

**Essays on *Wired for Survival*:
Integrating Neuroscience and Institutional Analysis and Development**

By

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Abstract

In *Wired for Survival: The Rational (And Irrational) Choices We Make, From The Gas Pump to Terrorism* (2008) I argue that we are biologically wired for survival. Our first order political and economic institutions are codified not in law, treaty, government, or culture, but in the neural networks embedded in our bodies and our brains. Yet today when we think about organization and government, we typically focus on discovering arrangements that produce ideal outcomes without considering the real capacities and experiences of the people who are the object of our efforts. Then we attempt to select the “best” fit, create artificial enhancements or reengineer our selves, institutions, organizations, and networks to achieve our ideals. North (2005) argues that to create adaptive institutions, our minds must evolve. But the evidence suggests that we can’t change our minds or our institutions without changing our brains. Successful adaptation requires remapping our selves, the way that we interact with others, and consequently, the way that we think and make choices. This essay summarizes what we know about the biological basis of choice and develops implications for institutional analysis and development.

This is an essay based on a book I published last fall – *Wired for Survival: The Rational (And Irrational) Choices We Make, From the Gas Pump to Terrorism* – that among other things, puts forth a theory of human choice that is based on a combination of empirical evidence and theoretical speculation in institutional political economy and cognitive neuroscience.

While I have always been keenly interested in the mysteries of human choice, it was here in the Workshop for Political Theory and Policy Analysis that I first had the opportunity to seriously explore assumptions about human choice and in particular, the proposition that standard rationality assumptions do not always generate scientifically or practically useful explanations of individual or social decision making.¹

There are many reasons why the Workshop provided a fertile environment for exploring “bounded rationality” but chief among them is a strong commitment among Workshop scholars to the principle of methodological individualism. As you may recall, this research principle requires that one explain social phenomena by showing how it results from individual actions, which in turn are explained by reference to the intentional states that motivate these individuals. It involves focusing on what Talcott Parsons called “the action frame of reference,” what Workshoppers call “the action arena,” or what others refer to as the “micro” foundations of “macro” phenomena.²

¹ Note that the term “bounded rationality” is generally attributed to Herbert Simon (1986, 1982, & 1959), who was a cognitive psychologist and seminal influence on the modern study of human and artificial intelligence.

² For an overview of the origins and development of the principle of methodological individualism, see Heath (2009).

Proceeding from this principle, many Workshop scholars have found evidence that human choice often deviates from standard rationality assumptions. Consider for example the evidence that has emerged from field and laboratory studies of people who are solving problems that involve managing common pool resources such as fisheries, forests, grazing lands, or water resources, or making voluntary contributions from private resources that improve social welfare.³ The cumulative research reveals that some individuals and some groups are “naturally” better at achieving social returns than others and identifies some of the problems that they solve in achieving these returns. However, research has yet to explain why these differences exist or why they persist over very long periods of human history.

Human variability under similar institutional design and development conditions suggests that we need some new tools to develop a deeper understanding of human behavior. And this is where my inquiry into the biological basis of human choice comes in: Following the principle of methodological individualism, it is my effort to further advance our understanding of human motivation and our capacity for action. This essay will give you a taste of what I have found thus far and conclude with some thoughts on the implications for how we approach institutional analysis and development as the cognitive social sciences further develop in the years ahead.

The Biological Underpinnings of Human Behavior

³ For overviews of field evidence on common pool resource (CPR) management, see Ostrom and Nagendra (2006), Dietz, et al. (2003) and Ostrom (1990). For experimental evidence on CPR behavior, see Ostrom, Gardner, and Walker (1994). For overviews of the experimental literature on voluntary contributions, see Kagel and Roth (1995), Davis and Holt (1993), and Smith (1991).

Human activity arises from the interaction among chatty bundles of neurons and glia cells in the brain (assisted by molecules acting as neurotransmitters), which receive incoming signals from other cells located throughout the nervous system.⁴ As you may recall, the human nervous system includes a very sophisticated somatosensory system that allows us to literally and figuratively get a feel for our environment. In other words, our perception of what is going on in the world around us is not just in our heads but arises from neural chatter throughout the nervous system in response to cues in our physical and social world. As Francis Crick (1994) put it, we are a “pack of interacting nerve cells and their associated molecules,” and who we are, what we perceive, think, and do emerges from these largely involuntary and transitory neuronal interactions that occur in response to our experience in our environment.

Marcus Raichle argues that to understand the biological basis of mental life we need to understand and differentiate between task-related activity and “spontaneous intrinsic functional activity.”⁵ Estimating that task-related neuronal activity accounts for less than 10% of functional brain activity whereas spontaneous, intrinsic activity consumes more than 50% of the brain’s energy budget, he views the brain not as a system simply responding to changing circumstances but as one operating on its own with sensory information modulating the operation of the mind-body system.⁶

The implications of Raichle’s research are subtle but profound. Brain activity is continuous and energy-intensive, consuming over 20% of total body energy. The energy

⁴ For an overview of developments in understanding the role of different types of glia cells in brain function, see Allen and Barres (2009).

⁵ Presentation, Decade of the Mind conference at George Mason University, May 2007.

⁶ See Raichle (2006) and Raichle, Macleod, Snyder, Powers, Gasnard, and Shulman (2001).

intensive spontaneous intrinsic activity in the brain that is the subject of Raicle's research is associated with cycling glutamate. Glutamate sustains the metabolic processes that keep us alive and well. It also functions as a neurotransmitter in the brain, which enables neural signaling. If maintaining system balance expends the greater part of the brain's total available energy, than either our brains primarily operate on the neurobiological equivalent of auto-pilot, or some as yet undiscovered mechanism exists that allows us to reallocate brain energy from spontaneous functions to directed functions. In the former case, our environment and our somatosensory systems potentially play a greater role in thinking and choice than we typically imagine and in the later case the brain retains its super power status.

The current evidence suggests that our brain may be necessary for thinking and governing behavior but it is probably not sufficient. Our "mind" is a brain and a body state that represents a specific physical and social state, which is fleeting but recordable. It emerges from neurobiological signaling that ultimately synchronizes around a common estimate of excitation or inhibition that the brain recognizes as a focal point. We can call this focal point, which is a biological composite of our current and past experience in the world, a "state of mind."⁷ In other words, it may take a whole body – including the brain – as well as cues in our environment to engage in cognition and behavior. Gerald Edelman (2006) puts it succinctly: "Our brains are embodied and

⁷ For a more detailed discussion of theories and evidence, see Polski (2008), Chapters Four-Six.

our bodies are embedded (in a physical and social environment),” which means that thinking and choice occurs in a homeodynamic mind-body-environment context.⁸

Homeodynamics

While there is still much to be learned about our thinking and choice processes there are several propositions for which there is considerable consensus. First, our primary mode of reasoning is pattern recognition, which gives us substantial latitude to imagine, create and to adapt to novel situations. While we do not operate according to formal rules of logic or externally imposed codes, some of us are capable of learning and employing logical systems and creating and conforming to beliefs, rules, and practices.

Second, our thoughts and choices emerge from intuitive and dynamic interactions among brain, body, and environmental cues. Our memories are artful reconstructions more a kin to inventions than archival records. We reason based on the gist of things, which makes it difficult for us to work with detailed information. As a consequence, human reasoning trades off precision for rapid, associative power, which means that it is error-prone and subject to bias.

Third, our biases are innate, pervasive, and automatic. Heredity, experience, training, sensations, emotions, anatomy, physical circumstances, and the presence of others affect thinking and behavior in ways that are not predicted by standard theories. Our past and our biases are sources of friction that tend to lock us into status quo routines and particular mindsets, which take the biological form of neural networks or cognitive maps. While we can reassess our past experience, acquire new experience,

⁸ For a recent overview of theories of “grounded cognition,” see Barsalou (2008).

and reform our cognitive maps, these changes are not easily achieved and require concerted effort including pharmacological and human interventions.

In short, thinking and choice is homeodynamic: It emerges from interactions among activities in an external state (our physical and social surroundings); an internal state, which emerges from the sensory activities involved in perceiving and coping with our environment (including maintaining homeostasis); and a brain state, which is represented by the mental maps that emerge from neurobiological signaling triggered by cues in our environment and our body (Figure 1). Rather than strictly rational optimizers, we are complex, highly advanced sensors that adapt intuitively to particular physical and social contexts.

External states

Contrary to folk theory, intuitive thinking and choice is fact-based, data driven, and logical although not perfectly so: As Vernon Smith argues based on his research on economic behavior, human choice is “ecologically rational” (Smith, 2003). Consistent with Smith’s general idea, in my view of the neuroscience research, our intuition is informed and structured by a combination of genetic predisposition, past experience, and immediate experience. Cues in our physical environment inform cells in our bodies and brains of tangible opportunities and threats, which triggers adjustments to maintain homeostasis and motivate action. Similarly, our social environment provides cues about intangible opportunities and threats that potentially interact with tangible cues to stimulate molecular activity and activate signaling within and among networks of neuronal “circuits.”

Internal states

While our physical and social environment provides cues that help us get a feel for things, we need our bodies to sense and process these cues and take the actions required to successfully adapt. We have a very sophisticated and largely automated internal sensory system that works in tandem with our brains and our other perceptual systems to understand and mentally represent a place, things, people, and situations, and to adjust to changes.

Internal sensory signaling creates neurobiological maps that provide directions for those members of the nervous system – including the brain – that are involved in serving the chemical cocktails associated with sustaining proper body temperature, blood oxygen concentration, and PH levels, all of which help us regulate our thoughts and behavior.

Standard approaches to decision-making assume that we all have the same body-sensing experiences and motivational maps, that internal states do not differ among individuals or in different environments, and that sensory experience does not influence thinking or choice. Yet internal dynamics and the physiological structure of motivational systems are a critical component in thinking and choice and like so many other human attributes, there is considerable variation among individuals.

Brain states

The brain is a necessary partner in cognition: when it is damaged, thinking, choice, and behavior are often impaired. When it is severely damaged, life itself is compromised. As Damasio (1999) observes, our brains both preserve and expand our

ability to sense internal and external states and to adapt to changes in these states. How our brains do this – both consciously and unconsciously – is one of the most challenging research enterprises in neuroscience.

In addition to understanding “unconscious” or spontaneous thinking and choice another challenge is to understand activity in the brain when we are consciously and deliberately engaged. The goal of this research is to be able to identify which neural networks are involved in particular actions and experiences, describe the signaling pathways that link these networks, and uncover the molecular structures that support connectivity. This line of research is important because it can help us understand the components of our decision making processes and their sensitivity to different stimuli, which in turn may tell us something important about the nature of behavior.

Social Dynamics and Collective Action

It is cliché but nonetheless true that we are inescapably social creatures: The boundaries between our unique selves and those with whom we are interacting are tenuous and easily pierced. "Them" is often us: Thinking, choice, and action are influenced by the actual, imagined, or implied presence of others. In social interaction, our minds are viral, and they are contagious.

The ability to understand social signals and engage in collective action requires the ability to represent the experience of others in our own minds and to perceive and communicate mental desires and beliefs, which requires neurobiological mechanisms that allow us to quickly and fairly accurately intuit the motivations, feelings, beliefs, and intentions of others. But how might we do this?

Lawrence Barsalou (2008) argues that cognition is “grounded:” That is, cognition emerges from multiple neurobiological experiences including simulations, action situated in a particular environment, and body states. Our ability to mentally imagine or simulate perceptual, motor, and introspective states suggests that during experience, we have ways to capture neurobiological signaling patterns and store them in memory. One line of research focuses on a system of “mirror neurons” that allows us to simulate and mimic the states of others – to “get inside their head” – and thereby estimate their intentions and respond accordingly. When we simulate the actions or feelings of others, it triggers the same neurobiological activity that we would experience if we were engaged in the identical action or emotional state.

There is also considerable evidence that body states can trigger cognitive states and be effects of them (Barsalou et al. 2003): A good deal of what we learn and experience becomes embodied in facial expressions, postures, gestures, and so on. These body states then become associated with specific states of mind, which include sensations, emotions, memory, and thoughts. Social interaction can trigger body states, and body states can affect how we feel and what we think, which in turn, affects motivation and performance. The pervasive human sensitivity to facial expressions and other biometric signatures such as gait, gestures, and vocal intonation is a good example of embodiment effects.

All other things being equal, a person with extensive, wide-ranging experience and broadly developed skills is better prepared to accurately understand others' intentions than someone with less experience or skill: The larger our repertoire of

cognitive maps, the more accurately we can understand others and predict their intentions. Conversely, in those situations when we observe others looking on helplessly or exhibiting "cluelessness," assuming it does not reflect disease or disorder, it likely reflects a dearth of similar training, experience, or perhaps capacity, rather than a motivational deficit or a failure of will.

Social change is a similar mind-body-environment challenge. Change would be a relatively simple exercise in individual choice except for the fact that we live in social groups in particular environments that may or may not be conducive to the changes we wish to or ought to make. Although changing ourselves when we want to change is difficult in the best circumstances, changing an entire social order when not everyone wishes to do so is an even greater challenge. Well-intended, large-scale social change efforts fail more often than they succeed because to change outcomes, one must change patterns of behavior. To change patterns of behavior, one must change many minds and bodies, which are embedded in contexts that include the physical conditions in which they live, their everyday rules of the game, and the relationships and networks that make up their social world.

To sum up, the evidence suggests that we are not strictly rational optimization machines but complex, adaptive sensors: Human choice arises from highly advanced, but biased sensory systems that adapt intuitively to a physical and social context that is partly real and partly imagined. Many of our thoughts and choices are automatic rather than the product of calculation: "Thinking" occurs after a choice has been made. However, many of us (but not all) have the capacity to develop and use logic tools and

institutions to shape and regulate thinking and behavior so let's turn next to the implications of homeodynamic choice for institutional analysis and development.

Homeodynamic Choice and Institutional Analysis and Development

It is a well-known Workshop tradition to situate discussions about institutional analysis and development in the context of the IAD framework: Figure 2 shows this framework and incorporates the institutional design considerations that have been incorporated over the years by Workshoppers using principles in game-theory, experimental economics, and public policy analysis to analyze individual behavior and collective action.⁹

Looking at the IAD framework through the lens of homeodynamic choice I am struck by several things. First, the framework does a very good job of capturing the categories of variables that can biologically affect individual and collective choice: Our bodies and brains are embedded in and influenced by our physical and social environment, which is captured in part in the IAD framework by “physical world,” “community attributes,” “rules-in-use,” and “patterns of interaction.”

Second, it is quite useful to think about an “action arena” in homeodynamic choice that is situationally specific, incorporates rules-in-use, and is influenced by a physical world and community attributes. The homeodynamic equivalent to an action arena is an individual or collective “state of mind(s)” or set of neurobiological maps that drive action.

⁹ For an overview of how the IAD framework can be used in policy analysis and design, see Polski and Ostrom (1999).

Finally, outcomes are also a separate category of variables in homeodynamic choice that are analytically distinct from choice processes. In homeodynamic choice it is particularly important to differentiate between intended and unintended outcomes. Consider for example swinging a bat in a street game of baseball with the intention of scoring a run and instead breaking a neighbors' window, or delivering a speech to a crowd intending to persuade a majority to support a policy and instead creating antipathy.

Homeodynamic choice also presents several challenges for the IAD framework. First, the existence of spontaneous intrinsic activity and "unconscious" or automatic choice suggests that variables such as community attributes and rules-in-use are not analytically separable: If they are effective in shaping action, then they are embodied in actors' cognitive maps, which means that they are endogenous to an action situation. While this does not diminish the importance of these variables in shaping behavior, it does present observation and measurement challenges. It also means that to change a situation, we must change the cognitive maps of the people in the situation, e.g. we must literally change people to change rules. Whether this is a sequential or simultaneous process is an open empirical question. Whether it is ethically or morally acceptable is an even more difficult question.

Second, from a homeodynamic choice perspective, an action situation is represented by individual and collective states of mind, which arise from the interaction of biological and environmental variables in brain, body, and external states. Embodied brains are embedded in an external state that is composed of a physical and social

environment. Both physical and social environments contain cues that trigger neurobiological signaling, which can alter states of mind. While a physical environment may be relatively fixed, a social environment both influences and can be influenced by the actors in the action situation. If important aspects of the physical world and social environment are embodied in the actors in an action situation and critical aspects of the action situation (states of mind) are dynamic, we have a substantial methodological challenge.

Similarly, we may expect that critical aspects of patterns of interaction in an institutional analysis and development dilemma are not analytically distinct: They are embodied and embedded in the homeodynamics of an action situation.

Figure 3 illustrates the challenge of homeodynamic institutional analysis and development. It seems to me that if we wish to do empirically grounded research in institutional analysis and development, we must augment our existing abilities to investigate physical and social phenomena with the ability to peer into human biological activity. In short, we need a new science of human behavior that incorporates social, biological, and physical sciences.

Envisioning Future IAD Research

At present, there are two social science sub-disciplines in what I see as the emerging new science of human behavior that are important for those who study institutional analysis and development: Cognitive Neuroscience and Neuroeconomics. Both are outgrowths of experimental research in their home disciplines (Psychology and Economics respectively) and both investigate human behavior by augmenting their

usual methodological tools with neuroscience methods, which typically include functional magnetic resonance imaging (fMRI) and lesion studies.¹⁰ In addition to sub-disciplines in the social sciences, there are researchers in sub-disciplines in the computational sciences that share an interest with social scientists in developing a deeper understanding of individual and group behavior: Complex social systems and artificial intelligence.

Some of these cognitive sub-disciplines are more mature than others: The cognitive psychologists and artificial intelligence researchers have been at this project for over 50 years, and the social complexity researchers and economists for about 10 years.¹¹ Researchers in all of these disciplines study decision-making and there is considerable overlap in their approach, which leads some to argue that we are advancing toward a merger that will result in a “Cognitive Social Science.”

While the brave new science of human behavior is producing some interesting results that show potential for providing empirical foundations for a few of the propositions of the Anglo-Scots moral philosophers as well as more modern institutional analysts, progress is severely limited by current technology and a commendable reluctance to undertake *in vivo* research on human subjects. Interested Workshoppers

¹⁰ Researchers sometimes combine fMRI and lesion studies with electroencephalography (EEG) and positron emission tomography (PET) studies. Some also use transcranial magnetic stimulation (TMS).

¹¹ While Hayek (1952) ventured into psychology and cognitive science very early in his career, it was not until the 1990s that a significant number of economists followed suit and very few cite his interest and contribution in this area.

should look for developments that integrate methodological advances in neuroscience, molecular biology, and (bio)informatics such as the following:¹²

fMRI: Functional magnetic resonance imaging (fMRI) is a magnetic resonance imaging tool (MRI) for identifying task-related activity in neurons in the brain based on changes in metabolic or blood flow: The measure of interest is the ratio of oxygenated to deoxygenated hemoglobin or the blood oxygen level dependent effect (BOLD response).¹³ The assumption is that changes in the BOLD response indicate that relevant parts of the brain are active and therefore associated with task activity. Diffusion tensor imaging (DTI) is an additional MRI method that produces *in vivo* images of biological tissues. Extended DTI scans can be used to identify the white-matter connectivity in the brain, which allows researchers to see which neural networks in which regions of the brain are engaged in functional activity. Blow (2009) reports that as field strengths for human MRI magnets improve and radio-frequency transmission problems are solved, MRI will become a tool that can help researchers understand underlying mechanisms, e.g. that can both identify cells and help us understand how they form, grow, and interact.

Near Infrared Spectroscopy (NIRS): NIRS, which detects changes in blood hemoglobin concentrations associated with neural activity, can be used to investigate brain function where fMRI cannot be used, e.g. on freely moving subjects and on infants. While NIRS is much more portable than fMRI machines, it can only be used to

¹² In developing this section of the paper, I am indebted to Jim Olds, Director of the Krasnow Institute at George Mason University for a very helpful discussion.

¹³ See Kay and Gallant (2009) for an analysis of developments in current data analysis techniques that allow researchers to “see” what subjects in fMRI studies perceive. For cautionary critiques of fMRI studies, see Abbott (2009) and Kriegeskorte, et al. (2009).

scan cortical tissue, whereas fMRI can be used to measure activation at all levels throughout the brain.

Nuclear Magnetic Resonance Spectroscopy (MRS): MRS (NMR spectroscopy) is a technique that relies on analyzing the magnetic properties of cell nuclei to provide information on the number and type of chemical entities in a molecule. Providing more information than infrared spectroscopy (IR), MRS can, among other things, be used to study dynamic effects in a cell environment such as change in temperature and reaction mechanisms. Recent innovation has been in the field of protein MRS, which is an important technique in structural biology.

Optogenetics: Optogenetics combines optics (light-activation) and genetics to peer into and control targeted neurons in specific neural circuits in living animals in order to understand brain information processing and the relationship between activation in specific neural circuits and behavior. Optogenetics includes developing genetic targeting strategies such as cell-specific promoters to deliver the light-sensitive probes to specific populations of neurons in the brain and integrated fiber optic and solid-state optical tools. Optical fibers, which can deliver light deep into the brain as well as to superficial brain areas such as the cerebral cortex, provide a more specific targeting tool than drug or electrode interventions.¹⁴

Positron Emission Tomography (PET): Like fMRI, PET is an imaging technique that detects changes in blood flow in the brain. PET produces a three-dimensional image of local variations in blood flow, showing functional processes in the body at the

¹⁴ For a report on recent developments in the use of optogenetics, see Buchen.

molecular level. While some imaging scans such as computed tomography (CT) and magnetic resonance imaging (MRI) can identify anatomic changes in the body, PET and single photon emission computed tomography (SPECT) are capable of detecting areas of molecular biology detail even prior to anatomic change. When PET scans are read alongside computed tomography (CT) or magnetic resonance imaging (MRI) scans, researchers can obtain information about both what the structure is, and what it is doing biochemically.

Figure 1: Homeodynamic Choice

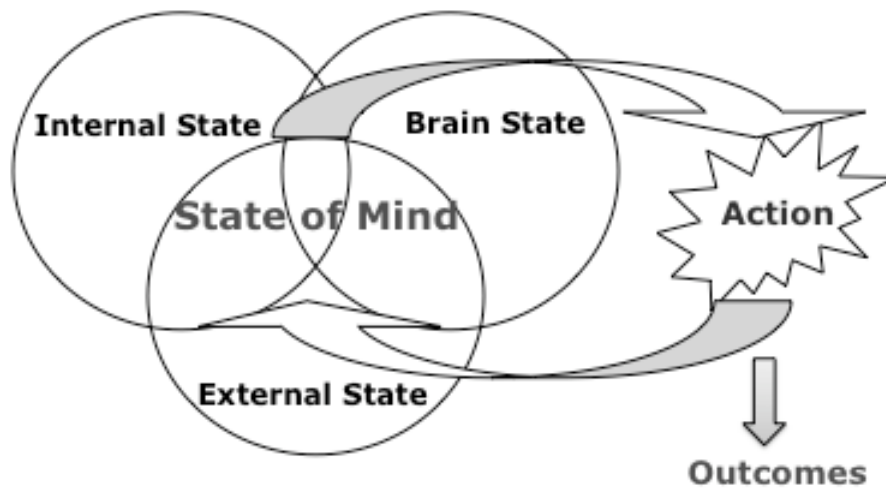


Figure 2: Institutional Analysis and Development Framework for Policy Analysis
Source: Polski and Ostrom (1999)

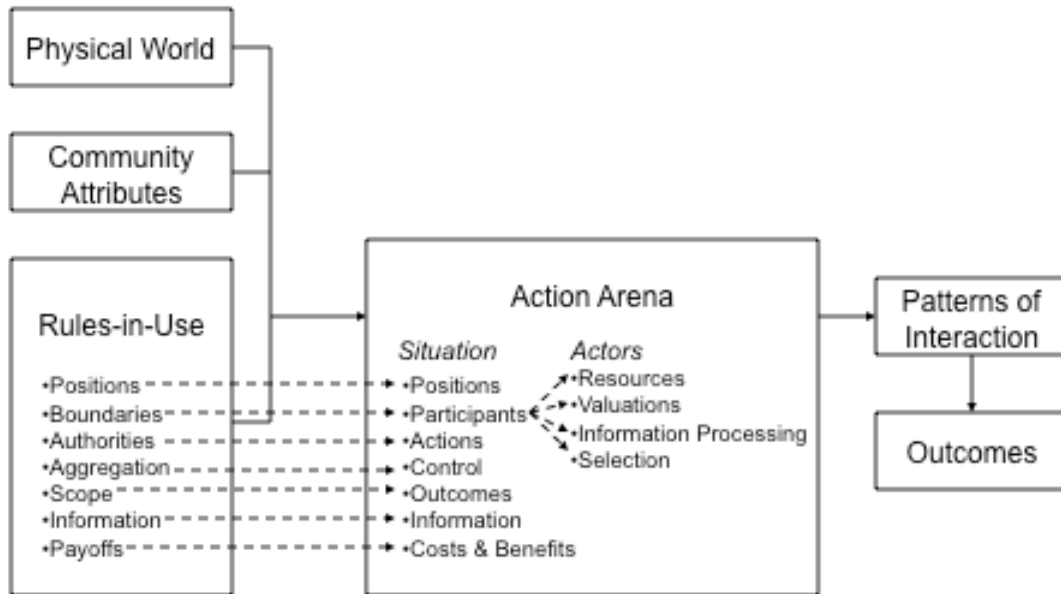
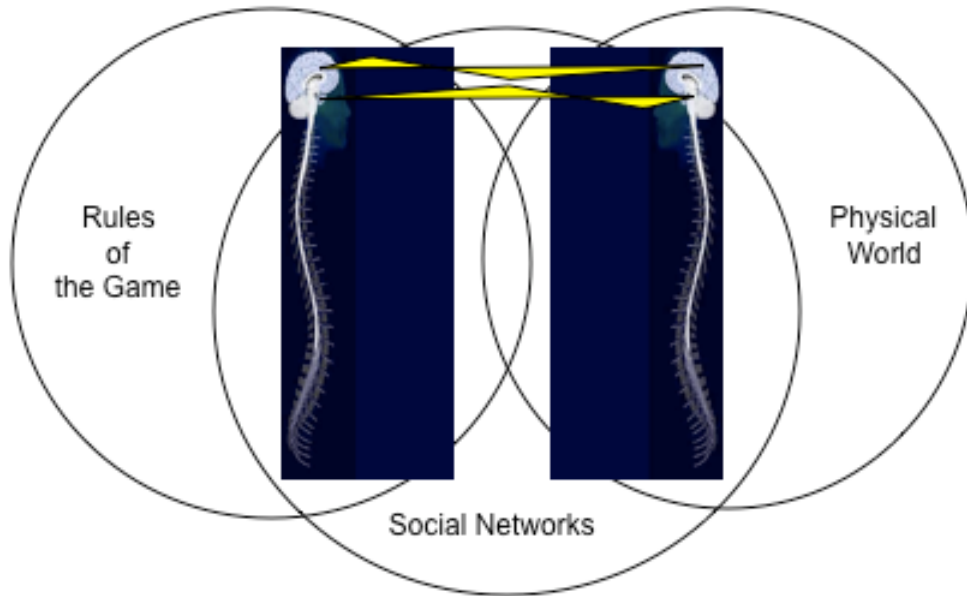


Figure 3: Homeodynamic Institutional Analysis and Development



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