A SYSTEMS ANALYSIS OF COMMUNICATION: DEFINING THE NATURE OF AND PRINCIPLES FOR COMMUNICATION WITHIN HUMAN ACTIVITY SYSTEMS

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ABSTRACT

Communication within Human Activity Systems plays a critical role in organizational change. However, research on communication typically expresses communication as a tool to evaluate the current state of an organizational system, or as a vehicle to change the current state of the system to a more desired future state. It is rarely considered from a holistic viewpoint, being a complex system with an integrated effect on the organization as a whole. The holistic understanding of communication as an emergent system from the interaction of elements and activities within Human Activity Systems is required to better manage factors impacting effective communication. Presented in this article is an ontological framework characterizing the behavior of communication in Human Activity Systems as well as its role in organizational change, encompassing the nature of communication and its impact on Human Activity Systems. Furthermore, principles for communication, within the bounds of Human Activity Systems, are derived to provide researchers and practitioners a methodology for assessing the interaction of these two systems. These principles are expected to provide a change in perspectives of communication in Human Activity Systems and allow for a more optimal design of both systems and their interactions.

Keywords: Human Activity Systems, communication system, organizational change

INTRODUCTION

The role of communication in organizations has attracted the interest of researchers in the fields of psychology (Fairhurst, 2016; Roberts & O'Reilly lll, 1974; Zenger & Lawrence, 989), engineering management (Clampitt, DeKoch, & Cashman, 2000; Ford & Ford, 1995; Robertson, Roberts, & Porras, 1993; Worley & Doolen, 2006), economics (Becker, 1976; Polek, 2010; Ruggles & Ruggles, 1972), linguistics (Alvesson & Karreman, 2000; Chomsky, 1975; Hymes, 1972), and many others involving the socio-technical sciences. With research spanning over decades, communication remains a relevant topic from social and day-to-day interactions to life

critical healthcare decisions (Greenberg et al., 2007; Nagpal et al., 2010; Sutcliffe, Lewton, & Rosenthal, 2004).

Communication according to Shannon (1948) is the act in which one mind affects another (Skyttner, 2005), conveying a concept or empirical truth that is representative of an empirical object elsewhere. Devito (1986) stated that communication is the "process or act of transmitting a message from a sender to a receiver, through a channel and with the interference of noise" (p.61). For this research, the authors define communication, similar to Devito's, as the process of transferring a message from one sender to one or more receivers, subject to environmental conditions. While a substantial amount of research has focused on specific communication disciplines, such as information transfer (Schreiber, 2000), cryptography (Menezes, Oorschot, & Vanstone, 1997), and communication theory (Craig, 1999), the practical impact of communication within organizational settings is limited to the application of communication as a means of achieving a goal, or the adaptation of communication as an outcome of reaching that goal; to this end, communication is typically either applied as a tool or as a measurement instrument in situations of change occurrence (Pundzienė, Alonderienė, & Buožiūtė, 2007a; Puvanasvaran, Megat, Hong, & Mohd.Razali, 2009; Witherspoon & Wohlert, 1996). As such, much of the existing research, though having practical value, does not explore communication as the emergent system from the interaction of elements and processes within organizational practices and thus being directly interconnected with the observed human activity system.

Furthermore, research on the role of communication associated with organizational change has traditionally investigated its impact on new process implementations (Kwak & Anbari, 2006; Worley & Doolen, 2006). For instance, some research studies have been particularly focused on the impact and importance of communication on effective implementation efforts such as Lean and Six Sigma (e.g., DiFonzo & Bordia, 1998; Lewis & Seibold, 1998; Lewis, 1999; Schweiger & Denisi, 1991). Additional studies have explored the impact on communication due to organizational change (Elving, 2005; Worley & Doolen, 2006), and/or the dynamic relationships between management support and communication effectiveness in driving organizational change (Clampitt et al., 2000; Pundzienė et al., 2007a; Worley & Doolen, 2006). A study by Pundzienė, Alonderienė, & Buožiūtė (2007) explored the connection between managers' communication competence and the success of the change managment, suggesting that such change initiatives are dependent on the degree of internal communication. The deficiency of communication competence in organizational settings was found to be a prominent factor in most of the 70 percent of change initiatives failures that occur (Gilsdorf, 1998; Patterson, 2000; P. M. Senge, 1999). Such failures are consequences of not reconizing that communication is performative and that discussing change brings about change, also that sharing information brings about a shared understanding and agreement (Ford & Ford, 1995). Ford and Ford (1995) stated, "Change is created, sustained, and managed in and by communication" (p.560).

It is, therefore, widely accepted, and empirically demonstrated by practitioners and researchers, that communication is a vital element in organizational change (Lewis, 1999; Robertson, Roberts, & Porras, 1993). Management communication tactics largely influence not only the success or failure of new process implementations efforts but also affect the existing organizational culture and team climate. Research on the communication tactics used for influencing employee's perceptions, behaviors, and emotions has offered valuable insight into how employees respond to incentives, their personal concerns regaurding change, and their learning characteristics in learning-by-doing processes for adaption to the organizational change (Calvo-Amodio, Patterson, Smith, & Burns, 2015; Oreg, Vakola, & Armenakis, 2011; Piderit, 2000; Wittig, 2012). Hence, change management and the dynamic communication between managers and employee emerges as a relevant factor in initiating and sustaining change initiatives.

Despite the above mentioned, few research works have directly studied the communication competence of the managers and how they learn to communicate effectively and efficiently with their employees through the organizational change (Frahm & Brown, 2006; Penley, Alexander, Jernigan, & Henwood, 1991; Pundzienė, Alonderienė, & Buožiūtė, 2007b). Even fewer studies have identified communication as a system with a complex, dynamic, and integrated presence in new process implementation efforts (Boulding, 1956; Hammond, 2003; Skyttner, 2005). Notwithstanding that these latter studies incorporated managers' communication competency, communication during uncertainty, and the cultural impact of communication within the organization, our understanding from a systems theory perspective about the role that communication plays in organizational change is limited. In an effort to enhance our understanding, the authors seek to define communication as an emerging system within organizations and propose an ontological framework to guide new process implementation efforts.

The research presented in this paper encompasses the nature of communication in human activity systems as well as its role in organizational change. As a result of the literary exploration, an ontological framework is presented to characterize the behavior of communication as a system in new process implementation efforts incorporating the conveyance and convergence of information. Finally, systems principles are derived and presented for communication systems within the bounds of Human Activity Systems.

COMMUNICATION IN HUMAN ACTIVITY SYSTEMS

An organization is classified as a system if it has a general *purpose*, structured *order* of operations and/or authority, and *pattern* of cultural or systemic behavior; referring to the general reason for its existence and consistency over time (Skyttner, 2005). Likewise, Calvo-Amodio et al. (2014) describe systems as perceived wholes, composed of interconnected components, with a specific purpose in a given context. Thereby, systems are framed and defined per the analyst's *Weltanschauung* (or worldview) developed as a set of *a priori* beliefs and feelings. Organizations fall into the definition of systems in being a whole, comprised of many departments or work

stations, that are all connected via some form of communication and exist within some form of location boundary.

In accordance with Boulding's (1956) theory, organizational systems are open and self-regulated systems that require energy to maintain order and function under the natural progression of entropy. Entropy in a system is the randomness or disorder present that pushes the system to low energy state (Skyttner, 2005). Open, or living systems, reduce local entropy through the interrelationships of their entities and the energy attained through the environment which directs the system toward its desired state by means ingrained within the system rather than those achieved externally from the environment around the system (Hitchins, 1992).

The involvement of people, machines, and information systems composing the human activity system of the organization provides the internal energy needed to self-regulate and sustain the organizational system. In his research, Boulding (1956) discusses nine levels of general systems theory that range from basic to transcendental systems. The third level, for instance, involves cybernetics and explores the self-regulated system structures, constraints, and possibilities to understand the control and communication between humans and the machines within the system (Wiener, 1961). According to Vancouver (1996), the cybernetic process is where the association between the human systems and organizational systems merge. Cybernetics may be best described as the "theory of machines" and the way in which they behave rather than what they are and how they are composed (Ashby, 1957). At the heart of cybernetics is the exploration of functionality and behavioristic natures about a "thing", such as a machine, organism, or organization, understood through communication models (Berlo, 1960; Deutsch, 1952), organizational role theory (Biddle, 1986; Katz, 1964), and symbolic interactionism (Stryker & Statham, 1985). The study of cybernetics is largely based on information transfers across channels, feedback mechanisms, and systems controls.

Skyttner (2005) argues that cybernetics and the transfer of information is an attribute of the interaction between system elements rather than a commodity stored in a computer system. Cybernetics is linked to communication theory in biological research with the transfer of signals (Kohonen, 2012), such as through the firing of synapsis and the influence of the mind given a sign or message, composed of one or more signs (Skyttner, 2005) creatively displayed in a shop keeper's window.

While organizations are open, self-regulating, and adaptable systems (Boulding, 1956; Katz & Kahn, 1978; Vancouver, 1996), communication as a system within the human activity system is the means by which it maintains order and facilitates the system's progression toward a desired state. The communicaiton system achieves this by controlling the internal energy among the other system components and guides the entire system. Skyttner (2005) argues that there are three types of systems; the concrete, conceptual, abstract or unpercievable systems. While human activity systems may be classified as concrete systems, having physical and definable characteristics, the

communication system is of a more conceptual form. Conceptual systems are systems composed of concepts or ideas and can only exist within some form of concrete system; an organization or even a computer for example. Returning to the idea of cybernetics, conceptual systems provide the ability to control and regulate concrete systems.

In cybernetics, and more specifically with the use of communication channels and feedback loops, information about the system is obtained and used to assess, control, and adjust the system to a desired state. This process may be demonstrated in the context of the adaption of organizational culture during organizational changes. To reach the desired state of a system, the resistance of system components toward change (i.e., teams and individual employees resistance and perception of change) must be minimized by means complementary to the objectives of the system's components (i.e. benefits as perceived by the team or individual). Resistance to change comes naturally in organizations due to the nature of people and the threat of altering their behaviors, habits, and norms; even if there is a general agreement on the reasons for the change and the goals of the organization (Lewin, 1947; Muo, 2014). Individuals differ in their willingness and ability to adapt to new situations (Darling, 1993). This resistance emerges regardless of the incentives or management promises, for change still brings a sense of unease in its uncertainty.

Living systems are characterized by their goal seeking and energy transducing behaviors. Likewise, human activity organizations have the ability to develop over time, self-regulate, self-maintain, and exhibit autonomy within the system (Skyttner, 2005). Living systems are further characterized as autopoietic systems, signifying the ability to self-renew and -sustain by understanding and specifying the interactions among system components (Varela, Maturana, & Uribe, 1974). Autopoietic systems are systems that have the capability of component-producing processes and are defined as a unity. The nature of such systems are characterized by the network of production of components. Organizations demonstrate this characteristic through the evolution and growth of production processes, departments, and even chain organizations across the globe. Living systems are also considered energy transducers given their capacity for transforming energy from their surrounding environment into information that will help them reduce local entropy, by which they maintain the system and perform more efficiently (Skyttner, 2005). An application of this may be the collection of performance data about a specific manufacturing department that becomes information conveyed to management, whereas management may then be able to make changes to that department in order to improve its performance. The networks, which create relationships between components, aid in the conservation of the autopoietic organization. Varela et al. (1974) state that the networks of component productions, which affect the system organization, will dissolve over time if they are altered or disrupted. Autopoietic systems must overcome the disintegrating effects of entropy on the networks of component-producing processes to maintain its unity. This process of disassembling, rebuilding, creating or decimating takes place while the unity maintains its wholeness and identity, determined from within rather than from environmental feedback (Zeleny, 1977). In this way, the environment can modify the internal processes of the system but not fully explain the organization of the system.

A Systems Analysis of Communication

Autopoietic systems, such as human activity organizations, adapt and evolve over time to exist in a changing environment. In an evolving market with technological advancements and stronger competition, organizations have to co-exist and adapt in such environments if they wish to remain competitive. In the adaptation process, organizational changes emerge, requiring a review of outdated or dying (obsolete) processes along with their interconnections to other processes as well as products and system entities. While turnover and the reproduction within the system are necessary actions to update the system, the system retains its identity by maintaining the fundamental organization of the system and its components (Varela et al., 1974). Entities of the system that require updating are subjected to upheaval, and the uncertainty of change as the management assesses the state of such entities. To reduce the amount of disorder among the entities, management needs to lead a change initiative that conveys a vision, incorporates effective communication, and considers interpersonal relationships among entities (Battilana & Casciaro, 2013).

In addressing the complexity and integrated nature of communication, Sebeok (1991) stated that communication maintains the organization of all living organisms which are interlinked, both as whole organisms and components of the whole. In this sense, communication impedes the disorganizing effects of the Second Law of Thermodynamics, defined as entropy, and produces change propagated throughout the living system components. Communication and sender-receiver information transfers incorporate semiotics, which is the study of signs and symbols to communicate and their use or interpretation. Semiotics has been applied to advertising and marketing (Zakia & Nadin, 1987) and linguistics (Saussure, 1983), delving into textual symbols, body language, as well as nature and patterns in culture phenomena (Barrett, 2015). Signs include words, sounds, or visual objects and images (Moriarty, 1995), such as those incorporated into visual management boards for shop floor production.

Communication among entities provides the cybernetic processes needed to adjust and maintain the autopoietic aspect of human activity systems. Without communication among system entities, these would cease to exist within the same identity, goals, and objectives as the main system, affecting the whole system. According to Buckley (1967, 1968), complex adaptive systems, such as social and also human activity systems, are characterized by feedback loops and maintain their existence through means of structural changes. This concept of feedback is illustrated for human activity systems by Natarajan (2010) in his research of communication in technical organizations. Natarajan's research resulted with the inclusion of a feedback loop to Shannon's (1948) renown Transition Model of Communication, arguing that communication needed to have a feedback loop for transmitting valuable information not only from sender to receiver but also back to the sender. In omitting the roles of sender and receiver but rather focusing on the actions taking place, it is possible to see communication not only as an interaction between two entities but rather the conveyance of a message and convergence of a message.

A Systems Analysis of Communication

It is believed that conveyance and convergence are two conceptual subsystems that, when combined, make communication possible. As a result, communication may be redefined as the transmission and reception of signs. While each of these subsystems are able to exist independently, communication is not possible without homeorhetic interaction between the conveyance and convergence (i.e. the transmission and reception) of signs. The following section describes each of these subsystems in further detail, including their role in the overall communication system.

CONVEYANCE AND CONVERGENCE OF INFORMATION

In the Media Synchronicity Theory, communication is a task of two subsystems, the conveyance of information among individuals and the convergence of information within individuals (Dennis, Fuller, & Valacich, 2008). The communication system is composed of these two subsystems have both an interpersonal and cognitive aspects that facilitate the transmission, reception, and processing of information (Miranda & Saunders, 2003; Robert & Dennis, 2005; Zigurs & Buckland, 1998). The theory identifies physical means by which media impacts how individuals can transmit and process messages that facilitate synchronicity among them (Dennis et al., 2008). While conveyance is an independent subsystem that does not necessarily require high synchronicity, the convergence of information is dependent on the use of media and its capabilities, familiarity of tasks, and familiarity among individuals communicating.

Conveyance. Conveyance of information is comprised of the media and processes used to convey a message to one or more individuals; this includes face-to-face, email, and various facilitating software interactions such as Skype and WebEx. According to Tajfel and Fraser (1978) there are four interpersonal communication components inherent to the process of communication between sender and receiver, these components include:

1. The verbal system, comprised of the expletives and phonemes that compose speech
2. The intonation or use of pitches, stresses, and junctures that enhance speech
3. Paralinguistics, additional vocalizations shared by members of a cultural group, including pauses, tones, drawls, and other fillers
4. Kinesics, incorporating non-verbal body and facial movements

While these four interpersonal communication processes are mostly inherent to face-to-face communication, Miranda and Saunders (2003) in their research on the social construction of meaning for information sharing, developed a conceptual model with two key information sharing aspects, 1) the media environmental effects and 2) media choice effects on group members. The authors make the claim that such research on information sharing is important because no single individual has all of the information needed to make informed decisions, and thus, information sharing among groups allow for meaningful decisions toward a pre-constructed goal. This theory assumes that all members of the decision-making group have equal access to all of the information. The study considered both face-to-face and multimedia environments to operationalize the breadth

and depth of information sharing, supporting the theory that information sharing aided in intersubjective interpretation. It was also realized that the media chosen for the study affected both the depth and breadth of the information sharing, in addition to providing support for the theory of task closure.

Within human activity systems, the syntactic, semantic, and pragmatic levels of communication, as explained by Skyttner (2005), determine the state of the system by identifying and interpreting system indicators and control the system based given the knowledge of the sender. For this research, the levels are considered elements within the conveyance subsystem. Therefore, when expressed as goal seeking, the elements are defined as:

1. Syntactic element: the data element in which the sender merely identifies the signs within the system and makes inferences as to what the signs mean based on his/her internal relation and linking between the signs identified.
2. Semantic element: the information element in which there is a general understanding of the signs and their significance as related to the system and the system's goals
3. Pragmatic element: the knowledge element in which the role of signs is impacted by the personal and psychological components of communication and their role in regulating the function of a system.

A sender may, when communicating with one or more receivers, identify a need to communicate based on factors within the surrounding environment or system. Once the sender has detected the system indicators (or signs) and gained information about the state of the system from these signs, the sender may transmit a message, based on his/her developed knowledge, in an effort to control or regulate the system. The transmission of information, with meaning and context, form the message and conveys the knowledge of the system from the sender to the receivers. Wurman (1991) reinforces this concept in his quote, '*Information without communication is no information at all.'* The transaction of meaning as abetted by the conveyance of information between systems, or system components, is the essence of communication (Skyttner, 2005).

Convergence. The convergence of information considers the psychological component of a group or individual. Information processing emphasizes the transmission within individuals rather than among individuals (Dennis et al., 2008). This communication process is also subjected to the characteristics, capabilities, and limitations of both the sender and the receiver on a physical, educational, and experience level (Ippolito & Stevens, 2014). For convergence to take place, the receiver of the message must be able to adequately receive the message and understand the message. By understanding the message, the receiver subconsciously integrates the message and changes his or her mental model based on the content of the message and its criteria (i.e. its salience, urgency, etc.) as shown in Figure 1.

Colin Cherry (1966) described four elements that retard the efficiency, effectiveness, and efficacy of a message being received and converged, these elements include:

- Uncertainty of acoustic patterns – the tone, accent, clarity, or loudness of the sender
- Uncertainty of language and syntax - sentence construction and proper synonyms
- Uncertainty of environment – distractions by noise, background interferences
- Uncertainty of recognition – making cognitive connections, familiarity with the sender

These elements act as a boundary around the receiver and influence whether the message is received, how well the message is understood, and cognitive reasoning based on what the receiver knows about the sender and his or her potential meaning.

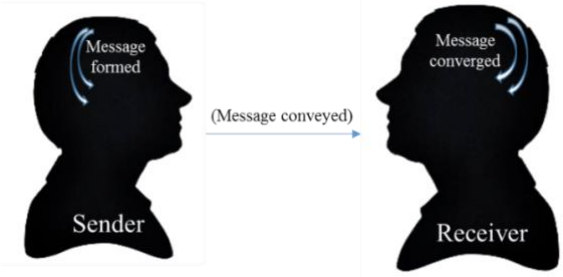

Figure 1. Conveying and Converging a Message

Checkland (1981) offers a different perspective on the element impacting the convergence of information to the sender in human activity systems. Rather than focusing exclusively on the language usage and verbal elements, attention is placed also on the mentality of the sender and his/her mental predisposition. Motivation to process a message, as stated by Contento (2011), depends on the receiver's predispositions, their attitudes and expectations based on their own beliefs, habits, and experiences. Therefore, the success of information convergence depends on the nature/nurture or worldview of the receiver, or his/her "weltanschauung". In his soft systems methodology, Checkland (1981) uses CATWOE to capture different perspectives associated with a system development. CATWOE stands for Customers, Actors, Transformation, Weltanschauung, Owners, and Environmental constraints. In his methodology, Checkland defines the environmental constraints as the "elements outside the system which it takes as given" (Checkland & Scholes, 1990). These constrains are important because they help to contain and define the problem context (Basden, Bergvall-Kåreborn, & Mirijamdotter, 2003). Basden et al. (2003) state that the environmental constraints can be broken into two different types of constraints, determinative and normative. Determinative constraints are basic and natural constraints, such as gravity, human nature, and organic structures, whereas normative constraints are softer and more amendable to change, such as ethical norms, organizational structures, and interpretations. The operational definitions for weltanschauung, Environmental, and Recognition as described by Checkland (1981), Basden et al. (2003), and Cherry (1966) are defined in this research as:

1. Weltanschauung – the predisposition of the receiver that allows for the motivation and understanding to process the message as received from the sender.

2. Environmental – the determinative and normative constraints surrounding the receiver, both their physical environment and distortions of noise as well as the culture of people or team surrounding the receiver.
3. Recognition – the degree of recognition between the sender and receiver, how well the receiver knows the sender's mannerisms, preferences, habits, and style.

Assessing Convergence. Measuring understanding, or the convergence of information, is one of the more challenging aspects of educational programs for instructors and trainers and is rarely defined outside the instructor's impression and students' reactions (Sundberg, 2002). However, for employees in the workforce, some training programs are assessed by 1) reaction, 2) learning, 3) behavior, and 4) results (Kirkpatrick, 1979). Learning is successful when students/employees understand and converge the information into their mental models. The convergence component is defined in this research as the receiver's actual understanding of a transferred message with respect to the original meaning of the message as intended by the sender. A conceptual design of this process is shown in Figure 2. When both lines intersect, the receiver understands the message as the sender had intended. However, complexity incurred by either the rate of information transfer or the complexity of the message will result in a reduced convergence possibility.

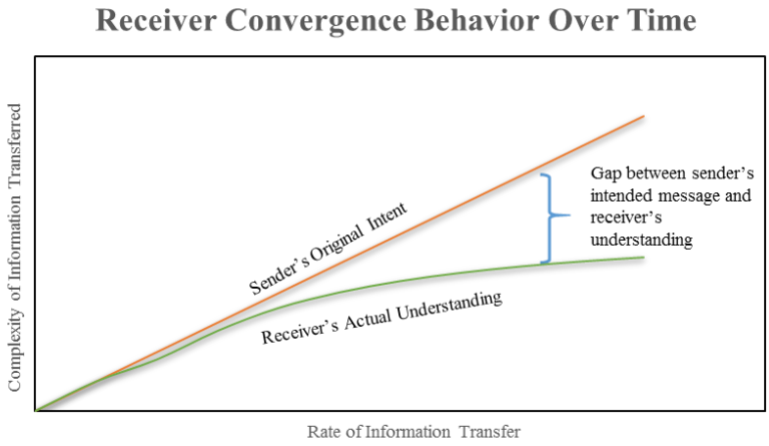

Figure 2. Process of Convergence

The communication system through the conveyance and convergence of information across an organization experiencing change has a direct impact on the success of the change (DiFonzo & Bordia, 1998; Lewis & Seibold, 1998; Schweiger & Denisi, 1991). In summary, successful organizational change depends on how information extends to all parts of the organization in addition to how effectively the information is received and understood. With an understanding of how the subsystems of conveyance and convergence are constructed and how they independently impact either the construction of the message or the reception of the message, it is possible to identify specific factors retarding the operation of either subsystem. These factors may come from the within the subsystems or externally from the environment. It is hypothesized that these two communication subsystems act as the cybernetic processes needed to adjust and maintain the

autopoietic human activity system of the organization. These two communication components, when combined, illustrate the process of human communication within a human activity system.

ONTOLOGICAL FRAMEWORK FOR THE COMMUNICATION SYSTEM IN HUMAN ACTIVITY SYSTEMS

In further developing the concept of communication as an emergent system of the combined subsystems of conveyance and convergence, it is beneficial to refer to Rousseau (2017b) and his research on General Systems Theory. In the late 1930s, the biologist Ludwig von Bertalanffy began a movement to discover universal principles that apply to systems in general rather than theorize about specific types of systems. Accordingly, Bertalanffy (1950a) developed a new discipline based on principles for systems in general. The quest for these valid principles for general systems led to the exploration of systems as a whole rather than the reductionist method of analyzing individual parts comprising the system. Rousseau (2017) proposed that applying standard scientific and philosophical models to systems concepts will yield systems principles that can both express and quantify the nature of systems, including conceptual systems such as communication.

Rousseau pointed out that properties with causal powers can be characterized in terms of energies, and on this basis proposed three main principles proposed namely 1) the Conservation of Properties, 2) Universal Interdependence, and 3) Complexity Dominance. The Conservation of Properties principle, according to Rousseau (2017), states that: *the energy associated with the emergent property in system formation is exactly matched by the sum of the energies lost by the parts participating in that interaction* (p.7). The interaction of parts yields an emergence of new properties not present in the parts before the system formation; however, it also results in submergence in that the properties of the individual parts are diminished compared to what they were before the system formation. The emergence of new system-level properties, and the diminishing of part properties, can be characterized in energy terms. To elaborate, this principle declares that the sum of the energies lost in the interaction between parts in forming the system equal the specific amount of energy associated with the formation of the emergent system-level causal powers resulting from the interaction of parts. Realizations of this principle extend from an atomic level to a human activity one; resulting in more power and capability as a whole system, but less independence and autonomy as with the individual parts. With respect to a team, the individual members may gain more success as a whole when grouped as a team but their individual freedom to act as they wished will be suppressed.

For communication, the emergence of the communication system through the combined subsystems of conveyance and convergence creates the ability for individuals to transfer messages between a sender and receiver(s) in a rational, understandable fashion. However, applying the law of submergence, the communication system is also constricted by linguistic rules and the lowest level of communicative ability between the sender and receiver, this last point meaning that even

though one sender/receiver may be well articulated and knowledgeable, they must communicate on a level that is understandable to the sender/receiver who is at a lower level of communicative ability. Therefore, the communication system between the sender/receiver is improved at the expense of the individuals within the communication system who must adapt their conveyance and convergence based on the linguistic level of the individuals and their knowledge of the system. Figure 3 illustrates this principle as it applies to the communication system.

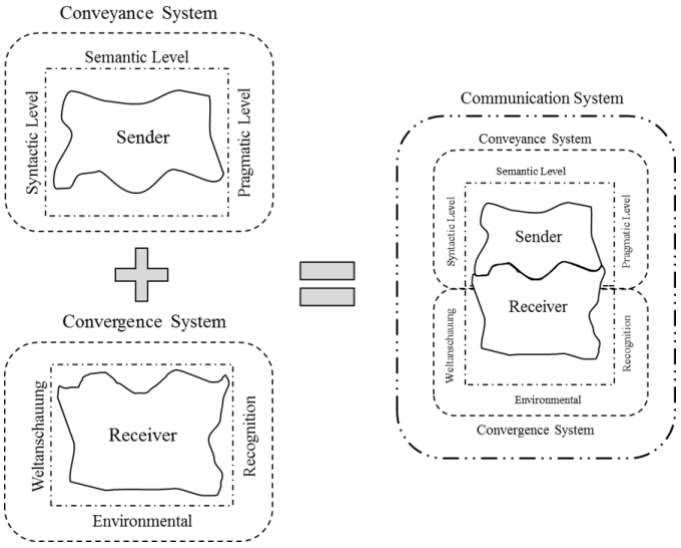

Figure 3. Conservation of Properties within the Communication System

The second principle is the Universal Interdependence which illustrates a containment hierarchy of systems within systems. This principle expresses at its core that a system, all systems short of the universe and lowest atomic element, is part of a larger complex system (super-system) and contain at least one lower-level system (subsystems). Rousseau (2017) states that this principle: *implies that systemic properties are determined as a balancing act between the bottom-up influence of the parts and the outside-in influence of the systemic context* (p.8). Systems embedded within systems are subjected to the first principle of emergence and submergence within the hierarchy of systems, having an influence on the super-systems while also being influenced by lower-level subsystems. Rousseau (2017) emphasizes the importance of this principle as a core concept of systems thinking, that systems are not only present in a surrounding environment but connected to and influenced by that environment. He states that systems properties are therefore impacted from a bottom-up influence (via lower-level subsystem interactions) as well as outside-in influences (via interactions between the system and super-systems in the environment).

The communication system is also governed by this second principle of hierarchical influence; it is both an emergent system from the combined subsystems of conveyance and convergence as well as a subsystem to the overarching human activity system. The communication system is impacted both from the interactions of the subsystems (bottom-up influence) as well as the surrounding environment which is the super-system of the human activity system (outside-in influence). In a

hierarchical management system within an organization, each member in the hierarchy has a different understanding of the human activity system, termed in this research as System Knowledge (SK). The system knowledge of an individual refers to how well they understand the system they are directly apart of or influenced by. Team members working directly with the system (i.e. as information technology (IT) support, with equipment, tools, processes, etc.) have a ground zero level of system knowledge (SK lv:0); meaning they have a general understanding of the micro system and its elements and functions. Team members convey information about the micro system to the team leader, or vice versa, who has a more complex understanding of the micro system from various perspectives of each team member. The complexity of the communication system increases as knowledge of the system increases. At the executive level, the system knowledge includes an understanding of the macro system; the human activity system as a whole. Knowledge increases through the interaction of the higher-level employee with one or more lower-level employees resulting in an emergence of a more complex communication system for each higher-level employee as shown in Figure 4. Information conveyed to the executive level is conveyed back down through the management hierarchy in the form of directives, orders, or requirements. This cybernetic feedback from the executive level results in changes made to the organization.

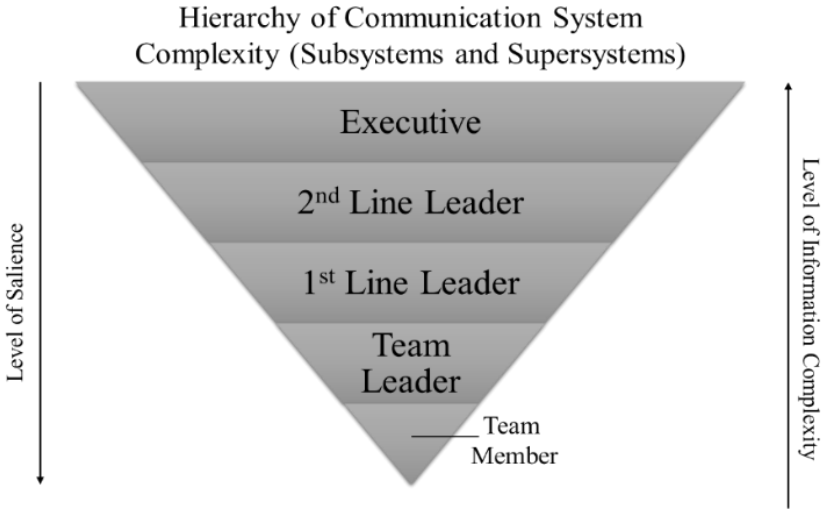

Figure 4. Flow of Information across the Management Hierarchy

Shown in Figure 5 is the communication system between the team member and the team leader. The team member communicates with a basic understanding of the human activity system whereas the team leader communicates with an understanding composed of various team members' perspectives of the system and consequently has a greater system knowledge resulting in a more complex communicative ability.

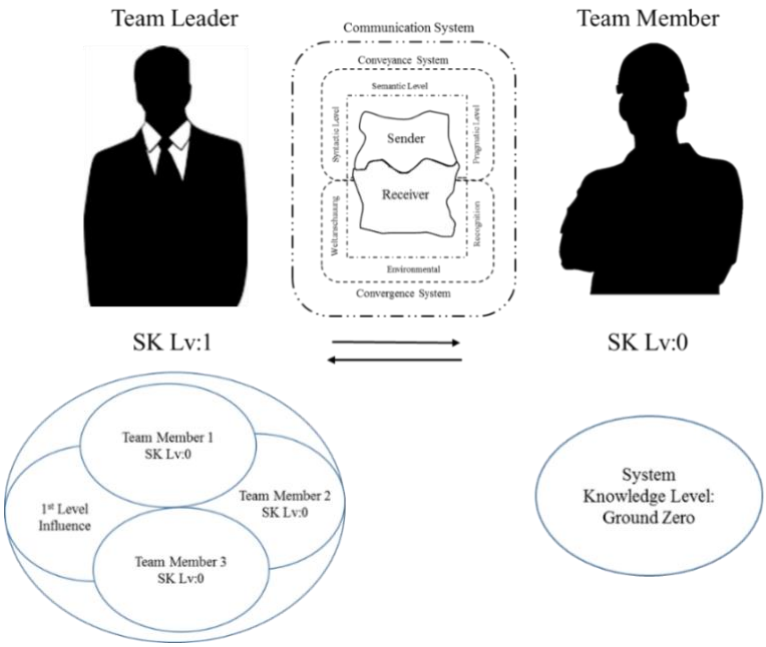

Figure 5. The Communication System between a Team Lead and Team Member

In addition, the team leader also communicates with the 1st line leader and is influenced by the feedback from the 1st line leader's interactions, such as a task requirement or feedback on ways to improve the system. The communication system is therefore influenced by the interaction of the lower subsystem (communication between team leader and team member) as well as the higher super-system (communication between the 1st line leader and the team leader).

The complexity of interactions increases the complexity of the communication system. Each level of system knowledge incorporates more information about the system from more perspectives but on a more macro system understanding. As the complexity increases, the fidelity of the system, with regards to the noise of specific details, is filtered until only the most meaningful information reaches the top of the management hierarchy. Figure 6 show the progression of influence on the communication system from the bottom-up and top-down. In addition, the communication system is influenced by the outside-in influences of the surrounding human activity system, illustrated by the dashed line. The environment, organizational culture, as well as customer demands and supplier relations all impact the communication system.

The third principle is that of Complexity Dominance. This principle embodies the concept that, when two subsystems come together to form an emerging system, there is submergence in which both subsystems give up energy to form the whole system (as discussed in principle one). Rousseau (2017c) states that: *the impact of submergence on a part is proportional to the complexity differential between the part and the whole* (p. 9). The subsystems composing the emerging system contribute the same amount of energy to formulate the new system. However, the subsystem of greater complexity is expected to feel much less impact than the subsystem of lower complexity.

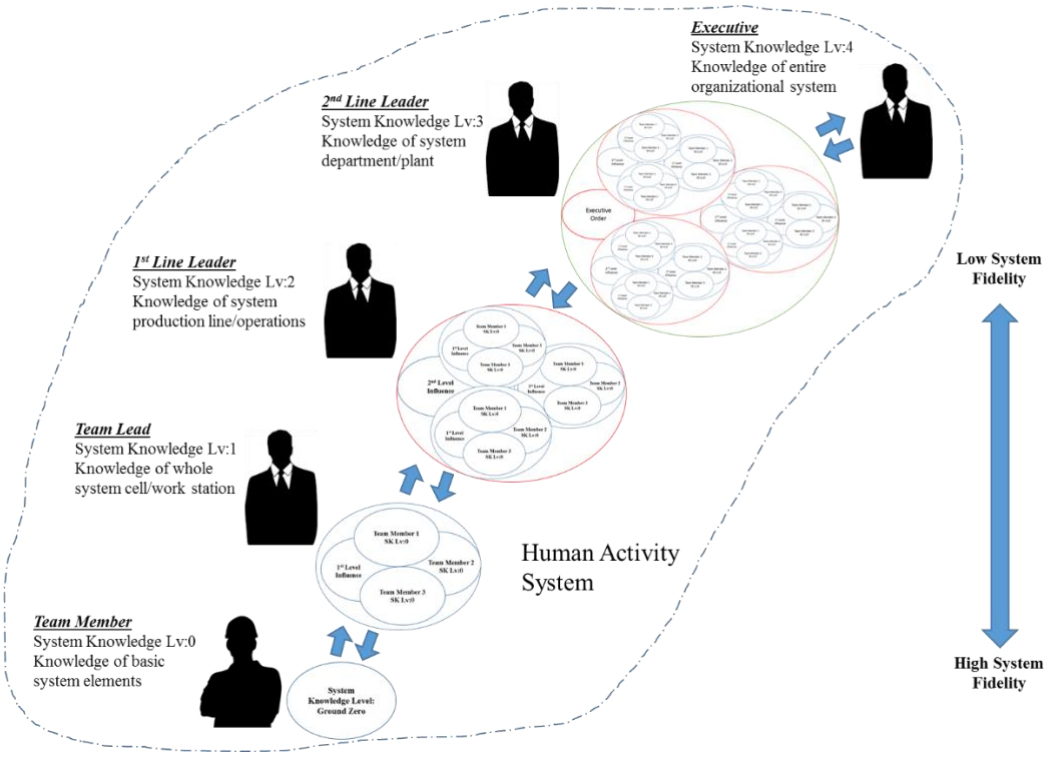

Figure 6. Bottom-up and Outside-In Influences on the Communication System

Considering once more the communication system, this third principle is realized between the subsystems of conveyance and convergence. While each subsystem must equally give up energy to form the emerging communication system, this submergence is proportional to the complexity differential of each subsystem to the emerging system. This principle will come into play where there is a difference in complexity between the conveyance system and the convergence system. In practice both are likely to be complex but it would be unusual for them to be exactly similar complexity. For example, someone with better educational level and greater experience may find it easier to express themselves accurately than someone with lesser abilities. In terms of the present model, the former case represents a more complex system than the latter case. When these two systems communicate, the less complex one will have to work harder (expend more energy) to understand a message sent by the other, and work harder (expend more energy) to formulate a comprehensive and accurate message to be sent. Conversely the more complex system will expend less energy to produce an adequate message and to understand what the other party is trying to convey.

In practical situations this mismatch is minimized by training both systems in a common language. This is especially important in complex scenarios where effective actions depend on minimizing the convergence time. An example of this is the jargon used by NASA mission controllers. However, when unanticipated events occur then communication becomes vulnerable to complexity mismatches again. For this reason, it is important to minimize complexity mismatches between conveyance and convergence systems in mission-critical or hazardous scenarios. In complex organizations, efficiency can be maintained by compartmentalizing complexity

differences into communication tiers. It is important to understand, that in the subsystems of conveyance and convergence, the interactions of the sender and receiver and to recognize that the roles of sender and receiver are not fixed, they swap depending on the person who is either sending or receiving the message. In this way, the complexity of the subsystems of conveyance and convergence may be linked to the system knowledge of the person conveying or converging information. The convergence of information for a higher-level manager may be more complex due to multiple sources conveying information about the microsystem, or the amount of details about the system conveyed. Ultimately, not all of the information about the system is conveyed, only that which needs to be conveyed according to the sender, resulting in a convergence gap between what the sender (lower-level employees) understands about the system and what the receiver (higher-level employees) learns about the system.

Alternatively, as shown in Figure 7, it may also be assumed that the information conveyed by the higher-level employee is much more complex in nature, given the higher system knowledge, in addition to the influence from managers one level higher. For a lower-level employee, the higher system knowledge and influences from higher management levels may make it difficult for the lower-level employee to converge the information conveyed due to its complex nature. The complexity of the subsystems of conveyance or convergence is illustrated by the weighted arrows pointing to either the sender or receiver of information.

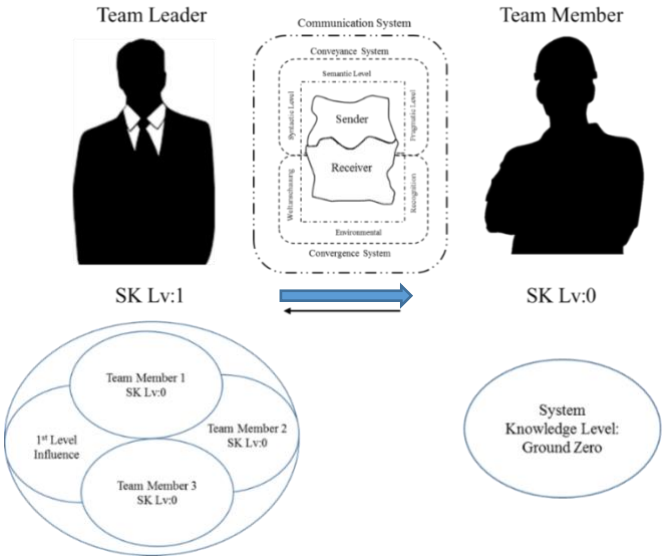

Figure 7. Complexity Dominance of Information Convergence from a Higher-level System Knowledge to a Lower-level System Knowledge

By applying these three principles to the communication system and considering the construction of the conveyance and convergence subsystems as discussed previously, a better understanding of the whole system and its interaction with its surrounding environment may be obtained. The final step in the ontological framework is to combine the subsystems and form a hypothesis on the system's processes and emerging system structure. Skyttner (2005) states that human

communication incorporates four phases of message development, comprising the processes of conveyance and convergence. These phases are:

Phase 1. Development of a message for the sender to transmit
Phase 2. Externalization of the message to transmit signs, symbols, sounds and motions
Phase 3. Reception of the message by the receiver assimilating the signs and symbols
Phase 4. Integration of such signs and symbols into internal contents used by the receiver

Skyttner describes two transformations that ensure the success of the communication system toward the system's goal; the externalization of information by the sender and integration of information by the receiver. These transformations occur in spite of the uncertainties described previously by Cherry (1966) and may be described in parallel to the conveyance and convergence subsystems. Conveyance includes the first two phases of the message development and transmission; what is appropriate and necessary to transmit and what channels are used to transmit the message. Convergence includes the same channels used to transmit the message, subjected to the physiological limitations of the receiver (such as optical or hearing limitations), as well as the cognition of the receiver and the process of integrating that message. The full framework for the communication system within Human Activity Systems is illustrated in Figure 8.

By defining the interactions of the communication system and the subsystems of conveyance and convergence, it is easier to observe the communication capabilities of the sender and the receivers and the factors influencing the transmission of messages. It is important to point out that the model does not include an observable feedback loop as shown in the model by Natarajan, Wyrick, and Lindeke (2010). This is attributed to the idea that the subsystems take on roles that are dependent on the interaction of both subsystems. For instance, the sender is only the sender when there is the conveyance of a message and the receiver is only the receiver with he/she is not also conveying a message but rather listening and receiving that message. Kourkouta and Papathanasiou (2014) affirm this in their research on communication in nursing by stating "communication is never unidirectional. It is an interaction in which each sender becomes receiver and vice versa" (p. 65). However, rather than a binary interaction of a message transmission and then responding feedback, the roles take place simultaneously where the sender of a verbal message may also be receiving a non-verbal message from the intended message receiver; this following more of a Schrödinger's paradox where the messages are both sent and received in dual-superposed quantum states, also known as superpositionality. This proposition is perhaps more true for face-to-face interaction and verbal communication than with media aided communication, which demonstrates more of a binary interaction between sender and receiver. However, with media aided communication the elements of time and displacement from sender/receiver enter the equation. This inherent interaction of the two independent subsystems replaces the traditional concept of feedback as an emerging characteristic of the communication system.

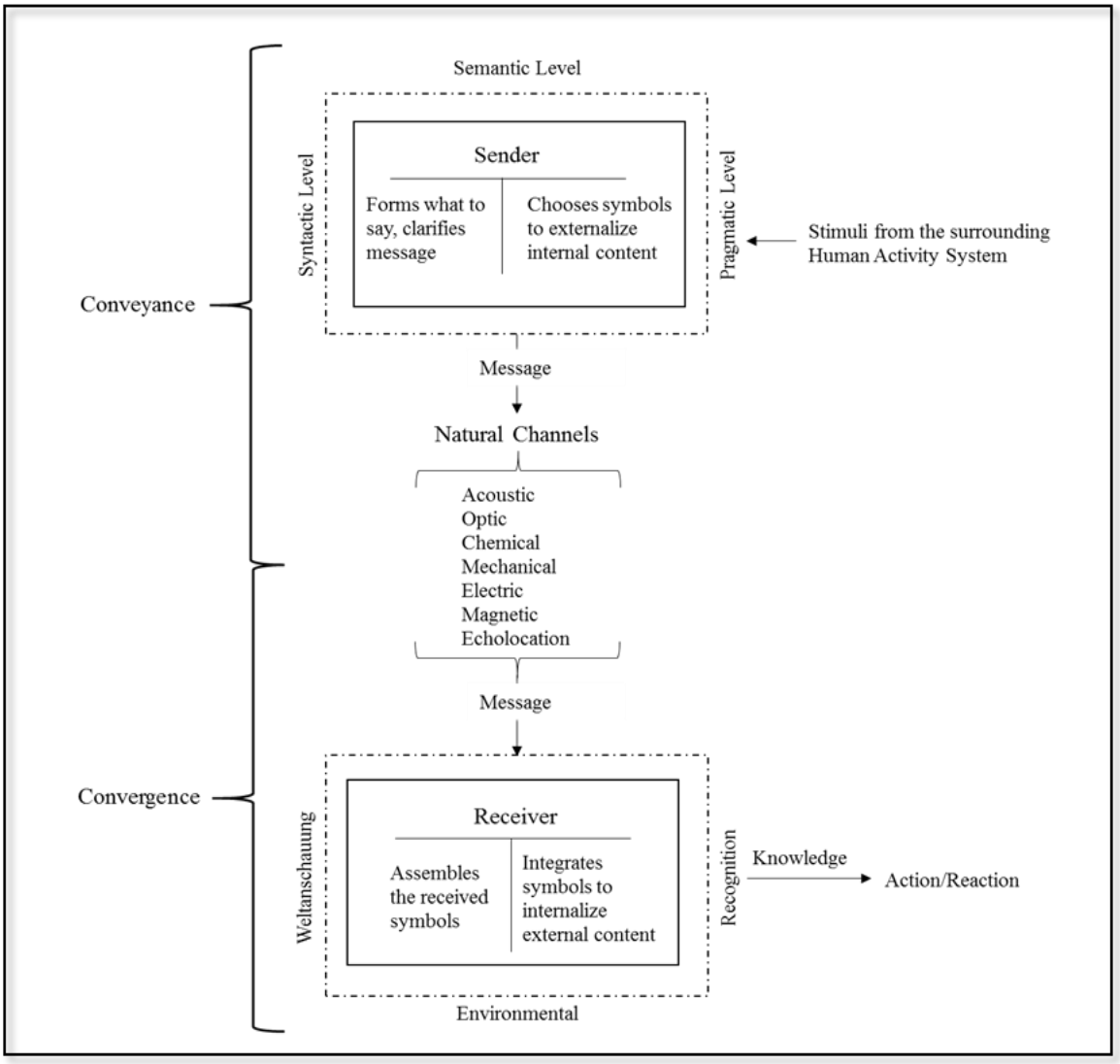

Figure 8. Communication System Model for Human Activity Systems

In addition to the communication system model illustrating the elements and relationships between the conveyance and convergence subsystems, the process arrows depicting an interaction between the Human Activity System, composed of a convergence and conveyance subsystems, and its environment. This last relationship provides the final link between the communication system emergence and its impact on the Human Activity System, adjusting the Human Activity System from a current to a future, more optimal, state of operations in pursuance of the Human Activity System's goal.

The resultant behavior of Human Activity Systems is illustrated in

Figure ***9*** with the Transition-Phase Management Model adapted for Human Activity Systems from Calvo et. al. (2014). The model exemplifies the theoretical transition between the initial Human Activity System state and the desired Human Activity System state, depicted as having a traditional learning curve behavior (shown in the angled line from t_0 to t_f). Organizations experiencing new

process implementations or culture changes experience the behavior illustrated in the transition model where the culture of the organization is adapting and maturing from an initial to desired state of system operability by some form of learning by doing behavior; finally coming to equifinality after time t_f.

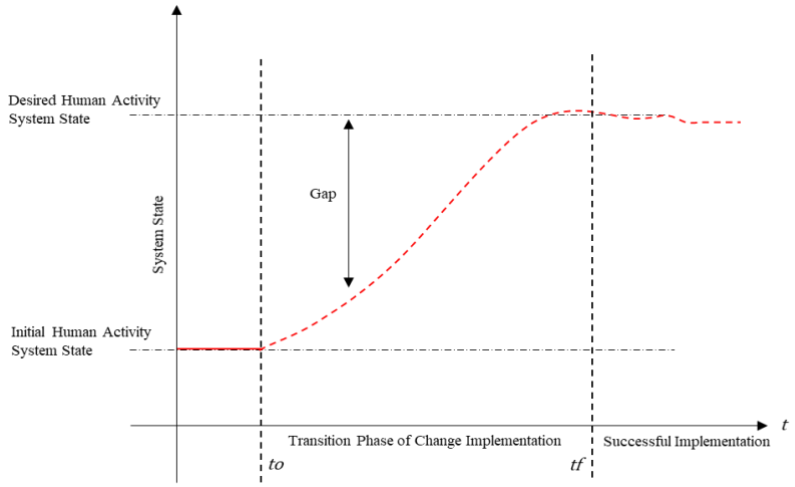

Figure 9. Transition-Phase Management Model Adapted for Human Activity Systems (Adapted from Calvo et al., 2014)

The communication system, as a facilitator in influencing and adapting the Human Activity System through the conveyance and convergence of information, provides a catalyst for transitioning an existing organizational culture from the initial Human Activity System state to the desired Human Activity System state. Through an interaction with the Human Activity System environment, the communication system inputs stimuli from the environment then considers the system's health and integrity based on the characteristics of the stimuli (aka system signs). If necessary to control or adapt the state of Human Activity System, the stimuli is transformed into a message with change directives for an action/reaction to adjust the current state of the system toward a desired future state. The interaction between the two systems and resulting Human Activity System behavior is illustrated in Figure 10.

One final note refers to the behavior over time of the A, B, and C lines; these lines demonstrate different scenarios resulting from the communication system emergence through the various levels of submergence of the conveyance/convergence subsystems. For scenario A, the Human Activity System may have excess resources for information dissimulation across the organization, through small group formations with daily meetings or coaches and trainers available. In this way the conveyance of information is more readily spread and the convergence of information is more successful due to rapid and continuous feedback from the coaches/trainers conveying the information and reinforcing the learning of key elements. In this way, the Human Activity System will reach the desired future system state more readily than demonstrated in scenario C which lacks either resources or constructive reinforcement of conveyed information. This lack of reinforcement will result in a gap between the conveyance and convergence of information, as explained in Figure

2, and the system is likely to take longer or never reach the desired system state at all. Finally, scenario B shows the most optimal relationship between the communication system and Human Activity System, balancing the feasible number and utilization of resources to optimize the conveyance of information and reinforce information convergence. Scenario B is one most beneficial for Human Activity Systems due to the sustainable balance between resources utilization and the success of the impacting communication system, whereas scenario A may not be sustainable long term or induce unnecessary burdens on the Human Activity System resources.

DEFINING COMMUNICATION SYSTEM PRINCIPLES

Now that communication has been defined and illustrated as having the structure and behavior of a system and its impact on Human Activity Systems recognized, it is important to develop principles for the communication system within the boundaries of Human Activity Systems that might guide understanding and evaluation of such interactions. By doing so, the reader may better understand the basic assumptions underlying the nature and behavior of the system and systems interactions.

Stated by Rousseau (2017), system principles provide guidelines or sets of rules for what is known about the nature of a system and sets the foundation for conduction systems research. Principles provide a general "truth" about the nature and behavior of system(s) considered and help lay the foundation for a better understanding of these systems. Furthermore, principles can be established from observation and experience and be redefined with empirical evidence, thus becoming more scientific and provable. Ludwig von Bertalanffy proposed that systems share principles that are valid for all systems in general. This is demonstrated in the display of similar structures and isomorphic behaviors among systems of focus in different fields (Bertalanffy, 1950b). This is true as well for specific domains such as communication. Thus the communication system and the scientific community's interpretation of what communication is, what it means to communicate, and what impact communication has on other complex systems can benefit from the use of systems principles.

Aligning with Rousseau's (2017a) quest for explanatory (rather than descriptive) principles and cohesion among specialized disciplines, this research incorporates a following literature exploration with the intent of deriving a general set of system principles for the communication system. A sample selection of communication-based journals were included as a starting point for exploring what researchers were defining as communication, including various practical and academic disciplines and perspectives. The intent of this exploration was to develop a sense of what independent areas of research and practices were considering as "principles" of communication within Human Activity Systems. This sample included journal articles from Communication Theory, Healthcare, Engineering Management, Psychiatry, and Education to name a few. The key words "Communication is" was used as a seed for mining specific phrases researchers would use to describe the process or nature of communication. The sample included 50 journal articles and 85 independent qualifiers. Such qualifiers included "Communication is - an intrinsic characteristic of human nature" (Kourkouta & Papathanasiou, 2014) and "Communication is - the mobilization of all senses" (Moussas, Karkanias, & Papadopoulou, 2010).

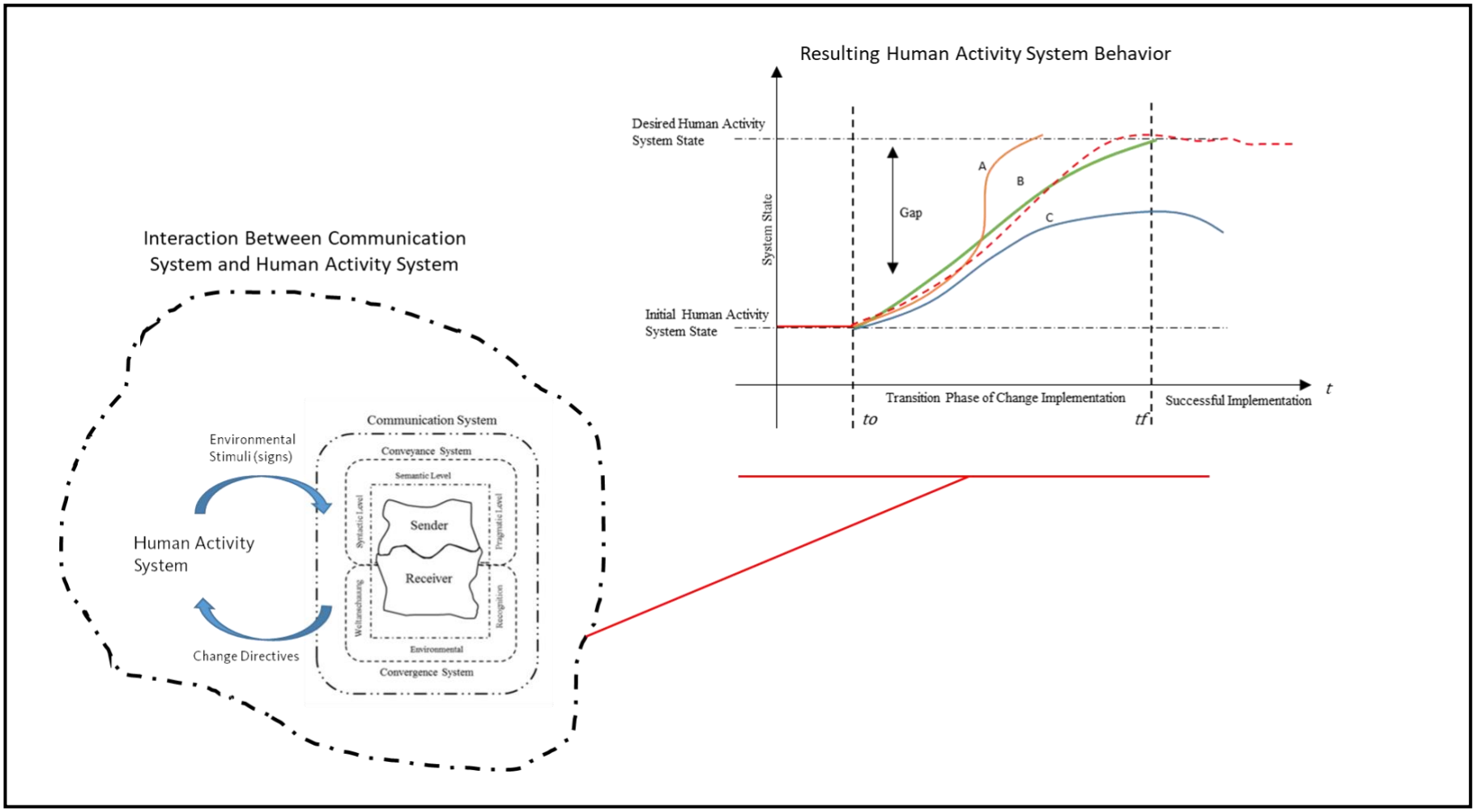

Figure 10. Communication System Interaction with Human Activity Systems and Resulting Behavioral Change

From these 85 qualifiers, 22 principles were derived as a set of communication principles in Human Activity Systems (see Table 1). This general set of principles that could apply to all disciplines bounded between the interaction of human beings (as opposed to all communication between animals, humans, plants, etc.). These principles were linked back to a what Rousseau (Rousseau, 2018) calls the Activity Stages of a Scientific Endeavour. Similar to the phases of a project, these stages include the initial "Reflection" stage of conceptualizing the problem, context, history, etc. and structuring how to go about understanding it. The second phase is the "Research" stage where exploration of the system takes place and interacting with the system to predict and explain the system components and emerging characteristics. The third phase is the "Design" stage which considers the principles relating to the design of the system, including but not limited to the components and their interactions. Lastly, the "Intervention" stage considers how the system is deployed and the intention of the analysis with respect to the purpose of the system.

All 22 principles developed for communication were divided from their compatibility within the four Activity Stages. In addition and simultaneously, each principle was grounded in a particular worldview with regard to a worldview question et al., 2016b). The term "worldview" stems from three main elements, according to Rousseau et al. (Rousseau, et al., 2016a) including, the perspective of the nature of knowledge, the universe, and one's subjective significance of their existence in the world. Worldview is defined further as including the terms Epistemology, Ontology, Metaphysics, Cosmology, Axiology, and Praxeology with regards to systems in general and how researchers might understand or approach systems based on the questions for each worldview term. As an example, for the communication system, the ontology of the system addressing the question "what exists?" includes a reflection of the general characteristics, relationships and purpose of the system within the bounds of Human Activity Systems.

Table 1. Communication System Principles for Human Activities Systems, Adapted from Rousseau (2018)

Stage	Communication Systems Principles in Human Activity Systems	Worldview category and question (Rousseau, 2018)
Reflection	A communication system is a conceptual system comprised of meaning, value, concepts, and relationships within and across the boundaries of a Human Activity System.	Ontology – What exists?
	Communication systems emerge from a homeorhetic process between convergence and conveyance of information in concrete systems.	Cosmology – What is its origin/history/current state/destiny?
	The meaning of information is inherently different between a sender and a receiver due to differences in their worldviews, capabilities, and how they interact with their environments.	Metaphysics – What is its nature?
	Success of the communication system in reaching its goals is largely dependent on the degree of shared rules of commonality, behaviors, and social norms between the sender and receiver of information which adds significance and salience to the context of the information.	Cosmology – What is its origin/history/current state/destiny?
	Communication systems facilitate maintaining control, adjusting behaviors, and reducing entropy in human activity systems.	Praxeology – How should we live and why?
	The communication system interaction between conveyance and convergence of information demonstrates superpositionality, where information exists between the states of sender/receiver at the same time until measured.	Cosmology – What is its origin/history/current state/destiny?
Research	Information within the Human Activity System consists of physical space, culture, social and intellectual conditions and is bounded by the framework of those conceptual or concrete systems.	Ontology – What exists?
	The communication system is a holistic system comprised of multiple parts, interconnected, and working toward a system goal within a given boundary as determined by the system analyst.	Epistemology – What/how can we know?
	The communication system is a living system, demonstrating autopoiesis and the ability to evolve with cultures, environments, and kinds of other systems over time.	Cosmology – What is its origin/history/current state/destiny?
	The communication system initiates and sustains change toward an improved state of operability, sustainability, cohesion, cooperation, maturation, and overall improved functionality and homeostasis.	Praxeology – How should we live and why?
	The communication system facilitates variety management in Human Activity Systems with requisite variety of rich interconnectedness and dynamic functionality.	Praxeology – How should we live and why?
	The communication system emerges from the submergence of the conveyance and convergence subsystems and their independent capabilities.	Cosmology – What is its origin/history/current state/destiny?
Design	Congruence between the 1) message sender, 2) message contextualization, 3) channel(s) utilized, and 4) receiver determines the capability of the communication system to facilitate reaching the Human Activity Systems goal.	Cosmology – how is the system organized?
	The communication system behavior changes based on the content and origin of information from the Human Activity System.	Epistemology – What/how can we know?
	The communication system is a unidirectional and hierarchical system, changing in ***state*** within organizational levels and changing in ***kind*** across organizational levels.	Cosmology – What is its origin/history/current state/destiny?
	Changes in the ***state*** of the communication system require alignment between systems with similar properties, whereas changes of ***kind*** require alignment between systems with different properties.	Cosmology – What is its origin/history/current state/destiny?
	Changes in the communication system ***state*** and ***kind*** transition the Human Activity System from an initial state of operability and functionality to a desired future state.	Praxeology – How should we live and why?
	The communication system mobilizes all information channels conducive to optimizing information flow between a sender and receiver.	Cosmology – What is its origin/history/current state/destiny?
Intervention	The communication system success relies on active participation of all elements directly related to the Human Activity System adaption.	Praxeology – How should we live and why?
	Success of the communication system to facilitate change relies on fluid, timely, and complete information between key actors and stakeholders of the Human Activity System.	Cosmology – What is its origin/history/current state/destiny?
	Preservation of the communication system requires continuous and relevant information for monitoring and adjusting the Human Activity System.	Praxeology – How should we live and why?
	Success of the communication system may be demonstrated though the improved cadence and homeorhesis of the Human Activity System behavior.	Epistemology – What/how can we know?

CONCLUSION

Defining system principles provides a methodology to assess systems, design systems, and develop strategies for effectively implementing system interventions. While principles can be almost anything to anyone, there is a need to develop more scientific principles that are precise, clear, and measurable. For instance, how the interaction between the communication system and Human Activity System can be known and measured and how the convergence of information can be improved to optimize the impact of the emerging communication system on the Human Activity System behavior Ultimately, the system principles listed in Table 1 will provide a foundation for 1) guiding judgment about the emerging communication system in Figure 8 and 2) create action for optimize the interaction between the communication system and Human Activity System as shown in the various scenarios in Figure 10.

The purpose of the research presented was to develop an ontological framework that characterized communication as a conceptual system, emerging from the interaction of information conveyance and convergence. Subsequently, a set of system principles were developed to provide a set of rules for assessing the communication system interaction within Human Activity Systems. It is assumed that the research on the communication system and the subsystems of conveyance and convergence may provide managers and researchers insight into the various factors affecting the behavior of communication throughout the organization during new process implementation efforts. The knowledge of such, will prepare managers to consider various factors impacting the effectiveness of information conveyance and convergence on change management. Furthermore, it is anticipated that the development of system principles for the communication system within the bounds of Human Activity Systems will provide a change of perspectives in communication research and engineering management practices for a more optimal design of both systems and their interactions.

FUTURE WORK

The framework for the process of human communication in human activity systems is still under development and requires additional research to identify its full potential in engineering management. Limitations to this research included a brief, purposeful selection of literature articles from communication journals to develop the principles presented in Table 1. Further development of system principles for the communication system in Human Activity Systems will include a broader, more exhaustive sample. Additionally, future research will strive to translate the theoretical framework for the process of human communication as shown in Figure 8 into a pragmatic model that can be tested through design of experiments methods. Finally, exploration of the communication system will seek to understand how managers can profit from their

knowledge and manipulation of the communication system to optimize this impact throughout the organization.

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