acres. The crops that they grow vary from region to region. In the wet regions they mostly grow rice and maize, while in the drier region the main crops are maize, sorghum, and millet. Farming is still done with a hoe in hand, and labor is a major constraint on productive capacity. In the medium and dry region, farmers also practice small-scale agro-pastoralism, but herds are modest, averaging around three heads of cattle. Table II.I provides summary statistics for our overall sample.

All of the villages historically practiced some form of communal labor/sharing of essential resources. In recent years, these norms have been deteriorating. In our long-form interviews, farmers expressed speculation that these changes are a result of increasing integration into local labor markets. Clan and kinship networks, however, are still active. This is most visible in the physical layout of villages, as households are still arranged around traditional clan structures, with a small number of independent households circling a common courtyard separated from other clans. Nevertheless, the modernization process has influenced farmers.

Table II.I - Summary Statistics			
	Mean	S.D	Median
Age	46.8	13.34	43.32
Sex	0.62	0.49	1
Income (Tsh)	1.73e06	1.97e06	1.12e06
Household size	6.82	3.24	6
Market Integration	36%	23%	36%
Avg Contribution	40%	22%	40%

Significant changes include improved housing, motorbikes, local dukas (stores), cell phones, and to a very limited extent, electricity. Despite these changes, rural life remains a matter of face-to-face interaction; strangers are a novelty, formal governmental support is extremely limited (in non-election years), and market access is severely limited. As a result, these populations provide a rough approximation of how ancestral peasant farming communities would have lived for the majority of agrarian history.

In all of our regions, local government is composed both of locally-elected officials, and regionally-appointed administrators who are directly responsible to the district governments. Current forms of local governance represent the outcomes of 130 years of political change and experimentation across all scales in Tanzania. Inferring the range of political inequality that existed in the pre-colonial era is difficult, but based on reconstructions by historical linguists and anthropologists, it appears that community political life centered around ritual specialists, mainly rainmakers who had some limited power and political authority (Haakansson, 1998). Their primary function was dealing with the magic needed to maintain consistent rains while their political domains involved mediating conflicts between members of the community and allocating land.

While under British rule, the colonial government imposed a system of chiefdoms upon ethnic and regional groups as a way of consolidating the number of individuals and groups with which the administration would interact. These leaders were given responsibility for coordinating harvests on collective fields and provisioning justice. While chiefs held considerable local authority, they were still ultimately accountable to the crown. After independence, the chiefdom system was replaced with a variety forms of local political governance that had all be developed by the central government in Dodoma, resulting in the system described above.

Descriptive statistics are shown in *Table I*. Our initial sample of individuals who played in the dictator game was 180, of those 126 were randomly selected, two months later, to participate in the public goods game (21 in each village). Of the in 126 the sample 40 had to be dropped due to name matching problems between the first and second experiments. Fortunately, the summary statistics are identical between the 86 individuals and the 126, showing that the loss was randomly distributed and thus unlikely skewed our sample, despite reducing the total number of observations. In both cases, subjects were invited to participate in the

study by an agricultural extension officer a week before the actual experiment date.

3.3.2 Modified Dictator Games - Measure of 'Other regarding Preferences'

In each village, two months before the public good games were run, we conducted a modified dictator game as part of a larger study on developmental canalization and other-regarding preferences (Andrews and Marcoul, 2016). For these experiments, we built on earlier protocols (Fehr, Bernhard, and Rockenbach, 2008; Silk et al., 2005) and ran four modified dictator games in which participants chose between two alternate allocations of money for themselves and an anonymous partner. We focus on these simple allocation choice games, as opposed to more sophisticated cooperation games, mainly to maximize comprehension among participants.[8]

To illustrate how the games operate we will work through each game, beginning with the two costly games, in which players can choose to be egalitarian, but at a cost to themselves. The results from the costly games are the most unambiguous.

In the Sharing Game, participants had to choose between two cash allocations; \$10 for themselves and \$10 for their partner, (10,10), or \$15 for themselves and \$5 for their partner, (15,5), forcing participants to choose between an egalitarian outcome and a self-interested outcome, but in which the egalitarian option comes at a cost. We use this game to measure the participant's willingness to pay to reduce self-advantageous inequality. If a participant chooses the egalitarian choice, she is paying a cost in order to benefit an anonymous partner. Clearly, no self-interested individual would do this.

In the Envy Game, the participant chooses between (10,10) and (13,18). Choosing the unequal option allows the participant to grow the pie and increases the reward for both players, while simultaneously placing herself at a relative disadvantage to her partner, thereby creating disadvantageous inequality. Therefore, by choosing (10,10) the participant is incurring a cost to ensure that the other player is not placed at a relative advantage. It is thus a measure of an aversion to self-disadvantageous inequality and like the in sharing game, no self-interested player should choose the egalitarian option.

In the 'costless games', participants can change their partner's payoff at no cost to themselves. In the Generosity Game, a participant chooses between (10,10) and (10,15). She can increase her partner's payoff at no cost to herself, or choose an egalitarian option. Unlike in the Envy Game, in the Generosity Game the players are not foregoing an increase in their allocation if they choose the egalitarian choice; therefore, it measures willingness to give when it comes at no cost to the self. In addition to measuring generosity, by combining the results from this game with participants' choices in the Envy Game, we can produce a stronger and more robust measure of an aversion to self-disadvantageous inequality (if a

[8] In risk elicitation games played in rural Senegal, Charness and Visceiza (2015) show that, when confronted with relatively complex games, a significant fraction of the subjects will not understand the games they involved in and, hence, make inconsistent choices.

participant refuses to be generous (10,10) *and* they display envy (10,10) then we will say that the subject is strongly averse to self-disadvantageous inequality).

The Harm Game is a costless version of the Sharing Game. At no cost to oneself, participants decrease his or her partner's payoff. Here, the choice is between (10,10) and (10,5). As above, we can combine these results with those from the Sharing Game to get a stronger measure of an aversion to advantageous inequality (if players choose (10,10) in both games then they are unwilling to place themselves above their partner *and* are strongly averse to self-advantageous inequality).

For our analysis, we combine the choices each participant made in the four games to create a composite choice matrix that can measure more complex forms of behavior. Our composite choice variables measure six main behavioral types: 1) Selfishness 2) Spite 3) Altruism 4) Aversion to self-disadvantageous inequality 5) Aversion to self-advantageous inequality 6) Egalitarianism. This classification is represented in *table II.II* below.

Table II.II – Behavioral Types Choice Matrix

	Percent of Sample	*Sharing Game* (15,5 or 10,10)	*Envy Game* (13, 18 or 10,10)	*Generosity Game* (10, 15 or 10,10)	*Harm Game* (10, 5 or 10, 10)
Selfish	42%	15, 5	13,18	-	-
Altruism	19%	10, 10	13, 18		
Strong Altruism	9%	10, 10	13, 18	10, 15	10, 10
Spite	22%	15, 5	10, 10	-	-
Strong Spite	10%	15, 5	10, 10	10, 10	10, 5
Aversion to DI	31%	-	10, 10	10, 10	-
Aversion to AI	28%	10, 10	-	-	10, 10
Egalitarian	12%	10, 10	10, 10	10, 10	10, 10

Note: Percentages do not add to 100% because not all categories are mutually exclusive

3.3.3 Interpersonal Trust

The level of trust that an individual possesses is a function of three variables. First, basal dispositional trust it is intrinsic to a person's personality and is accounted for by genetics and epigenetics. Interpersonal trust is the level of trust person has due to learning from repeated social encounters during their lives. Institutional trust is the result of macro social forces, such as governments, culture and the presence of social structures such as courts that enforce contracts, etc.

Because our focus is on the different effects that interpersonal and disposition levels of trust have on voting behavior, our analysis needs a way to control and separate these two variables. While we can partially control for interpersonal/institutional trust through community and village level dummy variables, we also opted to construct a variable that captures our participant's expectations of what they believed a typical member of their community would choose in each of the four dictator games. By measuring expectations of social/economic behavior, we can extract proxy levels of interpersonal trust in the community because a trusting person would report that their fellow members are more altruistic

and fair. An individual who does not trust his neighbors would assume that they are selfish and spiteful.

Thus, after each participant completed the four real games but before they had been paid, they were asked to go through each game again, but this time reported what they thought a typical member of their community would pick. Using this information, we can distinguish between dispositional and interpersonal trust by asking whether there is a discrepancy between an individual's actual behavior in our dictator games and their reported expectations. Because we know that behavior in dictator games is highly heritable (Isreal et al, 2009; Cesarini et al, 2008), then if a person stated expectations differ from their actual behavior then they are reporting their interpersonal levels of trust. For this to be true, though, we must be able to show that there is at least a partial difference between a person's actual behavior and their stated expectations. If there is no difference between these two variables, then it would be impossible to determine the source of variation.

To determine if this is, in fact, the case we checked to see if there is a correlation between our primary behavioral variables and a person's stated expectations. Encouragingly, there is no significant relationship between behaviors and expectations in regards to selfishness, spitefulness, aversion to disadvantageous inequality and aversion to advantageous inequality. On the other hand, there is a significant positive correlation between behavior and expectations in regards to both altruism and egalitarianism. The fact that we find variation between stated preferences and actual behavior means that measuring social expectations is a somewhat distinct measure of interpersonal trust.

3.3.4 Public Goods Game with Leader - Measure of Preferences for Political Inequality

Our second experiment measures preferences for political inequality with a modified *iterated public goods game*. Our experimental specification has the addition of a vote to structurally change the game and introduce a leader (high PI). After the 5th or 6th round, each individual anonymously casts a vote as to whether they want the game to continue for the remaining rounds, with or without a leader.[9] If a majority of the group votes for a leader, then one individual is *randomly* selected from the seven participants to become the 'leader.' Leaders can adjust all the other participants' contributions to the public good, and extract payment for themselves from the common pot (corruption). By introducing the ability to vote for a leader, we can test for preferences for the distribution of decision-making authority.

As mentioned above, subjects were recruited as part of a larger study on social preferences and had previously played a modified dictator game that measured a broad range of 'other-regarding preferences' (see above). Participants were paid a show up fee of 1000 TSh, and were paid out from one randomly selected round of the game. The average payout for any individual was equivalent to a single day of paid labor in the local labor market,

[9] The number of rounds varied between 9-11.

approximately 4000 TSh.

The public good game shares many features consistent with the kinds of iterated PG games in the experimental literature. In each treatment, seven individuals played the public goods game together. The participants were all invited to a public building in the village where the rules of the game were explained, and the subjects were tested for comprehension. Once understanding was achieved, the participants were informed that they would make each of their choices anonymously (aided by voting blinds) and that the total amount that each individual contributed to the collective pot would be combined, then doubled and redistributed evenly amongst all individuals, regardless of his or her contribution. Consistent with the rest of the literature, participants were not informed as to the total length of the game to minimize the effects of backward induction by creating an unclear time-end horizon.

After each round, each person's contribution was anonymously displayed on a whiteboard so all participants could see the contributions without knowing who gave what. With the results posted for all to see, each round the researchers explained the total net payoff for each contribution, given the other contributions made that round. These explanations were done in order to increase the comprehension of the rules of the game to all participants.

The vote for the leader happened on the 5th or 6th round. These rounds were chosen because, during pretesting, the total value of contributions to the public good typically sank below half of the amount contributed in the first round by this time. Before the round began, the participants were informed that they were being presented with a chance to change the structure of the game – they could vote to have one participant randomly selected as a leader. But before they cast their votes, the researchers explained how the leadership mechanism would work, with plenty of examples.

To begin with, the leader has two powers. First, after each individual determines his or her contribution to the common pot, the leader can arbitrarily and anonymously adjust each individual's contribution. Second, after the changes to the common pot have been made, and the total contributions doubled, the leader is then able to 'pay himself' by extracting funds from the common pot. *Crucially, there is a limit as to how much the leader can pay himself.* He cannot remove more from the common pot than the total number of participants multiplied by the total initial endowment. This limitation ensures that t*he total amount that the leader can extract would never leave a non-leader with a lower payoff than if each individual was perfectly rational and contributed nothing to the public good.* To reiterate, if a leader is maximally corrupt and forces maximum contributions to the public good and then extracts as much payout as he can, then each non-leader cannot receive a payoff strictly lower than what they would receive if they never voted for a leader in the first place - assuming that each individual was maximally rational and never contributed to the common pot either.

This mechanism is crucial because it means that we can predict that a rational individual should be ambivalent as to whether there is a leader or not. If there is no leader, then each

individual would simply hold on to their own initial endowment. And if they voted for a leader, the rational participant would assume that the leader would also be self-interested and therefore maximize his or her payoff by forcing contributions, and then extracting the maximum amount as a payout. But the total rate of extraction is limited in such a way that each individual would remain with exactly the same amount as if they never voted for a leader in the first place and everyone else was maximally rational. This logic was fully explained to the participants using numerous examples. Given the assumptions of rationality and self-interest, and insensitivity to the probability of being selected as a leader,[10] 50% of individuals should vote for a leader, indicating no preference for political inequality – thus our null hypothesis. In short, our participants should be ambivalent to the mechanism that adjusts PI.[11]

3.4 Results

Hypothesis 1 states that significantly more than 50% of the population should be unwilling to vote for a leader. Our results show that 68% of our sample did not vote for leader. This proportion is significantly different from a randomly distributed mean of 50% (t-test: $n=86; p<0.001$) and therefore confirms our first hypothesis. To check the influence of ideology on preference for political inequality, we use years of education and political participation as proxy variables for inculcation. Using a logit model we find no relationship between our variables that measure ideological inculcation and voting behavior.[12] Further, because rational expectation about payoffs between leadership conditions are held stable, we are also able to rule out immediate economic considerations.

Our second hypothesis states that there should be a positive relationship between being pro-social and the willingness to accept high levels of PI/leaders. To test this prediction, we created a model in which our subjects' 'other-regarding preferences' were used as an

[10] This is a defensible assumption given the prevalence of the base-rate fallacy which causes individuals to ignore base-rate probabilities (Bar-Hillel, Maya, 1980).

[11] The expected payoff E for a perfectly rational individual who expects others defect is equal to their initial endowment u. The expected payoff for a person who votes for a leader is the maximum overall contribution, $2un$ to the common pot minus the maximum extraction un, divided by n.

$E = (2un - un)/n$

$E = u$

Therefore, given this payoff each individual should expect a payoff to be equal to the leaderless condition.

Yet, because we randomize leadership selection, each individual has a 1/n chance of being voted a leader and thus able to extract the maximum payoff for themselves. Given this probability the expected payoff would be:

$E = (2un - un)/n + (1/n)un$

$E = 2u$

Therefore, there is actually an incentive to vote for a leader in our game, which should actually be biasing people to vote for a leader, but because this depends on individuals identifying this base-rate chance, which individuals are notriously bad at doing (Bar-Hillel, Maya, 1980), we assume that the effect will be negligible.

[12] In our model we have two proxies for ideological inculcation, years of education and political participation. Education measures inculcation due to exposure during schooling. While political participation measures the range of political activities a person participates in and thus measures their exposure during adult life.

independent variable to predict voting behavior. In order to achieve consistency with the established literature on WEIRD subjects, we combined three behavioral profiles (altruistic, aversion to advantageous inequality (AI) and egalitarians) to create a composite category for pro-social individuals (see *Table II.II*). The results of this analysis are reported in Table II.III. We find a significant and positive correlation between being pro-social and voting for a leader (logit:$n = 86 : p < 0.10$).

Table II.III - Other Regarding Preferences and the Liklihood to Vote for a Leader					
	Model 1 Pro-social	Model 2 Egalitarian	Model 3 w. Ideology	Model 4 w. Contributions	Model 5 w. Demographics
Prosocial	0.784∗ (0.468)				
Egalitarian		1.44 ∗ ∗ (0.627)	1.500 ∗ ∗ (0.641)	1.403 ∗ ∗ (0.653)	1.66 ∗ ∗ (0.7)
Education			0.561 (0.0563)	0.542 (0.0591)	
Political Participation			−0.003 (0.007)	−0.001 (0.007)	
Contribution				0.001 ∗ ∗ (0.001)	
Age					−0.007 (0.0189)
Sex (Male)					1.511 ∗ ∗ (0.614)
Income (TSh)					$1.06e-07$ $(1.39e-07$
Market Integration % Calories purchased					0.406 (1.30)
Kongwa Regional Dummy					−0.309 (0.732)
Wami Regional Dummy					0.558 (0.714)
Constant	−1.072 ∗ ∗∗ (0.321)	−0.976 ∗ ∗∗ (0.262)	−1.252 ∗ ∗∗ (0.42)	−1.276 ∗ ∗∗ (0.4403)	−2.21∗ (1.33)
* Significant at 0.10; ** Significant at 0.05; *** Significant at 0.01					

To test hypothesis 2b we decomposed our 'pro-social' index into its constituent parts: egalitarians, altruists, and those who are averse to AI. Running a separate analysis for each of three independent behavioral profiles showed a significant relationship between being an egalitarian and voting for a leader (logit: $n = 86, p < 0.05$), but *not* for being altruistic or averse to AI. This result shows that individuals who chose equal allocations in all four dictator games are significantly more likely to vote for leaders than the rest of the population. Running an odds ratio, we find that egalitarians are 4.24 times more likely to vote for a leader than those who are not, and that pro-social individuals are only 2.19 times more likely. This means that the positive relationship between being 'pro-social' and voting for a leader is primarily accounted for by the egalitarians and not other pro-social orientations In order to check the robustness of these results, we included a number of controls to this model, the first being our proxies for ideological inculcation: education and political participation. When including these variables we find no significant impact on the relationship between egalitarianism and voting for a leader. Neither is this relationship affected by in-

cluding a person's average contribution to the model.[13] Finally, after controlling for age, sex, income, market integration, and region, the effects are still robust, and egalitarians are still significantly more likely to vote for a leader (logit: $n = 86, p < 0.05$). Note that the only control that is significantly related to voting for a leader is sex.

Hypothesis 2c states that there should be a positive relationship between the expectation (social norm) that other community members are pro-social and the willingness to vote for a leader. The results of this analysis are reported in *Table II.IV*. We find a positive, significant relationship between pro-social expectations and voting for a leader (logit: $n = 86, p < 0.05$). After adding controls for ideology, the association between pro-social norms and voting for a leader decreased to the 10% significance level (logit: $n = 86, p < 0.10$). The reduction in significance can be accounted for by the fact that there is a negative relationship between political participation and the expectation that others are pro-social (logit: $n = 180, p < 0.10$). Controlling for a person's average contribution does not affect this relationship. Subsequently, controlling for age, sex, income, market integration and region does not change the relationship and in fact, it increases to the 5% significance level (logit: $n = 86, p < 0.05$). Using an odds ratio, we find that these individuals are 2.88 times more likely to vote for a leader.

Table II.IV - The Effect of Pro-social Norms on the Likelihood of Voting for a Leader

	Model 1 Pro-Social Norms	Model 2 w. Ideology	Model 3 w. Contributions	Model 4 w. Demographics
Pro-Social Norms	1.056 * * (0.501)	0.967* (0.501)	0.948* (0.571)	1.81 * * (0.534)
Education		0.031 (0.023)	0.026 (0.027)	
Political Participation		0.031 (0.18)	0.062 * * (0.187)	
Contribution			0.001 * * (0.001)	
Age				−0.004 (0.02)
Sex (Male)				1.379 * * (0.618)
Income (TSh)				$1.32e-07$ $(1.43e-07$
Market Integration % Calories purchased				0.645 (1.367)
Wami				0.222 (0.769)
Kongwa				0.984 (0.826)
Constant	−1.072 * ** (0.321)	−1.25 * ** (0.428)	−2.311 * ** (0.627)	−2.796 (1.746)

* Significant at 0.10; ** Significant at 0.05; *** Significant at 0.01

In order to remain consistent with our previous findings from 2b, which shows that the

[13] The average contribution score is calculated by deriving the person's average contribution and subtracting from it the average group contribution – this provides us with a person's average contribution as relative to the group's average contribution. Note that there is a significant positive correlation between a person's average contribution and voting for a leader.

positive relationship between being pro-social and preferences for PI is primarily accounted for by egalitarians, we ran models to test if social norms pertaining to egalitarianism were better predictors of PI aversion. These regressions are presented in *Table II.V*. The initial analysis shows a significant, positive relationship between egalitarian norms and voting for a leader (logit: $n = 86$, $p < 0.01$) and this is more significant than strictly pro-socia norms. In line with our initial results, there is no relationship between altruistic/AI averse norms and voting for a leader. Using an odds ratio, we determined that people who expect that others are egalitarian are 6.11 times more likely to vote for a leader than the rest of the population. These results are not affected by either education, political participation, or other demographic controls. There is no relationship between other pro-social tendencies and voting for a leader.

Table II.V - The Effect of Egalitarian Norms on the Likelihood of Voting for a Leader

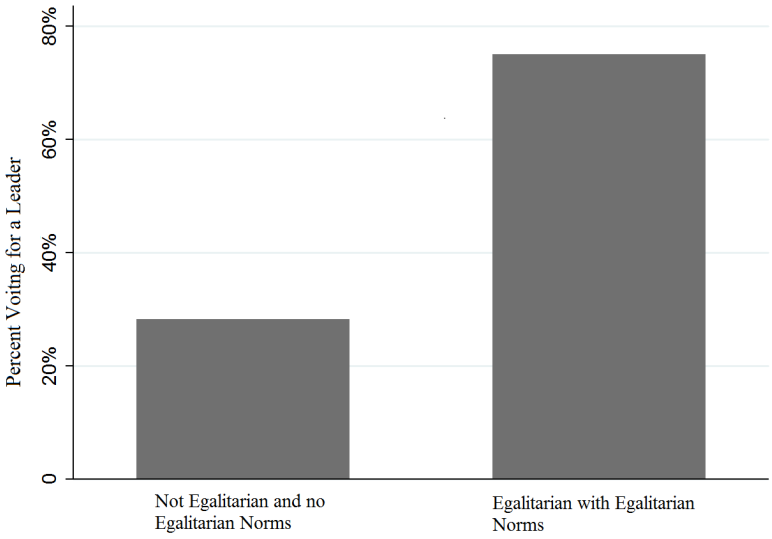
	Model 1 Egalitarian Norms	Model 2 w. Ideology	Model 3 w. Contributions	Model 4 w. Demographics
Egalitarian Norms	$1.81 * *$ (0.736)	$1.92 * *$ (0.758)	$2.197 * *$ (0.803)	$2.218 * **$ (0.789)
Education		0.050 (0.49)	0.044 (0.053)	
Political Participation		0.042 (0.191)	0.097 (0.206)	
Contribution			$0.001 * *$ (0.001)	
Age				-0.001 (0.021)
Sex (Male)				$1.564 * *$ (0.682)
Income (TSh)				$1.46e-07$ $(1.44e-07$
Market Integration % Calories purchased				0.759 (1.49)
Wami Regional Dummy				-0.069 (0.727)
Kongwa Regional Dummy				0.493 (0.861)
Constant	$-0.962 * **$ (0.256)	$-1.326 * **$ (0.455)	$-2.662 * **$ (0.733)	-2.82 (2.021)

* Significant at 0.10; ** Significant at 0.05; *** Significant at 0.01

To determine whether there is an interaction effect between pro-social behavior and norms and the willingness to vote for leaders, we combined norms/behavior into a single binary variable. If an individual played a pro-social strategy and pro-social had pro-social expectations, then they are coded as 1 and everyone else is 0. As seen in *Table II.VI*, we find a significant positive relationship between this metric and the likelihood that an individual voted for a leader (logit: $n = 86, p < 0.05$). This effect is robust under full demographic controls (logit: $n = 86, p < 0.05$). These individuals are 4.24 more times likely to vote for a leader than the rest of the population. In line with our previous findings the effect increases in significance if we limit the analysis to egalitarian behavior and norms (logit: $n = 86, p < 0.05$) and add in full controls (logit: $n = 86, p < 0.01$). Running an odds ratio with those who are both egalitarian and expect others to be so, we find that they are 7.63

times more likely to vote for a leader. The proportion of individuals in each category who voted for a leader are reported in *Figure II.I.*

Figure I.I - Percentage of Egalitarians with Egalitarian Norms Voting for a Leader



This graph shows the percentage of individuals who are willing to vote for a leader. In the first column we have individuals who are *not* egalitarians that expect others to be egalitarian. In the second column we have individuals who *are* egalitarians that expect others to be egalitarian. These individuals are 7.63 times more likley to vote for a leader than the rest of the population.

Table II.VI - The Combined effect of Norms and Behavior on Voting for a Leader

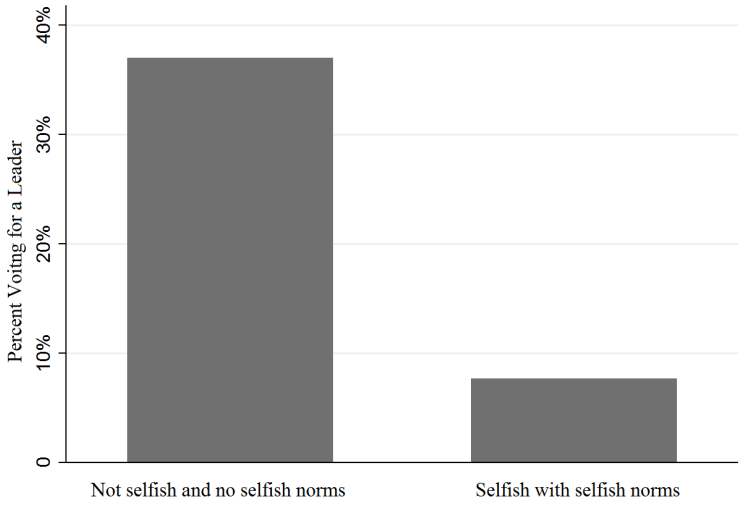
	Model 1 Pro-social/Norms	Model 2 w. Controls	Model 3 Egal/Norms	Model 4 w. Controls	Model 5 Selfish/Norms	Model 5 w. Controls
Pro-social and Norms	1.44 * * (0.627)	1.58 * * (0.706)				
Egalitarain and Norms			2.032 * * (0.859)	2.312 * ** (0.414)		
Selfish and Norms					−1.952* (1.074)	−1.85* (1.092)
Age		−0.003 (0.019)		−0.002 (0.0201)		−0.008 (0.02)
Sex (male)		1.345 * * (0.597)		1.503 * * (0.649)		1.245 * * (0.585)
Income		$1.63e-07$ $(1.45e-07)$		$1.36e-07$ $1.42e-07$		$1.02e-07$ $(1.37e-07)$
Market Integration % Calories purchased		0.23 (1.227)		0.438 (1.455)		0.108 (1.244)
Wami Regional Dummy		−0.177 (0.705)		−0.047 (0.72)		0.004 (0.704)
Kongwa Regional Dummy		0.816 (0.737)		0.541 (0.846)		0.778 (0.701)
Constant	−0.974 * ** (0.262)	−2.519* (1.415)	−0.934 * ** (0.253)	−2.524 (1.881)	−0.539 * * (0.243)	−1.557 (1.272)

* Significant at 0.10; ** Significant at 0.05; *** Significant at 0.01

Hypothesis 3. states the converse of hypothesis 2 a. and 2 c. - that individuals who are selfish and think others are selfish should be more averse to PI. First, while we do not find a significant relationship between playing selfishly and the willingness to vote for a leader, we do find a negative relationship between expectations of selfish behaviour in others and voting for a leader (logit: $n = 86$, $p < 0.10$). Using an odds ratio calculation, we determine that people who expect others to be selfish are 2.59 times less likely to vote for a leader.

Using the same methods discussed above we combined selfish behavior and expectations together into a single composite variable, to assess the effect that both being selfish and expecting others to be selfish would have on voting behavior. Here, we find a negative and significant relationship between selfish behavior/expectations and willingness to vote for a leader (logit: $n = 86$, $p < 0.10$). This relationship holds true after controlling for age, sex, income, wealth, market integration and education (logit: $n = 86$, $p < 0.10$). An odds ratio test reveals that the people are 5.33 times more likely not to vote for a leader.

Figure II - Percentage of Selfish Individuals with Selfish Norms Voting for a Leader



This graph shows the percentage of individuals who are willing to vote for a leader. In the first column we have individuals who are not selfish and do not expect others to be selfish. In the second column we have individuals who are selfish and expect others to

3.5 Discussion

Our first major finding is that in social dilemmas, 68% of individuals in our study did not vote for leaders. In other words, 68% of individuals are averse to high levels of political inequality. These findings are consistent with Western populations where approximately 30-40% of the population are willing to accept autocratic forms of decision making (i.e., Ruve and Wilke, 1984; Van Vugt 2003; Samuelson, 1993). While it is too early to comment on whether these preferences are heritable, the fact that there is a sizable and somewhat stable proportion of individuals across cultures who are averse to PI implies that this preference structure may be connected to heritable personality constructs (i.e., Cesarini et. al. 2008). Two facts strengthen this idea. First, by holding expected outcomes stable between the levels of political inequality, we were able to show that the decision to vote for a leader

is not merely a payoff maximization strategy. Second, the proportion voting for leaders is unaffected by ideological inculcation – this shows us that exposure to political ideas, whether they come from educational systems, or in daily participation in politics did not affect whether or not an individual favors political centralization.

If the reason for the aversion/acceptance of political inequality is not merely the result of cultural inculcation or rational maximization, then a puzzle remains: why should individuals care about the distribution of political power? As outlined in the literature review, we suspect that the aversion to PI is an intuitive, negative emotional reaction that is evoked in response to the threat of political control and the potential for exploitation - a knee jerk. The fact that our game sets up a situation where the selection of leaders is randomized, means unless the participant has either a high level of dispositional or interpersonal trust, they should expect to be exploited by leadership structures.

Despite the fact that a majority of individuals in our study were averse to political inequality, a sizable portion, 32%, were willing to vote for a leader within our game. We propose that these participants assume that a randomly selected individual would restrain self-interest and act as an inexpensive coordination mechanism to help the group to stabilize high and equal payoffs, rather than as a power grab.

Our second major finding confirms that pro-social individuals are more willing to accept inequalities in political power (Samuelson, 1993; De Cremer, 2000; Smith et. al. 2007). However, unlike previous research, by decomposing pro-sociality into its constituent parts our results show that it is primarily economic egalitarians who account for this association. *In short, this tells us that there is an inverse correlation between preferences for economic equality and political egalitarianism* – the more one wants an even distribution of resources, the more they are willing to accept autocratic forms of decision making.

Research in behavioral genetics has shown that preferences for economic equality are highly heritable, accounting for some 49% of the variation within a population (Bell, Shermer and Vernon, 2009). The firm correlation between economic egalitarianism and the acceptance of political inequality raises the possibility that the acceptance of autocratic decision-making is indeed heritable as well, or at a bare minimum that economic egalitarianism form a content bias that predisposes individuals to accept more autocratic norms.

Unfortunately, it is not immediately clear why egalitarians, over other prosocial orientations, prefer autocratic forms of decision making. Samuelson (1993) suggests that because pro-social individuals are more concerned with fairness, equality and group-oriented returns, they are more willing to accept any structural reform that allows for collective action problems to be resolved in an equitable way. In our view, this explanation actually better explains why *egalitarians*–rather than general pro-social types–accept leaders, and yet we believe this argument is still only partly correct.

Alternatively, egalitarians may prefer autocratic rule because of the inherent instability of economic equality itself. Economic egalitarianism is unique because it is a preference that

demands that all payoffs be equal - its consideration is not simply self-interested, nor can it be achieved through mere generosity, but it requires that all individuals receive the same allocation. Therefore, it is a coordination problem *par excellence*, because it demands that all participants adopt the same patterns of behavior and therefore receive the same outcome. In the absence of any central redistribution mechanism, a perfectly even distribution of resources across a population is a highly unstable equilibrium. In any society in which individuals are free to play behavioral strategies that align with their preferences, this heterogeneity will naturally cause any egalitarian equilibrium to be lost. This coordination problem is unique to egalitarians because it is only this preference that is concerned with the payoffs of *every* other individual – all must be equal. In contrast, generous or altruistic individuals can be generous with little regard for how others act because they can garner reputational benefits, and selfish or spiteful behavior require no coordination at all – it is only egalitarians who have this unique constraint.

Indeed, under normal conditions, strict egalitarianism requires the voluntary acquiescence of all individuals to a single behavioral rule for it to be achieved. Other researchers have proposed secondary mechanisms that could allow egalitarianism to be achieved, such as altruistic punishment. Unfortunately, problems with third party punishment and the costs of mutual monitoring make such strategies prohibitively costly in large groups (Boyd et. al. 2003). O'Gorman et. al. (2009). However, others (Hooper, Kaplan and Boone, 2010) have shown that as group size increases these costs can be abated by endowing *a single individual, a leader,* with the power to monitor contributions and mete out punishments. Therefore the challenge presented by such a massive coordination task may cause egalitarians to become less resistant to political inequality because it can operate as an inexpensive coordination mechanism.

The story told above may indeed account for the *ultimate* causal relationship between egalitarian economic preferences and political inequality, but we do not believe that it can account for the *proximate* causes of such behavior. We doubt whether the thought processes that motivates individual behavior involves; uniquely unstable equilibria, costly third party punishment, and cheap coordination mechanisms, are part of the underlying decision-making processes that produce behavior.

Instead, we propose a general psychological mechanism that can account for the linkage between egalitarianism and autocratic preferences. The basic argument is this: *the tendency to vote for leaders is predicated on trust, and while high levels of trust are directly correlated with pro-social behavior, it is only egalitarians who perceive a coordination challenge that must be solved.* Therefore, the combination of high levels of trust and the existence of the coordination problem makes egalitarians, more so than any other group, more willing to accept autocratic forms of leadership.

If this explanation is correct then dispositional and interpersonal levels of trust should only predict autocratic preferences when there is a coordination problem to be solved. This

explains why it is solely egalitarians who prefer autocratic forms of decision making. Further analysis also shows that this otherwise robust correlation is not present for egalitarians who expect that their community members are selfish or spiteful. Nor is there a correlation between voting for a leader amongst non-egalitarians who have egalitarian expectations. This confirms findings by Smith et. al. (2007) that trusting types calibrate their preferences for politial leadership by the degree of perceived mutual interest.

On the other side of the coin, our theory predicts that individuals who view the world as more competitive, and express selfish individual motivations should also be less willing to accept autocratic rule due to the threat of exploitation. While we do not find that selfish types alone are more averse to political inequality, we do find that expectations that others are selfish are highly correlated with an aversion to PI. We suspect that solely selfish individuals may be more ambivalent to political inequality as they may desire the position of leadership and power. Additionally, individuals who are both selfish and assume others are selfish are even less likely to vote for leaders than individuals who only have selfish norms (5.66 times for behavior and expectations vs 2.58 times for just expectations).

To understand this correlation, consider a situation in which no one in a community trusted each other because everyone believed that each individual was 'out only for themselves.' Now, add to this the potential for political hierarchies, but say that due to the proliferation of weapons (stone axes) there was a rough symmetry in formidability, and that meant that no individual could be assured that he or she would dominate the political landscape. Under these conditions, any individual's best options for a political system would be a system of mutually-enforced political egalitarianism because any kind of political inequality would result in maximum exploitation. Being selfish and expecting that others are selfish as well, means that enforcing political egalitarianism is a good strategy to avoid exploitation.

What is interesting is that these conditions appear to be best approximated in hunter-gatherer societies. While we have no data from trust games among foragers, we do have results from Public Goods Games, Ultimatum Games, and Third Party Punishment games. Research suggests that there is a high correlation between expressed behaviors in these games and trust (Deustch, 1962; Fehr, 2009). In foraging societies, behavior in these games is less pro-social than in large-scale, complex societies and the behavior of individuals corresponds more closely with the predictions from rational actor models (Henrich, et. al. 2010). One of the implication of these results is that trust is actually very low in hunter-gatherer societies. Therefore, the political egalitarianism and reverse dominance hierarchy observed in hunter-gatherer societies may, in fact, be the result of low levels of trust. Conversely, the political centralization that followed the advent of agriculture might reflect the development of norms (probably religious (Norenzayan, 2014)) that promoted trust amongst otherwise anonymous individuals.

3.6 Final Considerations

The existence of a general aversion to political inequality, amongst roughly two-thirds of the population has large theoretical and practical implications for the social sciences. For example, one of the primary research questions in political science is accounting for the spread, and stall of democracies in the late 20th century. Robinson and Acemoglu (2005), argue that this transition is primarily the result of non-elite citizens attempting to maximize their material well-being through promoting democratic reforms which allow their economic interests to better represented than in a dictatorship. An explicit assumption that these authors make is that individuals do not have political preferences that extend beyond their material self-interest, yet they recognize that if such preferences did exist they could dramatically alter this transition. Our results add a complication to this view, not only because we demonstrate the existence of preferences for political inequality independent of economic considerations or mere ideology but that the population is not homogenous and instead displays significant variation. While the majority of people may prefer political egalitarianism, there is a sizeable (30-40%) who also favor more autocratic forms of leadership.

Additionally, In anthropology, one of the most persistent questions about prehistory and the formation of states is in regards to how early states consolidated political power and centralized decision making. This debate is split into functionalist and conflict camps. The conflict theorists assume that all differentials in political power stem from coercion and manipulation (Carneiro 1970; Flannery and Marcus, 2012). While the functionalists note that in small-scale societies maintaining power differentials through force alone would be prohibitively costly and as such, early attempts at political centralization had to be cultivated voluntarily (Johnson and Earle, 2000; Turchin, 2005; Hooper, et. al. 2010). Note thought that in this debate, there is the implicit assumption that individuals have some form of aversion to political inequality that must somehow be overcome and yet those involved do not typically account for why such a bias would exist, nor the underlying variation which we have found. Consistently, this simplified understanding of political preferences finds its way into formal models that attempt to account for the rise of incipient political centralization because they often assume preferences for political inequality are perfectly, randomly distributed (eg. Powers and Lehmann, 2013).

Importantly, counter to many liberal ideologies, our findings strengthen the idea that preferences for political inequality and economic inequality are in fact two somewhat distinct traits. The fact that there is a negative correlation between these two traits was first noted in 1959 by the sociologists Martin Lipset (1959). He showed that while the working classes in the United States, Russia, Germany, Japan, and Britain all were all significantly more in favor economic egalitarian and redistributive economic policies, they were also more supportive of autocratic forms of governance.[14]

[14]Both Lipset's and our own research run directly counter to the findings related to 'Social dominance orientation' measures. The SDO purports to measure autocratic tendencies and preferences for inter/intra-

Over the course of the 20th century, we have seen this correlation unfolded in the rise and spread of communism. In both China and Russia, the redistributive and egalitarian policies of the communist regimes were supported by strong political centralization and autocratic rule. Conversely, the opposite was true in the democratic world. While citizens were promised democratic freedom and expanded political participation, their societies were also affected by higher rates of economic inequality. Bartling et al, (2009) has found that this underlying variation results in individuals self segregating themselves within societies as well. Individuals who are averse to economic inequality make up a greater proportion of people working for governments and organizations which attempt to influence political power/authority such as NGOs, while individuals who are less averse to economic inequality tend to work in business sectors which often seek shelter from the authority and regulation of government power. The process of self segregation based off of dispositional preferences for political leadership, may account for the divergent ideolgies in the private and public sectors of what constitutes legitimate expressions political power.

group hierarchy (Pratto et. al., 1994). To contrast our findings and theirs, one of the single best predictors of high SDO (autocratic individuals) is little empathy and altruism. Therefore, an explanation is required as to how two research programs can draw such different findings. The main difference between our test for PI aversion and SDO can be seen in the kinds of questions that compose their Likert scale. Consider these typical questions from the metric: "Sometimes other groups must be kept in their place"; "Inferior groups should stay in their place"; or "To get ahead in life, it is sometimes necessary to step on other groups." We believe that the SDO metric is not testing for preferences for political inequality or autocratic preferences as defined by the distribution of decision-making power among individuals and groups. Instead, the SDO simply measures in-group favoritism, parochialism, xenophobia, and racist tendencies. This is important because SDO is often thought to give a good indication of the kinds of personality types that are willing to support autocratic policies and centralization but instead it only measuring the kinds of personalities that favor the ability of one's particular social group to dominate and exploit others.

Chapter 4

Acute Adapations and Long-Term Dynamics: Drought and Socio-Political History

"No man steps into the same river twice, for it's not the same river and he's not the same man" - *Heraclitus*

4.1 Introduction

While the climatological and economic models that analyze the impacts of climate change are rapidly increasing in their sophistication, our understanding of how climate change will affect social life is far more modest. Here, our knowledge of the macro-scale, socio–political consequences of agents adapting to climatic shocks is limited by a lack of a coherent theory on human social behavior and of social change. As it stands, our understanding of 'economically unproductive' responses to climate shocks, such as violent conflict, religious behavior, and the *longue durée* socio-political impacts, is hampered by a lack of general understanding of individual behavior and historical dynamics. Therefore, scientists and policy analysts alike are often limited by a view of climate change and adaptation, that does not account for the constrained dynamism that is inherent in human social affairs. In light of this, our goal to increase our knowledge of how, historically, the adoption of micro-scale adaptation strategies have restructured macro-scale, socio-political developments.

Take the current example of the Syrian migration crisis. The civil war began as farmers from the countryside poured into cities when droughts ravaged their livelihoods (Kelly et al., 2011). The rapid urbanization combined with the relative economic deprivation to touch off grievance against Assad's dictatorship, and Assad's refusal to concede escalated the conflict to a civil war. For the young men in the cities, the lack of economic prospects made joining the rebellion a viable option for those who could not return to their farms (De Châtel, 2014). As a result of the ensuing war, some 7.6 million people have already fled from Syria and are now seeking refuge across the Middle East and the EU. However, as the

migrants come to resettle in Europe, cultural differences and ancient antagonisms between east and west are provoked and manifested in anti-immigration backlashes that have led to fears of the end of the freedom of movement within the EU.

While this example illustrates one pathway by which droughts can influence socio-political history, it is by no means the only path that can unfold. Unfortunately, due to the relatively recent nature of anthropogenic climate change we have only a small range of modern examples that can inform our understanding as to how larger social dynamics are likely to evolve. Fortunately, as our ability to reconstruct climatological records increases in sophistication, historians and archeologists are beginning to document a significant number of cases studies that demonstrate how the impact of climate shocks can create the necessary conditions for altering socio-political history. From these examples, we can begin to glean invaluable insight into often neglected *longue durée* social dynamics.

With a focus on sub-Saharan Africa, this paper investigates the range of *traditional*[1] adaptation strategies deployed by individuals, families and groups in non-industrial societies to survive and buffer the impacts of droughts. We pair our analysis of adaptation strategies with a review of case studies from the historical and archeological literature that illustrate how these behaviors have altered macro-scale historical dynamics.

For our analysis we adopt a standard definition of adaptation used in the policy literature: "as a response to global warming that seeks to reduce the vulnerability of social and biological systems to current climate change and thus offset the effects of global warming" (UNFCCC, 2016). However, instead of orienting our work towards providing policy insight, our goal is to provide a non-normative, historically descriptive account of how the evolution of social systems are altered by drought and the micro-level adaptation strategies that are deployed in response. Our approach is motivated by a belief believe that social scientists must develop an understanding of the exact mechanisms by which climate shocks contribute to socio-political change as well as a nuanced idea of what kinds of social systems these shocks promote. Once we have cataloged both of these things, the identified mechanisms and pathways can be subject to formal modeling attempts, and statistical analysis to rule out incorrect theories and unlikely potentials. In a sense, this paper is an attempt to establish a collection of 'baseline' descriptive accounts of the known mechanisms and pathways within the literature.

4.1.1 Mechanism for Change

We propose that droughts contribute to large-scale social change by a primary mechanism; during the stress induced by droughts, the range of adapation strategies multiply as people with limited information search strategies that smooth consumption – in turn this diversity changes underlying social networks and introduces new cultural practicies that can faciliate

[1] Pre-colonial or developing societies where the majority of the population is engaged in subsistence farming and where there are limited state apparatuses.

broad scale change. This mechanism is roughly analogous to the functioning of transposable genetic elements (see Pray and Zhaurova, 2008) discovered by Barbara McClintock in her Nobel Prize winning work. McClintock showed that when under stress, portions of an organism's genome known as transposons or 'jumping genes' copy and paste themselves from one part of the genome to another and thus rearranges underlying genetic networks increasing variation in subsiquent generations. This diversity then increases the chance that future generations are better adapted to the new selective conditions that produced the source of stress.

In the social world, all societies have existing mechanisms for coping with external shocks (Adger, 2006), yet when droughts stress this adaptive ability beyond its absorbent capacity, the existing adaptation structure 'breaks.' The result is risk, uncertainty and existential threats, that motivates individuals and groups to seek new adaptation strategies to cope. As new strategies are tried and tested, the adaptation process generates social and cultural variation and dynamism, and in turn, this alters the structure of social relationships in a patterned yet unpredictable manner.

Additionally, the alterations that humans make when adapting to droughts are real, they mark, change and reorder physical and social reality. In the process of responding to climate shocks, the adaptation strategies adopted can introduce new adapative challenges in seemingly unrelated domains, (i.e. Politics) that subsequently generations inherit. In this way, adaptation constantly recreates the nature of social reality. *This cyclical process of environmental adaptation, social change, and new recurrent problems is a primary driver of social change throughout history.*

Time, therefore, is central to understanding how droughts impact socio-political outcomes. The flow of time is what generates and allows for the dynamism and emergent features in social life. If actors were able to re-calibrate their behaviors immediately, with complete information and perfectly rationally, then and only then, might human history remain in equilibrium. Yet, because none of these assumptions are justifiable outside of toy models, the iterative process of adaptation, macro-scale changes, and new selective environments, creates the chassis for an endogenous motor of change throughout history.

These new social arrangements do not in-and-of themselves cause large scale socio-political change, but instead, when paired with the uncertainty that the droughts induce, the new social arrangements can create the necessary conditions which allow socio-political systems to develop new emergent properties and travel down divergent pathways.

4.1.2 On Causality and Necessary Conditions

Before entering into our formal analysis, because of the often leveled criticism of geographical determinism, we believe that is necessary to discuss the nature of the 'causal' role that droughts and climate have played throughout human history. In all historical analysis, determining the causal processes that underlie any social change is fraught with two

primary problems. First, the processes that have built political structures are the result of a myriad of interrelated causal forces; individual motivations, group dynamics, cultural forces, and economic realities, all interacting with the natural ecologies. However, despite the ever-present potential for stochasticity and chaos throughout history that the complicated interaction of seeingly random forces generates, there are also well known statistical regularities and patterns. The most striking of such being the formation of states across Eurasia, the Andes, and Mesoamerica, beginning some 5000 years ago; which can only be accounted for by the operation of common underlying principles. Thus, it is likely that these basic patterns in history are the result of *human nature* interacting with a world governed by consistent *physical laws*.

Nevertheless, the idiosyncrasies of humans interaction means that isolating direct causal mechanisms in history is nearly impossible. This problem is made worse by the fact that historians are significantly limited by their data, and the farther one moves back in time, the less information we have on peoples' social behavior and thus the more we must rely on simplified models of human behavior.

Therefore, due to these ambiguities, instead of positing a significant causal role for droughts and climate shocks through socio-political history, we argue that droughts can break societies adaptive capacity, and in doing so generate uncertainties, and dynamism as individuals and groups search for new adaption strategies. *This uncertainty and dynamism alters underlying networks and this help to establish the necessary, but almost never sufficient, conditions for macro-scale socio-political change.*

In light of this, consider that throughout history; social systems can proceed for long stretches of time in a relative state of equilibrium, where the actions of individuals have little-to-no impact on perturbing the system from its course. Nevertheless, during periods of crisis, the conditions for chaos are created and this generate the potential for significant structural reorganization within a society. Networks can rapidly be restructured, and the interactions between individuals and groups can change in both their qualitative and quantitative characteristics. Therefore, while we still hold that the primary driving forces in human history is the agency individuals acting within groups – the backdrop of necessary conditions for social systems to be perturbed from one path to another can be created by climate shocks stressing societies adaptive capacity.

To account for these dynamics the ensuing analysis is structured in the following way. First, we present six general categories of adaptation strategies typically deployed in traditional societies in response to droughts. These include (a) agricultural preparations, (b) subsistence diversification, (c) reciprocity, redistribution and debt, (d) migration, (e) violence and war and (f) religion. For each of these strategies, we report the main stylized findings from the adaptation literature, with notes from our primary research in Tanzania. Then, to provide a window into macro-level social dynamics, we provide historical examples as to how these adaptation strategies have impacted past societies across Africa and other

pre-industrial civilizations.

4.2 Agricultural Preparation

As the growing season draws near, farmers' eyes anxiously scan the horizon for dark rain bearing clouds. In the face of mounting risk and ambiguity, anxiety can be a motivating force that gives rise to the adoption of new behavioral strategies before crisis strikes. Over millennia, agricultural societies across the world have evolved cultural and economic adaptations to ensure that they will not be caught off guard by climatic uncertainties. Irrigation was the key to smoothing these variations in the crucibles of civilization in China, the Fertile Crescent and Egypt (Trigger, 2004). Sub-Saharan Africa never saw the same development of comprehensive irrigation networks. Conceivably this was due to the high rates of Malaria in river basins and drove the development of farming into highland regions that were dependent on more consistent rain-fed agriculture (Diamond, 1999).

Despite lacking large-scale irrigation networks, subsistence agricultural communities across Africa developed numerous preventive adaptations for dealing with drought.[2] The most basic form of preparation that farmers adopt involves the selection of which crops to grow. In pre-colonial times, before farmers were encouraged to grow crops such as maize for markets, sorghum, finger millet, and yams dominated the agricultural landscape. Each of these crops has their own biological adaptations that enable them to be resilient to late or erratic rainfalls. Take sorghum, for example, it enters into dormancy under severe drought conditions and only begins to germinate and grow when moisture is present, (Rosenow et al., 1983) allowing it to survive far better in dry-land conditions than maize.

Beyond crop selection, intercropping allows for complementary drought resistant benefits for dryland agro-systems. Intercropping involves growing different crops on the same field to derive synergistic advantages. Intercropping has two primary benefits. First, by increasing the variety of crops on a field, a farmer can diversify their investments. The diversity ensures that even if one crop fails, others may still survive. Take, for example, the Dogon of the Sahel, who sow several varieties of sorghum, maize, groundnuts, fonio, sesame, and even rice, along with their main crop of millet (Van Beek, 1990). This strategy means that during a drought some plants will survive while others will not, and thus prevent total harvest failure. Additionally, when markets are present, it prevents against a price collapse in a single commodity.

Intercropping has the added benefit of creating synergistic relationships between crops, which can provide ecosystems services that further increases the ability of agrosystems to overcome recurrent problems, such as drought (Vandermeer, 1992). For example, intercropping legumes provide a constant source nitrogen fixation, while large banana trees provide shade cover and reduce evaporation rates, allowing soils to retain moisture for

[2] Some sub-Saharan African societies did use extensive irrigation, such as the Chagga on the side of Mount Kilimanjaro but examples like these are exceedingly rare.

longer (Steiner, 1982). Unfortunately, intercropping is accompanied by non-negligible costs because harvests are usually lower than that of those for mono crops. Intercropping requires more effort in planting, weeding and harvesting, and a need for specialized knowledge/training. In short, there is a cost to not-specializing. To our knowledge, there is no quantitative measure of the prevalence of intercropping across Africa, but in our interviews of small scale Tanzania farmers, extensive intercropping was practiced by only one of seventy-six households.

Finally, as Malthusians may argue, droughts could generate a desire to intensify production and either store the surplus or sell it on the market to produce income as a form of self-insurance (but see Sandmo, 1971). Though, in pre-industrial and developing societies which do not have ready access to nitrogen fertilizers, modern irrigation, and/or pesticides/herbicides, the range of intensification options available to farmers are extremely limited. Thus, when peasant farmers want to increase yields they typically do so with extensification, rather than intensification. However, bringing more land under cultivation involves marginal land that is more vulnerable to droughts, and imposes substantial labor costs on households. Thus in sparsely populated parts of Africa, such as semi-arid regions, labor acts as a major constraint on productivity and intensification.

4.2.1 Social and Historical Dynamics of Agricultural Preparation

Nevertheless, some historical evidence is coming to light amongst archeologists that suggest that in pre-colonial Africa, agricultural intensification was perhaps more widespread than it was during the early colonial period - due to small 'island' pockets of intensive agriculture scattered across the continent (e.g., Hakansson, 1989). However, these analyzes indicate, that the surplus was not always used to buffer the effect of shocks like droughts. Instead, because of the threat of post-harvest losses,[3] it was more common to convert surpluses into either cash (if markets and monetization were present) or into reciprocal social bonds.

Converting surplus into reciprocal bonds illustrates that adaptations are not always, simply, the independent actions of individuals, but that these strategies can alter the structure of social networks, and as such become fundamentally intertwined with politics more broadly. In inter-group relations, surplus food can be used to establish networked alliances and reciprocal relationships with other communities who are suffering from food shortage (Hakansson, 1989; Schoenbrun, 1998). Internally, the surplus could also be used to ferment social bonds amongst community members as well as reproducing social hierarchies through pot-latching and feasting (Winterhalder and Kennett, 2006).

The political nature of preparation strategies is clearly illustrated in societies with hereditary chiefs and rudimentary state apparatuses – when political inequality begins to emerge political elites, typically extract taxes, either in the form of labor or agricultural goods.

[3] Either due to pests, mold or theft

When corruption is not endemic, these taxes can help build community-wide preparatory adaptations, such as grain storage, irrigation networks, terracing or cultural monuments. Crucially, the system that collects and distributes taxes alters the underlying social fabric of society.[4] However, these political machinations are double-edged swords, because when droughts and food shortages strike, a social order built upon the distribution of surplus can fracture as the underlying bonds unravel in the face of scarcity and localized competition (eg. Pauketat, 2004).

Archeological analogs from drought-prone regions in pre-Columbian North America demonstrate the relationship between droughts, social deterioration, and collective grain storage. Amongst the Fremont people of the Great Basin, drought led communities to store up to three years of maize within large communal granaries that occupied prominent places at the center of villages (Simms, 2008).[5] Storage in these villages was not simply an individual affair but was coordinated by the group. However, the collective action ended after a series of multi-decade droughts in the 13th century. As village life began to collapse under the weight of persistent droughts, families began to construct their own storage units, often built into sheer cliff faces that were unreachable without ladders and these hard to reach units were thought to have been built to restrict access from unwanted community members (Coltrain and Leavitt, 2002). The change in storage unit consturction indicates not just a direct concern over food theft and scarcity, but also a loss of the collective social institutions that enabled large-scale communal grain storage.

A second pathway by which drought perpetrations can influence socio-political history is through the establishment irrigation networks. Based on observations of the Near East, Wittfogel (1956) famously (and contentiously!) proposed that large scale irrigation projects were necessary precursors to the development of political centralization and autocratic rule.[6] His argument is built on the idea that the coordination challenges involved in digging, maintaining and distributing water through large irrigation networks could only be solved by autocratic rulers who could exercise a high degree of authority over their subjects.

However, during the mid-to-late 20th century, evidence accumulated by archeologists showed that incipient civilization with strong, centralized institutions, often developed well before the implementation of large-scale irrigation networks (see Trigger 2003). Additionally, anthropological studies have also shown that complicated water delivery systems across traditional societies have been managed successfully through community norms and therefore, do not necessarily require large centralized states (Ostrom and Gardner 1993).

Nevertheless, despite these contradictory observations, Wittfogel's hypothesis had never been tested empirically until very recently (Bentzen, Kaarsen and Wingender, 2012). In-

[4] For example, contrast the Incan *mita* labor system where every individual farmer contributed labor on a rotating cycle, with Buganda, where it was only the most productive farmers who were taxed, but where the grain was to be redistributed amongst all during times of drought (Claessen, 1987)

[5] It is suspected that this form of coordination was done by councils as there is little evidence for large-scale socio-political consolation Fremont societies.

[6] Such as in ancient Egypt, Mesopotamia, and China

deed, the initial analysis confirms Wittfogel's intuition; there is a connection between the early development of large-scale irrigation networks and an entrenchment of politically centralized institutions. However, in line with earlier criticism, the empirical evidence shows that irrigation does not directly cause despotism. Yet, the analysis still indicates a strong correlation between irrigation and despositism. Instead, the proposed causal mechanisms is that, when adaptation strategies involve large-scale, capital-intensive projects like irrigation networks, these ventures are such that they are easily captured, monopolized and controlled by local elites. By gaining control over water and thus agricultural productivity, elites can use their control of the irrigation networks as a way to solidify their economic and political power bases. Thus, the adoption of irrigation systems helps to establish the necessary conditions for the expansion of political centralization. Without the presence of capital-intensive infrastructure to control and exploit, the primitive accumulation required for high levels of elite control and political centralization would be more difficult.

The lack of widespread irrigation within sub-Saharan Africa may have been an important factor in determining why pre-colonial Africa did not evolve states as early as did Eurasia, Mesoamerica, and the Andes. Crucially, this example reminds us today, that with the development of capital-intensive adaptation strategies, (such as GMO's) there is the possibility to create the potential for elite capture that can encourage political consolidation by aspiring and entrenched elites (e.g., Platteau, 2004).

4.2.2 Summary

While the most basic pre-industrial agricultural preparations for droughts involve purely economic considerations such as; crop selection, intercropping, storage, extensification, and irrigation when a new preparatory strategy is adopted it can reorder social networks and by doing so help establish the necessary conditions for socio-political change. As illustrated above, when intensification and storage are possible, the challenges involved in mitigating post-harvest losses can motivate individuals and communities to search for alternate uses for the surplus grain, such as fermenting reciprocal and political networks. While these alliances can help smooth consumption, when drought becomes particularly severe, the ensuing subsistence insecurity can generate strong selection pressures on individuals and intense internal competition can damage the social bonds within a community. The resulting social deterioration can, then, decrease the ability of communities carry out collective action, which is often decisive for adapting to climatic uncertainties, leading to a downward socio-economic spiral (for a contemporary discussion see Adger, 2003).

The second major micro-to-macro 'drive belt' that we have identified is that when agricultural preparation strategies are capital intensive or requires significant collective action, then these adaptation strategies can present themselves as ripe for elite capture. When people become dependent on technologies that elites control, then access to these technological solutions can be manipulated to produce high levels of economic inequality. When

a majority of a societies population is dependent on agricultural productivity, then those economic inequalities can be transformed into political control (*see section 4.4*).

4.3 Subsistence diversification

Income diversification strategies are crucial to the economic livelihoods of subsistence farmers across the world. When a drought or other shock strikes, a family with a diversified set of income generation activities can buffer their consumption by having family members working in economic sectors that are uncorrelated with local agricultural production. Formally, income diversification strategies are when agents spread their production portfolios across uncorrelated occupations and thereby mitigating some of the risks of shocks (Barrett, Reardon and Webb, 2001).

Traditionally in Africa and other semi-arid parts of the world, *agro-pastoralism* has been seen as the primary risk diversification strategy used to cope with droughts (Binswanger and McIntire, 1987; Bromley and Chavas, 1989). The logic behind this approach is that a portion of an agropastoralists livestock act as an economic buffer and are sold as liquid assets during droughts (rather than killed and consumed) to purchase grain through markets (e.g. Sandford, 1983).

Despite the prevalence of these claims, the empirical evidence for the buffering effect of agro-pastoralism is comparatively weak. In East Africa, research shows that instead of a surge in livestock market activity during/following droughts there is, instead, a weak decline in overall market activity, indicating that cattle are not being sold at rates that many models would predict (Fafchamps, Udry, and Czukas, 1998). Moreover, this research shows that livestock sales only offset income losses due to droughts by a relatively marginal amount, by approximately 15-20%. Our research suggests that the decrease in market activity and the minimal buffering effect of livestock is due to farmers being hesitant to liquidate their cattle during droughts because the purchasing power amongst local trader's decreases and the markets become flooded with sick animals, which drives prices down (see Akerlof, 1970).

In response to the relatively weak ability of agro-pastoralism to self-insure farmers, many households participate in *local off-farm labor markets* as an alternate diversification strategy. Over the past two decades, extensive research has shown that upwards of 40% of total household income across African smallholders (and upwards of 50-60% in Latin American and Asia) is accounted for by local off-farm labor wage labor (Reardon, et al, 2007).[7] Furthermore, this evidence also suggests that this number is increasing, which perhaps is due to population growth, land scarcity, and an increase climatic variation.

However, the evidence is ambiguous as to whether the increase in local off-farm income diversification is driven by an increase in droughts (e.g., Kazianga and Udry 2006; Porter,

[7] Ideally this strategy should be coordinated at a household level, rather than at an individual level. At a family level, individuals are still able to benefit from both classical comparative advantage and diversified non-correlated income generation activities.

2012; Liao, et al. 2015). To illustrate why this may not be the case, consider Sen's (1981) observation that droughts typically result in a complete local economic crash – this means that the range of opportunities for local diversification can become very rare in times of drought. The evidence supports this intuition, for example, while rural off-farm labor market participation is higher in harsh agro-climatic zones (Haggblade 2007; Reardon et al, 2007), this work is *not local*, but instead involves substantial migrations outside of the region and therefore the response may be better categorized as migration. The consequence of this is that, while local off-farm economic activity may provide some small buffer against droughts, the impact on household income is far from complete self-insurance (e.g., Liao, 2015).

4.3.1 Social and Historical Dynamics of Income Diversification

Unfortunately, determining the motivations for income diversification is made even more challenging because the diversification literature is primarily ahistorical and thus it obscures two important points. First, for most of human history, the opportunity for individuals to participate in local non-farm labor markets has been extremely limited, and thus the primary form of diversification involved of consumption - changing the kind of foods one ate.[8] Second, recent diversification into off-farm labor markets may, in fact, be driven by macro-level policies such as the introduction of structural adjustment programs, which dismantled government subsidies on agricultural inputs and thus increased the production costs borne by individual farmers forcing them to search for additional sources of income (Bryceson, 1999).

Nevertheless, in times of drought, there is little doubt that families seek other forms of off-farm income as a way to smooth consumption. Perhaps the greatest irony is that for the most vulnerable segments of a population, income diversification strategies can generate poverty traps rather than paths to enrichment and risk reduction (Zimmerman and Carter 2003; Carter and Lybbert, 2012). While wealthier households with superior endowments are better able to access transportation and high skilled lucrative jobs markets; poorer families have little option but to enter into increasingly saturated economic sectors. These crowded low-skill labor markets only serve to lessen the vulnerable's already minimal wage bargaining capacity. In turn, the cheap labor allows employers to decrease production costs, and the crowded towns can drive an increased demand (especially in food) letting producers reap high profit margins (Turchin and Nefedov, 2009).

Thus, diversification strategies can sometimes result in the Matthew Effect, where the rich get richer, and the poor, get poorer (Merton, 1968). The inequality that this process generates can establish the basis for rising social tensions and early forms of class conflict. In our study villages, farmers reported that community members had accused wealthy families of practicing witchcraft to cause droughts and allowing the wealthy to exploit cheap labor

[8] This include the adoption of starvation diets.

from their less fortunate neighbors.

A vivid example of how diversification strategies can produce this kind of inequality comes from the Ugogo, a tribe to the west of our study sites in central Tanzania. In times of drought, Gogo families will often sell/rent' their female children to wealthy members of neighboring communities, such as the Maasai, for a fixed number of years. The children provide a range of domestic duties from cleaning, to taking the cattle to pasture. For the Maasai, this has been a particular boon because it allows for their children, who have traditionally taken cattle to pasture, to be able to attend school and become educated. For the Gogo families, this generates some income and reduced the total caloric strain on families and yet is a prime example that there is nothing 'progressive' about many adaptive behaviors.

To demonstrate the complex interactions between drought, subsistence diversification and social change over the *longue durée* we will present one final example. The story is set between 300-1500 AD in the Great Lakes region of East Africa. Ominously, an unintended by-product of this process is arguably the creation of two economically specialized and distinct castes – the Hutu farmers and the Tutsi Pastoralists (Schoenbrun, 1998).

In what is modern day Rwanda, 1700 years ago, the original Bantu migrants arrived in East Africa and adopted an agro-pastoral lifeway by combining their historical subsistence practices of shifting yam cultivation with the agro-pastoral practices of Cushitic and Sudanic populations already in the area (Ehret, 1998).[9]

By the mid-first century AD, overpopulation combined with deforestation[10] to stress both the region's ecological and socio-political foundations. Then, beginning around 950AD, a series of long-term droughts added to the anthropogenic degradation and severely exacerbated the region's strained agricultural systems (Russell and Johnson, 2005).

The resulting crisis contributed to two waves of agricultural innovations, diversification and subsequent intensification. The first response, around 950 AD, involved intensifying cattle keeping and grain cultivation in the newly cleared lowlands. Second, around 1200 AD, in the highlands, where the rainfall was more consistent, intensive Banana cultivation began to dominate the agricultural landscape. These specialized innovations, paired intensification and diversification together to create a complimentary agronomic system of lowland cattle herding and highland banana cultivation – yet each was practiced a different ethno-social group (Schoeburn, 1998). Such, 'group based' economic specialization established some of the necessary preconditions for the development of a caste system (Henrich and Boyd, 2008). Thus, in the great lakes region, emerged the cattle-owning nobility, the Tutsi, and peasant highland banana cultivators the Hutu. Crucially, though it must be said that segregated economic diversification is not a sufficient condition for the development of large-scale social

[9] As an aside, Christopher Ehret (1998) argues that it was this combination of techniques that allowed for the Bantu populations to spread eventually across the continent, by utilizing forested areas that were previously devoid of food producing people.

[10] Which was intensified by the need for charcoal for the growing iron industry.

castes and class system. Instead, other factors such as prejudice, cultural myths, reduced interaction, and endogamy are all somewhat necessary for the full emergence of such regimes. Nevertheless, this economic inequality allowed for the primary accumulation needed for the formation of the Bugandan state and institutionalized inequality. Importantly, what this example reminds us is that while income diversification may be a viable individual level economic adaptation – it can result in the formation of classes and castes as we are currently seeing in the case of South Asians in both Dubai and Qatar.

4.3.2 Summary

By spreading income generation strategies across multiple uncorrelated economic activities, rural smallholders can, if marginally, buffer the risks of droughts on household consumption. The two most common forms of income diversification found in pre-industrial and developing societies are agro-pastoralism and local rural-off farm wage labor.

While the standard economic literature has focused on the individual and household incentives to participate in rural-off farm labor markets, the broader social science research suggests that because this insurance is incomplete, diversification strategies often lead to poverty traps and rising rates of economic inequality (e.g., Zimmerman and Carter, 2003). When rural farmers flood low skilled job markets, they can drive down wages and subsequently production costs for producers (Goldstone, 1991). Again, we must stress that droughts do not in-and-of themselves produce poverty traps, but instead when individuals seek out new adaptations, because of climate shocks, they often have inadequate information and the odds stacked against them. Situations like this can create the necessary conditions for negative feedback cycles whereby individuals continuously adopt dominated strategies, due to a decreasing range of available (or known/desirable) options.

Second, when the same set of income diversification strategies are adopted by a group of people, the diversification process can, when interacting with other socio-cultural variables, help generate large scale socio-economic classes and castes (Henrich and Boyd, 2008). The historical economic development of modern Great Lakes region of East Africa involved a set of complementary diversified economic specializations that were adopted following severe droughts and aided in producing sharp ethnic divisions between herders and farmers. While the economic trade between these two groups produced a diversified agro-social system that was resilient to droughts, it also contributed to the economic segregation of ethnolinguistic groups, which was necessary for the development of persistent institutionalized inequality that came to characterize the region (Schoeburn, 1998).

4.4 Reciprocity Redistribution and Drought

Next to kinship, friendship, and reciprocal bonds are the most cohesive force in any society. The benefits of friendships and social networks stretch beyond the intrinsic value of laughter and company because these social relationships can act as vital safeguards in times of crisis

and shock. As Townsend (1994) influentially proposed, subsistence farmers often establish 'informal contracts' with each other to reciprocally provide gifts of food, money and support whenever one suffers a shock. Thus, for many rural farmers, the bonds of friendship and family are also the strongest form of drought insurance (Kadigi et al, 2007).

The first formal models describing social insurance networks were developed to explain how these informal insurance systems provided protection against *idiosyncratic* shocks, like health emergencies. However, these systems are fundamental to coping with drought and other *aggregate* shocks as well, but with somewhat less effectiveness (e.g., Foster and Rosenzweig, 2001 Maaskant, 2015; Masawe, 1992). For example, across Tanzania farmers frequently make zero interest gifts of food and money to friends and family who are experiencing droughts. This practice is known as "*mchango*" in Swahili. *Mchango* is an obligation, but it requires that the negative shock that a person experienced was due to forces beyond their control for gifting to be necessitated. Nevertheless, a majority of Tanzanians report that social networks are the single most important risk mitigation strategy that they have for dealing with drought, (Kadigi et al, 2007) even if formal models suggest that these networks frequently fail to provide comprehensive insurance (Townsend, 1994; Foster and Rosenzweig, 2001).

The informal reciprocal bonds that make up these networks are not solely established for the purpose of risk mitigation, but instead are embedded within cultural customs and existing social relationships (Fafchamps and Gubert, 2005). In the Morogoro region of Tanzania, 86% of farmers report that their main source of credit comes from these informal networks, with friends and relatives supplying about 47% of the funds (Masawe, 1992). In regards to social structure, these networks are more prevalent amongst households of lower socioeconomic status who do not have access to formal credit institutions (Fafchamps and Gubert, 2005) and thus these systems are typically seen as a coping mechanism of the poor.[11]

It has frequently been mentioned to the author that in the face of an aggregate shock (i.e., drought), these networks should be rendered ineffective because a drought will affect all members of a community, making it so that individuals would be unable to support each other. This assumption neglects the fact that there are significant sources of heterogeneity in these networks that make them resilient to large aggregate shocks. The first source heterogeneity comes from the fact that linked partners are often dispersed geographically (Foster and Rosenzweig, 2001). These dispersed networks are typically the result exogamous marriage patterns that spread kinship networks across regions (Levi-Strauss, 1969). The benefit of geographical separation is that the dispersed systems can ensure that the reciprocating partner's income generation strategies are relatively uncorrelated (Stark and Bloom, 1985). For example, migrant family members tend to send proportionally more remittances back home when there is a drought in their home village, while in contrast, it is more common for neighbors to provide support in response to idiosyncratic shocks

[11] Formal credit institutions can help absolve the pressures and social obligations involved in participating in a gifting network.

(Maaskant, 2015).[12]

Wealth inequalities are the second primary source of heterogeneity because they allow for even local networks to remain resilient during aggregate shocks. This fact is not lost on villagers, because the research shows that individuals select reciprocal partners not simply by personality characteristics and relatedness but that they also consider wealth, particularly in livestock, and the 'richness' of a potential partners' social network (Comola, 2008).[13]

The result of this is that social insurance networks disproportionately link poorer individuals with wealthier individuals. This asymmetry creates a 'star' like network were wealthy individuals sit at the center of the system and are highly connected to everyone else; while the density of mutual connections amongst the poorer elements is reduced. These asymmetrical networks mean that wealthy individuals have more linkages and thus there is a greater outflow of support from them to the rest of their community – they give away more than they receive. This dynamic inevitably results in a redistributive effect that lessens the overall amount of inequality in a community, but at a cost to individual incentives to acquire more wealth (Platteau, 2000).

It is important to note that these networks have a significant impact on the overall economic growth amongst subsistence farmers. Theoretical and empirical research by Marcoul, Mopatara, Luckert and Zugala, (2016) shows that households who participate in social insurance networks actually invest less effort in agricultural enterprises than autarkic households do. The stylized rationale behind this finding is that when individuals have both insurance against shocks and the obligation to help others within their network - this disincentivizes the investment of effort into agricultural production and wealth generation. On the other hand, households that do not participate in insurance networks lack both the security of social insurance and the coercive demands of others. These two factors operate to incentivize investment into agricultural production in order to self insure and accumulate wealth without the fear of appropriation by friends and family. The implication of this is that the uncertainty caused by droughts can create the need for insurance, and in these conditions, individuals may reduce effort and production because they are taxed, and yet insured by family.

4.4.1 Social and Historical Dynamics of Reciprocity and Debt

Beyond the economic development literature, the impact that climate shocks and reciprocity have had on human social behavior can be traced far back into our evolutionary history. Theoretical models of the evolution of altruism commonly evoke the selection pressures that external threats like droughts and inter-group conflict had on our hominid ancestors (Bowels and Ginitis, 2011; Kameda et al, 2010). These models show that while harsh envi-

[12] The difference in these patterns likely have to do with trust and monitoring costs associated with friends, family, and neighbors.

[13] For example, people will selectively choose reciprocal partners who have many friends who are also wealthy, and by doing so, they can integrate themselves into more affluent cliques.

ronments and climatic uncertainty can induce short term selfish and competitive behavior, if individual survival is dependent on cohesive group functioning, then sharing, reciprocity and generalized altruism can be selected for over the long run (Smaldino, Schank and McElreath, Richard 2013).[14] The result of this logic is that humans' hyper-elaborate cooperative tendencies and norms may be due to the process of adapting to periodic shocks by creating social insurance networks of mutual reciprocity and aid.

This evolutionary heritage has endowed our species with a suite of powerful psychological mechanisms that underlie the logic of reciprocity and social exchange more broadly (Cosmides and Tooby, 1992). These adaptations help determine who we should trust (Nowak and Sigmund, 2005), detect when we are being exploited (Trivers, 1971) and identify situations where we can take advantage of others (Buss and Duntley, 2008). Yet, perhaps the most crucial insight into the psychology underlying reciprocity comes from Marcel Mauss (1950). In his famous work the *Gift*, Mauss realized that gifting is not merely an act of interest-free aid. Instead, giving a gift creates a social and psychological debt that motivates people to reciprocate to absolve the sense obligation that the original gift created. To demonstrate the profound significance of a gift, modern behavioral economics has found that in many tribal societies, large gifts in economic games are often rejected, because the recipient is avoiding placing themselves in a state of indebtedness and thus vulnerability (Henrich et al. 2001).

It is precisely these kinds of social debts that sit at the heart of social and economic inequalities, because economic asymmetries are rarely simply just about one individual having more wealth than another. Instead, due to the disproportionate flow of 'gifts'/credit from rich to poor in traditional communities, (Comola, 2008) these networks create a disparity in obligations and subsequently the basis for political power. The well-off can use the fact that their debtors cannot always pay back their credit as a political pathway to accumulate favors, obligations and asymmetrical power relationships (Bourdieu, 1986).[15] While this process has operated all throughout history and formed the basis of social order during feudalism, it is perhaps, best and dramatically demonstrated in the 20th-century history of the Western nation's Food Aid programs (Friedman, 1982; Ball and Johnson, 1996; Dunning, 2004).

After World War II, the western worlds agricultural systems benefited greatly from government subsidies and the accelerated pace of technological innovation – in particular the widespread use of synthetic fertilizers, mechanized tractors and the green revolution. The result of these changes was a rapid agricultural intensification and a large surplus in grain stocks – mainly wheat. In the USA this surplus created public concern that the excess com-

[14] Our research confirms there is a developmental effect from the experience of crisis event that results in more spite and envy and as such if shocks can generate pro-social behavior we suspect that this can only happen through cultural evolution and the development of pro-social norms.

[15] Psychologically we suspect that what happens is the experience of unpaid debts creates a sensation of vulnerability and dependency that promote the acceptance of other individuals influence due to their reduced bargaining power.

modity would flood domestic agricultural markets and drive down prices - putting farmers out of business. When the government stepped in and set agricultural price floors the result was that the US government purchased the excess surplus. Alas, the US could not store the grain indefinitely– nor could they release the grain back onto local markets for fear of saturation and thus this pressure added to the need for external markets that the US could effectively dump their excess grain.

Meanwhile in Africa, the process of decolonization was underway and the surge of African nationalism corresponded with high levels of international investment in modernizing the continent through industrialization. This development involved an attempt to reorganize agricultural sector to become oriented towards the production of cash crops - which was thought to be a vital step in integrating Africa into the world market. The intention was that because of cheap labor and a tropical climate Africa would have a comparative advantage at producing labor-intensive cash crops, which could generate the income needed to purchase grain from countries who had an advantage in cereal production.

In 1954 the United States enacted P.L. 480 – a government policy that aimed to ship the United States grain surplus off to economies in the developing world as a part agricultural policy, part aid, and part diplomatic strategy. Alas most developing countries did not have the requisite purchasing power to buy the commodities and consequently Food Aid was created. Yet, 20% of the original food aid took the form of regular transfer programs –the food was not free and was instead sold on credit (see Zahariadis, Travis and Ward 2000; Ball and Johnson, 1996). A consequence of these credit-based sales was a form of indebtedness - a bond of dependency between developing nations, and the West.

By the end of the 1960's the developing world was importing ~66% of their wheat through food aid programs from western countries, including Great Britain and France. These shifting economic conditions corresponded with a series of severe droughts in the 1970s that resulted in famine across much of Africa. The ensuing crises only increased the inflow of aid which served to increase both formal debt levels and the sense of political obligation and favoritism that donor countries had towards their patrons.

It is crucial to understand that while all of this was happening, the west, the United States, Great Britain and France, were engaged in the cold war with the Soviet Bloc. In the global south the Cold War involved a competition (economic, militarily and culturally) for proxy states and political allies across the developing world as part of a global power struggle centered on economic ideologies and military might. Due to their political nature, food aid programs were used by both sides in this conflict (Dunning, 2004 Zahariadis, Travis, and Ward, 2000). The major players courted potential allies, particularly during crises, with aid and in turn accumulated both informal and formal political debts which were used to curry future support. Subsequently, these allowed for the donor nations to establish economic and political footholds in the developing world.[16]

[16] In some cases, particularly in countries with strong colonial legacies, these food aid programs directly operated to reaffirm the post-colonial economic dominance of the former colonizers.

4.4.2 Summary

On a micro-level, subsistence farmers across the world form networks of mutual insurance through the reciprocal exchange of gifts in order to smooth consumption during shocks such as droughts. While the effects of drought are aggregate, existing heterogeneities within sharing networks, such as geographic dispersal and modest economic inequality (Olson, 1971), help insurance systems be resilient to the impact of droughts. In turn, these two sources of heterogeneity help establish the basic structure of social networks within communities.
The macro-scale historical impacts that the formation of reciprocal bonds amongst individuals and communities attempting to cope with resource variability is immense. Due to the antiquity of these strategies reciprocal networks are fundamentally ingrained within the socio-cultural and economic fabric of life (Axelrod, 1984). Yet, at the core of the socio-political impact of these bonds is the fact when gifts are used to smooth consumption in the face of drought, they *establish obligations and debts*. Yet, the sense of obligation, when paired with the security of insurance, can depress economic growth, (Marcoul, Mopatara, Luckert and Zugala, 2016). While the unavoidable asymmetries of socio-economic life means that the networks can also accentuate existing economic inequalities and provide the basis for political control and manipulation. The presence of droughts helps to create the conditions in which political inequalities can become established because the existential threats of droughts produce the requisite insecurity which generates the necessity of insurance networks in the first place- from here human nature and the individual agency does the rest in converting any inequalities into political control.

4.5 Migration

Mere-exposure,[17] sunk costs,[18] territoriality,[19] cultural norms and social networks are the things that make a place home. Unless individuals possess some behavioral disposition that predisposes them to move (e.g., Dreber et al, 2009) these forces create strong ties between people and places, motivating them to stay and defend their homes (for a full effect of this tendency on the evolution of eusociality see Wilson (2012)). Therefore, of all of the responses to drought (with perhaps the exception of war and rebellion) migration is frequently the last resort, only adopted when all other coping mechanisms fail (Gray and Mueller, 2012).
In response to the dramatic and popularized concerns over climate refugees (e.g., Myers, 2002) the question as to whether environmental factors such as droughts influence migration rates has become reopened. Despite the critics arguing that most migratory behavior is motivated by purely social, economic and political factors, extensive research has confirmed that there is a strong positive correlation between drought and migration (Findley,

[17] Liking something because one is familiar with it (Borenstein & D'Agostino, 1992).
[18] Valuing something more that its current value because of previous investments (Arkes, & Ayton, 1999).
[19] Defending more vigorously something due to prior possession (see bourgeois Strategies) (Maynard-Smith, 1982)

1994; McLeman and Barry, 2006; Tacoli, 2009). However, unsurprisingly the relationship between the two is more complicated than a direct stimulus-response causal linkage (e.g., Meze-Hausken, 2000). Instead, the impact of drought on migration is the result of the simultaneous need to reduce household caloric intake and increase income generation. How agents solve this problem, whether through migration or not, is heavily mediated by social structure, economic incentives, and cultural history.

As such, the climate migration literature has identified some stylized facts about droughts that are worth considering. First, amongst the world's poor and vulnerable, droughts tend to produce short term, short distance, circular migration (Findley, 1994). By definition, circular migration ultimately results in migrants moving back into their previous households after the shock has ended. Typically, only a select few individuals from a home will ever migrate, and the rest of the family will continue to reside in the affected area. Usually, it is the young men who move but culture permitting, young or non-economically productive women may migrate as well (e.g., Ezra and Kiros, 2001). The fundamental adaptive logic behind circular migration can be understood as a strategy to reduce the household size and thus the necessary caloric requirements.

Also, while away, the migrant will retain both a social and economic position within their family and are expected to find work in either other rural communities as temporary rural wage labor or migrate to cities and enter the workforce and send back remittances.[20] Drought-induced labor migration has dramatically increased the rates of rural to urban migratory patterns across Africa and has been a primary factor in the rapid urbanization process (Barrios, Bertinelli and Strobl, 2006). Though, it is important to note that amongst the poorest and the most vulnerable, the impact of a drought on their already modest incomes often means that the poorest do not have enough resources to cover travel costs, and thus become exposed to the full force of a drought (Julich, 2011).

In contrast, long-distance migration will often decrease in response to a drought (Findley, 1994; Tacoli, 2009). This decrease is because long distance migration requires both more planning and financial resources than circular migration. As a result, the immediate action needed in response to a drought typically makes long distance movements impractical. For example, a study in Mali found that migrations to France were cut in half during drought years (Findley, 1994). Nevertheless, for those families that did manage to send migrants abroad, the migrants were able to send back about twice as much in remittances than individuals who migrated within the country. The greater income earning potential amongst long distance migrants likely explains some of the contradicting evidence that shows that international migration, such as from Mexico to the USA, can increase in response to droughts (Nawrotzki, Riosmena and Hunter, 2013). The reason for these differing patterns

[20] It is important to note, that this kind of short-term migration for labor, is only possible once markets and a suitable division of labor have developed within a region. For example, amongst a population that is either uniformly hunter-gatherers or subsistence farmers, moving in search of wage labor would not simply be viable.

can likely be accounted for (a) when there is high-income inequality between neighboring countries, (b) when migrants are highly mobile, and (c) when previous migration routes are well established, then under these conditions droughts can encourage long distance international movement.

4.5.1 Social and Historical Dynamics of Migration

In regards to the impact that drought-induced migration can have on broader social dynamics, much attention recently has been paid to the fact that climate change migration has the potential for generating violent conflict (Reuveny, 2007). Unfortunately, the Syrian immigration crisis reminds us that inter-group dynamics (i.e., tribal instincts, xenophobia, territorialism and conflicting norms) can create escalating tensions between residents and migrants. However, there is nothing inevitable about migration and conflict. Take, for example, hunter-gatherers living in drought-prone regions who have sophisticated cultural mechanisms for maintaining approved access to other groups' territory as an insurance policy for droughts. For example, the Ju/hosain! are famous for their practice of *Hxaro* which involves the ritual giving of gifts between groups to establish reciprocal bonds and formal allegiances that allow communities to migrate and access each other's waterholes in times of drought (Weissner, 1977).

Nevertheless, it is a sad reality that when migrants breach cross-cultural boundaries, differences in norms and cultural expectations can result in segregation and polarization that can impair both naturalization and integration. The end product of this process can be ghettoization, economic marginalization, and socio-economic subordination amongst the migrants (Massey, Gross, Shibuya, 1994). This segregation can generate strong socio-political tensions. For example, the rapid rates of urbanization in the developing world are bolstered by high levels of young males fleeing droughts. Urban-male youth bulges' raise the serious possibility of violent crime and social conflict (Urdal, 2006). Currently research in sub-Saharan Africa shows that while young males overcrowding cities does not, in isolation, predict political instability. But when that youth bulge is characterized by poor young men, with low educational attainment, who migrate to cities with stagnant economic growth and a lack of political freedoms – then there is a significant and robust association between urban youth bulges and violent conflict (Urdal and Hoelscher, 2009). Under such political economies, droughts can provide cities with the young male, rural-urban migrants needed to trigger destabilization.

Though, let us remember that rural-urban migration induced by droughts is not a strictly modern phenomenon, and therefore, historical and archeological analogs can provide us with a map as to how different social pathways may unfold. In pre-colonial Africa, Ndichu (2009) has suggested that the influx of laborers and slaves that provided the labor needed for the development of many early African city-states and kingdoms may have been the result of migrants fleeing droughts from neighboring territories. This process is well documented

in the formation of Great Zimbabwe in the 13th century (Huffman, 2009). The medieval climatic optimum that aided in the growth of Zimbabwe's predecessors Mapungubwe to the south ended in the late 1200's with the onset of the little ice age. Based on the intrusion of foreign styles of pottery, archeologists have traced a linkage between a multi-decadal drought which affected the Mapungubwe, to the population subsequently migrating north to the newly formed state of Great Zimbabwe (Huffman, 2000). An analysis of the marginalized residential neighborhoods on the outskirts of the Great Coral suggests that when these migrants arrived, they became an underclass who were used as a source of labor to fuel the mines and fields, which supported Great Zimbabwe's trade connections with the Swahili city states (Kim and Kusmiba, 2008).

Second, while there are contemporary fears that the movement of migrants across the EU could lead to the re-imposition of national boundaries, and the loss of the Schengen, historical examples shows that the opposite is possible as well. That is, climate migration can generate the conditions necessary for socio-political unification and political centralization. The most vivid example of this comes from the initial formation of the unified Egyptian state (Turchin, 2009). In the last centuries of the 5th millennia BC, the Sahara, which at that time was a savannah, began to dry into a desert. As the range of habitable lands contracted, the two largest populations in the Sahara, the Cushitic, and Nilo-Saharans began long migrations to the fertile lands of the Nile river basin.

This mass migration not only increased population pressure and competition for limited resources within the basin but it also created a meta-ethnic frontier – a borderland where two very different cultures meet – which are often places of strong social tension (Turchin, 2003). By 3500 BC, the institution of sacral kingship had diffused from the southern Nilo-Saharans (Nubians) to the northern Cushitic (ancient Egyptians) and set the stage for the development of Early Dynastic Egypt. In response to these new conditions, new centralized political hierarchies began to emerge. The strong group selection pressures caused by intense conflict along the densely populated fault line lead to one of the Cushitic groups with strong collective institutions and sacral kingship, moving south, conquering Egypt and unifying the country - before turning north to destroy their northern Nubian rivals.[21] The role that drought played during this process was subtle and a background process, as the long-term drying of the Sahara was the driving force behind both the population packing and the formation of the meta-ethnic frontier, which fueled the unification dynamics.

4.5.2 Summary

Modern characterization of drought-induced migration portrays farmers, 'dodging a bullet' and migrating to avoid an immediate existential threat – this could not be farther from the truth. Instead, drought affected households often use circular migration to intra-national destinations as a temporary adaptation strategy. The logic behind circular migration is two-

[21] The result of this process is on display on the palette of Narmer.

fold; first, it lessens the caloric strain on the family members who remain in the affected area, and second, the migrated family members move to unaffected regions and send back remittances to smooth household consumption.

While the macro-scale drama of climate shocks driving the Great Era of Migrations appears to be an exception to the rule (McCormick et al, 2012), the small scale circular movements of people can still generate a dynamism that facilitates macro-scale social change. When droughts are severe, and other existing buffers falter, the result can be mass rural-urban migrations (Urdal, 2006). While these migrations can stimulate growth in cities, they can also place a strain on infrastructure, and ghettoize the mostly male migrants into low skill occupations with limited opportunities, which excludes them from the prosperity generated by their economic activity. When there is limited economic growth and a lack of political freedoms this 'urban male youth bulge' can act as a significant political destabilizing force (Urdal and Hoelscher, 2009).

Second, perhaps one of the most underappreciated forces in history is the power of meta-ethnic frontiers (Turchin, 2003; 2007). That is, places where distinct ethnic groups interact with each other. The reason for these fault-lines importance is not just because of inter-cultural exchange, but because of our species parochial nature and tendencies for intergroup conflict imposes strong selection pressure on groups living along the frontier. This conflict either results in the groups developing strong cooperative institutions that aid in inter-group conflict or being defeated. Droughts help generate these fault-lines by circumscribing the amount available arable land, which can drive diasporas to migrate and settle along these meta-ethnic frontiers, and this can either result in ethnic fractionalization, absorption or unification.

4.6 Violence and War

Ultimately, preparation, diversification, reciprocity, and migration often fail to fully insure individuals against the impacts of droughts. When these coping mechanisms are unsuccessful individuals may resort to violent conflict as an adaptation to forcefully secure access to limited resources. This means that when subsistence becomes insecure, then high-risk-high-return strategies like predatory warfare can be a valuable adaptive solution to food shortages (Crofoot and Wrangham, 2010).

The news media has fueled much speculation about the role that climate change and extreme weather events play in motivating armed inter-group conflict. In response to these alarmist fears, social scientists have begun a large, systematic empirical analysis of the relationship between drought and civil strife. Over the past ten years, the results of this research has become clear; the majority of studies find a significant positive correlation between drought and civil insurrection (e.g., Burke, Hsiang, Miguel, 2014; Hsaign, Burke, 2012; Harari and La Ferrara, 2013). For example, a meta-analysis found that for each increase in the standard deviation in temperature or rainfall variation, there is a corresponding 14% increase in global

intergroup conflicts globally (Haisang, Burke, Miguel, 2013). Additionally, by analyzing the prevalence of civil conflicts involving 25 deaths or more and the patterns of El'Nino, Hsaing, Meng and Cane (2011) have found that since the 1950's the presence of El'Nino/Southern Oscillation has played a significant role in 21% of all civilian conflicts internationally. In sub-Saharan Africa, Burke et al. (2013) estimated that a one-degree increase in temperature results in a 4.5% increase in armed conflicts and that when factoring in climate change, by 2030 armed conflict should increase by 54%.

Using a more sensitive measure, the Palmer Drought Severity Index, Couttenier and Soubeyran (2014) found that in years with moderate to severe droughts there is a corresponding non-trivial 1.2-5% general increase in the likelihood of armed civil war in Sub-Saharan Africa. The results from their analysis highlights that there are serious interaction effects between drought, social structure, and war. First, countries that are more ethnically fractionalized and affected by drought are more prone to conflict, than those are that are more homogenous. While this suggests that diverse nations are more vulnerable to climate conflict, it is important to consider that Garcia and Rynal-Querol (2004) found that ethnic fractionalization is non-monotonically related to civil war. That is, countries with a very many, or very few ethnic groups are less likely to have a civil war than countries with a moderate number of somewhat significant minorities. The intuition behind this finding is that without a significant ethnic minority to challenge the state or dominant group, warfare and insurrection are likely to be ineffective.

No study to our knowledge has explicitly tested whether poorer countries experiencing droughts are more liable to experience a civil war. Though, more generally, natural disasters have been shown to increase the likelihood of armed conflict by depressing GDP, and therefore, it is likely that this effect is stronger in poorer nations where a greater share of the population is living close to the subsistence level (Bergholt and Lujala, 2012). So, in line with the general literature, it is likely that poverty exacerbates the correlation between droughts and civil wars (Blattman and Miguel, 2010). The lack of empirical data on this connection is probably accounted for by the fact that most analyzes on droughts are limited to sub-Saharan Africa, which is relatively economically homogenous when compared to the rest of the world.

Additionally, the effect of poverty must be considered in conjunction with economic inequality. Recent findings suggest that the relationship between inequality and civil war is not mediated through strict individual level inequality, (typically measured through Gini coefficients) but instead is facilitated by *horizontal inequalities* between ethnic groups (Cederman et al, 2011). That is, when there is high inequality between ethnic groups, such as between blacks and whites in the United States, then civil wars become more frequent. Again to our knowledge, the relationship between drought, horizontal inequality and civil war has yet to be tested.

Finally, Couttenier and Souberyran (2014) analysis reveals that drought-stricken countries

with relatively weak democratic institutions are more likely to suffer a civil war than those with more robust democratic institutions. The exact reason for this connection is still not clear because there are at least three plausible explanations, that are not mutually exclusive, which could account for this relationship. First, droughts reduce a state's tax revenue and therefore the state becomes less able to both buy off rebels or fund an adequate military to suppress opponents. The inability to support a military is particularly important in dictatorships because mass exclusion from political processes has a tendency to breed armed rebel groups amongst civilians, particularly when democratic forms of governance are visible. Second, because droughts decrease economic opportunities within most formal economic sectors, the loss of wages increases the attractiveness of joining a rebellion for a 'soldiers pay.' Moreso, it also enhances the attractiveness of the potential prize of controlling and consuming state resources and revenues.[22] Finally, the relative deprivation induced by droughts may also increase the salience of grievances against politically oppressive regimes, as was the case in the harvest failures in 1788, and 1789 in France. Currently, though, explanations for the micro-level individual rational for drought-induced civil conflict, focuses on economic incentives and opportunity costs with relatively little attention paid to economic and political grievances.

In contrast to civil wars, there is far less information on the connection between droughts and interstate wars. The earliest evidence of a potential link comes from a survey of the Standard Cross-Cultural Sample, a database of 186 mostly pre-industrial societies, which shows that resource variability, including drought and famine, increase the likelihood of inter-group warfare (Ember and Ember 1992). Amongst modern states, Nelson (2010) has found that there is a significant positive correlation between a country experiencing a natural disaster and their participation in inter-state conflicts. Counter-intuitively, though, Nelson shows that in no cases since the 1950s has a disaster stricken country been subjected to aggressive military predation by an opportunistic rival, but instead when political tensions already exist*, the country affected by the disaster is actually more likely to begin a conflict.* The rationale behind this is that states that have weak governments and ineffective emergency responses may use small scale wars as a nationalistic distraction to shore up legitimacy after an inadequate response to a devastating natural disaster.

4.6.1 Social and Historical Dynamics of Violence and War

The current focus on economic incentives motivating wars (Blattman and Miguel, 2010) contrasts with standard historical and cultural analyzes, which tend to place more emphasis issues of justice and grievances. For example, it is entirely possible that droughts help create high levels of internal competition, and these combine with existing levels of inequality, relative deprivation, and political exclusion to inflame previously held grievances against

[22] State taxes are much easier to appropriate as 'whole' in dictatorships than democracies due to political consolidation.

the state (Gurr, 1970). In line with this reasoning, Andrews and Marcoul (Forthcoming) have found an effect whereby individuals who have been exposed to severe weather events during their youth become more envious and more spiteful toward members of their own in-group. Potentially, this effect could cause individuals to favor aggressive and predatory responses to droughts.

In light of the probable role that grievances play in creating civil conflict, we must also consider that states may respond to threats of civil war by adopting either more egalitarian redistributive policies or moving towards democratization as a way of averting full-blown conflict. Lagi, Bertrand and Bar-Yam (2011) have found that since the 1950s, drought-induced food riots across Africa, have increased the rate of democratization within nations. Their results show that democratic legislation becomes 16.7% times more likely due to a drought and successive food riot. The proposed causal link between droughts, food riots and democratization, is that the mass mobilization involved in food riots creates a situation where there is an immediate threat of collective violence against current elites. In line with Acemoglu and Robinson's theory on democratization (2006) in order to retain their relative advantage, ruling autocrats are sometimes willing to make concessions towards democratization, to avoid being completely deposed or a lengthy civil war. When governments fail to concede to such demands, then the likelihood of civil war increases, as was the case the Syria Revolution.[23]

Finally, we must address the millenarian concern of total social collapse under the weight of climate change and extreme weather events. First, let us say that one must always restrain the naïve impulse to 'blame the weather' as ultimately it is human nature, cultural institutions, and our rationality that determines the fate of any society. However, as our tools to reconstruct historical weather patterns become more sophisticated, researchers are beginning to identifying more links between droughts, warfare and the collapse of ancient civilizations (e.g., Cullen et al, 2000; Haug et al, 2003; Diamond, 2005).

A clear and well-studied example of this pattern comes from the North American Southwest in the 13th-14th centuries AD (see LeBlance, 1999). In the late 13th century just as the first large-scale signs of socio-political inequality emerged across the region, in sites like Chaco Canyon, a multi-decadal drought ravaged the historic Anasazi populations (for an account of the rise of inequality see Lekson (2009)). As the drought wore on, the incipient centralized political entities factionalized, and indications of raiding, warfare, and cannibalism dramatically increased throughout the archeological record (Lekson, 2009; Leblanc 1999).

In response to the growing conflict, towns were abandoned, and new settlements were built on defensible hilltops and even in cliff faces such as Mesa Verde (Dean et al, 2000). These defensive actions further strained communities because their new locations were often far

[23] It is likely that this internal pressure towards democratization has become more effective over the course of the 20th century as citizens in the West are no longer willing to allow their governments to support African Dictators (i.e., France and the Ivory Coast).

from both water sources and prime agricultural land. As warfare in the region increased, communities became larger and denser as individuals left their scattered holdings for safety in numbers. As the villages grew, they also began clustering together in tightly bound districts that maintained lines of sight to ensure mutual defense. The result of the rapid growth and clustering was to compound the pace of ecological deterioration because agricultural intensification and overharvesting had a positive feedback further amplifying the severity of droughts (Duff, Adams and Ryan, 2010). Eventually, the intensity of the conflict increased to such a degree that the residents abandoned the region and it is still not populated to this day.

4.6.2 Summary

The causes of war will always be more complicated than straightforward conflicts over resources. Nevertheless, unaligned interests and asymmetries in formidability mean that groups skilled in arms can conquer, control, and consume the resources of their opponents. Exactly why droughts generate the conditions that promote an increase in violent conflicts is likely a complicated mixture of economic opportunity costs, (Blattman and Miguel, 2010) loss aversion prompting high-risk strategies, (Kahneman, 2003) and the relative deprivation inflaming pre-existing political and economic grievances (Gurr, 1970).

One of the peculiarities of history is for long stretches of time; a system can remain in relative equilibrium, but once a crisis begins, chaos becomes possible, and the smallest actions can push a system down into a very different pathway (for a mathematical analysis of fact see May, (1976)). The threat of violence born from droughts and food insecurity appear to be able to drive political systems down two paths. First, towards redressing grievances and reducing economic/political inequalities and in the second case, towards war and conflict.

Once a social system heads down the second path, the long-term impacts of drought-induced conflict become relatively inseparable from war more broadly and can include rapid technological innovation, political consolidation, genocide, mass migration and socio-political collapse. While it would be causally naïve to attribute these macro-level phenomena solely to droughts, climatic shocks can act can as significant triggers to establish the necessary conditions for conflict within already fragile socio-political systems. This is because they cause the existing adaptive capacity to falter and force individuals to find alternative modes of coping which can drive people to violence.

Nevertheless, when wars and droughts do coincide they tend to exacerbates each other, making famine more likely. Food becomes a political tool to gain and control allies. Additionally, it serves as forage for soldiers and is redirected to the front from farmers and cities. These cumulative effects are made worse by farmers abandoning prime farmland to non-mans land, and in eras before total war, the mass rural-urban migration of peasants seeking safety in numbers acts as a significant strain on urban social systems, which further exacerbate tensions and health concerns.

4.7 Religion and Ritual

From a secular scientific worldview, the strangest response to drought is the prevalence religious behavior. Yet, our survey of the ethnographic literature and own field research has led us to conclude that religious responses to climate shocks are indeed non-trivial. This is because people often attempt to prevent, understand, and respond to droughts through religion. Despite the fact that some readers might object to characterizing religious behavior as an adaptation, we sympathize with them, but stress the definition adopted at the beginning of this paper states: '. . . a response that *seeks* to reduce vulnerability. . . '. Here, the key is that adaptations are an *attempt* to mitigate risk – these are not always effective.

Because of the lack of research on religious adaptations in the climate change literature, and the inherently socio-cultural nature of religion this section will not be organized like the rest of this paper. Instead, we will begin by examining why a connection between drought and religious behavior exists by analyzing the underlying cognitive architecture that links climatological processes to religious practice. We then we evaluate potential adaptive benefits of religious behavior and discuss some historical examples as to how these micro scale actions have impacted social history.

4.7.1 Religious Cognition and Droughts

The mind is a causational relation generating machine (Barrett, 2004; Kahneman, 2011). Throughout everyday life, the mind naturally searches for meaning, attributes causation, and creates stories that tie together complicated interactions in both the physical and social world. Alas, a wealth of psychological research shows that the mind readily attributes causation even when there is scant evidence on which the explanations lie (Kahneman, 2011).

As we come to understand the basic foundations of how the mind works, we have realized that the brain evolved to its current complexity under selection forces generated by the challenges involved in learning from, and competing/cooperating with other individuals (Dunbar, 1993). The result of this selection is that our mind is adept at determining causation and motivations in social interactions amongst other humans (Cosmides, 1989). As such, much of our mental life and neurological processes are dedicated to determining the source of human social motivations to establish/maintain/exploit/leave cooperative relationships, crush a competitor, and/or learn new skills from others (Spreng and Grady, 2010).

The mind is far less sophisticated at determining causation in the physical world. A primary reason for this is simply due to the imperceptible scales of space and time that affect causation in the natural world. While newborn infants have been shown to possess some intuitive understanding of gravity and other fundamental physical processes (Spelke, 1991), the mind is far less well suited for determining complicated geological processes, such as

rainfall patterns and probabilities more generally (Wilke and Barrett, 2009). Nevertheless, when the mind encounters some phenomena that it cannot readily explain, such as erratic rainfall patterns, it often attributes causation in a way that it can understand, and as such it quickly attributes causation to *agents with intentional minds* with motivations and emotions that are easily recognized by social cognition (Barret, 2004). In other words, people often attribute complicated geological processes to the supernatural beings who possess human-like motivations but whom also possess meta-magical powers that stretch beyond normal human limitations (Barret, 2004). Thus, it is not surprising that near universally, humans have traditionally assumed that it is the hands of God(s) that bring the rain.

One of the unique facets of religious and spiritual life is that when gods are conceived of as 'being like us'; that is possessing cognition and emotions recognizable to humans, is that people assume that supernatural beings are responsive to reciprocal relationships (Stark, 2000). This reciprocal relationship between humans and gods forms the basis of sacrifice and prayer. As a consequence, religious experts (i.e., rainmakers) constitute the bedrock of religious and political life in many subsistence societies across the world because they are seen as being able to extract favors from the divine, whom can transcend ordinary physical processes (Harakansson, 1998). In sub-Saharan Africa, leaders have not traditionally been warlords or economic magnates but instead have been experts in magic and have been legitimated with social power and prestige because they have managed to convince their followers that they have control over the uncontrollable.

The fickleness of the weather, gods, and people, ensures that religious experts spend an inordinate amount of time finding ways to appease these supernatural powers, and coax the rain from them. Angry gods cause droughts and gods typically become angry when (a) individuals fail in reciprocal relationships between themselves and the divine (b) when immorality corrupts communities[24] and/or (c) when malicious sorcery has manipulated the gods. As such, beyond sacrifice and prayer, the duties of religious experts include moral teachings, and providing protection from witches. A sad repercussion of this logic is that during times of drought, witchcraft accusations and murders increases (Miguel, 2005). While these killings typically target poor older women, who act as a strain on families' financial resources, such blatant economic rationale does not undermine the prevalence of religious justifications for such behavior.

4.7.2 Is Religious Behavior Adaptive During Droughts?

The persistence of religious behavior in response to immediate existential crises like droughts remains somewhat of a mystery because religious behavior is costly, involving both time and material resources and yet has no tangible impact on either increasing the food supply or on

[24] A good illustration of this comes from one of our communities. In response to the loss of full seasons harvest due to increased variability in rainfalls, community members suspect that it was due to the youth increasingly practicing sodomy.

changing rainfall patterns.[25] Thus, the persistence of ritual responses to droughts and crisis events raises a serious question: is there an adaptive function to turning to religion and rituals in times of stress or is it simply a maladaptive spandrel of the human psychological complex?

On an individual level, many studies have investigated the impact of religiosity on stress reactions and have found mixed results. Religious behavior amplifies stress in some people while reduces it in others (for a meta-analysis see Ano and Vasconcelles, 2005). These inconclusive findings lead us to suspect that the real adaptive function of religious behavior may be found its ability to mediate the adverse effects of anti-social, harmful competitive behavior (envy, spite, sabotage, abandonment, theft, exploitation, and murder, etc.) that can be produced by droughts (for an ethnographic account see Vaughn, 1986).

The underlying argument between religiosity and social cohesion began with Durkheim, who noted that religious behavior serves a social function by binding people together into co-operative communities and sanctioning free-riding (1915). This collective nature of religion is crucial because, in times of drought, there are very real individual level advantages to becoming more selfish (because of the zero-sum nature of the problem of dwindling food supplies). Nevertheless, endemic selfish behavior can lead to a loss of the synergistic benefit of large scale cooperation. Collective action is crucial to many adaptive strategies (Adger, 2005) such as community defense from raiders and pests, aggressive predation and war, and to avoid debilitating internal conflicts and disputes. Therefore, an increase in religious behavior may inoculate communities against anti-social tendencies and improve the effectiveness of collective responses to droughts. Unfortunately to our knowledge, there is currently no research testing this hypothesis.

Although, recent psychological research is beginning to uncover the proximate causes of how religious behavior promotes cooperation. For example, the kinds of synchronized movements found in religious rituals, such as dancing, singing, and even moving in coordination has been shown to increase levels of trust and cooperation in prisoner dilemmas, by releasing significant amounts of oxytocin (Arueti et al, 2013). Other research has shown that having both visual and auditory primes about retributive supernatural deities also increases 'other-regarding behavior', by reminding people omnipotent supernatural deities are watching judging an individual's, and punishing their actions. The result is that people restrain selfish tendencies (Norenzayan and Shariff, 2008).

4.7.3 Social and Historical Dynamics of Religious Behavior

Despite the potential functional benefit of religion in the face of droughts, it is clear that the informational content of religious beliefs matters because the content can either aid in cooperation, efficiency or otherwise can lead to outright maladaptive superstitions. For

[25] The presence of costly rituals would not be such a problem if it just happened in one community because we could write it off as a cultural idiosyncrasy, but instead, it is a global pattern that transcends cultural and geographic boundaries.

example, in 1897 when rinderpest finally made its way down into South Africa, a prophet emerged who preached that if people killed all of their cattle, the rinderpest infestation would end, and new herds of cattle would rise out of the ocean, replacing those that were lost (Kahler, Personal Communication). This example raises an important point about functionalism and adaptation. A general principle of evolution is that adaptations tend only to work *on average,* meaning that there is much room for maladaptive expressions to take hold – bear in mind that this is not the unique province of religion, as we are well acquainted with this principle from modern 'rational' governmental policy.

It is also important that we consider that religious life does not take an amorphous form in communities; instead, it is accompanied by real social structures (i.e.,. Church hierarchies). Particularly, there is a direct correlation between religion and political power in most societies across the world. Traditionally, rainmakers often double as local leaders and chiefs. The implication of this is that a leader's legitimacy is built around their capacity to deliver on their religious obligations to ensure rainfall (or in the case of Egypt, floods). If and when droughts occur that stretch a community's adaptive capacity, this can create a direct legitimation crisis for religious leaders who are then seen as not upholding their side of the social contract that ordains them with political power (for an example of droughts-inducing political fractionalization see Lekson 2009).

While droughts can lead to political fractionalization, it is also possible for these dynamics to promote political consolidation through the use of religion. Take for example the merging of political and religious institutions witnessed in the formation of the 13th-century kingdom of Great Zimbabwe as an example (Huffman 2009). In the cultural predecessors of Great Zimbabwe, the archeological evidence indicates that there was a separation in the ritual spaces dedicated to rainmaking practices (on the top of high hills in the region) and the sites of political power (large cattle corals). After a multi-decadal drought, which proceeded the formation of the Great Zimbabwe, all remains of rainmaking on scattered hills were consolidated inside the political epicenter of the Great Coral. The implication is that after the drought had passed, the once separate political and religious offices became bound together. We suspect that as the droughts became particularly severe the range of religious practices trying to bring the rain began to multiply as people searched for solutions. One of these attempts may have included new forms of rainmaking that combined secular and religious powers into a single office, and its origin may have coincided with the return of the rains, providing it with the legitimacy needed to become socially entrenched.

4.8 Conclusion

When the existing adaptive capacity of a society is stretched to its limits by a shock, individuals and groups begin to try and test new adaptive solutions. While there is no guarantee which of these strategies will become successful and established in a population the process of adapting to risk and uncertainty can restructure social and cultural relationships as part

of the process. In doing so, these new network structures have different sets of feedbacks that allow for new emergent properties to emerge. These new traits cause new selective challenges and when iterated this process endogenously drives change.

Ultimately, these adaptation strategies simultaneously produce and are a product of social structures. While humans have internal motivations that operate somewhat independent of culturally proscribed social structures, on a deeply fundamental level the social worlds that we live in, the built environments, the social relationships, the inequalities, the institutions all in shape the range of strategies an individual can deploy to deal with a crisis. For example, the viability of income diversification strategies is vastly different for a subsistence farmer living in a pre-colonial African chiefdom than they are for a modern farmer living close to a thriving metropolis. So, as human nature and cultural strategies interface with pre-existing social structures, the result of this constrained dialectic is the production of new forms of social arrangement, and unpredicted and unintended macro-scale consequences. And while our focus has been on collective action, political dynamics and inequality, there is nothing that precludes these interactions from affecting technological innovation, art, or gender relations.

We must stress, though, that these processes are primarily unintentional. There is good reason to have serious doubts about the rational ability of individuals to strategically cause deep historical changes. The multitude of contingent psychological, social, political, economic, ecological and geological factors that interact with each other to produce long-term change are utterly imperceptible and incalculable to individuals within their normal lives. For example, there is little chance that an iron age farmer in the Great Lakes of East Africa could have known that by choosing to specialize in banana cultivation that her decision, when taken in aggregate would perhaps lead to the formation of ethno-economic castes. Instead, during acute shocks and immediate crisis, peoples' concerns are far more immediate and concerned with their own survival and that of their families.

Even for trained social scientists our ability to predict how history will unfold is tragically limited. This indeterminacy is due to the simple fact that even simple behavioral rules when iterated over multiple time steps, can cause very complicated dynamics (May, 1976). When an analysis includes multiple interacting societies, cultural change, natural ecologies, and geological processes, our ability to pull back the layers of complexity and randomness to understand the underlying causal dynamics is still very much a work in progress. However, we do not believe that the ability of the social sciences to generate some predictive capacity on the interaction between climate shocks and social structures is completely in vain. Instead, we believe that the first step in this process requires a systematic historical review of how climatic changes and the adaptation strategies they provoke have interacted with social structures and culture to produce long-term macro-scale social dynamics. From this systematic analysis of historical change, we can generate a range of hypotheses and potential causal mechanisms to be tested with both formal models and statistical analysis.

Though we must remember that in real life, when people respond to shocks they have little care for the academic distinctions between strategies and therefore, behavioral strategies are often deeply intertwined and poorly differentiated from each other. This ambiguity is particularly striking when our level of analysis is the household, with multiple members all pursuing different strategies in concert. Take for example the fact that, migration interacts with income diversification and reciprocal sharing to form long distance support networks. Thus, our attempt at categorization and bracketing is not used because we believe that there is something platonic about the strategies identified but instead that discrete considerations are a useful pedagogical tool. This problem reminds us that we should not be too dependent on distinct categorization but should draw our focus onto large systems and to account for interactions across scales.

Finally, we would like to address the 'elephant in the room' - *not all adaptations are social progressive or desirable*. While the social sciences have seen significant advancements in our understanding of altruism and cooperation, the range of behaviors that humans adopt to thrive and deal with crisis often involve exploitation, war, subjugation, manipulation, superstition, and wastefulness. Sadly, even when intentions are benevolent or even neutral, the longer term repercussions of adaptation strategies can result in socially harmful long-term dynamics. The key for the social sciences is to identify these dynamics in a hope to help current, and future generations avoid them.

Chapter 5

Conclusion

The unique set of evolutionary adaptations that humans possess is the reason why our species has been able to thrive and adapt to climatic variation and change throughout history. However, in the process of adapting climatic realities, evolution has shaped our emotions, cognition, behavior, social structures and built environments. This process has been reciprocal, with humans changing and adapting to shifting environments and, in turn, environments across the world, changing and adapting to us.

The legacy of this ancient evolutionary process remains with us today. Even though the modern world is vastly different from the 'environment of evolution adaptation,' our minds and our social structures are still, in part, the product of millions of years of evolutionary selection. For example, our aversion to inequality is not merely the result of ideological inculcation, but is an evolved feature of the mind (Fehr and Schmidt 2000, Peterson et al. 2013). It was built to solve problems regarding the distribution of resources amongst highly mobile bands of hunters and gatherers and, as such, the cognitive mechanisms involved in IA reflect those ancestral conditions in their function. However, today, the information processing structures embedded in this neural architecture affects how people see economic redistribution on a global scale, and thus fundamentally impacts how we think about climate change and justice (Peterson and Tooby, 2013).

Evolution, though, is not solely just a mechanism for accounting for the changing frequency of genes within a population and the fundamentals of our psychology. Instead, it is a way of accounting change at a far more general level. It is a methodology of change that abides by three simple propositions – variation, selection and retention. With these three principles, it accounts for how our minds have been built, how the basics of our social behavior are established, how cultural change functions and how historical change is produced and maintained. Evolution is not merely a biological process; it is a method of change that spans all forms of change and complexity (Chaisson, 2002).

Ambivalently, though, the iterative process of variation, selection and retention is amoral. It does not promise pristine adapted behaviors, or social structures that are just and fair. Instead, given environmental and phylogenetic limitations, evolution selects for adaptations

that work better at promoting survival and reproduction than their predecessors. Because the process is, in a sense, blind, and only works on average, evolution can produce maladaptation very quickly (see Edgerton, 1992). The process by which maladaptation arise is also a function of the speed of ecological and social change, as adaptations for one epoch can be disastrous to the next. As cultural technologies have sped up the rate at which humans induce change, they have has also increased the rate at which old adaptations become obsolete vestiges. Many of these have to do with our group dynamics, because the rate of cultural and technological change has forced a globalized community upon us during the 20th and 21st centuries and thus fundamentally altered the scale of interaction.

Alas, the scale at which selection pressures operate is vital for understanding how evolution functions (Okasha, 2006; Sober and Wilson, 1999). Whether evolutions favors traits that places individuals before groups, or groups before individuals is a function of the relative importance of competition at varying scales. Because there are often conflicting selection pressures operating all at once, our evolutionary history has produced a species with an ambiguous mix of collectivist morals and private ambitions. In short, multilevel selection has created spite, caste systems, exploitation, violence, war and environmental degradation, just as easily as it has created produce altruism, democracy, peace, justice, and environmental consciousness.

Understanding multilevel selection is of the utmost importance for our modern challenges with climate change because its underlying logic is what produces the conflicting motivations that make dealing with overconsumption and high carbon economies so difficult (Waring et al, 2015). Sadly, despite our noblest attempts, our species is still very a selfish one. Even when can organize ourselves to act collectively in groups, it is often parochial, and tribalistic, and aimed at competition with, and the exploitation of other groups. Thankfully, cultural learning allows us to potentially circumvent these tendencies and has been the primary force behind pushing our cooperative capacity to scales of complexity that allows for international collective bargaining on INDCs (Boyd and Richerson, 2008). Nevertheless, the challenges of climate change require collective organization on an unprecedented scale, and thus it stretches thin our capacity for cooperation.

Perhaps in vain, though, there is some hope that by understanding evolutionary change and the fundamentals of our social behavior, that we can being to direct our social systems down more sustainable paths. In this thesis, we have explored the relationship between climate change and evolution across three different scales and three different social domains. In our first paper, we sought to uncover the individual level impact that severe droughts experienced during critical developmental periods, have preferences for economic redistribution. We found that people who were severely exposed to these shocks became more envious and spiteful to members of their own communities. From a practical perspective, this tells us that we must work to reduce the impact of these shocks on social systems and people because this shift in preferences can generate anti-social behavior that harms economic growth

and generates social tensions.

Second, we studied how these very same 'other-regarding preferences' affect the willingness of individuals to accept autocratic leadership in public goods problems. We found that evolution has sculpted our neurological machinery to be averse to political control because of the ever-present threat of exploitation, but that the acceptance of leadership depends on two fundamental principles. First, the need for coordination and second, low levels of conflicting interests. If there are attempts to develop large-scale supranational governing bodies to enforce INDCs; then there must be an understanding that the threat of climate change is real and that the need for collective action is real. However, this knowledge is not sufficient, additionally, such international bodies, must inspire trust through transparency and competence.

Finally, we analyzed how the adaptation strategies used to cope with droughts have impacted socio-political history. We found that when existing social systems become stressed beyond their adaptive capacity, people begin to search out new adaptive strategies, and in doing so this generates new social relationships and dynamism. These new conditions can help to open socials systems up to large-scale socio-political reforms. It is clear from our analysis though that these shocks do not always lead to desirable or socially equitable outcomes.

5.1 Implications

5.1.1 Implications of Chapter 2

Over the past 20 years, globally there has been a substantial rise in the number of climate-related natural disasters. Between the 2000-2013, the average annual frequency of climate disasters climbed to double that of the period between 1980-1989 (UNISDR, 2015). From 1994 to 2013, droughts have affected over 1 billion people globally and approximately 41% of those droughts were in Africa (UNISDR, 2015). The economic cost of these disasters is staggering. In the thirteen years between 2000 and 2013, natural disasters including floods, hurricanes, earthquakes and droughts, cost the world economy $2.5 trillion. To make matters worse, research now firmly suggests that these climatic dynamics will further the growth of economic inequality (Fenichal et al, 2016).

One of the major policy decisions that governments across the world face is how to allocate resources for national and international disaster relief and aid. Let us briefly consider two stylized courses of action. One, where the nations of world establish a fund or 'global support network' to help countries when they suffer from droughts and natural disasters and the second course of action, 'nothing,' which would force nations to become autarkic.

If the first path is chosen, the 'global support network' would increase the amount of insurance that individuals and states have against climate shocks, and by doing so it would require an increase in taxation across all member countries. If the findings of Marcoul and colleges (2016) on 'village level support networks' can be scaled up and generalized to this

context, then this kind of system would decrease economic investment due to the disincentives induced by financial security and the threat of taxation. *Ceretis Paribus*, this would result in an overall negative effect on economic growth amongst developed and developing nations alike.

Nevertheless, the insurance networks would buffer nations from the severe economic impacts of climate shocks, and this effect would be particularly strong in poorer countries such as those in sub-Saharan Africa. On an individual level, these networks would reduce the severity of existential threats that individuals suffer. In turn, these systems would also contribute to reducing the impact of poverty traps and starve off the further entrenchment of large scale socio-economic inequalities. Therefore, in aggregate, the total economic impact would be a function of the benefit of the buffering effect of these networks, and the cost that these policies would have on stifling economic growth.

Now let us consider what would happen if the global community decided to forgo such support networks and thus forced each nation bear the brunt of climate change as isolated, autarkic states. Counter to the prior example, the decrease in insurance and taxes would incentivize economic investment due to the need for self-insurance and the lack of taxation. This, in turn, should have a positive effect on economic growth.

Though, the externalities of such a policy would be that developing nations with weak institutions would become more severely affected by climate shocks. These shocks can depress economic growth and expose the most vulnerable segments of these populations to more crisis events and poverty traps, with the likely outcome being an increase in regional inequality. The ubiquitous presence of inequality averse preferences structures means that the increase in localized inequality would generate significant disutility amongst the affected individuals.

This effect is amplified by the fact that climate shocks experienced during youth produce 'other regarding' preferences that are more spiteful and more averse to self-disadvantageous inequality in adult life. The implication is that such individuals are more willing to forego non-zero sum interactions which could increase economic growth but which would place the individual at a relative disadvantage. Unfortunately, this envy is then paired with spite, an increase in the willingness to pay a cost to harm someone else to reduce inequality. With droughts affecting over a quarter of the world's population, this change in preference structure could have substantial effects on economic growth (Fehr and Kshetramade, 2008; Platteau, 2000) as well as promoting large-scale social disenfranchisement, socio-political resentment and instability.

Therefore, when considering these two options, it is clear that lower rates of economic growth may be a result of either choice. If nations opt for the "global insurance network' then the standard financial disincentives of taxation and security, would reduce overall economic investment while simultaneously buffering against the social and existential impact of shocks. On the other side, the lack of security paired with lower tax rates may incentivize

growth. However, the resulting crisis and inequality can shift preferences and motivate envy and spite which would have an adverse impact on economic growth. The altered preference structure may also contribute to rising social tensions, which could trigger civil conflict. Our point is simple; one cannot strictly pay attention to the economic impacts of such policies as the social and psychological externalities that they produce have tangible effects on social welfare as well.

5.1.2 Implications of Chapter 3

Historically, it is only relatively recently that centralized bureaucratic governments, rather than communities have become the legal bodies that codify, dictates, and enforce social norms, en mass. The spread of the state into the depths our social and economic lives was aided in no small part by both democratization and the construction of national identities during the 19th and 20th centuries (Anderson, 1987). In the west these identities were forged in the context of national level, economic and military competition that plagued Europe for centuries (Turchin, 2007). These conditions favored the growth of preferences and norms that allowed for centralisation to develop because the threat of military and economic defeat engender both the need for coordination and aligned individual and national interests (Hobsbawm, 1992). However the question remains as to whether climate change can have the same effect on galvanizing political centralization as a mechanism for establishing international cooperation.

Our second paper provides insight into the fundamental nature of the leadership in collective action dilemmas. Because leadership necessitates power differentials, it, in turn, produces a loss of individual autonomy. By doing so, the existence of power exposes individuals to the threat of exploitation. This threat means that organisms have evolved a robust suite of psychological mechanisms to resist political control. However, the advantages of leader/follower dynamics have sculpted the neurological machinery to be sensitive to cues that indicate the existence of both coordination challenges and mutual interests. If both of these conditions are fulfilled individuals become more willing to accept leaders.

The question remains, though, how does understanding the basic nature our political cognition help us adapt to climate change. Most importantly it provides us with insight into the conditions under which individuals are willing to accept supranational governing bodies with the ability to enforce INDCs. Additionally, it can shed insight onto how, and when individuals are likely to trust national government to impose strict controls on consumption and economic activity in order enforce sustainable lifestyles.

Currently, though, due to the innate reluctance towards strong centralized international leadership, most academic and policy efforts have focused on the search for 'win-win' market interventions (Adger, Arnell and Tompkins, 2007). The intent of these are to modify individual and corporate behavior without the loss of either economic or political freedom. While this is laudable, we suspect that for climate change, due to the immediate action

required, and the underlying collective action dilemma, the problem may necessitate strong centralized political leadership. As such, there should be serious discussion on the possibility that adaption and mitigation may involve trade-offs in both political and economic freedoms.

Our analysis indicates that for this kind of leadership to be perceived as legitimate, two basic conditions must first be fulfilled. First, individuals and nations must recognize that there is a fundamental coordination/collective action challenge that must be overcome. If people do not see the need for leadership as a mechanism to solve collective problems, then people will not accept such policies. In regards to climate change, this means that it must be understood that (a) climate change is a physical reality, and that human GHG emissions are the primary cause of it. (b) Climate change poses a real threat to all human societies if not mitigated. (c) To mitigate climate change, the action of all nations acting in concert is required.

Sadly, the establishment of the reality of climate change in the public arena has not been straight forward. Media campaigns by climate change deniers have been orchestrated by industries and individuals with vested interests in high carbon economies (Dunlap, 2011). By doing so, these organizations have stalled the development of international frameworks to deal with climate change by challenging the underlying reality of climate change, and that it presents a formidable collective action problem (McCright and Dunlap, 2003). The resistance by vested interests demonstrates of one our key findings that selfish individuals should be less willing to accept leadership in public goods games. On the flip side of the coin, this reminds us that education about the physical realities of climate change, and its underlying social problems is a vital policy objective because it could encourage support for stronger political measures to reduce CO^2 emissions.

Second, for individuals to accept strong leadership they must perceive substantial mutual interests between themselves and a potential leader. In essence by increasing the presence of mutual interests and trust, collective action problems become converted into a coordination challenge because they fundamentally alter the payoff structure by reducing the temptation to for corruption or defection (Skyrms, 2004). In light of the dubious challenge of building a pan-human sense of collective identity, it is likely that the mutual interest and trust that must underpin any internationally sovereign body can only be developed through institutional mechanisms that promoteas transparency and accountability in international bodies.

5.1.3 Implications of Chapter 4

While distinct in its particulars, social change follows roughly the same principles as evolutionary change – variation, selection and retention. Crucially, we now understand that mutations are not perfectly random, instead, the rate of mutation increases as individuals come under stress and these changes preferentially target certain parts of the genome over

others[1] (For a review see Pray and Zhaurova, 2008; Ridley, 2004). Mutations do not always affect actual genes or protein building sequences, but instead, they often affect the genetic mechanisms that connect those genes into networks. By altering the network structure these changes can produce new emergent structures and behaviors relatively easily (Ridley, 2004). This, in turn, creates more variation amongst offspring and this 'raw material' allows for genetic lines be more flexible in their adaptation process.

When a new trait spreads into a population, it alters the structure of that organism's world. Adaptive traits change the way an organism relates not only to their conspecifics but also the wider ecology that they inhabit. In the process of altering physical and social worlds, interrelated feedbacks, cause changing environments to generate new selection pressures (Odling-Smee, Laland and Feldman, 2003). The new environs, with their new selection pressures, become the habitats that subsequent generations inherit and then must adapt to. This whole process is fundamental to how evolutionary change operates.

The implication that this process has for global climate change is that we must be prepared for change in unexpected aspects of our social lives. The adaptation process will not smooth, nor will it be solely a fair, honest, peaceful, cooperative, affair. Instead, adapting to climate change can present us with the possibility of elite capture, rising rates of political and economic inequality, and the threat of violence. This raises a paradox – our social systems cannot stay as they are, and yet the examples of history tell us that the long-term impacts of shocks can be deleterious to both individuals and group. Fortunately, though some social systems are bound to be more pre-adapted to instability, yet sadly we have a poor idea as to which these are. In light of this, we advocate a simple evolutionary principle, variation. By promoting variation in social forms, we can ensure that as climates become more unstable, we can observe and learn from social systems that respond to changing circumstances with the traits and ease that we desire.

5.2 Limitations

5.2.1 Limitations of Chapter 2

Simply, the largest limitation of our first study is our sample size. While the total sample is 180 participants, the fact that we split our sample into in-group and out-group treatments, means that our partitioned analyzes contain 95 and 85 individuals in each group respectively. Even though this is above the 80 observation threshold for logit models, it does not leave us with many degrees of freedom to construct complex multivariate models.

A second limitation that is often mentioned to us is that because our severity index relies on self-reports of exposure to droughts we may face problems with endogeneity. While we have introduced multiple robustness checks to the study, without the possibility of perfectly objective individual measures, then possibility of some autocorrelation looms. Therefore,

[1] For example highly conserved regions critical to the development of necessary traits (like a heart) are not affected, while other regions are.

it has been suggested to us that instead using self-reported exposure, we should rely on absolute measures of climate shocks, such as PDSI or rainfall measures for each region. Unfortunately, this would be insufficient because it would neglect the high rates inter-region migration and other social factors that contribute to the vast heterogeneities levels of exposure within regions and villages.

Additionally, our analysis focuses on *relative* exposure because the significant evolutionary and neuroscientific literature demonstrates that the behavioral system involved in spite and envy is most sensitive to relative payoffs. Therefore, if we only relied on low-resolution climatological measures, we would lose the ability to track individuals' relative exposure. Nevertheless, when high-quality climatological data is available, or there is the possibility for a naturally occurring randomized control trial, we would recommend integrating these sources of data to compliment but not replace fine grain individual analysis.

The final limitation of our first study is a problem that is common to all experimental studies; the results from experiment may not be generalizable to broader contexts (Levitt and List 2007). The nature of this problem stems from the fact that while experimental specifications may logically abstract real world problems, there is little guarantee that an individual's behavior in an experiment will reflect their real world behavior. Typically, in experiments testing for 'other-regarding preferences,' the primary unit of analysis is altruistic behavior (Barr and Zeitlin, 2010). This focus has provoked criticism that even though experimental conditions typically employ one-shot anonymous conditions, there may still be reputational considerations between the subject and researcher, (List, 2007; Frazen, and Pointner, 2013) as well as the presence of the house money effect (Thaler and Johnson, 1990).

Both of these problems can be abated to some degree by increasing the total endowment and thus encouraging people to be more 'careful' about their choices, in the hope that this will align their decisions with their underlying preferences (Levitt and List, 2007). As such, our average payoffs in all of our games were equal to a day's wage labor in Tanzanian currency (for two hours of their time), which is proportional to over $100 CDN. Additionally, we suspect that the concern of reputational effects in our study is less severe than in studies that focus on pro-social behavior. This is because spite is typically something that individuals hide because it is socially undesirable and a signal that would decrease an individuals' attractiveness as a potential cooperative partner. Therefore, we suspect that incidences of spite are underreported.

The second criticism leveled against the experimental methodology is that even if the findings can be generalized outside of the game, the insights into behavior are limited to the immediate subject population and thus cannot always speak to human nature more broadly (Henrich et al, 2010b). While the broader literature supports our findings, we will seek to confirm our results by extending this research to other cultural contexts. Additionally, in these future studies, we will include post-experiment questions on the exact motivation that

each subject had in choosing their allocation.

5.2.2 Limitations of Chapter 3

As with our first study, the primary limitation with of our second paper is our sample size. Although our initial sample included 126 participants, due to a name matching problem between the participants in the first and second game we lost 40 observations. Our final total sample size for the analysis was 86, which sits on the minimum threshold needed for logistic regressions, and thus severely limits our degrees of freedom. Fortunately, our comparative statistics between this smaller sample and our larger complete sample of 180, are almost identical, indicating that the knockout was randomly distributed. Therefore, this did skew our sample.

Second, to completely isolate whether preferences for political inequality are separate from strict economic considerations, the leader/no-leader conditions must have the same expected payoffs. In our design, if a leader is selected, then each individual has a 1 in 7 chance of being randomly selected as the leader. If the leader is rational and self-interested, this will result in them being maximally corrupt and extracting the full amount from the public good. The result is that the expected payoff for the leadership condition is double that in the non-leader condition. Thus, if all participants were homo-economicus, then this would result in everyone voting for the leadership treatment. Therefore, because only 34% did, this indicates that individuals are actually more highly averse to leaders than strict rational actor models would predict.

Unfortunately, though, we are unable to determine if an aversion to self-disadvantageous inequality motivates the aversion to leadership or whether it is because of politically motivated anti-authoritarian tendencies. In future research we propose that this problem can be solved by (a) having the leader be someone not in the game, nor the community (b) having the leader be a 'non-person.' In this treatment the leadership position would be fulfilled by the flip of a coin to determine whether the leader enforces cooperation or is corrupt.

Third, whether leaders are corrupt or not, is known by the other participants. This may cause the leader to modify their behavior in light of potential post-game social sanctions. Thus, we did not analyze the leaders' behavior in our analysis because of these contaminating outside influences. Additionally, this may cause individuals to be more willing to vote for leaders, knowing that the 'communities watchful eye' could informally 'threaten' the leader to be cooperative. In future experiments we recommend having the identity of the leader be anonymous to reduce this potential effect. Additionally, as with the first experiment, we would like to introduce a post-game, open-ended question as to the individual motivations for voting for a leader.

The final consideration that we must contend with is the conflation of dominance and leadership. There has been a recent spat of popular, unpublished research that indicates that the voters who support Donald Trump are authoritarians (MacWilliams, 2016). Despite

this research's popularity it does little to distinguish between leadership and traditional dominance. Our concern is that their metric for authoritarianism preferences does not actually measure leadership preferences (Feldman, 2003). Instead, their metric is derived from a proxy that focuses on parenting attitudes. For example: Please tell me which one you think is more important for a child to have: independence or respect for elders? Obedience or self-reliance? Consideration or proper behavior? Or curiosity or good manners?

The problem with this metric, is that is ambiguous as to whether it is measuring is dominance or leadership. For example, wanting a child to be obedient could simply be a way of reducing challenges in family conflicts rather than a deep comment on authority. While a respect for elders might simply indicate a desire for submissiveness in children and not followership with the aim of coordination. In order to disentangle this conflation, we propose that our games, which strictly measure leadership preferences, are run in conjunction with both measures of SDO (Pratto et al, 2007) and the authority metric developed by Feldman (2003).

5.2.3 Limitations of Chapter 4

Due the use of a fundamentally different research methodology, the limitations of our fourth chapter are qualitatively different from the first two. Our first, limitation stems from a concern that the dramatic nature of droughts/famines means that they are relatively over-documented in the historical record in relation to other variables of interest. Particularly, without information on crucial social variables such as sex ratios, socio-economic inequality and parenting practices, this bias may cause researchers to over estimate the effect of droughts on politics simply due to their historic visibility.

Our second limitation is that the questions that historians ask and the factors that they pay attention to are not independent from their own personal lives and socio-cultural context. Thus, since the 1990's when climate change entered into public consciousness, it is possible that historians began to increasingly ask questions about, and pay more attention to, environmental and climatological factors. While this may correct for a previous dearth of research on historical climate change, it may also encourage an over reporting of climatological factors in modern historical research. This bias may be furthered by advancements in climate reconstruction techniques allow historians to probe parts of the historical record previously inaccessible.

The third limitation of this paper is a more general comment on the nature of historical analysis over the past century. The problem is simple; historical theories multiply with each generation of scholars, but very infrequently are they tested in such a way that false theories can be rejected and eliminated form the population. This means that the necessary ground work of establishing an empirical and formal theoretical basis of historical change is yet to take place. Part of the reason for this is that historians are yet to develop large-scale databases that combine both time-series data with the societal and ecological variables. This would allow the historian to preform time series analysis on social, economic, cultural and

environmental variables to help sus-out mechanisms of historical causation. Until large-scale databases like Seshat (Turchin et al, 2014) have are completed, we will have to be careful about the application of casual analytics linking droughts to social change.

5.3 Final Words

The first ever course that I took in University was a called "The Anthropology of Race and Racism" and the only the assigned reading for it was "Biology as Ideology" by Richard Lewontin, the long-time colleague, and collaborator of Jay Stephen Gould (1991). In my short introduction to the politics surrounding Sociobiology, I was quickly taught, with a moral fire, that the whole concept of 'human nature' was subtly and often intentionally built to reinforce and justify the chief evils of our day: capitalism, colonialism, and sexism. While Lewinton is a geneticist himself, I have observed generations of sociologists who have happily accepted these criticisms at face value because of the internal culture of social sciences. In turn, these ideas have been used to justify an often righteous rejection of neuroscience, evolutionary biology, reductionism, and the scientific method in the study of human social behavior.

As a young, good sociologist, I had internalized and mastered these criticisms, yet there came a point, in my education, when I asked myself, what I think now is the most central question in all of sociology, 'what are societies and how do they work?' Sadly, I was profoundly unequipped the question. The reason was, that the training I had received in post-modern social theory led, ultimately, to an infinite regress as to the foundations of human behavior and motivation. Human behavior was said to be the result of culture and language, and culture and language was said to be the results of human behavior, to ad infinitum.

The tautology, of course, has some enormous holes in it. For example, if culture was, in fact, the only determinant of social behavior then why have cultures separated by thousands of years, and thousands of miles have remarkably similar social behavior? Why do humans form families, friendships and groups in a way, that although is different between cultures, is still readily understandable to all (Brown, 1991)? Do animals have culture? More so, on a personal level, I knew that I had urges and feelings, emotions and motivations, which I did not learn, and that could drive my behavior with a greater force than any social norm. With the help of some serious introspection on my educational path, the big questions human history, and my own social behavior I came to realize that the only thing that could account for these discrepancies was evolutionary biology. This recognition began a long re-education that profoundly altered my life and led me an understanding that the rejection of biology in the social sciences was all to often built on each subsequent generations of social scientists inheriting an ignorance and biases from each previous generation. The damage from this is incalculable. Not only because it wastes student's and intellectual's time and resources by pursuing back alleyways, but also because it has impaired sociology's ability

to address pressing challenges that sit at the heart of climate change.

The range of questions that we need to understand to tackle climate change is vast, and despite my attempt in this thesis to address some of the most fundamental questions around inequality, collective action, and social change, there is still so much for us to understand. For example, is there an evolutionary basis for the fact that as incomes rise so too does consumption? Is our consumerism tied to our pursuit of social status and ultimately a vestige of ancient reproductive strategies? These questions are not trivial and answering them will provide us insight into how such consistencies in behavior and social patterns are produced and in turn generate information as to how we can use our evolved predispositions to reorient our societies down different paths. In the end, though, this thesis is but a single drop in the vast sea of information that is expanding at an unprecedented rate each day. Even with its limitations and shortcomings, I am overcome with awe and gratitude to have had the privledge to study the majesty of life and evolution as it applies to the greatest challenge our species has yet to face.

Bibliography

Abbink, Klaus and Benedikt Herrmann (2011). The moral costs of nastiness. *Economic Inquiry* **49**(2), 631–633.

Acemoglu, Daron and James A Robinson (2005). *Economic origins of dictatorship and democracy*. Cambridge University Press.

Adger, W Neil (2003). Social capital, collective action, and adaptation to climate change. *Economic Geography* **79**(4), 387–404.

Adger, W Neil (2006). Vulnerability. *Global environmental change* **16**(3), 268–281.

Adger, W Neil, Nigel W Arnell and Emma L Tompkins (2005). Successful adaptation to climate change across scales. *Global environmental change* **15**(2), 77–86.

Akerlof, George (1970). Vthe market for lemons: Qualitative uncertainty and the market mechanismv. *Quarterly Journal of Economics*.

Alexander, Richard D (1987). *The biology of moral systems*. Transaction Publishers.

Alger, Ingela and Jörgen W Weibull (2013). Homo moralis - preference evolution under incomplete information and assortative matching. *Econometrica* **81**(6), 2269–2302.

Andersen, Susan and Martin Teicher (2009). Desperately driven and no brakes: Developmental stress exposure and subsequent risk for substance abuse. *Neuroscience & Biobehavioral Reviews* **100**(4), 516 – 524.

Anderson, Benedict (2006). *Imagined communities: Reflections on the origin and spread of nationalism*. Verso Books.

Andras, Peter, John Lazarus and Gilbert Roberts (2007). Environmental adversity and uncertainty favour cooperation. *BMC evolutionary biology* **7**(1), 1.

Ano, Gene G and Erin B Vasconcelles (2005). Religious coping and psychological adjustment to stress: A meta-analysis. *Journal of clinical psychology* **61**(4), 461–480.

Archer, John (2006). Testosterone and human aggression: an evaluation of the challenge hypothesis. *Neuroscience & Biobehavioral Reviews* **30**(3), 319–345.

Arkes, Hal R and Peter Ayton (1999). The sunk cost and concorde effects: Are humans less rational than lower animals?. *Psychological bulletin* **125**(5), 591.

Arueti, Maayan, Nufar Perach-Barzilay, Michael M Tsoory, Barry Berger, Nir Getter and Simone G Shamay-Tsoory (2013). When two become one: the role of oxytocin in interpersonal coordination and cooperation. *Journal of cognitive neuroscience* **25**(9), 1418–1427.

Axelrod, Robert (2006). The evolution of cooperation: revised edition.

Bäckström, Martin and Fredrik Björklund (2007). Structural modeling of generalized prejudice: The role of social dominance, authoritarianism, and empathy. *Journal of Individual Differences* **28**(1), 10–17.

Ball, Richard and Christopher Johnson (1996). Political, economic, and humanitarian motivations for pl 480 food aid: Evidence from africa. *Economic Development and Cultural Change* **44**(3), 515–537.

Banerjee, Neela, Lisa Song and Hasemyer (n.d.). Exxon's own research confirmed fossil fuels' role in global warming decades ago. http://insideclimatenews.org/news/15092015/Exxons-own-research-confirmed-fossil-fuels-role-in-global-warming. Accessed 2016-04-25.

Bar-Hillel, Maya (1980). The base-rate fallacy in probability judgments. *Acta Psychologica* **44**(3), 211–233.

Barr, Abigail and Andrew Zeitlin (2010). Dictator games in the lab and in nature: External validity tested and investigated in ugandan primary schools. Technical report. Centre for the Study of African Economies, University of Oxford.

Barrett, Christopher B and Thomas Reardon (2000). Asset, activity, and income diversification among african agriculturalists: Some practical issues. *Available at SSRN 257344*.

Barrett, Christopher B, Thomas Reardon and Patrick Webb (2001). Nonfarm income diversification and household livelihood strategies in rural africa: concepts, dynamics, and policy implications. *Food policy* **26**(4), 315–331.

Barrett, Justin L (2004). *Why would anyone believe in God?*. AltaMira Press.

Barrett, Scott (2008). Climate treaties and the imperative of enforcement. *Oxford Review of Economic Policy* **24**(2), 239–258.

Barrios, Salvador, Luisito Bertinelli and Eric Strobl (2006). Climatic change and rural–urban migration: The case of sub-saharan africa. *Journal of Urban Economics* **60**(3), 357–371.

Bartling, Björn, Ernst Fehr, Michel André Maréchal and Daniel Schunk (2009). Egalitarianism and competitiveness. *The American Economic Review* **99**(2), 93–98.

Bateson M., B. Brilot and D. Nettle (2011). Anxiety: An Evolutionary Approach. *The Canadian Jounral of Psychiatry* **56**(12), 707 – 715.

Bauer Michal, Alessandra Cassar, julie Chytilová and Joseph Henrich (2013). War's Enduring Effects on the Development of Egalitarian Motivations and In-group. *Psychological Science* **56**(12), 707 – 715.

Baumgartner, Thomas, Markus Heinrichs, Aline Vonlanthen, Urs Fischbacher and Ernst Fehr (2008). Oxytocin shapes the neural circuitry of trust and trust adaptation in humans. *Neuron* **58**(4), 639–650.

Bell, Edward, Julie Schermer and Philip Vernon (2009). The origins of political attitudes and behaviours: An analysis using twins. *Canadian Journal of Political Science* **42**(04), 855–879.

Bentzen, Jeanet Sinding, Nicolai Kaarsen and Asger Moll Wingender (2012). Irrigation and autocracy. *Univ. of Copenhagen Dept. of Economics Discussion Paper*.

Bergholt, Drago and Päivi Lujala (2012). Climate-related natural disasters, economic growth, and armed civil conflict. *Journal of Peace Research* **49**(1), 147–162.

Bertaud, Jean-Paul (1988). *The Army of the French Revolution: From Citizen Soldiers to Instrument of Power*. Princeton University Press.

Binswanger, Hans P and John McIntire (1987). Behavioral and material determinants of production relations in land-abundant tropical agriculture. *Economic Development and Cultural Change* **36**(1), 73–99.

Bjørnskov, Christian (2007). Determinants of generalized trust: A cross-country comparison. *Public choice* **130**(1-2), 1–21.

Blattman, Christopher and Edward Miguel (2010). Civil war. *Journal of Economic Literature* pp. 3–57.

Boehm, Christopher (1999). *Hierarchy in the Forest: The Evolution of Egalitarian Behavior*.

Boehm, Christopher (2012). *Moral origins: The evolution of virtue, altruism, and shame*. Basic Books.

Bøggild, Troels and Michael Bang Petersen (2016). The evolved functions of procedural fairness: An adaptation for politics. In: *The Evolution of Morality*. pp. 247–276. Springer.

Bolton, Gary E and Axel Ockenfels (2000). Erc: A theory of equity, reciprocity, and competition. *American economic review* pp. 166–193.

Bornstein, Robert F and Paul R D'Agostino (1992). Stimulus recognition and the mere exposure effect.. *Journal of personality and social psychology* **63**(4), 545.

Bos, Peter A, David Terburg and Jack van Honk (2010). Testosterone decreases trust in socially naive humans. *Proceedings of the National Academy of Sciences* **107**(22), 9991–9995.

Bourdieu, Pierre (1988). *Homo academicus*. Stanford University Press.

Bourdieu, Pierre (2011). The forms of capital.(1986). *Cultural theory: An anthology* pp. 81–93.

Bowles, Samuel and Herbert Gintis (2011). *A cooperative species: Human reciprocity and its evolution*. Princeton University Press.

Bowles, Samuel, Eric Alden Smith and Monique Borgerhoff Mulder (2010). The emergence and persistence of inequality in premodern societies. *Current Anthropology* **51**(1), 7–17.

Boyd Richard, Gintis Herbert, Bowles Samuel and Peter J. Richerson (2003). The evolution of altruistic punishment. *Proc. Natl. Acad. Sci. USA* **100**(6), 3531 – 3535.

Boyd, Robert and Peter J Richerson (1986). *Culture and the evolutionary process*. University of Chicago Press.

Bromley, Daniel W and Jean-Paul Chavas (1989). On risk, transactions, and economic development in the semiarid tropics. *Economic development and cultural change* **37**(4), 719–736.

Brown, Donald E (1991). *Human universals*. McGraw-Hill New York.

Bryceson, Deborah Fahy (1999). African rural labour, income diversification & livelihood approaches: a long-term development perspective. *Review of African Political Economy* **26**(80), 171–189.

Burke, Marshall B, Edward Miguel, Shanker Satyanath, John A Dykema and David B Lobell (2009). Warming increases the risk of civil war in africa. *Proceedings of the National Academy of Sciences* **106**(49), 20670–20674.

Burke, Marshall, Solomon M Hsiang and Edward Miguel (2014). Climate and conflict. Technical report. National Bureau of Economic Research.

Bush, George, Phan Luu and Michael Posner (2000). Cognitive and emotional influences in the anterior cingulate cortex. *Trends in cognitive science* **4**(6), 215 – 222.

Buss, David M and Joshua D Duntley (2008). Adaptations for exploitation.. *Group dynamics: Theory, research, and practice* **12**(1), 53.

Byrne, Richard and Andrew Whiten (1989). Machiavellian intelligence: social expertise and the evolution of intellect in monkeys, apes, and humans (oxford science publications).

Calder AJ, Keane J, Lawrence AD and F. Manes (2004). Impaired recogniton of anger following damage to the ventral striatum. *Brain* **9**, 1958 – 1969.

Cappelen Alexander W., Tom Eichele, Kenneth Hugdahl Karsten Specht Erik Ø. Sørensen and Bertil Tungodden (2014). Equity theory and fair inequality: A neuroeconomic study. *Proceedings of the National Academy of Sciences* **111**(43), 15368–15372.

Carneiro, Robert L (1970). A theory of the origin of the state traditional theories of state origins are considered and rejected in favor of a new ecological hypothesis. *Science* **169**(3947), 733–738.

Carter, C Sue (2007). Sex differences in oxytocin and vasopressin: implications for autism spectrum disorders?. *Behavioural brain research* **176**(1), 170–186.

Carter, Michael R and Travis J Lybbert (2012). Consumption versus asset smoothing: testing the implications of poverty trap theory in burkina faso. *Journal of Development Economics* **99**(2), 255–264.

Cash, Kevin and Roger Evans (1986). Brood reduction in the American white pelican (Pelecanus erythrohynchos). *Behavioral Ecology and Sociobiology* **18**, 413 – 418.

Cassar, Alessandra, Andrew Healy and Carl von Kessler (2011). Trust, Risk and Time Preferences after a Natural Disaster: Experimental Evidence from Thailand.

Castillo, Marco and Michael Carter (2011). Behavioral responses to natural disasters. *Unpublished Manuscript*.

Cederman, Lars-Erik, Nils B Weidmann and Kristian Skrede Gleditsch (2011). Horizontal inequalities and ethnonationalist civil war: A global comparison. *American Political Science Review* **105**(03), 478–495.

Cesarini, David, Christopher T Dawes, James H Fowler, Magnus Johannesson, Paul Lichtenstein and Björn Wallace (2008). Heritability of cooperative behavior in the trust game. *Proceedings of the National Academy of sciences* **105**(10), 3721–3726.

Chaisson, Eric J (2002). *Cosmic evolution: the rise of complexity in nature*. Harvard University Press.

Chancel, Lucas and Thomas Piketty (2015). Carbon and inequality: from kyoto to paris. *Paris School of Economics*.

Chapais, Bernard (2009). *Primeval kinship: How pair-bonding gave birth to human society*. Harvard University Press.

Cheng, Joey T, Jessica L Tracy, Tom Foulsham, Alan Kingstone and Joseph Henrich (2013). Two ways to the top: Evidence that dominance and prestige are distinct yet viable avenues to social rank and influence.. *Journal of Personality and Social Psychology* **104**(1), 103.

Chirikure, Shadreck and Innocent Pikirayi (2008). Inside and outside the dry stone walls: Revisiting the material culture of great zimbabwe. *Antiquity* **82**(318), 976–993.

Claessen, Henri JM (1987). Kings, chiefs and officials: The political organization of dahomey and buganda compared. *The Journal of Legal Pluralism and Unofficial Law* **19**(25-26), 203–241.

Coleman, James S and James Samuel Coleman (1994). *Foundations of social theory*. Harvard university press.

Coltrain, Joan Brenner and Steven W Leavitt (2002). Climate and diet in fremont prehistory: economic variability and abandonment of maize agriculture in the great salt lake basin. *American Antiquity* pp. 453–485.

Comola, Margherita (2008). The network structure of informal arrangements: evidence from rural tanzania. *Paris: Paris School of Economics*.

Conradt, Larissa and Christian List (2009). Group decisions in humans and animals: a survey. *Philosophical Transactions of the Royal Society of London B: Biological Sciences* **364**(1518), 719–742.

Cosmides, Leda (1989). The logic of social exchange: Has natural selection shaped how humans reason? studies with the wason selection task. *Cognition* **31**(3), 187–276.

Cosmides, Leda and John Tooby (1992). Cognitive adaptations for social exchange. *The adapted mind* pp. 163–228.

Couttenier, Mathieu and Raphael Soubeyran (2014). Drought and civil war in sub-saharan africa*. *The Economic Journal* **124**(575), 201–244.

Crofoot, Margaret C and Richard W Wrangham (2010). Intergroup aggression in primates and humans: the case for a unified theory. In: *Mind the gap*. pp. 171–195. Springer.

Cullen, Heidi M, S Hemming, G Hemming, FH Brown, T Guilderson, F Sirocko et al. (2000). Climate change and the collapse of the akkadian empire: Evidence from the deep sea. *Geology* **28**(4), 379–382.

Damasio, Antonio (2008). Descartes' error: Emotion, reason and the human brain.

DARA and the Climate Vulnerable Forum (2012). Climate vulnerability monitor 2nd edition. a guide to the cold calculus of a hot planet. http://daraint.org/wp-content/uploads/2012/10/CVM2-Low.pdf. Accessed 2016-04-25.

Darwin, C (1871). The decent of man and selection in relation to sex [electronic version]. *New York: D. Appleton and Company*.

Darwin, Charles (1872). The expression of the emotions in man and animals. *London, UK: John Marry*.

Dawes, Christopher and al. (2012). Neural basis of egalitarian behavior. *Proc. Natl. Acad. Sci. USA*.

De Châtel, Francesca (2014). The role of drought and climate change in the syrian uprising: Untangling the triggers of the revolution. *Middle Eastern Studies* **50**(4), 521–535.

De Cremer, David (2000). Leadership selection in social dilemmasŮnot all prefer it: The moderating effect of social value orientation.. *Group Dynamics: Theory, Research, and Practice* **4**(4), 330.

De Dreu, Carsten KW, Lindred L Greer, Michel JJ Handgraaf, Shaul Shalvi, Gerben A Van Kleef, Matthijs Baas, Femke S Ten Velden, Eric Van Dijk and Sander WW Feith (2010). The neuropeptide oxytocin regulates parochial altruism in intergroup conflict among humans. *Science* **328**(5984), 1408–1411.

De Quervain Dominique, Urs Fischbacher, Valerie Treyer Melanie Schellhammer Ulrich Schnyder Alfred Buck and Ernst Fehr (2004). The neural basis of altruistic punishment. *Science*.

De Waal, Frans (2007). *Chimpanzee politics: Power and sex among apes*. JHU Press.

Dean, Jeffrey S, George J Gumerman, Joshua M Epstein, Robert L Axtell, Alan C Swedlund, Miles T Parker and Stephen McCarroll (2000). Understanding anasazi culture change through agent-based modeling. *Dynamics in human and primate societies: Agent-based modeling of social and spatial processes* pp. 179–205.

Dell, Melissa, Benjamin F Jones and Benjamin A Olken (2008). Climate shocks and economic growth: Evidence from the last half century. *Nber working paper*.

Deutsch, Morton (1960). The effect of motivational orientation upon trust and suspicion.. *Human relations*.

Deutsch, Morton (1962). Cooperation and trust: Some theoretical notes.

Diamond, Jared (2005). *Collapse: How societies choose to fail or succeed*. Penguin.

Dirks, Kurt T and Donald L Ferrin (2002). Trust in leadership: meta-analytic findings and implications for research and practice.. *Journal of applied psychology* **87**(4), 611.

Dow, Gregory K and Clyde G Reed (2013). The origins of inequality: Insiders, outsiders, elites, and commoners. *Journal of Political Economy* **121**(3), 609–641.

Dreber, Anna, Coren L Apicella, Dan TA Eisenberg, Justin R Garcia, Richard S Zamore, J Koji Lum and Benjamin Campbell (2009). The 7r polymorphism in the dopamine receptor d 4 gene (drd4) is associated with financial risk taking in men. *Evolution and Human Behavior* **30**(2), 85–92.

Driessen, M., J. Herrmann K. Stahl M. Zwaan S. Meier A. Hill M. Osterheider and D. Petersen (2000). Magnetic resonance imaging volumes of the hippocampus and the amygdala in women with borderline personality disorder and early traumatization. *Arch Gen Psychiatry* pp. 1115 – 1122.

Druckman, Angela, Pete Bradley, Eleni Papathanasopoulou and Tim Jackson (2008). Measuring progress towards carbon reduction in the uk. *Ecological Economics* **66**(4), 594–604.

Duff, Andrew I, K Adams and S Ryan (2010). The impact of long-term residential occupation of community centers on local plant and animal resources. *Leaving Mesa Verde: Peril and Change in the Thirteenth Century Southwest, The Amerind Foundation and University of Arizona Press, Tucson, Arizona* pp. 156–179.

Dunbar, Robin (1998). *Grooming, Gossip and the Evolution of Language*. Faber & Faber.

Dunbar, Robin IM (1993). Coevolution of neocortical size, group size and language in humans. *Behavioral and brain sciences* **16**(04), 681–694.

Dunlap, Riley E and Aaron M McCright (2011). Organized climate change denial. *The Oxford handbook of climate change and society* pp. 144–160.

Dunning, Thad (2004). Conditioning the effects of aid: Cold war politics, donor credibility, and democracy in africa. *International Organization* **58**(02), 409–423.

Durkheim, Emile (1915). The elementary forms of the religious life. *New York*.

Durkheim, Emile (2010). *Les règles de la méthode sociologique*. Editions Flammarion.

Durkheim, Emile (2014). *The rules of sociological method: and selected texts on sociology and its method*. Simon and Schuster.

Dvash, J., G. Gilam H. Ben-Ze'ev and S. Shamay-Tsoory (2010). The envious brain: The neural basis of social comparison. *Human Brain Mapping* **31**(11), 1741 – 1750.

Eckel, Catherine, Mahmoud El-Gamal and Rick Wilson (2009). Risk loving after the storm: A bayesian-network study of hurricane katrina evacuees. *Journal of Economic Behavior & Organization* **69**(2), 110–124.

Edgerton, Robert B (1992). *Sick societies*. Simon and Schuster.

Ehret, Christopher (1998). *An African classical age: eastern and southern Africa in world history, 1000 BC to AD 400*. Rutgers University Press.

Eisenberger, Naomi and Matthew Lieberman (2004). Why rejection hurts: a common neural alarm system for physical and social pain. *Trends in cognitive sciences* **8**(7), 294–300.

Ekman, Paul, Wallace V Friesen, Maureen O'Sullivan, Anthony Chan, Irene Diacoyanni-Tarlatzis, Karl Heider, Rainer Krause, William Ayhan LeCompte, Tom Pitcairn, Pio E Ricci-Bitti et al. (1987). Universals and cultural differences in the judgments of facial expressions of emotion.. *Journal of personality and social psychology* **53**(4), 712.

Ellison, Peter Thorpe and Peter B Gray (2009). *Endocrinology of social relationships*. Harvard University Press.

Ember, Carol R and Melvin Ember (1992). Resource unpredictability, mistrust, and war a cross-cultural study. *Journal of Conflict Resolution* **36**(2), 242–262.

Ezra, Markos and Gebre-Egziabher Kiros (2001). Rural out-migration in the drought prone areas of ethiopia: a multilevel analysis. *International Migration Review* pp. 749–771.

Fafchamps, Marcel and Flore Gubert (2007). The formation of risk sharing networks. *Journal of development Economics* **83**(2), 326–350.

Fafchamps, Marcel, Christopher Udry and Katherine Czukas (1998). Drought and saving in west africa: are livestock a buffer stock?. *Journal of Development economics* **55**(2), 273–305.

Fehr, Ernst (2009). On the economics and biology of trust. *Journal of the European Economic Association* **7**(2-3), 235–266.

Fehr, Ernst and Klaus M Schmidt (1999). A theory of fairness, competition, and cooperation. *Quarterly journal of Economics* pp. 817–868.

Fehr, Ernst and Simon Gächter (2000). Cooperation and punishment in public goods experiments. *The American Economic Review* **90**(4), pp. 980–994.

Fehr, Ernst, Daniela Glätzle-Rützler and Matthias Sutter (2013). The development of egalitarianism, altruism, spite and parochialism in childhood and adolescence. *European Economic Review* **64**, 369–383.

Fehr, Ernst, Helen Bernhard and Bettina Rockenbach (2008). Egalitarianism in young children. *Nature* **454**(7208), 1079–1083.

Fehr, Ernst, Karla Hoff and Mayuresh Kshetramade (2008). Spite and development. *The American Economic Review* pp. 494–499.

Feldman, Stanley (2003). Enforcing social conformity: A theory of authoritarianism. *Political psychology* **24**(1), 41–74.

Fenichel, Eli P, Simon A Levin, Bonnie McCay, Kevin St Martin, Joshua K Abbott and Malin L Pinsky (2016). Wealth reallocation and sustainability under climate change. *Nature Climate Change* **6**(3), 237–244.

Findley, Sally E (1994). Does drought increase migration? a study of migration from rural mali during the 1983-1985 drought. *International Migration Review* pp. 539–553.

FitzGerald, Gerard J (1992). Egg cannibalism by sticklebacks: spite or selfishness?. *Behavioral Ecology and Sociobiology* **30**(3-4), 201–206.

Flack, Jessica C, Frans BM de Waal and David C Krakauer (2005). Social structure, robustness, and policing cost in a cognitively sophisticated species. *The American Naturalist* **165**(5), E126–E139.

Flannery, K. (2012). *The creation of inequality: How our prehistoric ancestors set the stage for monarchy, slavery, and empire*.

Fliessbach, Klaus, Bernd Weber-Peter Trautner-Thomas Dohmen Uwe Sunde Christian Elger and Armin Falk (2007). Social comparison affects reward-related brain activity in the human ventral striatum. *Science* **318**(5854), 1305–1308.

Fliessbach, Klaus, Courtney B Phillipps Peter Trautner Marieke Schnabel Christian Elger Armin Falk and Bernd Weber (2012). Neural responses to advantageous and disadvantageous inequity. *Frontiers in human neuroscience*.

Forber, Patrick and Rory Smead (2014). The evolution of fairness through spite. *Proceedings of the Royal Society B: Biological Sciences* **281**(1780), 20132439.

Foster, Andrew D and Mark R Rosenzweig (2001). Imperfect commitment, altruism, and the family: Evidence from transfer behavior in low-income rural areas. *Review of Economics and Statistics* **83**(3), 389–407.

Foucault, Michel (1970). *The order of things: An archaeology of the human sciences*. Psychology Press.

Foucault, Michel (1977). *Discipline and punish: The birth of the prison*. Vintage.

Franzen, Axel and Sonja Pointner (2013). The external validity of giving in the dictator game. *Experimental Economics* **16**(2), 155–169.

Friedmann, Harriet (1982). The political economy of food: The rise and fall of the postwar international food order. *American Journal of Sociology* pp. 248–286.

Garcia-Montalvo, Jose and Marta Reynal-Querol (2004). Ethnic polarization, potential conflict, and civil wars. *Potential Conflict, and Civil Wars (July 2004)*.

Gardner, Andy and Stuart West (2004). Spite and the scale of competition. *Journal of Evolutionary Biology* **17**(6), 11195 – 11203.

Gardner, Andy, Ian CW Hardy Peter D Taylor and Stuart A West (2007). Spiteful soldiers and sex ratio conflict in polyembryonic parasitoid wasps. *The American Naturalist* **169**(4), 519–533.

Gavrilets, Sergey and Laura Fortunato (2014). A solution to the collective action problem in between-group conflict with within-group inequality. *Nature communications*.

Geraci, Alessandra and Luca Surian (2011). The developmental roots of fairness: Infants' reactions to equal and unequal distributions of resources. *Developmental Science* **14**(5), 1012 – 1020.

Gerritsen, Lotte, Indira Tendolkar Barbara Franke Alejandro Vasquez Sabine Kooijman Jan Buitelaar Guillén Fernández and Mark Rijpkema (2012). Bdnf val66met genotype modulates the effect of childhood adversity on subgenual anterior cingulate cortex volume in healthy subjects. *Molecular psychiatry* **17**(6), 597–603.

Goldman, Steven L (2006). *Science wars: what scientists know and how they know it*. Teaching Company.

Goldstone, Jack A (1991). *Revolution and rebellion in the early modern world*. Univ of California Press.

Gore, Timothy (2015). Extreme carbon inequality: Why the paris climate deal must put the poorest, lowest emitting and most vulnerable people first.

Gospic, Katarina, Erik Mohlin Peter Fransson Predag Petrovic Magnus Johannesson and Martin Ingvar (2011). Limbic justice - amygdala involvement in immediate rejection in the ultimatum game. *PLoS biology* **9**(5), e1001054.

Gray, Clark and Valerie Mueller (2012). Drought and population mobility in rural ethiopia. *World Development* **40**(1), 134–145.

Greene, Joshua (2014). *Moral tribes: emotion, reason and the gap between us and them*. Atlantic Books Ltd.

Gurr, Ted Robert (1970). *Why men rebel*. Routledge.

Guyer, A, C. Monk E. McClure-Tone E. Nelson R. Roberson-Nay, A. Adler et al. (2008). A developmental examination of amygdala response to facial expressions. *Journal of Cognitive Neuroscience* **20**(9), 1565 – 1582.

Hager, Kirsten, Bastian Oud and Daniel Schunk (2012). Egalitarian envy. *Jena Economic Research papers*.

Haggblade, Steven (2007). Alternative perceptions of the rural non farm economy. *Transforming the Rural Nonfarm Economy: opportunities and threats in the developing world* pp. 262–319.

Haidt, Jonathan (2001). The emotional dog and its rational tail: a social intuitionist approach to moral judgment.. *Psychological review* **108**(4), 814.

Haidt, Jonathan (2012). *The righteous mind: Why good people are divided by politics and religion*. Vintage.

Håkansson, N Thomas (1998). Rulers and rainmakers in precolonial south pare, tanzania: exchange and ritual experts in political centralization. *Ethnology* pp. 263–283.

Hakansson, Thomas (1989). Social and political aspects of intensive agriculture in east africa: Some models from cultural anthropology. *AZANIA: Journal of the British Institute in Eastern Africa* **24**(1), 12–20.

Hamilton, William D. (1970). Selfish and Spiteful Behavior in an Evolutionary Model. *Nature* **228**, 1218 – 1220.

Harari, Mariaflavia and Eliana La Ferrara (2013). Conflict, climate and cells: A disaggregated analysis.

Hatemi, Peter (2013). The Influence of Major Life Events on Economic Attitudes in a World of Gene Environment Interplay. *American journal of political science* **57**(4), 987 – 1007.

Hatemi, Peter K, Nathan A Gillespie, Lindon J Eaves, Brion S Maher, Bradley T Webb, Andrew C Heath, Sarah E Medland, David C Smyth, Harry N Beeby, Scott D Gordon et al. (2011). A genome-wide analysis of liberal and conservative political attitudes. *The Journal of Politics* **73**(01), 271–285.

Haug, Gerald H, Detlef Günther, Larry C Peterson, Daniel M Sigman, Konrad A Hughen and Beat Aeschlimann (2003). Climate and the collapse of maya civilization. *Science* **299**(5613), 1731–1735.

Heede, Richard (2014). Tracing anthropogenic carbon dioxide and methane emissions to fossil fuel and cement producers, 1854–2010. *Climatic Change* **122**(1-2), 229–241.

Henrich, J., Boyd R. Bowles S.-Camerer C. Fehr E. Gintis-H. and R. McElreath (2001). In search of homo economicus: Behavioral experiments in 15 small-scale societies. *American Economic Review, Papers and Proceedings* **91**(2), 73–78.

Henrich, Joseph (2009). The evolution of costly displays, cooperation and religion: Credibility enhancing displays and their implications for cultural evolution. *Evolution and Human Behavior* **30**(4), 244–260.

Henrich, Joseph and Natalie Henrich (2007). *Why humans cooperate: A cultural and evolutionary explanation*. Oxford University Press.

Henrich, Joseph and Richard McElreath (2003). The evolution of cultural evolution. *Evolutionary Anthropology: Issues, News, and Reviews* **12**(3), 123–135.

Henrich, Joseph and Robert Boyd (2008). Division of labor, economic specialization, and the evolution of social stratification. *Current Anthropology* **49**(4), 715–724.

Henrich, Joseph, Jean Ensminger, Richard McElreath, Abigail Barr, Clark Barrett, Alexander Bolyanatz, Juan Camilo Cardenas, Michael Gurven, Edwins Gwako, Natalie Henrich et al. (2010*a*). Markets, religion, community size, and the evolution of fairness and punishment. *science* **327**(5972), 1480–1484.

Henrich Joseph, Robert Boyd, Samuel Bowles-Colin Camerer Ernst Fehr Herbert Gintis and Richard McElreath (2001). In search of homo economicus: Behavioral experiments in 15 small-scale societies. *American Economic Review, Papers and Proceedings* **91**(2), 73–78.

Henrich, Joseph, Steven J Heine and Ara Norenzayan (2010*b*). Most people are not weird. *Nature* **466**(7302), 29–29.

Heyes, Cecilia (2012). New thinking: the evolution of human cognition. *Philosophical Transactions of the Royal Society of London B: Biological Sciences* **367**(1599), 2091–2096.

Hill, Kim R, Robert S Walker, Miran Božičević, James Eder, Thomas Headland, Barry Hewlett, A Magdalena Hurtado, Frank Marlowe, Polly Wiessner and Brian Wood (2011). Co-residence patterns in hunter-gatherer societies show unique human social structure. *Science* **331**(6022), 1286–1289.

Hill, Sarah and David Buss (2008). The evolutionary psychology of envy. *Science* pp. 60 – 70.

Hobsbawm, Eric J (1992). *Nations and nationalism since 1780: Programme, myth, reality*. Cambridge University Press.

Hoffman, Elizabeth and Matthew L Spitzer (1985). Entitlements, rights, and fairness: An experimental examination of subjects' concepts of distributive justice. *The Journal of Legal Studies* pp. 259–297.

Hooper, Paul L, Hillard S Kaplan and James L Boone (2010). A theory of leadership in human cooperative groups. *Journal of Theoretical Biology* **265**(4), 633–646.

Hsiang, Solomon M and Marshall Burke (2014). Climate, conflict, and social stability: what does the evidence say?. *Climatic Change* **123**(1), 39–55.

Hsiang, Solomon M, Kyle C Meng and Mark A Cane (2011). Civil conflicts are associated with the global climate. *Nature* **476**(7361), 438–441.

Huffman, Thomas N (1986). Iron age settlement patterns and the origins of class distinction in southern africa. *Advances in world archaeology* **5**(986), 291–338.

Huffman, Thomas N (2000). Mapungubwe and the origins of the zimbabwe culture. *Goodwin Series* pp. 14–29.

Huffman, Thomas N (2009). Mapungubwe and great zimbabwe: The origin and spread of social complexity in southern africa. *Journal of Anthropological Archaeology* **28**(1), 37–54.

Israel, Salomon, Elad Lerer, Idan Shalev, Florina Uzefovsky, Mathias Riebold, Efrat Laiba, Rachel Bachner-Melman, Anat Maril, Gary Bornstein, Ariel Knafo et al. (2009). The oxytocin receptor (oxtr) contributes to prosocial fund allocations in the dictator game and the social value orientations task. *PloS one* **4**(5), e5535.

Jablonka, Eva, Marion J Lamb and Anna Zeligowski (2014). *Evolution in Four Dimensions, revised edition: Genetic, Epigenetic, Behavioral, and Symbolic Variation in the History of Life*. MIT press.

Jensen, Keith, Josep Call and Michael Tomasello (2007). Chimpanzees are vengeful but not spiteful. *Proceedings of the National Academy of Sciences* **104**(32), 13046–13050.

Johnson, Allen W (2000). *The evolution of human societies: from foraging group to agrarian state*. Stanford University Press.

Johnson, Ryan T and S Marc Breedlove (2010). Human trust: Testosterone raises suspicion. *Proceedings of the National Academy of Sciences* **107**(25), 11149–11150.

Joseph, Jane, Caitlin Powell Nathan Johnson and Gayannée Kedia (2009). *The Functional Neuroanatomy of Envy*.

Joseph, Jane E, Xun Liu, Yang Jiang, Donald Lynam and Thomas H Kelly (2009). Neural correlates of emotional reactivity in sensation seeking. *Psychological Science* **20**(2), 215–223.

Joung, Shoou-Jeng and Hua-Hsun Hsu (2005). Reproduction and embryonic development of the shortfin mako, isurus oxyrinchus rafinesque, 1810, in the northwestern pacific. *ZOOLOGICAL STUDIES-TAIPEI-* **44**(4), 487.

Jülich, Sebastian (2011). Drought triggered temporary migration in an east indian village. *International Migration* **49**(s1), e189–e199.

Kadigi, Reuben MJ, NSY Mdoe and GC Ashimogo (2007). Collective arrangements and social networks: Coping strategies for the poor households in the great ruaha catchment in tanzania. *Physics and Chemistry of the Earth, Parts A/B/C* **32**(15), 1315–1321.

Kahneman, Daniel (2011). *Thinking, fast and slow*. Macmillan.

Kahneman, Daniel and Amos Tversky (1979). Prospect theory: An analysis of risk. *Econometrica* **47**(2), 263 – 291.

Kameda, Tatsuya, Masanori Takezawa, R Scott Tindale and Christine M Smith (2002). Social sharing and risk reduction: Exploring a computational algorithm for the psychology of windfall gains. *Evolution and Human Behavior* **23**(1), 11–33.

Kameda, Tatsuya, Masanori Takezawa, Yohsuke Ohtsubo, Reid Hastie, Keigo Inukai, Nobuye Ishibashi, Megumi Iwabuchi et al. (2010*a*). Are our minds fundamentally egalitarian? adaptive bases of different sociocultural models about distributive justice. *Evolution, culture, and the human mind* pp. 151–163.

Kameda, Tatsuya, Masanori Takezawa Yohsuke Ohtsubo-Reid Hastie Keigo Inukai Nobuye Ishibashi Nobuye, Megumi Iwabuchi et al. (2010*b*). *Are our minds fundamentally egalitarian? Adaptive bases of different sociocultural models about distributive justice*. pp. 151–163.

Kaplan, Hillard, Kim Hill, Jane Lancaster and A Magdalena Hurtado (2000). A theory of human life history evolution: diet, intelligence, and longevity. *Evolutionary Anthropology Issues News and Reviews* **9**(4), 156–185.

Kaplan, Hillard, Michael Gurven, Kim Hill and A Magdalena Hurtado (2005). The natural history of human food sharing and cooperation: a review and a new multi-individual approach to the negotiation of norms. *Moral sentiments and material interests: The foundations of cooperation in economic life* pp. 75–113.

Kaplan, Hillard, Michael Gurven Kim Hill and Magdalena Hurtado (2005). *The natural history of human food sharing and cooperation: a review and a new multi-individual approach to the negotiation of norms*. pp. 75–113. Cambridge: MIT Press.

Kazianga, Harounan and Christopher Udry (2006). Consumption smoothing? livestock, insurance and drought in rural burkina faso. *Journal of Development Economics* **79**(2), 413–446.

Keller, Edmond J (1992). Drought, war, and the politics of famine in ethiopia and eritrea. *The Journal of Modern African Studies* **30**(04), 609–624.

Kelley, Colin P, Shahrzad Mohtadi, Mark A Cane, Richard Seager and Yochanan Kushnir (2015). Climate change in the fertile crescent and implications of the recent syrian drought. *Proceedings of the National Academy of Sciences* **112**(11), 3241–3246.

Kelly, Robert L (2013). *The lifeways of hunter-gatherers: The foraging spectrum*. Cambridge University Press.

Keltner, Dacher, Deborah H Gruenfeld and Cameron Anderson (2003). Power, approach, and inhibition.. *Psychological review* **110**(2), 265.

Kendal, Jeremy, Jamshid J Tehrani and John Odling-Smee (2011). Human niche construction in interdisciplinary focus. *Philosophical Transactions of the Royal Society of London B: Biological Sciences* **366**(1566), 785–792.

Kim, Nam C and Chapurukha M Kusimba (2008). Pathways to social complexity and state formation in the southern zambezian region. *African Archaeological Review* **25**(3-4), 131–152.

King, Andrew J, Dominic DP Johnson and Mark Van Vugt (2009). The origins and evolution of leadership. *Current biology* **19**(19), R911–R916.

Knutson, Kristine M, Jacqueline N Wood, Maria V Spampinato and Jordan Grafman (2006). Politics on the brain: An fmri investigation. *Social Neuroscience,* **1**(1), 25–40.

Kosfeld, Michael, Markus Heinrichs, Paul J Zak, Urs Fischbacher and Ernst Fehr (2005). Oxytocin increases trust in humans. *Nature* **435**(7042), 673–676.

Lagi, Marco, Karla Z Bertrand and Yaneer Bar-Yam (2011). The food crises and political instability in north africa and the middle east. *Available at SSRN 1910031*.

Laland, Kevin N, John Odling-Smee and Marcus W Feldman (2001). Cultural niche construction and human evolution. *Journal of Evolutionary Biology* **14**(1), 22–33.

Laland, Kevin N, Kim Sterelny, John Odling-Smee, William Hoppitt and Tobias Uller (2011). Cause and effect in biology revisited: is mayrŠs proximate-ultimate dichotomy still useful?. *science* **334**(6062), 1512–1516.

Lallement, Julen Hernandez, Katarina Kuss Peter Trautner Bernd Weber Armin Falk and Klaus Fliessbach (2014). Effort increases sensitivity to reward and loss magnitude in the human brain. *Scan* **9**, 342 – 349.

LeBlanc, Steven A (1999). *Prehistoric warfare in the American Southwest*. University of Utah Press.

LeDoux, Joseph (1998). *The emotional brain: The mysterious underpinnings of emotional life*. Simon and Schuster.

Lehmann, Laurent, Marcus Feldman and François Rousset (2009). On the evolution of harming and recognition in finite panmictic and infinite structured populations. *Evolution* **63**(11), 2896–2913.

Lekson, Stephen H (2009). *A history of the ancient Southwest*. School for Advanced Research Press Santa Fe, NM.

Lenzen, Manfred, Mette Wier, Claude Cohen, Hitoshi Hayami, Shonali Pachauri and Roberto Schaeffer (2006). A comparative multivariate analysis of household energy requirements in australia, brazil, denmark, india and japan. *Energy* **31**(2), 181–207.

Lévi-Strauss, Claude (1969). *The elementary structures of kinship*. number 340. Beacon Press.

Levitt, Steven D and John A List (2007). What do laboratory experiments measuring social preferences reveal about the real world?. *The journal of economic perspectives* **21**(2), 153–174.

Lewontin, Richard (1991). *Biology as ideology: The doctrine of DNA*. House of Anansi.

Liao, Chuan, Christopher Barrett and Karim-Aly Kassam (2015). Does diversification improve livelihoods? pastoral households in xinjiang, china. *Development and Change* **46**(6), 1302–1330.

Libersat, Frederic, Antonia Delago and Ram Gal (2009). Manipulation of host behavior by parasitic insects and insect parasites. *Annual review of entomology* **54**, 189–207.

Lieberman, Matthew D (2013). *Social: Why our brains are wired to connect*. OUP Oxford.

Lipset, Seymour Martin (1959). Democracy and working-class authoritarianism. *American Sociological Review* pp. 482–501.

List, John A (2007). On the interpretation of giving in dictator games. *Journal of Political Economy* **115**(3), 482–493.

LoBue, Vanessa, Tracy Nishida Cynthia Chiong Judy DeLoache and Jonathan Haidt (2011). When getting something good is bad: Even three-year-olds react to inequality. *Social Development* **20**(1), 154–170.

Loewenstein, George, Leigh Thompson and Max Bazerman (1989). Social utility and decision making in interpersonal contexts. *Journal of Personality and Social psychology* **57**(3), 426.

Lupien, Sonia, Bruce McEwen Megan Gunnar and Christine Heim (2009). Effects of stress throughout the lifespan on the brain, behaviour and cognition. *Nature Reviews Neuroscience* **10**(6), 434 – 445.

Maaskant, Cornelis (2015). Risk Sharing within Geographically Spread Extended Families: Evidence from rural Tanzania. PhD thesis. University of Oxford.

MacWilliams, Matthew (2016). The one weird trait that predicts whether youŠre a trump supporter. http://www.politico.com/magazine/story/2016/01/donald-trump-2016-authoritarian-213533. Accessed 2016-04-27.

Marcoul, P., M. Luckert, S. Mohapatra and Zigah G. (2016). Blood is thicker than water': Economic implications of food gifting within kinship networks. *Unpublished Manuscript*.

Markus, Hazel R and Shinobu Kitayama (1991). Culture and the self: Implications for cognition, emotion, and motivation.. *Psychological review* **98**(2), 224.

Marlowe, Frank, Colette Berbesque Clark Barrett Alexander Bolyanatz Michael Gurven and David Tracer (2010). The ŚspitefulŠorigins of human cooperation. *Proceedings of the Royal Society B: Biological Sciences* p. rspb20102342.

Marx, K. (1976/1867). *Capital Volume I*. Penguin Classics. London.

Masawe, Joseph L (1992). Farming system and agricultural production among small farmers in the uluguru mountain area, morogoro region, tanzania.

Masclet, David, Charles Noussair Steven Tucker and Marie-Claire Villeval (2003). Monetary and nonmonetary punishment in the voluntary contributions mechanism. *American Economic Review* pp. 366–380.

Massey, Douglas S, Andrew B Gross and Kumiko Shibuya (1994). Migration, segregation, and the geographic concentration of poverty. *American Sociological Review* pp. 425–445.

Mauss, Marcel (1950). *The gift: The form and reason for exchange in primitive societies*. New York: Norton.

May, Robert M et al. (1976). Simple mathematical models with very complicated dynamics. *Nature* **261**(5560), 459–467.

Maynard-Smith, J and GR Price (1973). lhe logic of animal conflict. *Nature* **246**, 15.

Maynard-Smith, John (1982). *Evolution and the Theory of Games*. Cambridge university press.

Maynard-Smith, John and Eors Szathmary (1997). *The major transitions in evolution*. Oxford University Press.

Mayr, Ernst (1993). Proximate and ultimate causations. *Biology and Philosophy* **8**(1), 93–94.

McCormick, Michael, Ulf Büntgen, Mark A Cane, Edward R Cook, Kyle Harper, Peter Huybers, Thomas Litt, Sturt W Manning, Paul Andrew Mayewski, Alexander FM More et al. (2012). Climate change during and after the roman empire: Reconstructing the past from scientific and historical evidence. *Journal of Interdisciplinary History* **43**(2), 169–220.

McCright, Aaron M and Riley E Dunlap (2003). Defeating kyoto: The conservative movement's impact on us climate change policy. *Social Problems* **50**(3), 348–373.

McLeman, Robert and Barry Smit (2006). Migration as an adaptation to climate change. *Climatic change* **76**(1-2), 31–53.

Meegan, Daniel V (2010). Zero-sum bias: perceived competition despite unlimited resources. *Frontiers in psychology*.

Merton, Robert K (1968). The matthew effect in science. *Science* **159**(3810), 56–63.

Meze-Hausken, Elisabeth (2000). Migration caused by climate change: how vulnerable are people inn dryland areas?. *Mitigation and Adaptation Strategies for Global Change* **5**(4), 379–406.

Miguel, E., S. Satyanath and E. Sergenti (2004). Economic shocks and civil conflict: An instrumental variables approach. *Journal of political Economy* pp. 725 – 753.

Miguel, Edward (2005). Poverty and witch killing. *The Review of Economic Studies* **72**(4), 1153–1172.

Miller, John H and Scott E Page (2009). *Complex adaptive systems: An introduction to computational models of social life*. Princeton university press.

Myers, Norman (2002). Environmental refugees: a growing phenomenon of the 21st century. *Philosophical Transactions of the Royal Society of London B: Biological Sciences* **357**(1420), 609–613.

Nagel, Thomas (1974). What is it like to be a bat?. *The philosophical review* **83**(4), 435–450.

Nawrotzki, Raphael J, Fernando Riosmena and Lori M Hunter (2013). Do rainfall deficits predict us-bound migration from rural mexico? evidence from the mexican census. *Population research and policy review* **32**(1), 129–158.

Ndichu, RW (2009). *The most devastating Famines in East Africa in the last 1700 years*. Nairobi: Sanctified Printers.

Nelson, Travis (2010). When disaster strikes: on the relationship between natural disaster and interstate conflict. *Global Change, Peace & Security* **22**(2), 155–174.

Nesee, R. (1994). Fear and fitness: An evolutionary analysis of anxiety disorders. *Ethology and Sociobiology* **15**(5), 247 – 261.

Norenzayan, Ara (2014). Does religion make people moral?. *Behaviour* **151**(2-3), 365–384.

Norenzayan, Ara and Azim F Shariff (2008). The origin and evolution of religious prosociality. *science* **322**(5898), 58–62.

Nowak, Martin A (2006). Five rules for the evolution of cooperation. *Science* **314**(5805), 1560–1563.

Nowak, Martin A and Karl Sigmund (2005). Evolution of indirect reciprocity. *Nature* **437**(7063), 1291–1298.

Odling-Smee, F John, Kevin N Laland and Marcus W Feldman (2003). *Niche construction: the neglected process in evolution*. number 37. Princeton University Press.

OECD (2015). The rationale for fighting corruption. Accessed 02/07/2016 from http://www.oecd.org/cleangovbiz/49693613.pdf.

O'Gorman, Rick, Joseph Henrich and Mark Van Vugt (2009). Constraining free riding in public goods games: designated solitary punishers can sustain human cooperation. *Proceedings of the Royal Society of London B: Biological Sciences* **276**(1655), 323–329.

Okasha, Samir (2006). *Evolution and the levels of selection*. Vol. 16.

Olson, Mancur (1971). *The logic of collective action*. Vol. 124. Harvard University Press.

Ostrom, Elinor and Roy Gardner (1993). Coping with asymmetries in the commons: self-governing irrigation systems can work. *The Journal of Economic Perspectives* **7**(4), 93–112.

Pacheco, Jorge M, Francisco C Santos, Max O Souza and Brian Skyrms (2009). Evolutionary dynamics of collective action in n-person stag hunt dilemmas. *Proceedings of the Royal Society of London B: Biological Sciences* **276**(1655), 315–321.

Pandey, Udai Bhan and Charles D Nichols (2011). Human disease models in drosophila melanogaster and the role of the fly in therapeutic drug discovery. *Pharmacological reviews* **63**(2), 411–436.

Parry, ML, OF Canziani, JP Palutikof, PJ Van der Linden and CE Hanson (2007). Contribution of working group ii to the fourth assessment report of the intergovernmental panel on climate change, 2007. *Climate Change 2007: Working Group II: Impacts, Adaptation and Vulnerability*.

Passamonti, L., J. Rowe M. Ewbank J. Keane and A. Calder (2008). Connectivity from the ventral anterior cingulate to the amygdala is modulated by appetitive motivation in response to facial signals. *Neuroimage* **43**, 562 – 570.

Pauketat, Timothy R (2004). *Ancient Cahokia and the Mississippians*. number 6. Cambridge University Press.

Payne, Christa, Christopher Machado Nancy Bliwise and Jocelyne Bachevalier (2010). Maturation of the hippocampal formation and amygdala in Macaca mulatta: A volumetric magnetic resonance imaging study. *Hippocampus* **20**(8), 922 – 935.

Peace, Janet and John Weyant (2008). Insights not numbers: the appropriate use of economic models. *White paper of Pew Center on Global Climate Change*.

Perreault, Charles (2012). The pace of cultural evolution. *PLoS One* **7**(9), e45150.

Petersen, Michael Bang, Daniel Sznycer, Aaron Sell, Leda Cosmides and John Tooby (2013). The ancestral logic of politics upper-body strength regulates menŠs assertion of self-interest over economic redistribution. *Psychological Science* **24**(7), 1098–1103.

Petersen, Michael, Daniel Sznycer Leda Cosmides and John Tooby (2012). Who Deserves Help? Evolutionary Psychology, Social Emotions, and Public Opinion about Welfare. *Political Psychology* **33**(3), 395 – 418.

Phelps, Elizabeth and Joseph LeDoux (2005). Contributions of the amygdala to emotion processing: from animal models to human behavior. *Neuron* **48**(2), 175–187.

Phillips, M. and al. (2007). A specific neural substrate for perceiving facial expressions of disgust. *Nature* **389**, 495 – 498.

Piketty, Thomas (2014). Capital in the 21st century. *Cambridge: Harvard Uni*.

Pinker, Steven (1999). How the mind works. *Annals of the New York Academy of Sciences* **882**(1), 119–127.

Pinker, Steven (2003). *The blank slate: The modern denial of human nature*. Penguin.

Pinker, Steven (2011). *The better angels of our nature: Why violence has declined*. Penguin.

Platteau, Jean-Philippe (2000). *Institutions, social norms, and economic development*. Vol. 1. Psychology Press.

Platteau, Jean-Philippe (2004). Monitoring elite capture in community-driven development. *Development and Change* **35**(2), 223–246.

Porter, Catherine (2012). Shocks, consumption and income diversification in rural ethiopia. *Journal of Development Studies* **48**(9), 1209–1222.

Powell, Caitlin, Richard Smith and David Schurtz (2008). Pleasure in an Envied Person's Pain.

Powers, Simon T and Laurent Lehmann (2014). An evolutionary model explaining the neolithic transition from egalitarianism to leadership and despotism. *Proceedings of the Royal Society of London B: Biological Sciences* **281**(1791), 20141349.

Pratto, Felicia, Jim Sidanius, Lisa M Stallworth and Bertram F Malle (1994). Social dominance orientation: A personality variable predicting social and political attitudes.. *Journal of personality and social psychology* **67**(4), 741.

Pray, Leslie and Kira Zhaurova (2008). Barbara mcclintock and the discovery of jumping genes (transposons). *Nature Education* **1**(1), 169.

Prediger, Sebastian, Björn Vollan and Benedikt Herrmann (2013). Resource scarcity, spite and cooperation. Technical report. Working Papers in Economics and Statistics.

Price, George R et al. (1970). Selection and covariance.. *Nature* **227**, 520–21.

Price, Sara and Sarah Brosnan (2012). To each according to his need? Variability in the responses to inequity in non-human primates. *Social Justice Research* **25**(2), 140 – 169.

Pynoos, R., A. Steinberg and J. Piacentini (1999). *Biological psychiatry* **46**(11), 1542 – 1554.

Rabin, Matthew (1993). Incorporating fairness into game theory and economics. *The American economic review* pp. 1281–1302.

Range, Friederike, lisa Horn Zsófia Viranyi and Ludwig Huber (2009). The absence of reward induces inequity aversion in dogs. *Proceedings of the National Academy of Sciences* **106**(1), 340–345.

Reader, Simon M and Kevin N Laland (2002). Social intelligence, innovation, and enhanced brain size in primates. *Proceedings of the National Academy of Sciences* **99**(7), 4436–4441.

Reardon, Thomas, Julio Berdegué, Christopher B Barrett and Kostas Stamoulis (2007). Household income diversification into rural nonfarm activities. *Transforming the rural nonfarm economy: opportunities and threats in the developing world* pp. 115–140.

Reuveny, Rafael (2007). Climate change-induced migration and violent conflict. *Political Geography* **26**(6), 656–673.

Richerson, Peter J and Robert Boyd (2000). Built for speed: Pleistocene climate variation and the origin of human culture. In: *Perspectives in ethology*. pp. 1–45. Springer.

Richerson, Peter J and Robert Boyd (2008). *Not by genes alone: How culture transformed human evolution*. University of Chicago Press.

Richerson, Peter J and Robert Boyd (n.d.). Climate, culture and the evolution of cognition.

Ridley, Matt (2004). The agile gene: How nature turns on nurture.

Riedl, René and Andrija Javor (2012). The biology of trust: Integrating evidence from genetics, endocrinology, and functional brain imaging.. *Journal of Neuroscience, Psychology, and Economics* **5**(2), 63.

Riley, Margaret and John E Wertz (2002). Bacteriocins: evolution, ecology, and application. *Annual Reviews in Microbiology* **56**(1), 117–137.

Rosenow, DT, JE Quisenberry, CW Wendt and LE Clark (1983). Drought tolerant sorghum and cotton germplasm. *Agricultural Water Management* **7**(1), 207–222.

Rotge, Jean-Yves and al. (2015). A meta-analysis of the anterior cingulate contribution to social pain. *Scan* **10**, 19 – 27.

Roth, Alvin, Vesna Prasnikar Masahiro Okuno-Fujiwara and Shmuel Zamir (1991). Bargaining and market behavior in jerusalem, ljubljana, pittsburgh, and tokyo: An experimental study. *The American Economic Review* pp. 1068–1095.

Różycka-Tran, Joanna, Paweł Boski and Bogdan Wojciszke (2015). Belief in a zero-sum game as a social axiom a 37-nation study. *Journal of Cross-Cultural Psychology* **46**(4), 525–548.

Russell, James M and Thomas C Johnson (2005*a*). A high-resolution geochemical record from lake edward, uganda congo and the timing and causes of tropical african drought during the late holocene. *Quaternary Science Reviews* **24**(12), 1375–1389.

Russell, James M and Thomas C Johnson (2005*b*). Late holocene climate change in the north atlantic and equatorial africa: Millennial-scale itcz migration. *Geophysical Research Letters*.

Ruve, CG and HAM Wilke (1984). Social dilemmas and leadership. *European Journal of Social Psychology* **14**(1), 105–121.

Salmon, Catherine A (1998). The evocative nature of kin terminology in political rhetoric. *Politics and the Life Sciences* pp. 51–57.

Samuelson, Charles D (1993). A multiattribute evaluation approach to structural change in resource dilemmas. *Organizational Behavior and Human Decision Processes* **55**(2), 298–324.

Samuelson, Charles D and David M Messick (1986*a*). Alternative structural solutions to resource dilemmas. *Organizational Behavior and Human Decision Processes* **37**(1), 139–155.

Samuelson, Charles D and David M Messick (1986*b*). Inequities in access to and use of shared resources in social dilemmas.. *Journal of Personality and Social Psychology* **51**(5), 960.

Sandford, S (1983). Management of pastoral development in the third world. *Public administration*.

Sandmo, Agnar (1971). On the theory of the competitive firm under price uncertainty. *The American Economic Review* **61**(1), 65–73.

Sanfey, Alan, James Rilling Jessica Aronson-Leigh Nystrom and Jonathan Cohen (2003). The Neural Basis of Economic Decision-Making in the Ultimatum Game. *Science* **300**(5626), 1755 – 1758.

Schoenbrun, David Lee (1998). *A green place, a good place: Agrarian change, gender, and social identity in the Great Lakes region to the 15th century*. JSTOR.

Schultz, Wolfram, Léon Tremblay and Jeffrey Hollerman (2000). Reward processing in primate orbitofrontal cortex and basal ganglia. *Cerebral Cortex* **10**(3), 272–283.

Seligman, Martin E (1970). On the generality of the laws of learning.. *Psychological review* **77**(5), 406.

Sell, Aaron, John Tooby and Leda Cosmides (2009). Formidability and the logic of human anger. *Proceedings of the National Academy of Sciences* **106**(35), 15073–15078.

Sen, Amartya (1981). *Poverty and famines: an essay on entitlement and deprivation*. Oxford University Press.

Shamay-Tsoory, Simone G, Dorin Ahronberg-Kirschenbaum and Nirit Bauminger-Zviely (2014). There is no joy like malicious joy: Schadenfreude in young children. *PloS one* **9**(7), e100233.

Shultz, Susanne, Christopher Opie and Quentin D Atkinson (2011). Stepwise evolution of stable sociality in primates. *Nature* **479**(7372), 219–222.

Sidanius, Jim and Felicia Pratto (2001). *Social dominance: An intergroup theory of social hierarchy and oppression*. Cambridge University Press.

Silk, Joan B (2007). Social components of fitness in primate groups. *Science* **317**(5843), 1347–1351.

Silk, Joan, Sarah Brosnan Jennifer Vonk-Joseph Henrich Daniel Povinelli Amanda Richardson Susan Lambeth Jenny Mascaro and Steven Schapiro (2005). Chimpanzees are indifferent to the welfare of unrelated group members. *Nature* **437**(7063), 1357 – 1359.

Simms, Steven R (2008). *Ancient peoples of the Great Basin and the Colorado Plateau*. Left Coast Pr.

Singer, Tania, Ben Seymour John O'Doherty-Klaas Stephan Raymond Dolan and Chris Frith (2006). Empathic Neural Responses are Modulated by the Perceived Fairness of Others. *Nature* **439**, 466–469.

Skoufias, Emmanuel, Mariano Rabassa and Sergio Olivieri (2011). The poverty impacts of climate change: a review of the evidence. *World Bank Policy Research Working Paper Series, Vol*.

Skyrms, Brian (2004). *The stag hunt and the evolution of social structure*. Cambridge University Press.

Smaldino, Paul E, Jeffrey C Schank and Richard McElreath (2013). Increased costs of cooperation help cooperators in the long run. *The American Naturalist* **181**(4), 451–463.

Smetana, J., N. Campione-barr and A. Metzger (2006). Adolescent development in interpersonal and societal contexts. *Annual Review of Psychology* **57**, 255 – 287.

Smith, Eric Alden, Monique Borgerhoff Mulder, Samuel Bowles, Michael Gurven, Tom Hertz and Mary K Shenk (2010). Production systems, inheritance, and inequality in premodern societies. *Current Anthropology* **51**(1), 85–94.

Smith, Jennifer E, Sergey Gavrilets, Monique Borgerhoff Mulder, Paul L Hooper, Claire El Mouden, Daniel Nettle, Christoph Hauert, Kim Hill, Susan Perry, Anne E Pusey et al. (2016). Leadership in mammalian societies: emergence, distribution, power, and payoff. *Trends in ecology & evolution* **31**(1), 54–66.

Smith, Kevin B, Christopher W Larimer, Levente Littvay and John R Hibbing (2007). Evolutionary theory and political leadership: Why certain people do not trust decision makers. *Journal of Politics* **69**(2), 285–299.

Sober, Elliott and David Sloan Wilson (1999). *Unto others: The evolution and psychology of unselfish behavior*. number 218. Harvard University Press.

Sokal, Alan and Jean Bricmont (1999). *Fashionable nonsense: Postmodern intellectuals' abuse of science*. Macmillan.

Spelke, Elizabeth S (1991). Physical knowledge in infancy: Reflections on piagetŠs theory. *The epigenesis of mind: Essays on biology and cognition* pp. 133–169.

Spreng, R Nathan and Cheryl L Grady (2010). Patterns of brain activity supporting autobiographical memory, prospection, and theory of mind, and their relationship to the default mode network. *Journal of cognitive neuroscience* **22**(6), 1112–1123.

Stark, Oded and David E Bloom (1985). The new economics of labor migration. *The american Economic review* **75**(2), 173–178.

Stark, Rodney and Roger Finke (2000). *Acts of faith: Explaining the human side of religion*. Univ of California Press.

Stearns, Stephen C (2007). Are we stalled part way through a major evolutionary transition from individual to group?. *Evolution* **61**(10), 2275–2280.

Steiner, Kurt G et al. (1982). Intercropping in tropical smallholder agriculture with special reference to west africa.. *Schriftenreihe der Deutsches Gesellschaft für Technische Zusammenarbeit*.

Stern, Nicholas (2007). *The economics of climate change: the Stern review*. cambridge University press.

Tacoli, Cecilia (2009). Crisis or adaptation? migration and climate change in a context of high mobility. *Environment and Urbanization* **21**(2), 513–525.

Takahashi, H., M. Kato-M. Matsuura-D. Mobbs S. Tetsuya and Y. Okubo (2009*a*). The envious brain: The neural basis of social comparison. *Science* **5916**(5916), 937 – 939.

Takahashi, Hidehiko, Motoichiro Kato-Masato Matsuura-Dean Mobbs Tetsuya Suhara and Yoshiro Okubo (2009*b*). When your gain is my pain and your pain is my gain: neural correlates of envy and schadenfreude. *Science* **323**(5916), 937–939.

Teicher, Martin, Carl Anderson-Kyoko Ohashi and Ann Polcari (2014). Childhood Maltreatment: Altered Network Centrality of Cingulate, Precuneus, Temporal Pole and Insula. *Biological Psychiatry* **75**(4), 297 – 305.

Tomasello, Michael (2009). *The cultural origins of human cognition*. Harvard University Press.

Tomasello, Michael (2014). *A natural history of human thinking*. Harvard University Press.

Tooby, John and Leda Cosmides (2008). The evolutionary psychology of the emotions and their relationship to internal regulatory variables.

Tottenham, Nim and Margaret Sheridan (2009). A Review of Adversity, The Amygdala and the Hippocampus: A Consideration of Developmental Timing. *Frontiers in human neurosciences*.

Townsend, Robert M (1994). Risk and insurance in village india. *Econometrica: Journal of the Econometric Society* pp. 539–591.

Trigger, Bruce G (2003). *Understanding early civilizations: A comparative study*. Cambridge University Press.

Trivers, Robert L (1971). The evolution of reciprocal altruism. *Quarterly review of biology* pp. 35–57.

Tschannen-Moran, Megan (2014). *Trust matters: Leadership for successful schools*. John Wiley & Sons.

Turchin, Peter (2003). *Historical dynamics: why states rise and fall*. Vol. 41. Princeton University Press Princeton, NJ.

Turchin, Peter (2005). *War and peace and war: the life cycles of imperial nations*. Pi.

Turchin, Peter (2009). A theory for formation of large empires.. *Journal of Global History* **4**(02), 191–217.

Turchin, Peter and Sergey A Nefedov (2009). *Secular cycles*. Princeton University Press.

UNISDR (2015). The human cost of weather-related disasters 1995-2015. www.unisdr.org/WeatherDisastersReport2015FINAL.pdf. Accessed 2016-04-26.

Urdal, Henrik (2006). A clash of generations? youth bulges and political violence. *International studies quarterly* **50**(3), 607–629.

Urdal, Henrik and Kristian Hoelscher (2009). Urban youth bulges and social disorder: an empirical study of asian and sub-saharan african cities. *World Bank Policy Research Working Paper Series, Vol*.

Van Beek, Walter EA (1990). Harmony versus autonomy: Models of agricultural fertility among the dogon and the kapsiki. *The Creative Communion. African Folk Models of Fertility and the Regeneration of Life*.

Van IJzendoorn, Marinus H and Marian J Bakermans-Kranenburg (2012). A sniff of trust: meta-analysis of the effects of intranasal oxytocin administration on face recognition, trust to in-group, and trust to out-group. *Psychoneuroendocrinology* **37**(3), 438–443.

Van Vugt, Mark, Robert Hogan and Robert B Kaiser (2008). Leadership, followership, and evolution: some lessons from the past.. *American Psychologist* **63**(3), 182.

Van Vugt, Mark, Sarah F Jepson, Claire M Hart and David De Cremer (2004). Autocratic leadership in social dilemmas: A threat to group stability. *Journal of Experimental Social Psychology* **40**(1), 1–13.

Vandermeer, John H (1992). *The ecology of intercropping*. Cambridge University Press.

Vaughan, Megan (2007). *The story of an African famine: Gender and famine in twentieth-century Malawi*. Cambridge University Press.

Von Rohr, Claudia Rudolf, Sonja E Koski, Judith M Burkart, Clare Caws, Orlaith N Fraser, Angela Ziltener and Carel P Van Schaik (2012). Impartial third-party interventions in captive chimpanzees: a reflection of community concern. *PLoS One* **7**(3), e32494.

von Rueden, Christopher, Michael Gurven, Hillard Kaplan and Jonathan Stieglitz (2014*a*). Leadership in an egalitarian society. *Human Nature* **25**(4), 538–566.

von Rueden, Christopher, Michael Gurven, Hillard Kaplan and Jonathan Stieglitz (2014*b*). Leadership in an egalitarian society. *Human Nature* **25**(4), 538–566.

Vostroknutov, Alexander, Philippe N Tobler and Aldo Rustichini (2012). Causes of social reward differences encoded in human brain. *Journal of neurophysiology* **107**(5), 1403–1412.

Waring, Timothy M, Michelle Ann Kline, Jeremy S Brooks, Sandra H Goff, John Gowdy, Marco A Janssen, Paul E Smaldino and Jennifer Jacquet (2015). A multilevel evolutionary framework for sustainability analysis. *Ecology and Society* **20**(2), 34.

Wei, Dongtao, Kangcheng Wang Yimo Shen-Yimo Xue Du Wenfu Li Nicolas Dupuis-Roy Jiang Qiu Jiang and Qinglin Zhang (2013). Exposure to traumatic experiences is associated with abnormal neural mechanism during charitable donation. *Psychiatry Research: Neuroimaging* **214**(1), 42–47.

West, Stuart and Andy Gardner (2010). Altruism, spite and greenbeards. *Science* **327**(5971), 1341 – 1344.

Wiessner, Pauline Wilson (1977). *Hxaro: a regional system of reciprocity for reducing risk among the! Kung San*. Vol. 1. University of Michigan.

Wilke, Andreas and H Clark Barrett (2009). The hot hand phenomenon as a cognitive adaptation to clumped resources. *Evolution and Human Behavior* **30**(3), 161–169.

Williams, George Christopher (1966). *Adaptation and natural selection: a critique of some current evolutionary thought*. Princeton University Press.

Wilson, David Sloan and Edward O Wilson (2007). Rethinking the theoretical foundation of sociobiology. *The Quarterly review of biology* **82**(4), 327–348.

Wilson, Edward O (1999). *Consilience: The unity of knowledge*. Vol. 31. Vintage.

Wilson, Edward O (2012). *The social conquest of earth*. WW Norton & Company.

Winterhalder, Bruce and Douglas J Kennett (2006). Behavioral ecology and the transition from hunting and gathering to agriculture. *Behavioral ecology and the transition to agriculture* pp. 1–21.

Wittfogel, Karl August (1956). *The hydraulic civilizations*. University of Chicago Press.

Yu, Rongiun, Andrew Calder and Dean Mobbs (2014). Overlapping and distinct representations of advantageous and disadvantageous inequality. *Human Brain Mapping* **35**(7), 3290 – 3301.

Zahariadis, Nikolaos, Rick Travis and James B Ward (2000). Us food aid to sub-saharan africa: Politics or philanthropy?. *Social Science Quarterly* pp. 663–676.

Zak, Paul J, Robert Kurzban and William T Matzner (2004). The neurobiology of trust. *Annals of the New York Academy of Sciences* **1032**(1), 224–227.

Zhang, Le and Andreas Ortmann (2013). On the interpretation of giving, taking, and destruction in dictator games and joy-of-destruction games. *UNSW Australian School of Business Research Paper*.

Zimmerman, Frederick J and Michael R Carter (2003). Asset smoothing, consumption smoothing and the reproduction of inequality under risk and subsistence constraints. *Journal of Development Economics* **71**(2), 233–260.

Žižek, Slavoj (1989). *The sublime object of ideology*. Verso.

Appendix A

Consent and Dictator Game Introduction

Crop and Goat Project (CGP Tanzania): Drought, Inequality and Egalitarianism.

Thank you for taking the time to meet with us today. We are researchers from the University of Alberta, in Canada working in conjunction with researchers at Sokoine University of Agriculture here in Tanzania.

Today we will conduct a game help us understand economic decision making and social behavior. In total this should take around two to three hours, but for some of you it will go much faster depending on when you are selected. So if you cannot stay that long please let us know.

Before we begin I want to give you a general idea of what we are doing and how the games will work. We will play a game that lasts for many rounds where you can choose to how much money you invest into the community and how much you keep for yourself. In the game you can win real money, with an average payout being around 3000 tsh. Whatever money you win in the game will be yours to keep. How much money you win will depends on three factors - your own choices, the choices of other people playing the game and luck.

Now before we continue we must stress something incredibly important - we would like you not to tell anyone about the game for a week as it can spoil other peoples experience with the game, also we ask that you do not talk about the game while waiting.

Jeffrey Andrews will be providing the money but it is important that you understand that this is not Jeff's money. The money was given to them by the University of Alberta in Canada to be used for this research. The research is part of a PhD thesis and will make a valuable contribution to a growing body of scientific literature regarding how severe weather events affect communities and individuals; it is not meant as part of a development project.

Just so you know we will not attach your name to things you say during the survey, but because of our presence in the village, others will probably know that you are involved with the study. The information that we collect will be used in scientific reports and to aid future development initiatives, and may be shared with other academics back in Canada and at SUA. But outside these few people no one will have access to any of your information. If you have participated in previous household surveys for the CGP project this data maybe combined with the data from those other surveys in future analyses.

Before preceding any further let me stress something very important. You were selected randomly to participate in this research without understanding what we are doing here today. Therefore if at any time you find that you do not want to participate in the research you are free to leave. If you do so, we will not use any data collected with you. Also, if you decide that you do not want to participate after the study, please contact us up to two months after today and we will be able to completely remove all of your information from the research.

Feel free to ask me any questions about the project or this research before we begin the discussion. If you would like to ask more questions about this project you are also welcome to contact our project leader, Professor Faustin Lekule at Sokoine University in Morogoro

at 23 2604617 or John Parkins at the University of Alberta (jparkins@ualberta.ca). If you have concerns about this study, you may contact the Research Ethics Office in Canada at 780-492-2615. This office has no direct involvement with this project.

Before we begin with the survey and the game I am going to pass out _ _ _ _ dollars as a thank you for coming today as we recognize that you are taking time out of your day to be here. This money is not part of the game and is yours to keep, even if you choose to leave. *[After money have been given]* Please let me know now if you would like to continue with this research.

Appendix B

Dictator Game Script

1. Introduction to the game

[to be read after completing the household and farm section of the Survey]
Now we will switch to play the game, but before we run it, we will want to go over some simple instructions.
Before we begin, we must ask again that you do not tell anyone about the game (not your wife, husband, sister, friends, or children). This will spoil the study for someone else that could play the game after you.
[In-Group treatment] For each task that you will perform today, you will be asked to allocate money to yourself and another anonymous person that lives in your village. We do not know who that other person will be, and we will never will. You will never know who that person is either. On top of this, the person who you send money to will never know that it was you who sent them the money. All we know is that it will be another adult from this village. On top of that, no one besides those of us in this room are going to know what decisions you make today or how you plan to spend your money – in other words it is entirely anonymous.
[Out-group treatment]: Here is a list of villages. Your village is _____ (point to the name of the village). The other villages listed here are all different villages, very distant from here. For each task that you will perform today, you will be asked to allocate money to yourself and another person that lives in a very distant village. We do not know who that other person will be, and we will never will. You will never know who that person is either. On top of this, the person who you send money to will never know that it was you who sent them the money. All we know is that it will be another adult from one of these different villages. On top of that, no one besides those of us in this room is going to know what decisions you make, or how you plan to spend your money – in other words it is entirely anonymous.
[Experimental assistant writes participant ID on envelopes and distributes them to the participant one game at a time. After the end of each game, folding a decision sheet and placing it in the envelope is demonstrated. Experimental assistant ensures that decision sheets have in fact been put in the envelopes. At the end of each task, experimental assistant collects the envelope from the participant]
We will pass out two decision sheets for each task of the four tasks. For each task you are to choose one of those sheets, you will be able to keep the amount of money indicated next to the word 'keep', and you will send the amount of money to your partner that is indicated next the 'send'. You can only choose one of the two different options for each game and your choices will affect how much money you keep for yourself and how much you give to another person. After you are done making your decision for each task, you will need to fold the sheet with your choice and place it in the envelope we provided.
When we are done with each of the four games, we will shuffle all of your choices together, and you can draw one, you will be paid the amount that it next to the word 'Keep'. I also have a pile of decision sheets from people from [another distant village in our research]/[your village]. When we are all done, you can randomly draw one sheet from this pile, and you

will be paid the amount that that person sent you, so you will get the value that they chose to 'send' to you. The total amount of money that you make is therefore partly determined by how much money you choose to 'keep' for yourself and what another person has chosen to 'send' to you. Your choice will also affect how much money someone else makes.
[The experimenter now demonstrates the process and repeats what choosing each decision sheet means.]

2. Description of the Tasks [Use Task A (The Sharing Game) as the example]

[Experiment assistant passes out the decision sheets for task A.]
[Experimenter holds up a large size reproduction of the decision sheets and illustrates.]
There is a big letter A on the top right corner of the sheets. This is the name of this task is task A. Each task has two decision sheets and each decision sheet contains two sections with arrows. One arrow points to the word SEND and the other arrow points to the word KEEP.
[hold up the egalitarian sheet]
On this sheet, you can SEND 1000 tsh to another individual and you can KEEP 1000 tsh for yourself.
[hold up the selfish sheet]
Alternatively on the second sheet you can SEND 500 tsh to another individual and you can KEEP 1500 tsh for yourself.
Your choice will remain anonymous. After you decide which sheet you would like, fold that decision sheet and put it in the envelope provided. Take the other sheet and put in the garbage here. After the game, we will shuffle each of the envelopes, and you can choose one at random, we will pay you the sum indicated to KEEP on the sheet. Then you can draw from this pile and you get to keep, what someone else sent to you.

3. Comprehension testing

[To be run with each participant before making their choices]
If you choose the decision on this sheet, how much money do you send to another person?
If you choose this decision sheet how much money will you receive?
[If the subject has problems answering these questions explain the payoff implications of choosing "the other sheet" again and ask further comprehension questions. If the subject has still problems, then they will be removed from the experiment]

4. Payout:

[After the subjects make their choice, collect the four envelopes and shuffle them. Allow the participant to select one sheet. Pay them accordingly. Then present them with the pile of choices made by other members of the community. Shuffle them and allow them to select one. Pay them accordingly.]

Appendix C

Public goods game script

1. Introduction and general description

[Interviewer 1 begins instructions, interviewer 2 records everyone's ID numbers on the record.] Hello my name is *[interviewer 1]* and my colleague's name is *[interviewer 2]*. Please take a seat on one of the chairs. We would like to thank you all for being cooperative and for participating in the various activities today.

For this activity, there must be absolute silence. You are not allowed to talk to each other. While in the game, you cannot ask questions to other participants, but only to the researchers. This is very important. Please be sure that you obey this rule, because it is possible for one person to spoil the activity for everyone.

If one person talks about the activity while sitting in the group or with other people later, we will not be able to continue the activity. Do not worry if you do not completely understand everything as we go through the examples because we will take questions when we are finished explaining.

In this game you play multiple rounds where you can win money. However, only one round will count for payment, which will be chosen randomly once the whole activity is completed. For the round that is chosen, the money will be yours to take home and use as you please. Since we do not know which round will count, you should play each round as if you were deciding on real money.

In front of you on the floor is a tray. One side represents your Personal Pocket, represented with the one 'stickman' the other side represents a Group Pot, represented with the group of 'stickmen'. There are now 2,000TSH in your personal pocket. In this activity, you will have to decide how many Shillings you would like to keep for yourself in your personal pocket, and how many you would like to contribute to the group pot.

You must understand something very important about the group pot. The group pot will include the contributions from all the people participating in this activity. But once everyone has decided how much to give to the group pot, I will add up the total amount and the research team will double the amount. The group pot will then have twice the amount of money people contributed to it. I will then split all of the money in the group pot among all seven of the people participating in the activity perfectly evenly – regardless of how much they contributed. Each person's payoff will be rounded up to the nearest 100 TSH.

Everyone's donations and decisions will be anonymous, and the screens are here to ensure that. No one will know how much anyone else contributed. Do not look at other people's trays. Only the interviewer will know how much each person has donated and the interviewer will never tell anyone else. The number of coins contributed by each person will be reported once all the contributions have been made, but I will not say who donated each number of coins. Names or ID numbers of the people here will not be used throughout the activity.

2. Examples of the Game

Let's go over a few examples of how the game works.

[Interviewer 1 explains and demonstrates the coins. Interviewer 2 writes results on the large sheet of paper. Participants should be able to see all three examples at one time by the end of the explanations.]
Lets imagine that everyone gives all 2000 shillings to the group pot.
[Interviewer 2 writes and explain each number on the whiteboard for all to see: 2000, 2000, 2000, 2000, 2000, 2000, 2000," total (14,000), average (2000), double (28000), payoff (4000)]
Interviewer 1 explain: The total contribution was 14,000 TSH. In this case, the average contribution was 2,000 TSH. Now the research team will double this amount. The group pot now has 28,000 TSH. Everyone will get 4,000 TSH. Since everyone donated everything, everyone has 0 in their private pocket, and everyone gets 4,000 TSH from the group pot. Everyone has made 2,000 TSH more than their initial endowment.

Contributions	Total Cont.	Average Cont.	Doubled	Payout
2000, 2000, 2000, 2000, 2000, 2000, 2000	14000	2000	28000	4000

Example 2.
[Interviewer 1] Now lets imagine that the same thing happens, but in this situation one person decides not to put anything in the group pot and keeps all 2000 TSH for themselves. In this situation, there is a total of 12000, in the group pot. The average is about 1700. When we double that there is 22000 in the common pot and when we split that evenly amongst everyone gets 3500 from the common pot. Now, that means that people who contributed all 2000, get 3500 total, but the person who kept their money in their pocket gets 5500.

Contributions	Total Cont.	Average Cont.	Doubled	Payout
0, 2000, 2000, 2000, 2000, 2000, 2000	12000	1700	24000	3500

Example 3.
Now let's try an example where there is more variation in how much people give. In this case 4 people don't give anything to the group pot, 2 people give 200 TSH, and 1 person 400, and another person gives 1600 TSH. The results will look like this:

Contributions	Total Cont.	Average Cont.	Doubled	Payout
0, 0, 0, 200, 200, 400, 1600	2400	350	4800	700

Interviewer 1: The total donation is 2400 TSH. The average donation is 200 TSH, The research team will then double this number so that the group pot has twice the money, or 4800 TSH. This means that everyone gets 700 tsh from the common pot.
Now, the participants that donated nothing will get 2000 TSH from their personal pocket, as well as 700 TSH from the group pot and this makes 2700 TSH. While the participants that donated 200 will get 1800 from their personal pocket, as well as 700 from the group pot. This makes 2500 TSH. The participants that donated 1600 TSH will have 400 TSH from their personal pocket, as well as 700 TSH from the group. This makes 1100 TSH.
Points to Emphasize.
Here are some things to remember: First, the group as a whole gets the most money if everyone puts in all 2000 TSH. In the first example everyone donated everything, and everyone made 4,000 TSH. Before we begin the activity, does anyone have any questions?
Second, people who donate more money to the common pot, will make less than people who do not donate or donate less money. In the second case, 6 people donated 2000 TSH and made 3500. While the person who donated nothing made 5500.
Also keep in mind that if you put a lot and everyone else puts in little or nothing, you can end up with less than the 2000 TSH you started out with. Remember the third example. Some made 2700 TSH, while the person who donated the most made only 1100 TSH.
[Interviewers should answer questions, but they should stick to the script as much as possible. Also, they do not have to invite too many questions. They have to keep it short!]

3. Rounds 1-5

Interviewer 1: Now please use the trays we have provided and decide how much you would like to contribute to the group pot. Place the amount of coins you would like to contribute to the group pot on the green of the tray, with the picture of the group of people. Remember you do not have to contribute if you do not want to. The coins in the group pot will benefit everyone in the room. Then slide your tray under your chair.
[Interviewer 2 goes into the middle of the circle and records decision on data sheet. Individual contributions are recorded next to the ID of the contributor. Calculates the average, total, double, payoffs. Interviewer 2 writes the results of the donations on the large sheet of paper at the front of the room by writing all contribution amounts in increasing order.]
Interviewer 1: Thank you. Please move all your coins back to your personal pocket. Here are the results of all the donations in the room. Just to clarify, let's go over how much each participant made this round.
The person that donated X will have Y in his personal pocket, and will get Z from the group pot, totaling Y+Z. The person that donated A to the pot will have B in his personal pocket, and will get Z from the group pot, making B+Z. etc.
[Repeat for rounds 2 -5]

4. Voting for the Leader:

Interviewer 1: Before we play the next round we would like to know if you would be willing to vote for a leader that could help coordinate the activity. If four or more of you vote to have a leader we will randomly select one of you to become the leader and they will act as the leader for the rest of the game.
The leader will participate in the game with everyone else, he will still donate to the group pot and receive the payoffs from it. But unlike everyone else he will have two special abilities.
First, after all of your decisions have been made the trays are in the middle of the circle, the leader will come into the center and will be able to move any number of coins from any number of people's pockets to the common pot. We will shuffle the trays so that the leader will not know which tray belongs to whom – with the exception of his own.
Second, after the total contributions to the group pot have been calculated the leader may spend any of the money in his pocket to withdraw money from the common pool – as payment for his services. For every 100tsh that the leader spends from his pocket he can withdraw 500 tsh from the common pool. The money that he withdraws will no longer be in the common pot and thus will not be redistributed to everyone but will go directly to the dictator's total earnings.
Before we continue with the vote lets go over two examples that shows you how the leaders special abilities work.
Example 1.
One way the leader might behave is they could move all of the coins from everyone's pocket, including their own into the common pot. Thus there would be 14,000 in the common pot and the researchers would double that value to 28,000 and would redistribute 4000 to everyone including the leader. Everyone would make 4000tsh as everyone has 0 left in their pocket.
Example 2.
Another way the leader could behave is that he could 'pay' himself the maximum amount out of the common pot. To do this he would move all of the coins from the other players into the center, but keeping his own his hand. – that value is then doubled by the researchers so there is 24,000. Now the leader spends all 2000 of the coins he kept in his pocket to withdraw 10,000 from the doubled common pot. After he pays himself there is 14,000 in the common pot and that 14,000 is split evenly among all participants including the leader. In this case everyone else gets 2000 tsh and the leader makes 12,000, 10,000 for 'payment' and 2000 from redistribution.
Points to emphasize
First the leader can help increase the total group contribution by coordinating everyone and therefore can allow everyone to make 4000 tsh.
On the other hand the leader can withdraw money from the common pool – and thus could make it impossible for anyone to make more than 2000 TSH but themselves.

But note that the leader will never be able to extract more from the common pot to make is such that people would wind up with less than 2000. So if no one contributed anything to the common pot, they would make the same as if they voted for a leader who paid themselves the most they could.
The leader could also force everyone to contribute to the common pot and pay themselves a lesser amount than 10,000 but the choice is up to them.
Also the leader could choose to do nothing and let the game continue as normal without changing anything.
Are there any questions?

5. The vote:

Now we will give you the choice to vote for a leader or not – if four or more of you vote for a leader then we will randomly select one of you to become the leader – if less than four people vote for a leader then the game will continue as normal. If you vote for a leader they will remain in the game until we stop.
Now please, place one coin in the group pot side of your tray if you would like to have a leader, and place no coins in the group pot if you do not want a leader.
[If a leader has been selected read this to the leader]
You have been randomly selected by the group as the leader. Starting in this round you will be able to enter into the center of the circle after all decisions have been made – you can move any number of coins from the any persons pocket to their common pot or the other way around. Once you are done moving the coins let us know. Remember that if you wish to withdraw money from the common pot you must have some coins left in your pocket.
When you are finished we will double the value in the common pot and you can choose to spend any number of coins to withdraw money from the common pot. Remember every 200tsh coin can withdraw 1000tsh from the common pot. Please write down how much money you would like to spend/withdraw. When you are done please return to your seat and we will announce the results.
[announce the results as described above and proceed playing with the rest of the remaining rounds]

6. Payoff:

The cards are numbered from one to (8-12, depending on the length of the game). We will ask one of you to pick a card. The number that will be picked will determine which round you will be paid for at the end of the day. For example, if you pick card number one you will be paid for round 1 (point to round 1 results). If you pick card number three you will be paid for round 3 (point to round 3 results). Remember, you will get both what you kept in your private pocket, and the payoff from the group pot.