An Evolutionary Theory of Knowledge: Knowledge's Structure, Generation, Transmission and Significance to Social Theory

A Brief Sketch of Knowledge

The object of social theory is society as defined by its human agents and their interactions with one another and the environment. Any orderly interaction requires some set of knowledge that coordinates agent action with the features of the environment in which the agent acts and some mechanism that updates that knowledge. Though human cognition is affected by biological structure that has resulted from evolutionary processes, humans do not, *a priori*, have a fully developed base of knowledge that allows them to interact with the environment. They must develop such knowledge by interaction with the environment, which includes interaction with other humans. This knowledge and the process of learning by which it develops is typically taken for granted within economic theory (Hayek 1937). In what follows, I introduce a sketch of knowledge and learning whose elements will be further elaborated.

Reality is perceived through the senses. The data perceived by them is organized in accordance with prior beliefs, those statements concerning reality that one assumes as fact. As Kant (1998) observed:

> Even among our experiences cognitions are mixed in that they must have their origin *a priori* and that perhaps serve only to establish connection among our representations of the senses. . . they make one able to say more about the objects that appear to the senses than mere experience would teach, or at least make one believe that one can say this, and make assertions contain[ing] true universality and strict necessity, the likes of which merely empirical cognition can never afford. (128)

If data is lacking, one's theory of the observed phenomena fills in the details. If there is discrepancy between one's beliefs and one's observation of reality, beliefs must be updated so as to facilitate new data. If the belief that appears to be violated is a core belief, the observer may investigate further to

reveal the nuance that led to the apparent violation.

Such updating is a definitive element of agent learning. As part of the learning process, individuals attempt to copy the actions of others and the logic that drives those actions. They test predictions generated by this knowledge – i.e., their beliefs – against reality. Describing a process of learning, which is really the process of the generation and refinement of knowledge, requires a nested perspective. Learning occurs at different levels. At the most basic level, learning occurs within the body of the agent. Internal systems adjust according to input that is derived from external conditions (Hayek 1952a; Clark 2016). The interaction of these systems and the environment generate what we experience as consciousness (Dennett 1991). The consciousness generated operates in terms of categories (Searle 2006; Mises 2007). Agents hold that these abstract categories of objects are related causally to one another. What results is a mental model representing agent knowledge. The knowledge generated can be explicit, where the agent is conscious of the relationship assumed, or tacit, where the agent interacts with the objects without having explicitly identified the relationship that he implicitly assumes by his interaction with the environment (Polanyi 1958; Nelson and Winter 1982, 76-82). By speech and by action more generally agents communicate their *understanding* to one another. If the interaction of agents is to be rich and constructive, interpretation of language by agents – I use the word "language" to denote meaning both in words and in actions – must be common (Wittgenstein 1953). For this reason, learning tends to occur within a community where repeated interaction supports the development of shared language and concepts (Polanyi 1958, 207-9).

Learning occurs in groups. In this spirit, we see divisions in schools of thought in academia and the emergence of sects within religions. Division at the macroscale represent cohesion within the groups where common identity and language creates a notion of distinction between groups and a space of privacy within them. To the extent that groups have a means of communicating with one another, agents in these groups might also learn from one another. Divisions may result, not only due to

disagreements *within* a given framework of understanding where foundational assumptions are shared, but heterogeneously interpreted. Differences in belief concerning foundational claims may have radical effects on the interpretation of phenomena, including the tradition in contention. Despite this, subgroups that are at odds over interpretation within a tradition often share many practices and beliefs. Consider that we see a division within Islam concerning the legitimacy of the claim of either the Sunni or the Shia over inheritance of the legacy of the prophet Muhammed (Armstrong 2000; Denny 1994), yet we also consider the totality of Islam to represent a body of thought. Such bodies of thought include claims about objective circumstances as well as normative claims that are commonly implied by its assumptions. Common understanding of agents within a group provide the foundations for institutionally guided interaction. Institutions are *coordination devices*, which include norms, rules, and strategies, as well as formal institutions that explicitly denote a hierarchy of offices, each subject to particular rights and obligations (Ostrom 1986; 1990; Searle 2005).

Finally, knowledge is generated and acted upon in environments where resources are scarce. If a set of knowledge does not help an agent or group of agents survive in a given environment, agents employing that set of knowledge will, on average, not survive. Ideas, just like organisms, must adapt to the environment or else face lower rates of survival or extinction.

Explanatory Social Theory

The purpose of this explication of knowledge is twofold. First, a pure social theory requires coherence with its object of analysis: society (Wagner 2010; 2016). Society is comprised of individuals and is defined and continually transformed by the actions of these agents. As psychologist Carl Jung observed, the individual is "the instigator, inventor, and vehicle of all these developments, the originator of all judgments and decisions and the planner of the future (1957, 45)." In economics, we refer to such an actor as an *entrepreneur* (Kirzner 1973; 1997; Rizzo and O'driscoll 1985; Koppl 2002). The action of the individual is coterminous with logic. It is agent *understanding* of the environment that drives her

interaction with it (Mises 2007; Johnson-Laird 1980). This understanding may be implicit or explicit. The entrepreneur employs some given means to attain desired end, or more generally, to bring about some end state that she prefers to the state that would arise absent her intervention (Sarasvathy 2001). The end attained is a final good, while objects produces to serve as means for such attainment are intermediate goods (Menger 1871). If I build a net to catch more fish, the net is an intermediate good that serves as means to catch fish, which are final goods.

In describing the nature of a good, Carl Menger identifies agent understanding as necessary for the object's categorization as a good. In order for an artifact to be a good entails four requirements:

1. A human need
2. Such properties as render the thing capable of being brought into a causal connection with the satisfaction of this need.
3. Human knowledge of this causal connection
4. Command of the thing sufficient to direct it to the satisfaction of the need. (1871, 52)

We concern ourselves here with the second and third properties. Traditional analysis represents these second and third properties in a manner that lacks dimension. Most theorists have been ignoring the texture of agent knowledge.[1]

The second purpose descends from the first. If we are to formally model society, meaning that we model human action as guided by agent logic, we require identification the logic described as "a causal connection". Any explanatory theory can be described as a theory whose ontology is an abstraction of the agents, artifacts, relationships, and transformational processes present in the real world (Fleetwood 2015). Theoretical objects and processes must correspond to objects and processes in reality.

A robust social theory requires consideration of different levels of analysis. We have first to consider the logic of the human agent. It is action generated by agent intention that determines the

[1] Notable exceptions include Arrow (1974), Williamson (1973), Simon (1974), Hayek (1937), Aumann (1976), Ostrom (1990), among others.

ends toward which this logic is ultimately employed (Searle 1979). This action is affected, as well as interpreted, by other humans as they comprise part of the environment with which any social agent interacts. Agent interaction drives the formation of institutions. These represent shared knowledge that allow agents to communicate and, therefore, interact with one another in orderly fashion. They imply that a finely detailed social theory requires identification of the internal states that drive agent action as well as mechanisms that coordinate beliefs and, thus, actions between agents. What follows will provide a general structure of knowledge and elaborate on the role it plays in any social theory.

Rationality: Individual and Collective

Agent Learning and Cognitive Structure

Humans act. Human rationality drives that action (Menger 1871). Rationality is not, as implied within some systems of economic thought, utility maximization where preferences are reflected by a utility vector whose units are homogeneous (Debreu 1959; Arrow and Hahn 1971). Human agents act with intention to realize ends they most value. They attempt to maximize utility *ex ante*, however, this attempt is not the same as an accomplishment of the task. Utility maximization, whether local or global, is an outcome that occurs *ex post*, arising from a process of trial and error within an environment subject to competition and selection (Alchian 1950). This process yields a result typically assumed by neoclassical theory. It tends to bring agent expectations – agent knowledge – into convergence such that they match the objective reality, which includes the expectations of other agents.[2]

Human agents learn by two modes. The originary mode of learning, that which identifies and

[2] This is in accord with two points raised by Hayek (1937) concerning social theory that proposes convergence of agent expectations:

> . . . in order that all these plans can be carried out, it is necessary for them to be based on the expectation of the same set of external events. . . The plans of different individuals must in a special sense be compatible if it is to be even conceivable that they will be able to carry all of them out. Or, to put the same thing in different words, since some of the 'data' on which any one person will base his plans will be the expectations that other people will act in a particular way, it is essential for the compatibility of the different plans that the plans of one contain exactly those actions which form the data for the plans of the other. (37, 38)

exploits hitherto unperceived opportunities within the system, is a process of trial and error. The result of action is interpreted by observing agents. Agents who are better than others at predicting the future in an environment that constantly generates novelty, and therefore are better at accomplishing goals within it, tend to be those agents who lead by example (Dekker 2016; Henrich and Gil-White 2001). Other agents who recognize the value of an exemplar agent's strategy will attempt to adopt the exemplar's strategy. Most learning occurs by a process of copying the strategies of others and applying them within one's own context (Bikhchandani, Hirshleifer, and Welch 1998; Earl, Peng, and Potts 2007; Hayek 1967).

To formally model the agent, we move beyond general references to learning and identify in abstract the primary elements involved in this process. Ego consciousness is the thinking, observing part of the agent that affirmatively states "I am". It abstractly represents the reality of the human agent. Some parts of one's *understanding*, such as habits, do not lie within the purview of agent consciousness (Dewey 1906).[3] Knowledge is also embedded in action and processes that lie below the awareness of consciousness. Both knowledge contained in action and in conscious abstraction can be represented ontologically: represented in terms of objects, relationships between those objects, and processes that transform both of these (Lawson 2014; Menger 1963, 37)[4]. Explicit denotation of the agent's mental

[3] Dewey attempted to distinguish his theory from the Aristotelian logic, but this distinction seems to be self imposed. Dewey's use of evolutionary mechanisms to his system can be more properly thought of as an extension of Aristotelian logic rather than as opposition.

[4] While Menger does not employ the word "ontology", he does identify the components of ontology and the role of theory as describing the world as it *is*:

> . . . and in the field of economy, also, we will thus have to differentiate on the one hand between individual (concrete) phenomena and their individual (concrete) relationships in time and space, and on the other between types (empirical forms) and their typical relationships (laws in the broadest sense of the world). (37)
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> We have *gained cognition* of a phenomenon when we have attained a mental image of it. We understand it when we have recognized the reason for its existence and for its characteristic quality (the reason for its *being* and for its *being as it is*). (43)

model includes both explicit *and* tacit knowledge.

An agent's personal ontology – his knowledge – is the same as his beliefs about the world (Nonaka 1994).[5] It is by these beliefs that the agent will interact with his reality. We can conceptualize the personal ontology of an agent by the statement, "X counts as Y in C". For example, the raising of hair on one's neck, X, after receiving some strange or unexpected packet of information from a source C, may lead an agent to feel she is in danger, Y (Searle 2006). The agent endows the present scenario with particular meaning and takes action that she believes is appropriate given this integration of information into her knowledge. The same pattern of perception occurs with visual observation of a process. The physical reaction itself represents the most elementary form of interpretation upon which the agent may consciously elaborate (Hayek 1952a; Lewis 2016).

The agent's environment typically includes other agents. As these agents are also operating with some representation of reality, there must exist some means of coordinating action between them to reduce the incidence of one plan obstructing another. Consider that I chose to drive on the right side of the street today because that is custom in the U.S. (It is also law, but I expect that driver behavior in the U.S. would change little if the law was reduced to a simple norm.) There exists a belief in the mind of each driver that others will follow suit. This common belief represents an institution that coordinates the agents who act in decentralized fashion. Institutions represent common belief among agents about these objects and processes.

An agent's personal ontology includes only those objects known to the agent and thought to be

[5] Nonaka provides a definition of knowledge as process:

> It should be noted, however, that while the arguments of traditional epistemology focus on 'truthfulness' as the essential attribute of knowledge, for present purposes it is important to consider knowledge as a personal 'belief,' and emphasize the importance of the 'justification' of knowledge. This difference introduces another critical distinction between the view of knowledge of traditional epistemology and that of the theory of knowledge creation. While the former naturally emphasizes the absolute, static, and nonhuman nature of knowledge, typically expressed in propositional forms in formal logic, the latter sees knowledge as a dynamic human process of justifying personal beliefs as part of an aspiration for the 'truth.' (15)

pertinent to the task at hand. Consider some essential beliefs of a student in primary school. If the student is told that he must write an essay at the desk, the student must envision several things. First he must imagine what the arrangement of the desk will look like. He will sit in a chair at the desk and use a pencil to write on the paper. Thus, he links these objects in a cluster, understanding them by their functions and relationships. The desk will serve as a solid base on which rests the paper. He takes his ideas and uses the pencil to transform the paper from a blank sheet into a coherent (ideally) essay. If the student had no concept of what a desk or piece of paper or a pencil is, he would be unable to complete the task. The student will likely not concern himself with the texture of the ceiling or the color of the floor in accomplishing this task as, excepting special circumstances, they lie outside of the domain of the task at hand. Whatever student's action, the observer can derive at least some of the elements of that student's understanding from it (Koppl & Whitman, 2004).

The human mind tends to represent an environment in relatively simple terms. Humans can manage only a small number of chunks (objects), 5 to 7, within short term memory (Simon, 1974). Objects (chunks) may be simple or may exhibit complex, nested structure (Miller, 1955). These require experience that generates representations of these objects in the long-term memory. By holding objects of greater complexity in one's long-term memory, an individual is able to perform more complex operations using short term memory as long-term memory is capable of holding many more objects than short term memory (Miller, 1955; Ericcson & Kintsch, 1995). It stores these objects within a structure of objects, which is itself a macro-object. This sort of nesting greatly increases the ability of an individual to perform complex tasks. It is this function that allows experts, such as chess masters, to greatly outperform novices (Chase & Simon, 1973). Not everyone can be an expert, and no expert has a monopoly on knowledge. Due to computational limitation, knowledge must be distributed.

Defining Agent Rationality

Rationality includes two components. The first is described above as an agent's mental model or

personal ontology. This personal ontology represents some logical structure that relates objects in an environment by rules governing their interactions. For example, if the student in the above example press the pencil to paper and drags it, he likely expects that a dark line will be left wherever the pencil is pressed. The second component of rationality is classification. Agents not only need to understand their reality; they must also order ends. A classifier is responsible for this process (Booker, Goldberg, & Holland, 1989; Holland, 1992). Systems of artificial intelligence rate decisions according to a formula that scores strategies and the desirability of objects of analysis. Human agents rate decisions according to similar rules that they adopt to govern behavior (Gigerenzer & Goldstein, 1996). An individual who is choosing players for a pickup basketball team (let's assume these players have not met before), for example, may always choose the player from the group who is the tallest. Such an indicator may help that individual overcome his ignorance concerning each particular player. For ultimate (higher level) ends, the role of selection is taken on by passions, those drivers of sentiment that shade our interpretation of the external world and from which desire manifests (Polanyi, 1958; Hume, 1896; Carroll, 1895; Blackburn, 1995). Self-autonomy lies in the choice of man to govern his passions, or not.

We arrive at a more robust formulation of rationality within economics. Some economists assume that agents act in a manner that they expect will maximize utility (Stigler & Becker, 1977; Becker, 1998). All action is presumed efficient given some set of knowledge. While true, this tautology tells us little concerning how agents can adjust their plans in order to promote coordination at the system level (Hayek, 1976; Klein, 2012).[6] Within the static framework, agents cannot learn. They respond to incentives, adjusting their ownership of assets according to income and relative prices changes. I present a dynamic framework that allows agent knowledge to change as they *discover* new strategies and learn from agents they perceive to be superior. This allows for a robust formal description

[6] Klein refers to this as concatenate coordination. An appropriate interpretation of "concatenate" as a verb is "to join".

of entrepreneurship (Caton, 2017).

We can also identify a relationship between knowledge, preferences, and action. Knowledge represents an agent's *understanding* of the environment. It is from this knowledge that agent preferences emerge. In contrast to the assertion of Stigler and Becker (1977) who hold that, within an economic model, agent action must be the result of a change in the environment, not preferences, a dynamic model of society does not hold agent preferences constant. Even if they were constant, they are complex as instances of preference ordering is context dependent for a given preference function (Emmett, 2006). A change in knowledge will likely change the preference function of an agent.

There are two modes by which agent actions may adjust absent a change in the environment. In one circumstance, the agent preference changes due to a change in the mechanism that selects ends. The modeler can represent this by a change in a classifier. In reality, these changes are driven by a change in the degree of one's passion for an object or a change in the object of one's passion. Preferences depend also on available knowledge. Integration of new knowledge will drive changes in the agents' patterns of action.

Language Games: The Structure of Communication and Coordination

Within the tradition of Arrow-Hahn-Debreau, agent preferences are assumed to be independent of one another. There is no communication between agents except for perceived changes in prices. In this understanding of the economic agent and the society he helps comprise, there is no endogenous dynamic that can arise due to the creation of a disequilibrium condition for some agents by actions of another (Axtell, 2005). There is also no learning in the sense that agent knowledge changes endogenously. A robust social theory compatible with modern techniques of simulation must accommodate these features.

The static framework requires exogenous shocks to move a system out of equilibrium**.** A change in variable *x* leads to some magnitude of change or mean of a distribution of changes in variable *y.* The

processes that generate particular relationships between variables that arise through social intercourse are more roundabout. The application of the scientific method to economics strips away the subjectivity and complexity inherent in Human Action. It assumes away the effect of agent perception on social outcomes (Hayek, 1952b).

One way to integrate endogenous dynamics typically absent from theory is for the modeler to provide general scaffolding of action that is defined by some set of rules that govern behavior. For example, agents may respond to changes in the availability of a resource by incrementally adjusting the prices they are willing to pay for a unit of the good. Or maybe an agent has a rule where he responds to the relationship between the actual price of a good and the price that he believes to be the true price. Rules such as these and the parameter values that comprise them guide the interaction of agents.[7] They can be mixed and matched by the agent in an attempt to improve his or her position. The number of possible combinations are finite yet *vast*. The number of combinations is too large to be fully identified by any individual. Further, the injection of novelty may allow rules governing action to evolve.[8]

We approach this form of agent interaction and learning abstractly as part of a language game (Wittgenstein, 1953; Kripke, 1982; Lyotard, 1984; Hassard, 1994; Mauws & Phillips 1995; Bloor, 1997; Koppl, 2002). A language game is "a set of rules governing action and reaction" and guiding interpretation of action between different players (Koppl & Langlois 2001, 287). If a teacher walks into a room and says, "Let's begin!", the appropriate response of the students is to cease conversing and direct their attention to the teacher. The phrase spoken by the teacher under a particular circumstance evokes a response from the students. The response of the students is akin to the salivary response found by Pavlov (1927). The ability of humans to interpret phrases and action abstractly allow for a wide variety of responses of this sort.

[7] In many cases, parameter values are random or change depending on the environment.
[8] On application of rules, see Bloor (1997, 10).

Games tend to be more complex than the above examples. The pattern of call and response within a jazz performance, for example, does not generate results that are one-to-one. The play is structured, but it is also open-ended. A particular signal can emit a variety of responses from an agent depending upon the environment in which the signal is received and the state of that person's knowledge (Rescorla, 1988). Some responses may even generate novelty! While the response of any individual may be difficult to predict, when human agents communicate and interact, the system formed by their interactions tends to converge upon a circumscribed set of responses that define play within a given game:

> The rules of a language game are constraints, not marching orders. The rules of chess constrain us. Only certain moves are allowed. But the moves we make within the constraints are freely chosen. . . . Good players typically adopt rules of thumb, however, to guide their choices. Depending on the purposes of the analyst, these rules, too, may be thought of as part of the operative set of language games governing play of the game. (Koppl & Langlois, 2001, 290)

Rules that govern social games are not static. There is always room for development of the patterns of action that arise within the game. Agents may generate novel play that falls within the rules that govern interaction. Agents, sensing opportunity, may also take novel action that implicitly reinterprets the rules that govern play.

Rules guide both action and interpretation for observers both within and outside of a game (Koppl & Whitman, 2004; Hayek, 1962).[9] In a game of basketball, we expect that if a player places both hands on the ball after having dribbled, that player can take two steps before either passing or shooting, or he must cease movement across the court. After stopping, the player cannot legally dribble again. Given this rule, a player defending against someone who has ceased dribbling will expect that the

[9] Koppl and Whitman discuss *homo basketballicus* in this manner: Suppose we wish to describe the on-court behavior of professional basketball players. We construct a model under the assumption that basketball players are motivated solely by the desire to win basketball games. With this assumption we have defined an ideal type, which we will call *homo basketballicus*. This ideal type, combined with knowledge of the rules of basketball, leads us to certain conclusions about his play. For instance, he will likely pass the ball to another player when the other player clearly has a better chance of making a basket.

players range of motion has become constrained. This expectation coordinates the actions of both players. It is built upon knowledge of requisite objects, rules that constrain the use of these objects, and patterns perceived as arising within these rules.

Modeling Play and Learning within Games

Given a representative ontology of a game and the appropriate statistics, an interested party can create an agent-based model of high fidelity. For a game of basketball, statistics of interest might include the probability of a foul being called on a defender either per unit of time spent defending against a particular player or per shots guarded against a player. Another may include the probability of making a shot, assuming it is not blocked, from a particular area of the court. More significant for the framework described here, an agent-based model will also include player decisions contingent on the arrangement and motion of objects in the environment. For example, maybe when guarded by two players at the top of the key, Stephen Curry will pass the basketball 50 percent of the time, shoot it 25 percent of the time, drive to the hoop 15 percent of the time, and move to another area 10 percent of the time. Or a model may select plays based on the probability of some play being run by a particular team given the arrangement of players on another team. The better the modeler is at identifying circumstances of statistical significance to outcomes, the more accurate will the predictions of the model be. Once the appropriate rules guiding agent action are defined, a model of the game can be run numerous times in order to generate the probability of a team winning or losing.[10]

Or consider a model of traffic jams. In such a model there is a critical threshold at which average rate of movement of vehicles tends to slow at a greater rate than the rate of increase of vehicles on the road. A core theoretical model like this one can be integrated with real world data to predict patterns of traffic on a given road or expressway (Balmer, Cetin, et. al., 2004). In each of these models, however,

[10] These simulations are essentially the equivalent of a basketball videogame where "computers" control the play of each team.

the structure of agent knowledge is static.

The aim of this paper is to develop an abstract framework for modeling human action where the knowledge driving preferences changes to match the environment. That is, agents learn as they interact with the environment. The example of a basketball game is limited in that it is difficult to accurately model the manner in which particular players will learn from one another. A model could include learning within the game, but that model will more than likely not generate results that accurately predict outcomes in the game. Point prediction in a robust theory of society is a secondary goal that must follow first from understanding of the phenomenon in question.[11] We are interested in a model that allows agents to adjust their knowledge so as to allow for systemic coordination. In an agent-based model of basketball, this may be accomplished by allowing an agent to adjust the value of a parameter whose use is demonstrated by other agents. For example, maybe a certain agent only defends against a moving player by maintaining a close distance between himself and the player he is guarding. Upon observation of other players, the defender notices that he may adjust the distance according to the opposing player's distance from the basket. Likewise, a player may experiment with changing his direction and speed in order to coordinate with another player moving across the court.

A similar strategy for modeling is used in a heuristic rendition of Sugarscape (Caton 2017) where agents innovate and copy strategies with unique parameter values. As the environment, which includes other agents, changes, so too does the composition of strategies present along with composition of parameter values that guide these strategies. Changing strategies represent changes in knowledge that typically alter the means and ends of an agent at a given time and place. In a given context, the agent chooses the next action according to the arrangement of elements in the environment as well as those in the agent's mind.

[11] This is not to argue that tools for prediction generated from a purely positivist framework are not useful. Their explanatory power is limited to a different and smaller domain than that of pure theory.

Theory of Learning Process[12]

For a game like basketball to be played at all, every agent must have some basic knowledge of the rules and of strategies by which he or she might coordinate with another player. Each of the players on the court has a shared and interlocking mental models (Denzau and North 1994; Koppl, et. al., 2015) that includes the goals within the game and its rules and strategies. These mutually guide agent interactions. This set of behavioral rules, evidenced by the actions of players with knowledge of the rules constraining play, represents an institution. This knowledge is the *interface* by which agents interact with reality, and therefore, with one another (Simon 1969).

Cues within a game facilitate communication and planning between agents. In his discussion of language within a firm, Arrow (1974) refers to these as codes and recognizes their role in communication:

> Learning a foreign language is an obvious example of what I have in mind. The subsequent ability to receive signals in French requires this initial investment. There are in practice many other examples of codes that have to be learned in order to receive messages; the technical vocabulary of any science is a case in point.

Within an organization, the formulation of a special language serves both roles of communication, as well as secrecy and separateness. It's play helps to identify those who are in the in-group (Sowa 2007; Koppl 2002, 74). "Any in-group has a relatively natural concept of the world which its members take for granted (Schutz 1946, 464)." To the extent that these concepts are unique to the group, those outside the in-group are not privy to these concepts or the language used to describe them. Divisions of this sort exist at a variety of scales.

This pattern of shared knowledge and means of communication allows for knowledge creation within groups and organizations. It allows for learning. The learning process can be divided into three stages:

[12] Thanks to Anna Zaytseva and Melissa Eitzel whose discussion helped me to develop the structure of this model at the Santa Fe Institute in 2015.

1. Discovery: Generation of a novel idea or change to an existing idea
2. Interaction: Dialectic among agents of interest
3. Integration: Assimilation of innovation into understanding of agents and/or into external technology.

The entrepreneur drives this process. Concerning the generation of a change in *understanding*, Ikujiro Nonaka (1994), in a manner reminiscent of Viennese tradition, identifies:

> The prime mover in the process of organizational knowledge creation is the individual. Individuals accumulate tacit knowledge through direct "hands-on" experience. (21)

He notes that while tacit knowledge plays a significant role in the development of personal knowledge, experiences that generate such knowledge:

> Have to be counterbalanced by a further approach to knowledge creation that raises the quality of explicit knowledge . . . The interaction between knowledge of experience [tacit] and rationality [explicit] enables individuals to build their own perspectives on the world. Yet these perspectives remain personal unless they are articulated and amplified through social interaction (22).

The development of knowledge starts with the individual, however, it is only of use to others if that individual finds a way to share this knowledge. Sharing demands a common language as well as common understanding that facilitate the transmission of new knowledge (Grant 1996, 116). Common understanding does not imply identical understanding. Agents must have a sufficient degree of common understanding engage in a dialectical process that allows those involved the opportunity to work out differences of interest (Rosser 2000). They discuss and focus interaction around the new idea or innovation and posit alternatives. Eventually, the group may converge upon common understanding, in which case the new idea or innovation is integrated into the group's common knowledge. The three steps are discussed in detail below.

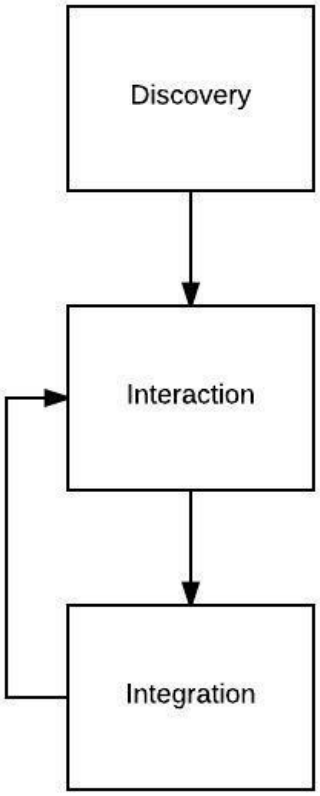

Figure 1
After the new idea is shared between two agents, the process of interaction and integration duplicates itself across populations and at different levels**.**

Discovery

The human agent is a node that gathers, interprets, and shares information. She takes action based upon her accumulation and interpretation of information. Intelligence lies in the ability to act in a manner that coheres with the environment. Humans search for patterns and meaning in their environment that allow them to predict likely future states (Hayek 1964).

Discovery is a result of search by an individual agent (Nonaka 1994; Floyd and Wooldridge, 1999). When an agent discovers new information, he must integrate it into his own framework. This requires a process of interaction within the agent as he must identify the relationship between the new

information and the existing framework. The information must cohere with the mental model, or else be disregarded absent a transformation of the mental model. In this sense, even in the process of discovery we see interaction and integration occurring between the agent's "mental model" and the outside world (Johnson-Laird 1980). The agent himself facilitates this process. He restructures his model through an ongoing process of trial, error, and reinterpretation (Hayek, 1955; Johnson-Laird 1980, 81, 108).[13] By this process, he hopes to overcome ontological uncertainty.[14]

It is likely, that the agent will have to employ different mental models depending on context. The level of coherence between mental models depends on the preferences of the agent in light of the demands of his environment. For this reason, many people are comfortable with participating in a religious group without worrying that the logic of their faith contradicts the logic of science. Given apparent contradictions between models, some may develop a rule where, in the case of a particular type of contradiction between models A and B, defer to model B. Others may take this further and engage in apologetics so that the models more faithfully cohere to one another.[15] As the logic of a given model or models has attained an adequate level of coherence, the new idea is ready to be communicated to other agents.

Interaction

Once the agent believes that he has sufficiently worked through the logic of the transformed

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[13] Hayek argues:

> Any model defines a certain range of phenomena which can be produced by the type of situation which it represents. We may not be able directly to confirm that the causal mechanism determining the phenomenon in question is the same as that of the model. But we know that, if the mechanism is the same, the observed structures must be capable of showing some kinds of action and unable to show others; and if, and so long as, the observed phenomena keep within the range of possibilities indicated as possible, that is so long as our expectations derived from the model are not contradicted, there is good reason to regard the model as exhibiting the principle at work in the more complex phenomenon. (206)

Concerning the relationship between the validity of a mental model's logic and learning, Johnson-Laird notes "if you are logically prudent, you attempt to test your mental model to destruction (81)."

[14] That is, uncertainty generated by a mismatch between the agent's mental model and the reality it is intended to represent.

[15] **See St. Augustine, Aquinas.**

ontology, this mental model must interact with the models of others. Much of the knowledge distributed between, and even within, agents is conflicting or, at least, not obviously compatible (Hayek, 1945; Dennett, 1991).[16] Agents engage in rhetoric to convince one another to adjust their beliefs. As Donald McCloskey argued, rhetoric is "the art of discovering good reasons, finding what really warrants assent, because any reasonable person ought to be persuaded. . . . Rhetoric is exploring thought by conversation (1983, 483)." We must communicate our ideas in a manner that can be understood by the receiving party. This requires that agents within a group converge on a common language to describe reality.

Not all communication is verbal. An agent may engage in *rhetoric by practice*. If he has discovered a superior form of action, those around him may notice that he has accumulated more wealth or is happier or that his actions seem effortless in comparison. Others may attempt to copy and learn from such an agent just by being in his presence. If one's practice draws a following, even if only locally, he functionally acts as an exemplar agent (Dekker, 2016).

The agent conveying this unique interpretation of reality has worked to overcome ontological uncertainty that arises due to a mismatch between each agent's mental model. An aligning of models represents an aligning of expectations (Lane & Maxfield, 2005). By engaging in rhetoric, the agent shares an idea in a manner that may convince another party to transform his or her mental model. Sharing agents can work to overcome ontological and semantic uncertainty by conversation. They continually reformulate their mental models to cohere with reality and the models of one another. The stage of interaction will often lead to a return to the first stage of discovery as both or either of the agents reinterpret facts in light of communication with one another. There is no guarantee of success in this process, though the process of competition and selection tend to promote convergence to strategies that promote survival in a given environment.

[16] Dennett refers to consciousness as containing "multiple drafts".

Integration

Integration occurs when both agents come to act from a framework that includes the new idea or ideas. This does not mean that their mental models are identical. Rather, they come to agree on interpretation of an aspect of reality, say, concerning how a piece of machinery should operate or the strategy their business should employ. The development of a common understanding improves the ability of agents to cooperate with one another as their action is coordinated around the same set of rules that govern behavior, plans, goals, etc… Once agreement has been arrived at, agents may discover new problems that require the process to occur again within the same group. Or, a group may attempt to influence how another group sees reality. They can investigate reality from a new perspective and analyze elements of reality of which they were not previously aware.

At higher levels, integration requires acquiescence of a perspective by those in leadership positions. Acquiescence by leaders is not independent of the beliefs of those subject to them. Likewise, agents who submit to the rule of a particular leader also submit substantial proportion of their beliefs to shaping by the leader. While *de jure* leaders may play a significant gatekeeping rule, they do not comprise exhaustively the set of leaders. “They are not people at the top of things so much as people at the edge of things, not leaders within groups so much as brokers between groups (Burt, 1999).” Leaders occupy positions within networks that allow them to connect to distinct groups (Granovetter, 1973). These leaders exhibit a high degree of prestige that allows them to exercise a similarly high degree of influence on the beliefs and practices of others (Henrich & Gil-White, 2001; Hodgson and Knudsen 2010, 165). There is a mutual process of shaping beliefs that goes on between levels of association. Once formation of a particular opinion reaches a significant threshold within a given population, the belief tends to be absorbed by those who would otherwise hold a different belief (Asch, 1955; Henrich & Boyd, 1998).

Competition and Selection

Our agents are carriers of strategy. Their survival is dependent upon their programming. This includes the ability of agents to reprogram themselves. Agent survival is subject to one rule: the inflow of resources consumed must be greater than zero and be equal to or exceed the outflow. Biological agents need to inherit structure that allows them to acquire sufficient nourishment in the form of calories and nutrients. Again, the term sufficient means that the inflow of nutrients required for survival must meet or exceed the outflow. Survival in the competitive market requires the use of strategies that generate more value than would be generated by the next best competing strategy.

This applies to firms, which are also agents. Competing firms[17] must generate value that exceeds the opportunity cost of their use of resources. The employee at a firm must value his wage, which includes both monetary and non-monetary compensation, more highly than the wage that the employee expects to receive in service of a competing firm. Likewise, revenues earned from the sale of products must exceed the monetary costs of production.

The survival of a firm is an indicator of the fitness its strategy. Growth of a firm augments this signal. If some set of knowledge is to be described as fit for an environment, it will spread to observing agents. The process of adoption by others is by no means ensured for any set of knowledge. Nor is such an idea guaranteed to be continually maintained by an agent who carries it. Knowledge that is helpful to an agent for a brief period may lose its usefulness. The ultimate test of knowledge is its ability to survive over long periods of time. Knowledge that promotes fitness must be replicated in the manner described above. Knowledge is an integral part of the evolutionary process (Campbell, 2013; Dewey, 1908).

The process of evolution at the level of the agent takes the general form:

Replicator → Interactor → Fitness (Hodgson & Knudsen, 2010, 107)

An interactor is the unit that is reproduced. These include, for example, "organisms or business firms

[17] I refer to firms in the sense of Foss and Klein who describe firms as agents comprised of capital combinations (2012).

(93)". The replicator is a particular set of knowledge that is replicated. Genes are replicated in an organism much as skills and routines are replicated in a firm. That knowledge promotes structure internal to the interactor that promotes survival in a given environment. In an organism this is a gene. In a firm this may be some routines, norm, language set, etc… In the case of an organism, the knowledge replicated leads the organism to instantiate structure that mediates between conditions of its internal and external world. Within a firm, the replicator is often itself knowledge embodied by routines and norms that, when duplicated, will likely need to adapt to the new environment in order to promote fitness. Individuals within the organization are able to cooperate as a result of these shared norms and mutual practice and development of routines (Nelson & Winter, 1982, 96-136; Hodgson & Knudsen, 2010, 78-88). They represent "organizational memory". The result of this cooperation, dependent on knowledge present in norms, habits, and routines impacts the fitness of the organization.

Table 1
Steps of Learning Process

	Content
Discovery	• New idea or extension of existing idea is generated by an individual. • Extension may consist new application of an existing idea that will alter technologies, where technologies include a broad range phenomena including but not limited to systems of governance, engines, computer processors.
Interaction	• There will likely exist disagreement concerning the extension and/or its application. • Agents engage in dialectical process with intention of overcoming disagreement. Intention may or may not be amenable to the concerns of both parties.
Integration	• In a purely dyadic relationship, the process is complete when both agents come to a common understanding, representing a concept around which cooperation centers.

	• At the scale of the group, when a sufficient number of members adopt common understanding, the remaining members will tend to adopt the same understanding.

Table 2
Categories of Interactions

Scale of Interaction-Integration Process	Description
Dyadic	Two individuals discuss discrepancy in understanding, each mutually adjusts his or her understanding until converge on common understanding concerning topic of interest. Dyadic interactions also comprise the core of the interaction-integration process at the group and inter-group levels.
Intragroup	If sufficient number of individuals in group adopt a particular understanding and there is no competing camp, the remainder of the group will tend to adopt the dominant understanding.
Intergroup	Convergence requires entrepreneurship, typically by those agents whose pattern of relationships comprise a structural hole (Burt 1999; Granovetter 1973). Dyadic relationships that span between networks that are otherwise unconnected represent intergroup interaction

Structure, Features, and Dynamics of Knowledge at the System Level

Institutional Dynamics

Just as influential persons "at the edge of things" can sway the beliefs of groups, so can individuals who have significant influence over formal institutions. Institutions are external manifestations of agent knowledge. Causation operates both from the bottom up and the top down

(Lopez & Leighton, 2013). Douglass North observes the relationship between agent belief and institutional structure:

> There is an intimate relationship between belief systems and the institutional framework. Belief systems embody the internal representation of the human landscape. Institutions are the structure that humans impose on that landscape in order to produce the desired outcome. Belief systems therefore are the internal representation and institutions the external manifestation of that representation. (2005, 49)

Whose ideas come to dominate this "external manifestation"? North tells us that "when conflicting beliefs exist, the institutions will reflect the beliefs to those (past as well as present) in a position to affect their choices. . . (50)" If there is not agreement among those in control, conflict may occur concerning the structure through which the power of the state or some other institutional structure is implemented.

These social structures exhibit causal efficacy over the actions and perceptions of agents subject to them. They represent part of the environment with which an agent interacts. They indicate beliefs of other agents who adhere to them. The outcome of the conflict over the operation of institutions changes the constraints of an agent's action and understanding of the world. In the case where mental models interact without the mediation of formal institutions – i.e., informal institutions – changes to agent mental models tend to be the result of voluntary action given the context from which it emerges. This is not the case when governance mechanisms, and the force that underlies them, is employed to implement rules and structure that cohere with the shared mental models and preferences of a particular agent or group of agents over those of other agents. While agents subject to the institution still act voluntarily, changes in incentives accompany the changes in structure. Institutions determine the cost structure of an array actions that an agent might consider. A change in institutional structure and incentive represent a change in the agent's environment. Institutions exhibit causation by constraining or altering the array of options that an agent considers to be available to himself. They place constraints on what states of reality agents consider to be realizable and reinforce this through the

provision of incentives and disincentives. These promote shared *understanding*.

Beliefs, and knowledge contained in those beliefs, are absorbed and reinforced by the agents subject to them. This active participation moves the belief from being a phenomenon that rests in the mind of an individual to an institution whose existence and significance in the world cannot be denied. The social world is filled with these. Some of these are simple, as in the coordination game where agents must choose the same strategy (i.e., drive on the right side of the road). In other cases, agents come to communicate through a common object whose value changes. The value helps guide the decisions of an agent. Consider cars at a traffic light. Drivers learn that they should continue through an intersection when the light is green. They should stop when the light is red. Agents do not need to communicate to coordinate, they need only act according to the meaning commonly imbued to the color of each light. Prices play a similar role as consumers and producers must adjust their use of resources in light of changes in income and prices.

By the example of the traffic light, we observe that the ontological description of an institution matches the ontological description of agent logic. Just as agents understand that, concerning non-social objects, *X counts as Y in C*, we see that the statement also holds for the interpretation of institutional objects. The agent interprets that red light as meaning that she must stop her vehicle before the start of the intersection just ahead. *A red light, X, counts as a signal to stop, Y, when my vehicle is approaching the intersection over which the light hangs, C.* If a city council decides to place stop lights or stop signs at new intersections, we expect that passing vehicles will obey the signals represented by the new light in the same manner as lights that existed before. The difference between the elements of a strictly personal ontology and the elements of an institutional ontology is simply that the latter are shared while the former refer to the understanding of a single agent.

If an institution ultimately represents a belief or set of beliefs that are submitted to by some group of agents, institutions themselves represent a special class of knowledge. Thus, the pattern of

knowledge creation and transfer described so far thus holds changes in ideas *and* institutions. Peter T. Leeson (2014) identifies that the British Officer Samuel Macpherson played a critical role in replacing the institutions of human sacrifice among the Konds who inhabited part of India by means of an interaction between groups (Table 2). He was unable to accomplish this by working solely within a given village, but rather served as the primary node of communication between villages in the process. Macpherson filled what Burt (1999) refers to as a structural hole; that is, a position of contact between groups who do not communicate between one another. The actor who occupies a structural hole can be a powerful broker between interested parties that he or she connects, and is therefore in a position to influence political outcomes (Christopoulos, 2006; Christopoulos & Ingold, 2015; Batilana, Leca, & Boxenbaum, 2009). Macpherson used this role to guarantee the execution of justice and property rights absent the system that had been dependent upon human sacrifice. This represented an attempt to remove an undesirable element from the Konds' system and integrate a more humane innovation in its place. By doing so, he was able to help integrate the Western notion of human rights into a system where violation of such rights was integral to its functioning.

Leeson also highlights the role of belief reinforcement within an institution. He recalls from Macpherson that "each head of house rolled his shred of flesh [from the sacrifice] in leaves, and buried it in his favourite field (156)." This served the role of "extending *knowledge* of the community's immolation to the inhabitants of villages who were not themselves able to participate [emphasis mine] (156)" and thus ingrained the society's institutional structure and the human sacrifice around which it centered into the beliefs and habits of those subject to it. To change the institution required that individuals in Kond society adopt new beliefs. Macpherson helped motivate *integration* of a Western ideals into the Konds' system by coordinating the practice of leaders across their society to cohere with human rights. In return the British offered to administer a system of justice (161-62).

As the story of Macpherson and the Konds indicates, our investigation of a process whereby an

agent's mental model interacts with the mental models of others through collective or coalescent action and belief, thus, leads us to a process of institutional formation and observation of their causal efficacy. Beliefs not only guide institutional formation, but may also change as a result of changes in institutional structure. The organization that emerges from shared understanding or submission to a formal institution is a form of social capital. This carries with it advantages:

> Social capital represents the ability of actors to secure benefits by virtue of membership in social networks or other social structures. At an organizational level, benefits include privileged access to knowledge and information, preferential opportunities for new business, reputation, influence, and enhanced understanding of network norms. (Inkpen & Tsang, 2005, 150)

These privileges come alongside obligations upon participants:

> Human institutions are, above all, *enabling* [emphasis author's], because they create power, but it is a special kind of power. It is the power marked by such terms as: rights, duties, obligations, authorizations, permissions, empowerments, requirements, and certifications. (Searle, 2005, 10)

In the case of the Khond's, each person in the village was obliged to participate in the system on some margin. Likewise, in the new system, participants were required to submit to legal enforcement by the British. In order for institutions to function, agents must embrace their roles as defined by their rights and duties of office. They must act upon the belief implied by their submission to the institution, its rules, and its language.

Games in and Between Networks

The existence of groups that generate and are subject to common knowledge innately contain a network structure. This network structure represents paths through which resources, including knowledge and information flow. In the case of Khond society, a network of villages were linked by the customs that centered around a system of human sacrifice. Those villages involved in the system shared common norms, beliefs, and practices, reflecting convergence of norms common to a group (Table 2). The same tendency holds for any institution. For example, Blondel, Guillaume, Lambiotte, and Lefbvre (2008) identify groups according to shared languages within groups of cell phone users. They found that communities that they examined in Belgium tended to center around one language or another. "For all

but one community of more than 10000 members," they report, "the dominant language is spoken by more than 85% of the community members (7)." They go on to note that of the two dominant language groups, French and Dutch, significant structural differences are detected in networks. This "seems to indicate that the two linguistic communities are characterized by different social behaviours and therefore suggests to search other topological characteristics for the communities (9)."

While this finding may seem obvious, the connection between relatively homogeneous norms and institutions in communities and a method for identifying them has received little attention by social theorists, though it has received attention in organization and complexity sciences. The existence of such communities should be of no surprise if we take seriously the notion of a language game. A language and the rules that govern its use must be common to agents participating in a particular game or set of games. According to Mauws and Phillips:

> Organizations should not be approached as objects but as processes, as ongoing social accomplishments that are sustained through constant interaction . . . the knots in the fabric of organization are language games and the usage of a term (or gesture or practice) is mediated by the language game in which it occurs. . . . Organizational members do not experience organizational membership as an external aspect of their life, but rather live it and are shaped by their interactions with the people and objects which make up the organization. (1995, 332)

They go on to explain that different organizations themselves comprise different uses and rules of language. "It is through language games that entities come into being (332)." Agents within a network or organization themselves carry bits and pieces of understanding that coalesce into a common map of the organization. The elementary bits of this map that are shared amongst a substantial portion of agents serve as a means of communication as well as a marker of distinction for the group.

This phenomenon does not seem to have been lost on some post-modern philosophers. Jean-Francois Lyotard notes that there has been much misplaced pessimism in the supposed identification of growing isolation in modern society. All groups share a special means of understanding and interaction between their members:

A *self* does not amount to much, but no self is an island; each exists in a fabric of relations that is

> now more complex and mobile than ever before. . . . Language games are the minimum relation required for society to exist . . . the quest of the social bond, insofar as it is a question, is itself a language game, the game of inquiry. It immediately positions the person who asks, as well as the addressee and the referent asked about: it is already the social bond. (Lyotard 1984, 15)

Language, in the broadest sense, is a necessary component of a group. Language games represent the dynamic links between the agents that comprise a group. Those able to mutually participate in these language games exhibit shared and compatible knowledge. The boundary of a group is coterminous with the boundary of some game or collection of games. We may then define a social group as an entity comprised of agents who collectively experience "a network of meanings" (Hassard 1994, 307) in regard to shared language and "a network of significations" in regard to relationships that comprise some organizational structure (320; Danford, 1978, 73-121). The concept of shared mental model, popularized amongst economists by Denzau and North (1994), carries with it substantial content that is necessary for the functioning of any social world.

While some games are confined within a given network, others reach across networks. The language game that contains perhaps the broadest reach is the game of market pricing. The first person who appears to have recognized this relationship is Saul Kripke (1982, pp. 112-113, n89). Others include David Bloor (1997) and Roger Koppl (2002). Kripke notices that there seems to be "a certain analogy between Wittgenstein's private language argument and Ludwig von Mises's celebrated argument concerning economic calculation under socialism." Prices are set, not by a central node, but by conversation between agents who participate in the market process (Mises, 1990; Hayek 1935, 1945). Mises and Hayek recognizes this fact. David Bloor identifies the former:

> Thus: 'Prices are . . . social phenomena as they are brought about by the interplay of the valuations of all individuals participating in the operation of the market' (HA: 331). Price is not like, preference, an individualistic fact, but a collective fact derived from specific form of collective organization. (1997, p. 75)

The value of prices are transformed by the interaction of market participants. As with the generalization described earlier, agents engage in dyadic interactions that reflect their beliefs. When bargaining agents

come to an agreement, they have converged on some perceived value of the good being exchanged. Just as groups tend to converge on sets of common knowledge, participants in the game of market pricing and exchange converge upon a bounded range of prices (Gode & Sunder, 1994; Caton, 2017). Unlike social norms tied to a particular group or society, this game is played by any agent who engages in exchange that is part of a chain of exchanges that spans between groups and societies. To the extent that mutual participation in a language game represents a "social bond", the game of market pricing is certainly the most inclusive game connecting agents and groups both close and far.

Experts and Dispersed Knowledge

Actors who comprise a community are not of equal knowledge and ability. As discussed earlier, some *expert* agents carry particular knowledge that they may convey to other agents who lack this knowledge. Some of these are paragons of leadership and ability. John Wooden, coach of UCLA's basketball team, for example, is commonly referenced as a model for leadership (Wooden & Carty, 2005). John C. Maxwell has served a similar role with his *Laws of Leadership* (1998). Persons in need of such skill attempt to emulate his practice and principles. It may be inefficient for every person alive to learn the skill taught and practiced by Wooden and Maxwell as much as it would be inefficient for every person to earn a Ph. D. in engineering. Acquiring knowledge carries with it an opportunity cost.

Knowledge must be distributed for there to exist a diversity of ideas that are able to compete with one another. Only through processes of experimentation and competition is a population of agents able to take full advantage of its creative potential (Hayek, 1946, 1960). We can think of this dispersion as existing in multiple layers. The most obvious is that only particular individuals hold certain types of knowledge. I pay a mechanic to work on my automobile because I trust his knowledge of the working of my vehicle better than I trust my own and because the expected cost of relying on my own expertise is higher to me than if I do rely on the mechanic. In developed and developing societies that have achieved modest progress, the skills offered by mechanics tend to be available to those who need and can afford

them.

There is another sense in which knowledge is dispersed. Some expert knowledge may belong to certain agents with a particular group, but that knowledge may not be widespread. Since particular bits of knowledge are dispersed across networks, locked behind the shells of particular language games, there exists a challenge of gathering and combining different concepts that, *in natura*, are separate from one another. Entrepreneurs may discover benefits from the mixing of these ideas. The dispersed nature of this sort of knowledge is especially apparent within groups of academics who whose ideas do not dominate the discipline but do comprise a school. Elinor and Vincent Ostrom, for example, gathered ideas from Austrian economics, philosophy, and political science in order to build powerful analyses of federalism and the commons (Ostrom, V., 2008; Ostrom, E., 1986, 1990).

Diversity within the population supports a plethora of ideas and understandings that can be drawn from to promote productivity and creativity. In regard to productivity within a firm, Scott Page argues that "when a collection of people work together to solve a problem, and one person makes an improvement, the others can often improve on this new solution even further. . . Diverse perspectives and heuristics improve problem solving (2007, pp. 13-14)." Those who are able to bring these diverse perspectives together stand to benefit.

This knowledge is not costless to access. Groups develop their own set of language games to cooperate. These will often be unique. Thus, integration of knowledge across networks requires ability to play a diverse collection language games not germane to a single group.

Institutional Feedback and Knowledge Transmission

This framework allows for the consideration of the factors that promote the transmission of knowledge such that agent actions are constrained by objective circumstances, which include each's own actions. Good institutions tend to provide each participating in them a channel through which he or she can modestly influence outcomes at the local and, to a lesser extent, system levels. In democracy,

channels for participation and communication include voting, campaign donations, and reciprocal favors by those who hold power to accomplish such favors. Authoritarian regimes a smaller set of these channels. In both cases in government, the feedback of the action of an officeholder or office holders are not directly linked to the economic outcomes they generate. Rather, they are linked to the incentives of office. Actions within the market order, though they may be temporarily shielded by layers of corporate bureaucracy in some circumstances, are subject to feedback of greater clarity and speed compared to the institutions that comprise the state (DeCanio 2014).

Feedback is a mechanism by which alert agents can adjust their activity to match objective circumstances. In the context of democracy, feedback tends to be less easy to interpret as goods provided by government tend to come in bundles and are paid for indirectly through votes and taxation (638). Markets, on the other hand, provide information at a higher frequency and with greater clarity in comparison to the state. Consider Hayek's example of the price of tin. If for some reason, the price of tin rises, purchasers of tin are forced to economize on their use. Some producers may substitute away from tin toward another metal and thus alleviate stress placed on the supply stream of tin induced by their demand. In like manner, firms may be forced to alter their strategies for the consumption and production of a metal whose price has increased. For example, elevated gold prices precipitated the development of the cyanide process, which dramatically lowered production costs and increased overall output (Rockoff 1984). The latter case is interesting as one set of knowledge – prices – led to a radically restructuring of another set of knowledge – gold production.

Conclusion: An Agenda for the Marriage of Complex Methods and Methodology

This framework has identified two parallel lines of thought. Primarily, it has drawn from the literature to provide a theory of knowledge. This theory takes Wittgenstein's language game as its starting point and delineates the elements, relationships, and processes implied by it. This framing allows for a dynamic interpretation of (not necessarily independent from one another) knowledge,

individual action and interaction generated from this knowledge, and institutions that embody this knowledge. This stream of thought meshes with the second: development and use of complex methods. These methods include agent-based modeling and network analysis. These allow for the observation of the formation of knowledge and institutions both experimentally and empirically.

Knowledge has structure. It exists within the human mind. It is embedded in action, interaction, and the environment. Knowledge is dispersed across society. Alternately, we can refer to knowledge as technology. It is the logic implied by useful social and physical configurations. This logic is abstract. It is subject to change over time. As such, it provides constraints as well as a space for creativity for those who employ and are subject to it. Provision of structure, vocabulary, and methods for modeling knowledge in any and all of its forms opens the door to the development of finely detailed economic and social theory whose applied models cohere closely to the reality it observes.

Citations

Alchian, A. (1950). Uncertainty, Evolution, and Economic Theory. *Journal of Political Economy* 58, 211-21.

Armstrong, K. (2000). *Islam: A Short History.* New York: The Modern Library.

Arrow, K. (1974). *The Limits of Organization*. Fels Center of Government.

Arrow, K. & Hahn, F. (1971). *General Competitive Analysis*. San Francisco, CA: Holden-Day.
Asch, S. E. (1955). Opinions and Social Pressure. *Scientific American* 193, 31-35.
Aumann, R. J. (1976). Agreeing to Disagree. *The Annals of Statistics* 4, 1236-1239.
Axtell, R. (2005). The Complexity of Exchange. *Journal of Economic Literature* 115, F193-F210.
Balmer, M., Cetin, N., Nagel, K., & Raney, B. (2004). Towards Truly Agent-based Traffic and Mobility Simulations. *Proceedings of the Third International Join Conference on Autonomous Agents and Multiagent Systems* 1, 60-67.
Battilana, J., Bernard, L., & Boxenbaum, E. (2009). 2 How Actors Change Institutions: Towards a Theory of Institutional Entrepreneurship. *The Academy of Management Annals* 3, 65-107.
Becker, G. (1996). *Accounting for Tastes*. Cambridge, MA: Harvard University Press.
Bikhchandani, S., Hirshleifer, D., & Welch, I. (1998). Learning from the Behavior of Others: Conformity, Fads, and Informational Cascades. *Journal of Economic Perspectives* 12: 151-170.
Blackburn, S. (1995). Practical Tortoise Raising. *Mind* 104, 695-711.
Blondel, V. D., Guillaume, J., Lambiotte, R., & Lefbvre, E. (2008). Fast Unfolding of Communities in Large Networks. *Journal of Statistical Mechanics: Theory and Experiment* 10, http://stacks.iop.org/1742-5468/2008/i=10/a=P10008
Bloor, D. (1997). *Wittgenstein, Rules and Institutions*. New York: Routledge.
Burt, R. S. (1999). The Social Capital of Opinion Leaders. *American Academy of Political and Social Science* 566, 37-54.
Campbell, D. (2013). Downward Causation in Hierarchically Organized Biological Systems. *Emergence: Complexity and Organization* 15, 139-151.
Caplan, B. (2003). Sitgler-Becker versus Myers-Briggs: Why Preference-Based Explanations are Scientifically Meaningful and Empirically Important. *Journal of Economic Behavior and Organization* 50, 391-405.
Carroll, L. (1895). What the Tortoise said to Achilles. *Mind* 4, 278-280.
Caton, J. (2017). Entrepreneurship, Search Costs, and Ecological Rationality in an Agent-based Model. *Review of Austrian Economics* 20, 107-130.
Chase, W. G. and Simon, H. A. (1973). Perception in Chess. *Cognitive Psychology* 4, 55-81.
Christopoulos, D. C. (2006). Relational Attributes of Political Entrepreneurs: a Network Perspective. *Journal of European Public Policy* 13, 757-778.
Christopoulos, D. C. & Ingold, K. (2015). Exceptional or Just Well Connected?: Political Entrepreneurs and Brokers in Policy Making. *European Political Science Review* 7, 475-498.
Clark, A. (2016). *Surfing Uncertainty: Prediction, Action, and Embodied Mind*. Oxford: Oxford University Press.
Danford, J. W. (1978). *Wittgenstein and Political Philosophy A Reexamination of the Foundations of Social Science*. Chicago: University of Chicago Press.
Debreu, G. (1959). *Theory of Value: An Axiomatic Analysis of Economic Equilibrium*. London: Yale University Press.
DeCanio, S. J. (2014). *Limits of Economic and Social Knowledge*. New York: Palgrave Macmillan.
Dekker, E. (2016). Exemplary Qualities: Market Coordination and the Valuation of Singular Products. *Journal of Valuation Studies* 4, 103-124.
Dennett, D. (1991). *Consciousness Explained*. New York: Little Brown and Company.
Denny, F. M. (1994). *An Introduction to Islam, Second Edition* New York: Macmillan Publishing Company.
Denzau, A. T., & North, D. (1994). Shared Mental Models: Ideologies and Institutions. *Kyklos* 47, 1, 3-31.
Dewey, J. (1906). The Experimental Theory of Knowledge. *Mind* 59, 293-307.
Dewey, J. (1908). Does Reality Have a Practical Character? In A. Boydston (Ed.), *The Middle Works*, 130-38.
Earl, P. E., T. Peng, & J. Potts (2007). Decision-rule cascades and the Dynamics of Speculative Bubbles.

Journal of Economic Psychology 28, 351-64.
Emmett, R. B. (2006). De Gustibus Est Disputandum: Frank H. Knight's Reply to George Stigler and Gary Becker's 'De Gustibus Non Est Disputandum' with an Introductory Essay. *Journal of Economic Methodology* 13, 97-111.
Ericsson, K. A. & W. Kintsch (1995). Long-Term Working Memory. *Psychological Review* 102, 211-245.
Fleetwood, S. (2015). Order Without Equilibrium: a Critical Realist Interpretation of Hayek's Notion of Spontaneous Order. In S. Pratten (Ed.) *Social Ontology and Modern Economics*, New York: Routledge.
Floyd, S. W. & Wooldridge, B. Knowledge Creation and Social Networks in Corporate Entrepreneurship: The Renewal of Organizational Capability. *Entrepreneurship Theory and Practice* 23, 123-143.
Gigerenzer, G. & D. Goldstein (1996). Reasoning the Fast and Frugal Way: Models of Bounded Rationality. *Psychological Review* 103 (4), 650-669.
Granovetter, M. The Strength of Weak Ties *American Journal of Sociology* 1, 201-233.
Grant, R. M. (1996). Toward a Knowledge-Based Theory of the Firm. *Strategic Management Journal* 17: 109-122.
Hassard, J. (1994). Postmodern Organizational Analysis: Toward a Conceptual Framework. *Journal of Management Studies* 31: 303-324.
Hayek, F. A. (1937). Economics and Knowledge. *Economica* 4: 33-54.
Hayek, F. A. (1945). The Use of Knowledge in Society. *The American Economic Review*, 519-530.
Hayek, F. A. (1946). The Meaning of Competition. In F. A. Hayek (Ed.), *Individualism and Economic Order,* Chicago: University of Chicago Press, 1948.
Hayek, F. A. (1952a). *The Sensory Order: An Inquiry into the Foundations of Theoretical Psychology.* Chicago: The University of Chicago Press.
Hayek, F. A. (1952b). *The Counterrevolution in Science: Studies in the Abuse of Reason*. Glencoe, Illinois: The Free Press.
Hayek, F. A. (1955). Degrees of Explanation. *The British Journal for the Philosophy of Science* 6, 209-225.
Hayek, F. A. (1962). Rules, Perception, and Intelligibility In B. Caldwell (Ed.), *The Market and Other Orders*, Chicago: University of Chicago Press.
Hayek, F. A. (1960). *The Constitution of Liberty*. Chicago: University of Chicago Press.
Hayek, F. A. (1967) Notes on the Evolution of Systems of Rules of Conduct: The Interplay between Rules of Individual Conduct and the Social Orders of Action. In B. Caldwell (Ed.), *The Market and Other Orders*. Chicago: University of Chicago Press.
Hayek, F. A. (1976). *Law, Legislation, and Liberty: The Mirage of Social Justice*. Chicago: University of Chicago Press.
Henrich, J. & Boyd, R. (1998). The Evolution of Conformist Transmission and the Emergence of Between-Group Differences. *Evolution and Human Behavior* 19, 215-241.
Henrich, J. & Gil-White, F. (2001). The Evolution of Prestige: Freely Conferred Deference as a Mechanism for Enhancing the Benefits of Cultural Transmission. *Evolution and Human Behavior* 22, 165-196.
Hodgson, G. & Knudsen, T. (2010). *Darwin's Conjecture: The Search for General Principles of Social and Economic Evolution*. Chicago: University of Chicago Press.
Hume, D. (1896). *Treatise on Human Nature*. Oxford: Clarendon Press, http://oll.libertyfund.org/titles/342
Inkpen, A. & Tsang, E. (2005). Social Capital, Networks, and Knowledge Transfer. *The Academy of Management Review* 30, 146-165.
Johnson-Laird, P. N. (1980). Mental Models in Cognitive Science. *Cognitive Science* 4, 71-115.
Jung, C. G. (1957). *The Undiscovered Self*. New York: Signet.
Kant, I. (1998). *Critique of Pure Reason*. Cambridge, UK: Cambridge University Press.
Kirzner, I. (1973). *Competition and Entrepreneurship*. Chicago: University of Chicago Press.

Kirzner, I. (1997). Entrepreneurial Discovery and the Competitive Market Process: An Austrian Approach. *Journal of Economic Literature* 35, 60-85.
Klein, D. (2012). *Knowledge and Coordination: A Liberal Interpretation*. Oxford: Oxford University Press.
Koppl, R. (2002). *Big Players and the Economic Theory of Expectations*. New York: Palgrave Macmillan.
Koppl, R. & Langlois, R. N. (2001). Organization and Language Games. *Journal of Management and Governance* 5, 287-305.
Koppl, R. & Whitman, D. G. (2004). Rational-choice Hermeneutics. *Journal of Economic Behavior and Organization* 55, 295-317.
Kripke, S. A. (1982). *Wittgenstein on Rules and Private Language: An Elementary Exposition.* Cambridge, Massachusetts: Harvard University Press.
Lane, D. A. & Maxfield, R. R. (2005). Ontological Uncertainty and Innovation. *Journal of Evolutionary Economics* 15, 3-50.
Lawson, T. (2015) A Conception of Social Ontology. In S. Pratten (Ed.), *Social Ontology and Modern Economics*, New York: Routledge.
Leeson, P. (2014). Human Sacrifice. *Review of Behavioral Economics* 1: 137-165.
Lewis, P. (2016). Systems, Structural Properties and Levels of Organisation: The Influence of Ludwig Von Bertalanffy on the Work of F. A. Hayek. In L. Fiorito, S. Scheall, and C. E. Suprinyak (Eds.), *Research in the History of Economic Thought and Methodology*. Emerald Group Publishing Limited.
Lopez, E. & Leighton, W. (2012). *Madmen, Intellectuals, and Academic Scribblers: The Economic Engine of Political Change*. Stanford, CA: Stanford University Press.
Lyotard, J. (1984). *The Postmodern Condition: A Report on Knowledge*. Manchester, UK: Manchester University Press.
Mauws, M. and Phillips, N. (1995). Crossroads Understanding Language Games. *Organization Science* 6: 322-334.
Maxwell, J. (1998). *The 21 Irrefutable Laws of Leadership: Follow Them and People Will Follow You*. Nashville, TN: Thomas Nelson Publishers.
McCloskey, D. N. (1983). The Rhetoric of Economics. *Journal of Economic Literature* 21, 481-517.
Menger, C. (1976). *Principles of Economics*. Grove City: Libertarian Press, Inc.
Menger, C. (1985). *Investigations Into the Method of the Social Sciences*. New York: New York University Press.
Miller, G. A. (1955). The Magical Number Seven, Plus or Minus Two: Some Limits on Our Capacity for Processing Information. *Psychological Review* 101, 343-352.
Mises, L. (1990). *Economic Calculation in the Socialist Commonwealth*. Auburn, AL: Ludwig von Mises Institute.
Mises, L. (2007). *Human Action.* New Haven, CT: Yale University Press.
Nelson, R. and Winter, S. 1982. *An Evolutionary Theory of Economic Change*. Belknap Press.
Nonaka, I. (1994). A Dynamic Theory of Organizational Knowledge Creation. *Organization Science* 5, 14-37.
North, D. (2005). *Understanding the Process of Economic Change*. Princeton, NJ: Princeton University Press.
O'driscoll, G. and Rizzo, M. *The Economics of Time and Ignorance*. Basil Blackwell Ltd.
Ostrom, E. (1986). An Agenda for the Study of Institutions. *Public Choice* 48, 3-25.
Ostrom, E. (1990). *Governing the Commons: The Evolution of Institutions for Collective Action.* Cambridge, UK: Cambridge University Press
Ostrom, V. (2008). *The Intellectual in Public Administration, Third Edition.* Tuscaloosa, AL: University of Alabama Press.

Page, S. (2007). Making the Difference: Applying a Logic of Diversity. *Academy of Management Perspectives*

Pavlov, I. (1927). Conditioned Reflexes: An Investigation of Physiological Activity of the Cerebral Cortex., http://psychclassics.yorku.ca/Pavlov/lecture19.htm

Polanyi, K. (1958). *Personal Knowledge: Towards a Post-Critical Philosophy*. Chicago: University of Chicago Press.

Rescorla, R. (1988). Pavlovian Conditioning: It's Not What You Think It Is. *American Psychologist* 43: 151-160.

Rockoff, H. (1984). Some Evidence on the Real Price of Gold, Its Cost of Production, and Commodity Prices. In R. Bordo & A. Schwartz. (Eds.), *A Retrospective on the Classical Gold Standard, 1821-1931*, Chicago: University of Chicago Press.

Sarasvathy, S. D. (2001). Causation and Effectuation: Toward a Theoretical Shift from Economic Inevitability to Entrepreneurial Contingency. *Academy of Management Review* 26, 243-263.

Schutz, A. (1946). The Well-Informed Citizen: An Essay on the Social Distribution of Knowledge. *Social Research* 13, 463-478.

Searle, J. R. (2005). What is an Institution? *Journal of Institutional Economics* 1, 1-22.

Searle, J. R. (1979). What Is an Intentional State? *Mind* 88, 74-92.

Searle, J. R. (2006). Social Ontology: Some Basic Principles. *Anthropological Theory* 6, 12-29.

Simon, H. A. (1974). How Big is a Chunk? *Science* 183, 482-488.

Simon, H. 1969. *Sciences of the Artificial*. Cambridge, MA: MIT Press.

Stigler, G. and Becker, G. (1977). De Gustibus non Est Diputandum. *The American Economic Review* 67, 76-90.

Wagner, R. (2010). *Mind Society and Human Action: Time and Knowledge in a Theory of Social Economy.* London: Routledge.

Wagner, R. E. (2016). *Politics as a Peculiar Business*. Routledge.

Williamson, O. E. (1973). Markets and Hierarchies: Some Elementary Considerations. *Organizational Forms and Internal Efficiency* 63, 316-325.

Wittgenstein, L. (1953). *Philosophical Investigations*. New York: MacMillan Publishing.

Wooden, J. and Carty, J. (2005). *Coach Wooden's Pyramid of Success: Building Blocks for a Better Life*. Ventura, CA: Regal Books.