

Social Entropy: An Information Measure of Institutional Complexity for Social Psychology

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ABSTRACT

Information theory has impacted disciplines across science and technology, including the 20th century's IT revolution. However, information theory has been applied much less to the social sciences and has not been applied at all to theoretical social psychology. While information-based statistical programs are used to analyze data across social disciplines, information theory has not been used to analyze social structure and the self as an informational process related to the conflict reducing characteristics of institutions. The present paper addresses this gap by suggesting Shannon information as a measure of the complexity within institutional settings in relation to the formally rationalizing drives of industrialized societies in contrast to the informal social control experienced in simpler societies. The paper analyzes social theory related to institutional complexity from several disciplines arguing that it is synonymous with information as suggested by Shannon. A post structural methodology for measurement of social complexity and directions for future research are suggested.

Keywords: Information theory, social structure, institutions, complexity, entropy, post structuralism.

To communicate is to make oneself predictable.
(Claude Shannon)

The mind came in on the back of the machine.
(George Miller)

*For the first time in the history of science we know
How we know and hence are able to state it clearly.*
(Warren McCulloch)

INTRODUCTION

Today's Information Landscape

Former US president Barack Obama described the current information context as a "Wild West information landscape." Here, Obama expresses two important realities. The magnitude of information content and connections between the users of this information in many increased in magnitude globally. More importantly, this increase is experienced in new social spheres or new informational levels attached to existing spheres that have been hard to regulate. These spheres are virtually lawless, operate outside the light of public scrutiny, and are increasingly

worrisome to law enforcement and policymakers (Naím, 2022; Neiwert, 2017; O'Connor and Weatherall, 2018).

An example of this trend is Q-Anon—an Internet political movement propounding fantastical conspiracy theories including one which portrayed Hilary Clinton as eating babies in the basement of a Washington, D.C. pizzeria. According to Pew Research Center (2020), almost half of adult Americans had heard of Q-Anon in 2020 and 20% of these indicated that the movement was “somewhat good” or “very good” for the country. Further, 12 political candidates for the US House and Senate, two of whom later won their races, associated themselves in some way with Q-Anon. This trend and its perceived connection to the January 6 insurrection, has spurred a flurry of books about the effect misinformation that originates in these underregulated spheres (Naím 2022; Neiwert 2017; O'Connor and Weatherall 2018).

Information-driven industries and products, now much empowered by these same information theory-based technologies, are also the source of socio-ecological problems, such as climate change that causes concerns beyond polar bears and icebergs. On these issues, public input is provided by those who are considered experts in technical fields within spheres of expertise. For example, research centers have been worried about the collapse of global temperature-dependent ocean currents, a driver of weather that is also central to the species and the nutrient mixing that supports sea life. The MIT Technical Review states that the Atlantic Meridional Overturning Circulation (AMOC) is predicted to decline by 45% in this century (Temple, 2021). This is in addition to the last century's market-driven global overfishing catastrophe, which left Cape Cod fisheries almost completely collapsed (Harris, 2013; Holmes, 1994; Pershing et al., 2015).

The Social Implications of Information

Other information-related problems constrained by complex institutional contexts are somewhat closer to the social sciences. According to a 2022 report by the National Alliance to End Homelessness, the proliferation of those without permanent housing is now at an unprecedented level and is increasing yearly, though recent COVID-related investments in human services have somewhat reduced the trend. On the topic of COVID, California's Silicon Valley, with the last year's market capitalization (total stock value of publicly traded companies) of \$14 trillion, reported a death rate among Hispanics that is three times that of White residents (*2022 Silicon Valley Index: Top 25% Hold 92% of the Wealth*, 2022). Among other disparities, this was summed up by the Joint Venture Silicon Valley CEO Russell Hancock.

We're generating wealth faster than ever before – personal assets, real estate, private company valuations, public company market cap, and in a million other ways...many in our region working full time are barely scraping by. Explain Silicon Valley to any kindergartner, and they'll tell you it's not fair. We need to make sure the wealth generation that drives up prices and demand for services also feeds back into the system. (*Silicon Valley Index: Top 25% Hold 92% of the Wealth*, 2022)

The present article agrees with Hancock on the social implications of health disparities while also agreeing with the power of the region's information technology to organize human efforts to meet its economic goals. However, I argue that rather than being the root of these disparities, some lesser-known facets of information-based power driving technology may instead be used

too little today in social science methodologies. While disciplines, such as psychology, have used information theory to analyze the computing capacity of the human brain (Gleick 2011; Pierce 2012), the social foundation of communication, which gives meaning to any sense of computation, has been much less studied. To rephrase Miller's statement above, to understand the burgeoning information landscape more clearly, one will require theorizing IT as the tool of social individuals constrained by social realities, not the other way around.

While cognitive science has studied the computing capacity of human cognition, social psychology has not applied information theory to the connection between the institutional context and its major focus, the constraint of mundane social interactions mediated by communication. That is, while information theory is used to build multi-trillion-dollar technology industries and communicate across millions of miles of space, it has not been used to understand some important social implications. To address this gap, I propose information theory here as a method for studying modern institutions in relation to the organization of mundane social conflicts, what I argue here as an important component of institutional content and communication.

The extent of rationalized and socially embedded conflict is difficult to fathom within the wickedly complex institutional context of the 21st century (Head and Alford, 2015; Peters, 2017; Rittel, 1967). For more than a century, social psychologists have looked to Max Weber and his heirs to assess the rationalizing role of institutions connected to the state and modern market exchange, while emphasizing the internalized character of all social structures. I argue that information theory could be used to assess the organization of human effort in these conflict-reducing institutions.

This paper begins with a quote from Claude Shannon, who proposed information theory, to suggest that its concepts, known more in physics, technology, and natural science than in social science, could be useful in explaining information barriers common in complex institutional settings. Contrary to popular assumptions about Shannon, his strength was not mathematics per se (Schumacher, 2015; Sonni and Goodman, 2018). Instead, the genius of his idea lies in the ability to use relatively simple equations to solve pressing problems related to communication, technology, and signals (Schumacher, 2015; Sonni and Goodman, 2018).

To apply similar ideas to social psychology, I consider Margaret Mead's unfulfilled enthusiasm for applying information theory to diverse social contexts (Gleick, 2011). Information theory developed by Shannon during his time at Bell Labs in the 1940s (Pierce, 2012; Shannon, 1948) was the basis for the IT revolution during the second half of the 20th century. The theory is also a driver of today's information-rich global context, now described by the term information society (Castells, 1991, 2010). Manuel Castell's term reflects his analysis of information as an economic variable and a driver of development.

Information Theory Across the Sciences

Shannon foresaw the impacts of his theory on sciences, such as genetics (Schweighauser, 2013), neighborhood racial dynamics (Gabriel, 2016), physics (Schumacher, 2015), engineering (Gleick, 2011), IT (Gleick, 2011; Pierce, 2012), biology (Hastings, 1996; Jost, 2006; Leiva et al., 1997; Schweighauser, 2013), and cognitive psychology (Pierce, 2012). Despite Margaret Mead's initial interest in the theory, information-related quantification has been slow to reach

the social sciences, partly because of the complexity of human and socio-environmental systems (Gleick, 2011; Sonni and Goodman, 2018). In the social sciences, Shannon's theory and its many academic descendants have been used most successfully in communication (Pierce, 2012), the field in which it was developed (Shannon and Weaver, 1971; Shannon, 1948; Sonni and Goodman, 2018), and quantitative social disciplines such as economics (Capurro, 2009). Shannon urged an expanded approach through which his ideas could be translated beyond signal communication and computing to other complex processes. This paper suggests that social psychology is one such field. However, Shannon's caveat about the spread of his ideas should be considered in this regard: "many of the concepts of information theory will prove useful in these other fields...the establishing of such applications is not a trivial matter of translating words to a new domain, but rather the slow tedious process of hypothesis and experimental verification" (as quoted in Schweighauser, 2013; see also Sonni and Goodman, 2018).

An Expanded Understanding of Information Theory for Social Psychology Information Theory and Complex Institutions:

Complex institutional contexts have not been analyzed with a focus on information diversity per Shannon or any other diversity measure of which I am aware. I aim to socialize Shannon's ideas beyond the existing applications of information theory in communication (Pierce, 2012; Shannon and Weaver, 1971) and applications of the related ecological measure called Shannon diversity to things, such as neighborhood composition (Gabriel, 2016) and urban ecology (Jost, 2006). This paper does not claim to be a comprehensive theoretical review of information in social science, but instead aims to uncover a novel footing for Shannon's ideas in social psychology.

Although social psychology focuses on individual interaction, including its psychological components, it also addresses the shared social structure used to communicate social expectations to individuals in larger groups (Mead, 2001; Zerubavel, 1991). Socialization through communication, as suggested by symbolic interactionist social psychology (Becker, 1986; Mead, 2001; Pascale, 2010), is the basis for the shared understanding among groups necessary to create meaningful interaction (Mead, 2001).

This study also focuses on the imitation among individuals in groups, termed memes or symbols (Blackmore, 2000; Dawkins, 1940), as the foundation of human institutions. Institutions are defined as complexes of people and things structured to constrain behavior (reduce conflict about acceptable behavior) in line with society's norms. In the process, I argue that "making oneself predictable" in the words of Shannon is a function of complex social influences in which communication reveals underlying elements of social, particularly institutional, order.

Information Measures for Intractable Socioecological Settings:

I argue that this social structure is partially reflected in Shannon's (1948) and Hartley's (1928) early work related to the entropy of English words. I suggest the concept of entropy as a measure of complexity or information, meaning the social content that is experienced by a population for meaningful informal debate or public engagement (van Stokkum, 2022). I equate the concepts of entropy, information, and complexity to some degree.

The ideas presented here synthesize the findings of my previous work in such a way as to reflect the experience of advocating for changes in local government settings where meaningful participation about resources is not available to the public due to information barriers (van Stokkum, 2019 see also the PPGIS and social GIS literature which suggests that increased access and even skill in fast IT like GIS is not seen to overcome barriers to public engagement; Brown and Kyttä, 2014; Brown, 2012; Miller, 1995; Pickles, 1999). In more than 20 years of research, I have encountered many urgent social problems of which the residents of US jurisdictions are unaware or feel unable to change (McCullough and van Stokkum, 2021; van Stokkum, 2007, 2019, 2022). The complexity of these problems has reached such an intensity that they have been termed wicked in some literature, indicating problems that are very difficult to resolve because of the changing character of related constituent networks and perceptions (Head and Alford, 2015; Peters, 2017; Rittel, 1967; Salwasser, 2004).

Such an increasing complexity stems, in part, from society's role (Foucault 1977) as the most basic information system (Goffman, 1963), in which individuals' well-being depends on a well-informed population (Sen, 2000). Expanding this view to include the element of human perception, Schumacher (2015), quoting Seth Lloyd, states that the bit, a basic unit in information theory, suggests the properties of Shannon's universe as an information system that computes the flow of its evolution. Here, Lloyd expands on early information theorists' vision of technology's power by observing its reflection of nature's relational character. Anything material is connected to everything else in the universe, making observation of it sensitive to initial conditions. Further, this synthesis of ideas is also meant to relate to inner city/barrio communities or the homeless, where institutions do not provide them with resources or opportunities, leaving issues such as public safety and provision of resources such as education or basic services to be resolved at the population level (van Stokkum, 2007; Noguera, 1995; see also urban ethnographies Anderson, 2000; Rios, 2011; Jones, 2009). Entropy in a social context is seen as having an inverse relationship with institutional complexity, such that entropy can be used to predict the social complexity encountered by a given population. In sum, I argue that this access to conflict at the population level or lack thereof is something that has not yet been measured.

Precis

The paper starts with a section outlining the fundamental connections between social structure and information. The next section explains information theory highlighting its emergence and outlining the qualitative intuition behind its quantitative components. This is followed by a section outlining the concepts in social psychology that align with information theory and support the suggested quantification of social complexity. The paper then turns to the implications of applying the concept of entropy to social contexts as a measure of complexity, including a more precise description of the meaning of quantitative results for social analysis. Concluding remarks include directions for future research.

INFORMATION THEORY AND SOCIAL STRUCTURE

Social Structure: Institutions, Conflict, Social Control

Unpacking these ideas more theoretically, formally rationalized institutions (Weber, 2013) transfer the work of resolving conflicts to internalized social control (Foucault, 1977), itself controlled by the powerful information-based institutions of the modern nation state in industrialized societies. Namely, large societies require individuals to control their behavior

through behavioral patterns they learn from shared meanings inherent in modern institutions. In modern industrialized social settings, the locus of control has moved to more internalized methods (Foucault, 1977). The conflict encountered by populations—conflict not subject to the fully internalized self-control meted out by institutions—constitutes the information content I suggest here, as a possible focus of Shannon information measures.

At its kernel, any perception of nature is viewed by information theorists as 100% social (Gleick, 2008; Pierce, 2012). Information, equated by Shannon with entropy, consists of work, i.e., the cost of perceiving any aspect of a complex world (Gleick, 2008; Pierce, 2012). Thus, the complexity of social problems can be analyzed as the complexity of humanity's perception and manipulation of nature. This equivalency is what I believe could be usefully applied to the social complexity of institutional contexts.

Definition of Conflict

Allying this thinking with social psychology, problems can appear unresolvable as they become muddled by the complexity of the ways in which humans know about them. Namely, people start to know more about how institutions work and about the rules of state-centered institutional resource distribution rather than understanding the facets of conflict resolution latent in those institutions. It is important first to define conflict.

Here, Freud's concept of innate human urges is useful: aggression and sexual desires. Conflict and its resolution are assumed to be the focus of human interactions, including their communication. Further, the term conflict is used here in line with the literature on institutions using the two major assumptions outlined above: 1) institutions focus on the reduction of conflict, and 2) the social order produced by institutions can be measured in communication/language without any explicit focus on specific resources or formal instruments of social control. Social psychologists argue that it is difficult for individuals not to naturalize familiar patterns of social interaction as universal, while they are constrained by socially constructed institutions that vary over space, time, and between groups.

Sen: Social Information Systems

Blindness to the social construction of institutions allows the outcomes of the institutional context to appear as an inescapable reality instead of choices constrained by human created rules. For example, Sen's (2000) discipline-changing work on drought and famine found that starvation (famine) only occurs when information about naturally occurring dry periods (drought) is obscured from the public perspective. Starvation, Sen reveals, is a social, much more than an environmental, phenomenon. More importantly, for the present paper, outcomes such as the lack of wide-spread starvation and increasing human well-being depend on a socially constructed pattern of institutions in relation to population-level needs.

Sen's findings reveal that when any democratically ruled public is exposed to information about drought and possible famine, starvation does not occur (in literally 100% of cases studied by Sen). Sen (2000) observed that there is always enough food for those in need to stem the tide of starvation. According to Sen's findings and those in social psychology research, humanity seems to lean innately toward empathy, as long as human attention is focused on people in need (Morelli and Lieberman, 2013; Schutte et al., 2001). Democratic institutions, such as a free

press, are needed for people to focus on human suffering, thus managing the tension between innate human conflict expressed through common urges and empathy.

Communication: The First Information Technology

Similarly, I argue that information theory may provide a way for populations to see institutions for what they are, better deconstruct complex societies and comprehend how institutions affect urgent environmental and human needs. This reflects Miller's observation quoted above. Simply knowing—paying attention to what and how we know something—has resulted in information revolutions in several human spheres. This kind of knowledge, I argue here, could be applied more specifically to the institutional structuring of social conflicts in relation to its outcomes as a way to mitigate the social blindness that has become a part of modern life.

We live in a world in which the quantity and speed of knowledge have increased much more rapidly than at any other time in history, which is another outcome of the explosion of information technology (Schumacher, 2015). While speech has been shown to be innate to humanity (Lieberman, 1991), writing and all subsequent information technologies are human tools used to perceive and transfer knowledge about the world (Gleick, 2011; Schumacher, 2015). These information tools drive the exploding rates of knowledge production.

Starting with writing, these tools have changed the human experience in ways that can only be called revolutionary. Dedicated social scientists, especially qualitatively oriented ones, may be tempted to ask: Is there not enough information in contemporary life and across fields of knowledge? Should socially leaning academics not seek methods, approaches, and theories that are relevant to underlying meaning and to humanity which is lost in the cracks of information-heavy methods? I believe that answers to these questions may change through a closer understanding of information theory and the concept of entropy.

INFORMATION/ENTROPY: TOWARDS ADDRESSING SOCIAL COMPLEXITY

Reflexivity

At the heart of information theory lies a suggestion of reflexivity. This statement may be surprising to qualitative researchers who are used to less-than-reflexive impacts of information-based phenomena, such as social media or cyber warfare (Naím, 2022; O'Connor and Weatherall, 2018; Sanger, 2019). However, what has been termed the universality of information-based methods can be hard to discern in recent applications of information theory, as reflected in Miller's above-mentioned quote. The quality of universality lies in the view of information as a process of signal reception centered in the human brain (Pierce, 2012; Shannon, 1948). Because of this decentralized definition of communication, information theory provides an internal lens to view itself as a human method for explaining complex interactive processes. However, as an engineer, Shannon maintained the goal of not only understanding but also changing material outcomes deeply impacted by human behavior (Sonni and Goodman, 2018). Through this focus on both the senders and receivers of communication, information theory offers scientific explanations for understanding diverse points of reference in strikingly similar ways to post-structural theory.

Similarly, the science of complexity suggests a new understanding of entropy as an effect of the human cost of perceiving information about a system (Waldrop, 1992). Entropy, even in physics, exists in humans, not in nature itself, troubling in this way the concept of randomness

(Gleick 2008). Entropy is now best understood as a human artifact of unperceived order. Observations perceived as random under this thinking have not been subjected to the human work required to perceive their hidden order. Similarly, using information-based methods, nature has been theorized to be a constant process of order arising from complexity—i.e., that which is perceived as less orderly. I suggest here that this tension between order and complexity outlined in information theory and its descendants suggests gaps in the existing social psychology research related to a social structure and its institutions.

The Social Construction of Entropy

In this paper, for the sake of clarity, I focus on Shannon's concept of entropy—not to be confused simplistically with the second law of thermodynamics, although the concepts as suggested above are now seen as equivalent (Waldrop, 1992). Based on the understanding that the relationship between symbols and messages or codes is arbitrary (Shannon and Weaver, 1971; Shannon, 1948), Shannon designed the concept of informational entropy as socially constructed and as the function of the likelihood of surprise (Schumacher, 2015) or uncertainty (Pierce, 2012) inherent in segments of communication or messages. Reducing messages to the least amount of clarification needed to reduce uncertainty is at the heart of this concept. Thus, entropy and related ideas can be seen as ways to depict the tension between pattern/predictability and diversity/complexity. Early information technology used this simple quantification of complexity to represent "numbers, words, or pictures" (Schumacher, 2015, p. 15), gradually making huge advances in the speed and magnitude of human communications. As is common to scientific analysis, Shannon and others began by searching for underlying mechanisms. Researchers asked what makes messages work as a means of communication. Shannon found that the diversity of possible messages creates the possibility of meaning, not the words themselves, as meaning changes over time (Pierce, 2012; Schumacher, 2015; Shannon and Weaver, 1971; Shannon 1948). Because of this, cryptology is possible (Pierce, 2012) as there are infinite systems for communicating the same meaning or hiding that meaning from enemies—a major signals communication goal in World War II. In his search for a theory of information useful in wartime information systems and electronics, Shannon proposed two key ideas: 1) the meaning of each message depends on the diversity of possible messages, and 2) the probability of any message is usually strongly associated with its context. Shannon sums up these foundations simply: "The actual message [must be] *one selected from a set of possible messages*" (Shannon and Weaver, 1971, p. 31 emphasis in the original). Communication, Shannon suggested, has emerged from diversity and choice. According to information theory, this play between diversity and predictability is represented by the basic unit of information, the binary digit, or the related term bit, which is represented by 1 or 0. A modern *byte* is a grouping of eight bits used in the subsequent coding techniques of the 20th century. Although reducing the world to a binary system may seem simplistic to social scientists, Shannon meant for his theory to unlock the complexity in systems of meaning that form the basis of communication. Further, the simplicity of Shannon's math emphasizes the centrality of choice (i.e., complexity) in every binary unit (Pierce, 2012). Though each unit *i* can be predicted with some accuracy, it is not certain unless a message is meaningless or produced by a dead, completely predictable system.

The Entropy Equation

The entropy equation suggests that the efficiency of a code is a function of the number of bits required to express the irreducible complexity of a message (Pierce, 2012; Shannon and

Weaver, 1971). I argue that this simple idea may be useful in depicting not only the content of signals but also their social meaning in relation to conflict and institutions (I specify this connection below). Shannon (1948) included a schematic in his initial work on communication that suggests that both relativity (point of view) and reflexivity (perception of positioning) are inherent in his theory. These ideas are relevant to post-structural social theory and the linguistic turn in sociology: the meaning expressed between individuals depends on both the sender and the receiver, and point of view matters in meaningful communication. The entropy equation suggests that the efficiency of any code is a function of the number of bits—the information content required to express whatever complexity cannot be reduced or compressed.

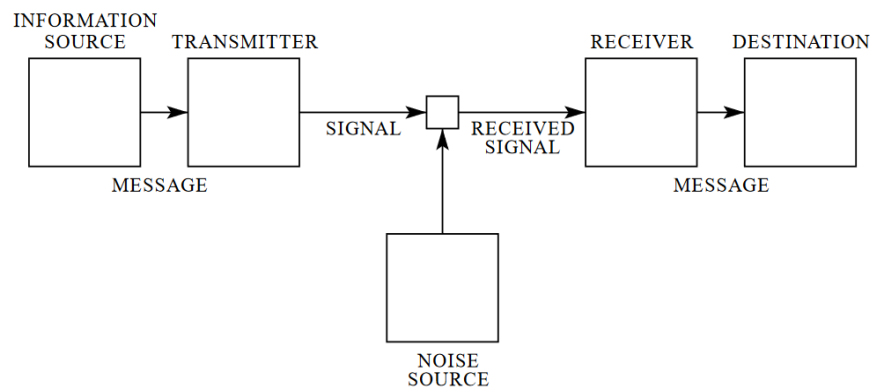


Figure 1 “Schematic diagram of a general communication system.” p. 2 (Shannon, 1948)

Post-structural communication complexity

Figure 1 depicts the sources of communication complexity. Here, we can see that the sender’s position constitutes only a part of the sources of complexity in any message transmission. Shannon shows that the resolution of uncertainty for the receiver of a message is as important as the sender’s intent (Pierce, 2012). As Shannon states, the need for communication arises only when the intended meaning *between* individuals is uncertain. Pierce (2012) sums up the process in this way: “...we must have a measure that increases with the amount of choice of the source and, thus, with the uncertainty of the recipient as to what message the source may produce and transmit” (p. 79). This complex uncertainty among human communicators defines entropy in information theory. In the following theorem, entropy is based on an average probability (a measure of uncertainty); is $\log_2$ (base 2), meaning that its unit is binary or represented in bits, and includes the amount learned from the message based on related probability (expressed in the negative second term):

$$E_j = -\sum_{i=1}^n p_i * \log_2 p_i \quad (1)$$

Using these components, the concept of entropy adapted from Schumacher (2015) accomplishes three goals that make it both simple and almost endlessly useful.

- Entropy does not depend on the representation of a message in such a way that its meaning assumes the central position.
- Entropy is additive. Strings of message entropy add up and do not multiply.
- Entropy quantifies the minimum number of bits required to capture the complexity reduced by a given message.

All three points are pertinent to social psychology, particularly Point # 3. Communication may often be redundant; however, information theory suggests that its role is related to the quantity of complexity needing clarification by a *given* message (Shannon, 1948). This idea is central to the following sections.

Shannon Diversity

As mentioned above, Shannon's work has been used to quantify the complexity or diversity of settings outside signal communication. For example, Shannon's concept of diversity in ecology is helpful because of its intuitive similarities to the entropy of institutional contexts. In his concept of diversity, Shannon uses an equation similar to what he used in the equation on information, but he substitutes the natural log instead of $\log_2$ as the natural log models the behavior of ecological populations and communities better than other log forms. This diversity measure is discrete rather than continuous and quantifies the number of distinct species in relation to their overall preponderance. Shannon's diversity index quantifies the complexity of any random draw for a single species from an ecological area. Greater diversity indicates more complex ecological possibilities, that is, more possible species of reasonable abundance suggests that the system is further away from monoculture or ecological uniformity. For social complexity within institutional settings, Shannon's diversity would measure the types of conflict faced by a population in relation to the number of types (more on this below).

Based on the existing social psychology research, I hypothesize that a measure of social complexity of this type varies over space and time and that this variation is inverse to institutional complexity. Complex institutions remove conflict from public deliberation; that is, interaction through communication depends on the tension between internalized institution-related control over conflictive urges per Freud and the social conflict commonly experienced within interaction among individuals. Here, social entropy measures the externalized types of conflict—the conflict open for population level interaction¹, instead of being internalized into pervasive modern systems of internalized social control (Foucault, 1977; Mead, 2001). Using this definition, we turn to social psychology and related literature, which, I argue, supports the idea of a complexity measure for institutional contexts focused on social entropy.

REVIEW OF PERTINENT LITERATURE

Information and Symbolic Expression

Information related to symbolic expression is ancient in origin, arising importantly, if not uniquely, from the works of Plato and Aristotle (Capurro, 2009). Surprisingly, the ancients conveyed the complex meanings of information, particularly in language, including both its representative and generative functions. Information as a reducer of uncertainty (Capurro, 2009) is thought to have arisen later in history, in line with Locke (2013) and Hume (1748). This section examines complex and disparate studies in the fields of social psychology and areas related to information and outlines the basis for entropy as a measure of institutional complexity. The section covers related ideas but focuses on the social psychological concept of symbolic interaction, starting with George Herbert Mead's understanding of the self as the

¹ Students of social theory may wonder at the use of the term population referring to Pierre Bourdieu's resistance to social analysis focused on a unit with clear boundaries (Bourdieu, 1983). The aim here is to connect the idea of a population created by institutional agreement to the effects of the institutional context on social interaction that is actually much freer flowing than any formally rationalizing understanding suggests.

internalized expression of social structure in each individual. The section also includes assumptions from cognitive science and psychology and from both old and new institutional literature. The section aims to outline what has been theorized in sociology about the relationship between formally rationalizing institutions and flows of information in society, including Foucault's ideas about links between the formalized systems of informational observation and internalized social control. Major contributions of Foucault and others, including Amartya Sen's work on the informational basis of decision-making and resource provisioning, to a social understanding of information form the pillars of this section. Sen suggests that, at a macro level, society is an information system that is central to the understanding and meeting of basic human needs. Irving Goffman's work is suggested as a basis for thinking of communication about social information (i.e., impression management about stigma and status), which occurs in the process of relationships. According to Goffman, social information is part of a networked human information system. The section then turns to Giles Deleuze's work on identity and pattern or repetition in representation, highlighting the socially constructed nature of categories that are necessary to communicate information.

The Self and Internalized Social Structure

Through a partial observation of a century of the evolution of social psychology and other ideas centered on social information, I will argue in this section that human categories and their associated symbols are completely social. Furthermore, I assume that although humanity can come powerfully close to truth, infinite distance exists between any human understanding and a truly complete understanding of the material world. Statistical noise, under this thinking, is pervasive and represents instances of an unperceived order as suggested in section 3. In sociology, this sense of the socially constructed character of knowledge about the human condition is the basis of contemporary ideas about social structure. Mead synthesized the idea of an internalized social structure early in 20th century sociology (Mead, 2001). Mead defined an individual's sense of self as an internalized sense of society's expectations. Here, social structure is defined as internal and cognitive rather than material, although its existence always has material consequences through human contact with people and things. Counterintuitively, it is the sense of self in the context of the social world that forms the basis of social interaction and the reproduction of social institutions (Becker, 1986; Mead, 2001). Social cooperation, even in mundane daily interactions, depends on this internalized view of the self in relation to society. The kinds of selves produced by society through socialization have gradually changed in relation to the expanding institutional context. This heterogeneous experience of social expectations in relation to conflict and institutional context is what, as I hypothesize, can be measured with information theory.²

Internalized Social Control and Fields of Conflict

Starting very close to the time Shannon published his paper on information and communication in the late 40s, social scientists turned to language and communication in social contexts. At

² Here again students of social theory may wonder at the absence of Bourdieu's field theory as it is the 20th century's most complex treatment of conflict as an engine of social order. I believe Bourdieu is pertinent but in this first attempt at explaining the meaningful measurement of social complexity using information theory, Bourdieu's social landscapes of conflict, termed fields, assume an institutional context. In this, I believe the present synthesis further extends Bourdieu's extension of critical theory on conflict. However, the complexity of the connection to Bourdieu's world of fields requires its own much longer treatment.

about the same time, the symbolic interactionist approach also took root in the discipline. Before Shannon's work on information, early- and mid-century social theorists focused on social problems, social control, norms, and values without largely focusing on language or communication. Gradually, social psychology came to view symbols and their imitation through social interaction—what Dawkins (1940) termed 'memes'—as central to an understanding of social structure, defined here as patterned interactions within enduring social networks.

The studies examined below come from early sociology and later 20th century research. Each piece focuses on an aspect of institutional behavior or social structure, highlighting the tension between institutionalized social control—conflict-reducing social mechanisms—and fields of conflict experienced by populations.

Foucault: A Genealogy of Social Control

Michel Foucault turns the discussion on information toward the changing nature of social control. Foucault argued that for the punishment of deviance in the modern state, the locus of control has moved from actions meant to cause bodily pain to much more internalized forms of control focused on identity. Foucault suggested that internalized control mechanisms, such as self-control in schools and emphasis on offender reform in judicial systems, are much larger in scale in industrialized societies.

Foucault bases this analysis implicitly on Weber's concept of formally rationalizing institutions, in which conflict is removed from social interaction through agreements on outcomes ordered through contracts and agreements and maintained by large-scale state bureaucracies. Together, these ideas suggest a mix of social control addressing the universe of possible conflicts, with some social conflicts removed from mundane interaction and internalization (formal rationalization), while other types of conflict are left open to populations for social deliberation (see van Stokkum, 2019). This mix includes low-level conflict experienced in normal interactions, all the way up to conflicts expressed through violence and war.

Sen: The Information Task of State-Centered Institutions

For Amartya Sen (2000), the government and policy connect academic knowledge and the use of the resulting information in society. While Goffman (see section 4.1 above) takes a micro approach to the analysis of information flows between dyads and triads in the context of groups, Sen explains information flows in society at the macro level, suggesting that human well-being depends on the character and clarity of human information systems. In Sen's model, capability levels within the populace define the "information task of public provisioning" (2000, p. 138), a link between information flows from the governed to political and organizational structures. Both positive and negative societal outcomes are the result of information processes related to the large-scale distribution of goods and services, such as education or pollution regulation. Sen (2000) suggests that higher levels of human well-being depend on adequate and widespread information about the lived reality of constituents. In complex societies, this information is codified into policy agreements that remove conflict over resource distribution at the population level. Based on these ideas, Sen suggests a method for connecting academia, government, and communities through more equitable and robust human information systems that keep pace with advances in science and technology. Thus, the character of a society's informational basis molds the capability of its population and affects equity among diverse communities.

Sen's work provides a basis for perceiving society as an information system that requires regular tuning and care. Sen hints that the success of institutions at meeting human needs for resources and communicating the character and location of those needs varies. Formally rationalized institutions, such as the state, are seen to codify possibly conflicting social processes related to material outcomes (Clarke et al., 2006), which was originally described by Weber as rule-based management devoid of passion and emotion (Calhoun, 2012; Weber, 2002, 2013). Namely, this process of rationalization changes expectations among people by codifying specific types of conflict over resources and relationships into institutions, thus removing conflicts over these from social interactions (Immergut, 1998). For example, people in industrialized societies do not tend to have conflicts with neighbors about water, and water delivery is handled so efficiently by public systems that populations hardly think about processes behind water flow from their taps (Gandy 2003; Swyngedouw 2004). Thus, institutions can be defined as the drivers of socialization that produce habitualized behavior with implications for both formal (e.g., the state, schools, and local government agencies) and informal (e.g., families and groups) institutions. 'Higher' scales are thought of as such because of their sovereignty over populations, e.g., through the rule of law or the implementation of policy.

In sum, the role of formal and informal institutions and the internalized social control they produce replace conflict at the population scale. Instead, conflict is transferred from the population-level into "higher" political scales connected to the state which exercises control over large distributive systems and other resources, which in turn demand this normative behavior from populations.

Deleuze: Institutional Contexts as Repetition and Difference

With the rise of information theory, social psychologists, if unknowingly, have examined Shannon's ideas about the importance of both receivers and senders of information within pattern-supporting institutions. Deleuze's (1994) work titled *Repetition and Difference* traces a razor-thin line between physical science, sociology, and philosophy. Deleuze calls the relationship between repetition (patterns) and difference (diversity) a new dialectic.

For Deleuze, material repetition, as perceived by humanity through systems of classification inherent in institutions or in scientific observation, is a socially defined threshold of *difference* rather than an observation of absolute similarity. Any perception of difference for Deleuze is simply part of the material reality falling outside socially accepted designations of sameness or similarity: "difference without [i.e., outside the boundedness of a] concept" (Deleuze, 1994, p. 24). The structure, process, or material that fall outside of socially perceived patterns of similarity are "the play of singularities" under a "general operation of laws" (Deleuze, 1994, p. 25). Deleuze suggests that the material world, filled with singularities, is symbolized by humanity through shared ways of seeing sameness, where none exists in any absolute sense. According to Deleuze, illuminating this social character of meaning, including that of science, is the key to any coherent process of change. Deleuze (1994) addresses the limitations produced in any model or human analysis through scientific simplification, while maintaining a stance very similar to that of Shannon: "The unequal is the most positive element" (p. 21). Echoing information theorists (Pierce, 2012; Seising, 2010; Shannon, 1948; Wiener, 2019), Deleuze argues that noisy or even unobserved data are part of some as-yet unknown patterns observable under alternate conceptual thresholds of difference.

In line with Latour (1993) and ANT, Deleuze argued that if the definition of a concept changes, new facts are 'discovered' as observation becomes possible under a new conceptual framework. The singularities lost between the boundaries of human symbolic categories are the substance of innovation and the expansion of human knowledge into previously unknown terrains. Symbolic categories, though limiting, are the basis for the shared understandings that produce the human condition and, with it, scientific innovation. In summary, new facts emerge based on the interaction between the meaning of a new concept and the generative observations it produces. This meaning then affects the ways in which people learn to perceive and interpret the world and matches the connection Shannon suggests between the magnitude of knowledge production and our understanding of its process.

MEASURING INSTITUTIONAL COMPLEXITY

Institutional Complexity as Barrier to Perceiving Institutional Impacts

I was a student in Caracas, Venezuela, during 9/11 and was in a class when word got out on national news channels. I was taken to the school administrative office after my class ended. The program coordinator instructed me to sit down, which was unprecedented in my experience. My anxiety was already rising, when the coordinator said in Spanish that the World Trade Center and [erroneously] the White House had been destroyed in bombing attacks. I sat stunned for a moment and then burst into tears, although I had never been to either site at the time and hardly knew the significance of the former. With many compatriots that day, my sense of the unique security of the US borders started to slowly crumble into a greater sense of global vulnerability. More importantly, my understanding of US standing, even among close allies, was about to become much more realistic. Fellow classmates drew closer to me as this bit of drama was played out. As I sat weeping, a classmate whom I considered my friend told the group, "Who cares if they deserve it? It was a terrible event." I looked up and was stunned again.

The moment was an awakening for me in many ways. I had studied with the same small group of students at Venezuela's Central University for over a year. This was the year in which we learned about the global political economy and planning for human well-being. Yet, it had not crossed my mind that such a negative, almost openly aggressive, view might be the opinion of an overwhelming majority—not just students, but also professors and staff. Then I realized that something in the composition of my country's shared understanding of its place in the world might lead us—US society—toward institutional blindness. Something in our shared worldview made the widely aggressive reaction to US actions to maintain its interests in the world—widely called US imperialism even by its allies—invisible to many citizens.

This personal experience has been provoking my consciousness since that day, prodding the question: What prevents us from knowing what our systems produce daily? This work suggests that this experience is germane to the argument presented here; namely, certain types of knowledge are informationally locked into society in such a way that they are inaccessible to the general population. Further, this inaccessibility or blindness may be producing much less-than-positive outcomes.

Social Complexity: A Socially Interactive Unit of Information

The assumptions used here are meant to connect the foundational ideas in information theory summarized above with information-oriented concepts and theories in social psychology and other disciplines that are pertinent to internalized social structure. In particular, there is a need

for a socially interactive unit of information to be both bound to language expression and free from dependence on a single form of representation. In summary, the present study has asked: What unit of social interaction can be seen as equivalent to Shannon's information? Based on the reviewed social and information theories, I equated several terms as a basis for answering this question and socializing Shannon's theory more comprehensively, including information, complexity, and uncertainty. Put more simply, the unit, I argue here, is social conflict in all its forms, even those that are non-violent.

Measuring Social Complexity

An Interactive Unit to Measure Complexity:

This section is meant to explain why this broad range of theories and my argument about its fit with information theory. Simply knowing what social conflict is locked in which institutions—starting with the level of formal rationalization in contrast to the entropy in any given population—perhaps offers some insight into how complex societies might move toward more equitable, ecological, and politically possible paths. These paths are suggested here as useful in maintaining Earth's socioecological systems as we know them.

Entropy, as we have seen, is measured in communication using the probability of letters and words reducing the complexity of the next bit of message uncertainty. Early theorists used the experience of the printers of English books as a basis for the probability of a letter appearing next in a message by analyzing the number of letters printers had on hand for everyday printing (thought to depend on a practical sense of their occurrences). A modernized version of this method is suggested.

Social media giants, such as Google, Twitter, and Facebook, use algorithms to assess their content—i.e., “searches” occurring on these platforms and in the content of posts (Kwan, 2016). Tech giants use these systems to flag posts related to things like racism or terrorist threats. The underlying algorithms could be used to determine the probability of content types within a loosely held universal scheme of topics used to assess the possible range of social information. One such scheme may be the use of ethnographic matrices in anthropology to study cultures that have not been previously contacted or studied. The topics of focus for ethnographers include things like the domestic sphere, family, work, education/training of children, ceremonies, gender roles, politics, tools, recreation, food, the arts, and religion. Each of these represents a sphere of a possible conflict that can be reduced by human institutions and is evident in communications among the members of society. These topics might take the place of the species in the Shannon diversity index in which species are recognized inductively but compared across space and time based on their meta organization into genetic and other groupings. For a social complexity measure, topics as recognized by an outlet of social media would become the equivalent of species counts in Shannon diversity. The prevalence of each topic would then provide the probability of occurrence (with the log form depending on an inductive assessment of model fitness).

Social Complexity and Language Complexity:

According to the thought presented here, using these categories of possible conflict, one can predict information complexity across groups and over time and may inversely relate it to institutional and linguistic complexities. On one hand, societies or groups with a large vocabulary in languages like English might apply words within institutional silos within the

much-reduced pools of conflict open for population interaction. This vocabulary would then become unlikely in normal communication, thus simplifying the mundane communication patterns that are likely to occur in the larger population but increasing the overall volume of vocabulary.

Simpler societies with less complex institutional silos might have a less voluminous vocabulary, but this more limited vocabulary may be more widely known and may be used in more complex ways (consider the recent argument about literacy in the colonial US and the widespread distribution of the pamphlet *Common Sense*, a document with a reading comprehension level arguably much above the great majority of the US population today). Communication in less institutionally complex societies may take on the existing population-level social conflict in more creative or charismatic ways (e.g., humor, riddles, stories, and myths). Namely, a more widely known vocabulary may be used in more complex ways to reduce the large amount of conflict commonly experienced by its populace.

CONCLUSION

Alienation And Perceiving Social Complexity

Sociologists, from the classical period, have suggested that the complexity caused by large-scale industrialized societies has alienated people from the fabric of material existence experienced much more closely by so called traditional societies. In these societies, particularly in historical times, all resources and relationships were evident to all members of the community, and the methods for making tools and other necessities were widely known. By the term alienation, theorists meant that modernized and industrialized societies became much less able to see human processes in relation to the affected people and humanity's impact on the material world.

I suggest here that information theory is focused on just this type of perception, meaning that simply knowing clearly what we know about the world (Schumacher, 2015) as ordered through institutions may help the populace of a society take further steps toward understanding these complex institutional contexts and the resulting, often uneven, distribution of resources. 'Seeing' through the naturalizing effects of social systems may reduce the frustration of organizing for causes that seem intractable or inaccessible to everyday people (Brown and Kyttä, 2014), a problem experienced widely across advocacy groups in my personal observation (McCullough, Lugo, and van Stokkum 2019; van Stokkum 2019, 2022).

This follows Goffman's use of the term 'reflexive' to describe social information: collecting, communicating, and creating social information through the cycles of interlocking impact, in which every point of view matter for material outcomes. Information-based analysis of social information as representative of conflict may also help ease the increasingly alarming calls by scientists about socio-ecological problems termed 'wicked' decades ago due to their shifting social foundation (Head and Alford, 2015; Peters, 2017; Rittel, 1967; Salwasser, 2004).

Directions For Future Research

Finally, to clarify the possible impact of Shannon's information on addressing complex social problems, I include a list of areas for future research all of which focus on characterizing societies or groups in relation to their institutional contexts as information systems.

- Analysis of information content in Google searches (composition of topics) across the US, including differences between inner cities or marginalized areas and elite (gated) communities. One research question might be: Do significant informational differences occur between areas better served by US institutions than those left to create institutional frameworks? This work might quantify the uneven experience of underserved communities and explain charismatic behavior strategies as a tool for addressing conflicts not addressed by the institutions of dominant society.
- Analysis of Tweets (composition of topics) across nation states, including differences between societies with less complex institutional contexts and economic/social "development." A possible research question is whether significant differences exist between geographical areas considered developed and those considered developing. This research might speak of institutional disparities between nation states in global regions without access to the powerful US financial and other institutions.
- Analysis of information content across historical texts starting in English, with future research across languages. The goal here is to assess changes over time. One research question might be how information content changes as cultures drift toward 'developed' institutional contexts.
- Qualitative analysis of the strategies used under different levels of information complexity to address conflicts that remain at the population level. In very complex institutional settings, this might mean that there is much conflict around a few topics, such as race or gender, in the US. Societies that are more informationally complex but labeled less developed (less institutionally complex) may have more individual-level strategies for resolving conflicts. A research question might be: What differences exist between locations with higher institutional complexity and those with lower institutional complexity (i.e., lower vs. higher information complexity) in their conflict-reduction strategies?

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