Doi: 10.4025/psicolestud.v22i3.33944

EPISTEMOLOGY OF SYSTEMS THINKING AND THE CONTRIBUTIONS OF HUMBERTO MATURANA

Joyce Lúcia Abreu Pereira Oliveira[1]
Maria Aparecida Crepaldi
Universidade Federal de Santa Catarina (UFSC), Florianópolis-SC, Brazil.

ABSTRACT. Epistemology of Systems Thinking (ST) has undergone important changes throughout the twentieth century and has gradually gained ground in scientific investigations and interventions in different contexts. Understanding its epistemological principles has been a challenge in undergraduate and graduate courses of different areas, and it is *sine qua non* for the implementation of systemic research and interventions. Thus, this article aims to present the historical and epistemological development of ST in the twentieth century and the contributions of Humberto Maturana for the advancement of postmodern science, with Biology of Cognition and Cultural Biology. It describes the paradigm shift from traditional science to postmodern science, as well as the basic assumptions that characterize them. We used a historical and epistemological spiral, along with the concept of recursion, to facilitate the understanding of the interconnections between researchers and theories that have contributed to the development of ST. The main concepts of the systemic theories that are recognized and well-known in the scientific community were presented, namely, the General Systems Theory, Cybernetics, the Communication Theory. Our conclusion is that the epistemology of ST has provided significant advances to science, because it integrates the epistemological assumptions of complexity, instability and inter-subjectivity in phenomena analysis, in research and interventions in different contexts.

Keywords: Epistemology; cybernetics; systemic thinking.

A EPISTEMOLOGIA DO PENSAMENTO SISTÊMICO E AS CONTRIBUIÇÕES DE HUMBERTO MATURANA

RESUMO. A epistemologia do Pensamento Sistêmico (PS) passou por importantes transformações ao longo do século XX e, progressivamente, ganha espaço nas investigações científicas e intervenções em diferentes contextos. Compreender seus princípios epistemológicos tem sido um desafio em cursos de graduação e pós-graduação de diferentes áreas, sendo condição *sine qua non* na produção de pesquisas e intervenções sistêmicas. Desse modo, este artigo tem por objetivo apresentar o desenvolvimento histórico e epistemológico do PS no século XX e as contribuições de Humberto Maturana para o avanço da ciência pós-moderna. Apresenta-se a mudança paradigmática da ciência tradicional para a ciência pós-moderna, bem como os pressupostos básicos que as caracterizam. Propõe-se o uso de uma espiral histórica e epistemológica, além do conceito de recursividade, para facilitar a compreensão das interconexões entre pesquisadores e teorias que contribuíram para o desenvolvimento do PS no século XX. São apresentados os principais conceitos de teorias sistêmicas com reconhecimento e visibilidade na comunidade científica, quais sejam, a Teoria Geral dos Sistemas, a Cibernética, a Teoria da Comunicação. Conclui-se que a epistemologia do PS tem possibilitado avanços significativos para a ciência, ao considerar de forma integrada os pressupostos epistemológicos da complexidade, da instabilidade e da intersubjetividade na análise dos fenômenos, em pesquisas e intervenções em diferentes contextos.

Palavras-chave: Epistemologia; cibernética, pensamento sistêmico.

[1] *E-mail*: joycelapo@gmail.com

LA EPISTEMOLOGÍA DEL PENSAMIENTO SISTÉMICO Y LAS CONTRIBUCIONES DE HUMBERTO MATURANA

RESUMEN. La Epistemología del Pensamiento Sistémico (PS) ha sufrido transformaciones importantes a lo largo del siglo XX y ha ganado terreno poco a poco en la investigación científica y en las intervenciones en diferentes contextos. Entender sus principios epistemológicos ha sido un desafío en áreas distintas de cursos de grado y postgrado, y es condición *sine qua non* para la producción de investigaciones e intervenciones sistémicas. Por lo tanto, este artículo tiene como objetivo presentar el desarrollo histórico y epistemológico del PS en el siglo XX y los aportes de Humberto Maturana para el avance de la ciencia postmoderna, con la Biología del Conocimiento y la Biología Cultural. Se presenta el cambio de paradigma de la ciencia tradicional a la ciencia postmoderna, así como los supuestos básicos que las caracterizan. Se propone el uso de una espiral histórica y epistemológica además del concepto de recursividad, para facilitar la comprensión de las interconexiones entre los investigadores y teorías que han contribuido al desarrollo del PS. Se presentan los principales conceptos de teorías sistémicas reconocidas y visibles en la comunidad científica, a saber, la Teoría General de los Sistemas, la Cibernética, la Teoría de la Comunicación. Llegamos a la conclusión de que la epistemología del PS ha permitido importantes avances en la ciencia, pues considera de manera integrada los supuestos epistemológicos de complejidad, inestabilidad e inter-subjetividad en el análisis de los fenómenos, en la investigación e intervenciones en distintos contextos.

Palabras-clave: Epistemología; cibernética; pensamiento sistémico.

Introduction

The epistemology of Systemic Thinking (ST) underwent important transformations throughout the 20th century. However, it encompasses paradigmatic changes that have been occurring for centuries, slowly, non-linearly, with advances, setbacks and oscillations in several fields of science (Gomes, Bolze, Bueno, & Crepaldi, 2014; Schmidt, Schneider, & Crepaldi, 2011). This article does not have the pretension of exhausting the subject, but, rather, present in a didactic and introductory way some essential elements for the understanding of the ST and the contributions of Humberto Maturana to postmodern science. For this, the publications of Vasconcellos (2010, 2012) gained prominence, for their clarity in articulation and scientific explanation on the main movements of contemporary science, although it is known that there are other versions on the theme, as well as researchers and theories not contemplated in this text.

The paradigmatic changes in science refer to the movement of transition from a traditional and modern science to a postmodern science. The first refers to the Cartesian mechanistic notion of world, also called reductionist or atomistic, which by making use of the analytic method, seeks the understanding of the whole from the separation of complex phenomena into separate parts (Vasconcellos, 2010, 2012). The metaphor used is that of the world as a machine, which needs to be separated into parts to be subject to scientific analysis (Capra, 1996; Capra & Luise, 2014).

Postmodern science involves a change in perception, in which the emphasis on the parts moves to the emphasis on the whole. This process marks the science of the 20th century, known as ST. According to Capra (1996); Capra & Luise (2014) the phenomena come to be understood as constituted by multiple facets, complex, interconnected and interdependent.

The ST gained theoretical framework and recognition in the first half of the 20th century and several theories and researchers contributed to its development. Vasconcellos (2010) emphasizes the importance and visibility of three systemic theories, namely: the General Systems Theory (GST), Cybernetics and the Communication Theory. Biology of Knowing also stands out, an epistemology developed by Humberto Maturana and Franscisco Varela, for its important contributions to postmodern science. These theories will be presented briefly throughout this article.

Considering that understanding the epistemological principles of ST has been a challenge in undergraduate and postgraduate courses in different areas, being a *sine qua non* condition in the production of systemic researches and interventions, the present study aimed to present the historical and epistemological development of the ST in the 20th century, and the contributions of Humberto Maturana to the advance of postmodern science.

For this, the basic assumptions of traditional science and postmodern science are presented; It is proposed the use of a graphic representation, constructed by the authors of this article, to facilitate the understanding of the interconnections between researchers and systemic theories; and a brief description of these theories is presented, relating them to the assumptions of the ST.

The basic assumptions of traditional science and postmodern Science

For purposes of didactic comprehension, Vasconcellos (2010) distinguished three dimensions of the paradigm of traditional science and three of postmodern science, in order to organize a frame of reference. Table 1 presents these basic assumptions.

Table 1. Basic assumptions of science

Traditional Science	New-paradigmatic science
Simplicity	Complexity
Stability	Instability
Objectivity	Intersubjectivity

Note. Organized from the descriptions of Vasconcellos (2010)

Traditional science is characterized by the assumptions of simplicity, stability and objectivity (Vasconcellos, 2010). In the epistemological assumption of simplicity there is the belief that by separating the complex into parts it is possible to know it and, in this direction, scientific researches establish an "attitude of analysis and search for linear causal relationships" (Vasconcellos, 2010, p. 69). The assumption of the stability of the world refers to the belief that the world is stable, that is, that there is regularity and ordering, whose functioning can be known, controlled, predicted, explained from the formulation of explanatory laws on phenomena. And the assumption of objectivity comprehends that reality exists independent of the observer, being possible to know it objectively, without the interference of the subjectivity of the researcher. The search for general and atemporal laws is one of the main objectives of traditional science (Schmidt, Schneider, & Crepaldi, 2011).

Postmodern science involves overcoming the assumptions of traditional science, being characterized by the assumptions of complexity, instability, and intersubjectivity (Vasconcellos, 2010). The dimension of complexity is based on three principles, whose epistemology was developed by Edgar Morin, namely, the dialogical principle, the principle of recursion and the hologramatic principle (Morin, 2011). The dialogical principle considers reality as *multiverse*, that is, part of the premise that multiple versions on phenomena coexist and rules out the need to arrive at a unifying understanding.

Recursion, in Latin, *recurrere*, means to run again, to go through again, and alludes to the relationship that is established between product and producer, that is, it conceives that the product is a producer of what it produces, making linear and unicausal explanations unfeasible. The third principle, the hologramatic, considers that the part is in the whole, just as the whole is in the part, a logic valid both in the biological world and in the sociological world. According to Morin (2011) the assimilated knowledge on the parts contributes to the understanding of the whole and vice versa, in a knowledge-generating movement.

The assumption of instability arises as a amendment of the idea of the stable world, of traditional science, when considering that the world is in a dynamic process of transformations. In this way, it integrates the indetermination of the phenomena and consequent unpredictability (Vasconcellos, 2010, 2012). The assumption of intersubjectivity considers the impossibility of knowing the world objectively,

when recognizing that reality emerges from the distinctions made by the researcher, in consensual spaces and as social construction (Maturana & Varela, 2001; Maturana, 2014a, 2014b).

The amendment of the assumptions of traditional science emerged on the scientific scene from the restlessness of researchers on how they were producing scientific knowledge (Grzybowski, 2010). According to Vasconcellos (2010), the limitations of the analytical method gave rise to a new scenario in the production of scientific knowledge that aims, at present, to integrate in an inseparable way the three assumptions of ST. The researcher suggests that this integration be named *new-paradigmatic* science.

The historical and epistemological context of Systemic Thinking in the 20th century

The epistemology of ST emerged strongly in the scientific scene in the 20th century and to facilitate the understanding of its historical and epistemological development, the authors of this article propose the graphic representation presented in Figure 1, named the historical and epistemological spiral of ST.

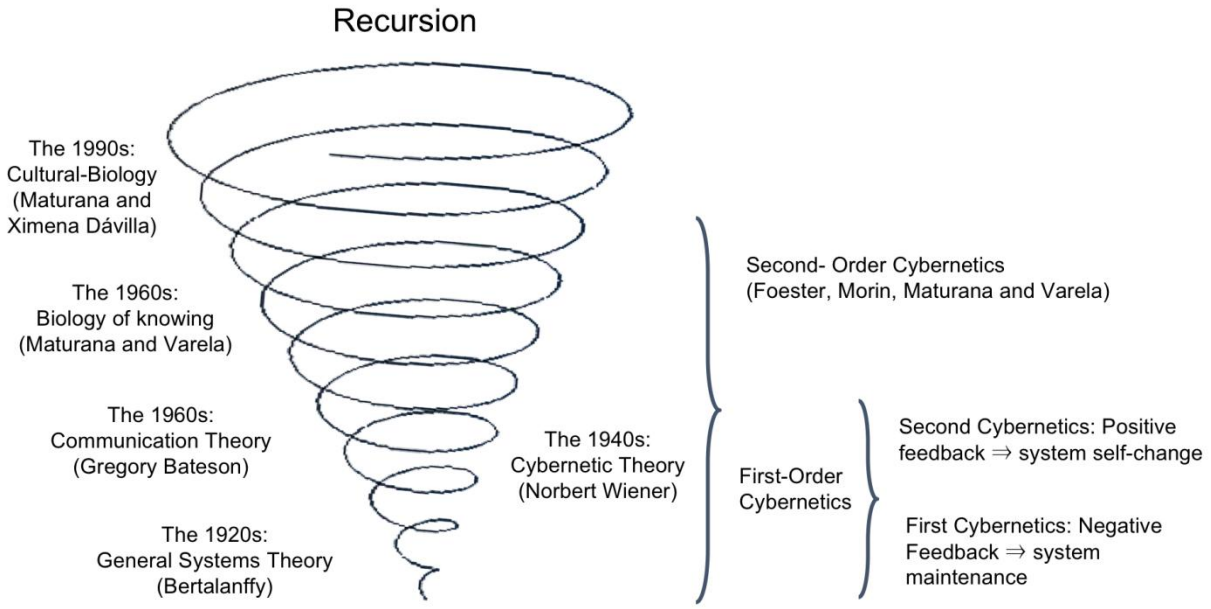

Figure 1. Historical and epistemological spiral of ST: proposal of graphic representation of the development of Systemic Thinking in the 20th century, elaborated from the descriptions of Vasconcellos (2010, 2012)

The image of the spiral is intended to represent both the historical development and the epistemological development of ST, relating them to the concept of recursion. As for historical development, the spiral symbolizes the non-linearity in which events occur throughout history and the recursive relationship between them. As for the epistemological development, it seeks to favor the understanding that theories elaborated in a given historical moment, contribute to boost and mobilize the production of other theories, that is, there are connections, articulations and interrelations between important researchers of the systemic theories produced during the 20th century.

The use of the spiral also proposes to create an *island of order in a sea of chaos*, a term used by Najmanovich (2002) to characterize the organization of certain elements in such a way that generates order and makes possible a supposed understanding, without disregarding the complexity in which the phenomena of study are immersed. The following will be presented briefly: the General Systems Theory (GST), Cybernetics, the Communication Theory, and the contributions of the renowned

researcher Humberto Maturana, for postmodern science, with the Biology of Knowing, developed with Francisco Varela and Cultural-Biology, elaborated with Ximena Dávila Yánez.

The General Systems Theory

In the 1920s, the biologist Ludwig von Bertalanffy (1901-1972) began the development of the General Systems Theory, which is characterized as an interdisciplinary theory, founded on the concept of interaction or relations between components. This is the "first attempt to develop systemic ideas as a new frame of reference for scientific knowledge" (Kasper, 2000, p. 66). The concern over issues that cross disciplinary boundaries has raised the need for broader categories of scientific thinking, of "universal principles applicable to systems in general, be they of a physical, biological or sociological nature" (Gomes, Bolze, Bueno, & Crepaldi, 2014, p. 7).

Central to this theory is the notion of *syste*m, defined as a complex of elements in interaction, whose basic principles are: totality / globality - the system is a cohesive whole, changing one part causes changes in all other parts of the system; non-summativity - the system is more than the sum of the parts, the systemic complexity can not be explained from the sum of its elements; bidirectionality/circularity - the relationship between any elements of the system is always bilateral, circular, non-linear; equifinality and retroaction - a feature that ensures circular functioning, keeping information in the system (Vasconcellos, 2010).

However, despite considering that there are different perspectives of reality (Kasper, 2000), it preserves the existence of an objective reality, that is, it maintains the understanding of a reality independent of the observer and, therefore, according to the distinction made by Vasconcellos (2010), this is not a *new-paradigmatic* systemic theory, because it does not consider the assumption of the intersubjectivity of postmodern science.

Cybernetics

Cybernetics greatly influenced the ST from the 1940s and is one of the most important theoretical sources (Kasper, 2000). Norbert Wiener (1894-1964), mathematician, graduated in philosophy is recognized as the main exponent of Cybernetics, characterized as the "area of science that studies the processes of control and transmission of information in living beings and machines" (Grzybowski, 2010, p. 375). It was especially boosted by research funded by the United States with a view to contributing to the improvement of machines used in World War II that had the performance of human functions (Gomes et al., 2014). This theory has important changes throughout its development and receives two denominations that characterize them: first-order Cybernetics - which is subdivided into First moment and Second moment, and second-order Cybernetics.

In the First moment of the first-order Cybernetics, the understanding is that the system operates with a purpose or goal and the mechanisms of regulation and control ensure its range. It deals with morphostatic processes, for maintenance in the same way, which is the result of negative feedback, that is, brings the system to the homeostatic equilibrium, from the correction caused by the negative feedback (Kasper, 2000; Vasconcellos, 2010). It is a systemic theory, for considering the complexity of the phenomena and their interrelations; however, its emphasis on the observer as the expert, maintains the assumption of objectivity; and the understanding based on linear causality, maintains the assumption of stability, of traditional science. Therefore, this moment of the theory is not aligned with the *new-paradigmatic* ST proposed by Vasconcellos (2010), because it is necessary that the three assumptions are considered in the analysis of the phenomena.

However, the Second moment of the first-order Cybernetics deals with morphogenetic processes, which result from the feedback or positive feedback and consequent amplification of deviations and production of new ways of functioning, if the structure of the system allows (Kasper, 2000; Vasconcellos, 2010). The assumption of instability is considered in this second moment of the first-order cybernetics and the notion of the world as a process in continuous transformation (Gomes et al., 2014). The first and second moments of the first-order Cybernetics deal with *observed systems*, that is, they maintain the objectivity and consideration of the observer independent of observed reality and,

therefore, do not integrate the assumption of intersubjectivity (Vasconcellos, 2010). Thus, although systemic, the General Systems Theory and first-order Cybernetics are not considered theories aligned with the *new-paradigmatic* ST.

The development of Cybernetics constituted a favorable context for the questioning of objectivity in scientific researches and made it necessary to consider the interference of the observer in the observed phenomena. This occurred from the approach of important scientists to this theory, among them the Chilean biologists Humberto Maturana and Francisco Varela, as well as the Austrian physicist Heinz von Foerster, and the French sociologist Edgar Morin.

Maturana and Varela, from the mid-1960s, brought important contributions to science with a scientific theory about how humans know, the Biology of Knowing. It is a theory of the observer that has at its base the understanding that *every act of knowing causes a world to arise* and all reflection occurs in language, constituting itself as a cognitive instrument of human beings (Maturana & Varela, 2001; Maturana, 2014a). Due to the relevance of the contributions of Humberto Maturana to the development of postmodern science, his main concepts and contributions will be presented later.

The notion of *observant system* was brought to Cybernetics by Foerster in 1972, when presenting the logical-biological foundations of a theory of the observer (Vasconcellos, 2010). By taking itself as an object of study, Cybernetics makes a qualitative leap and is now known as Cybernetics of Cybernetics and later Second-Order Cybernetics or Cybernetics of Observant Systems (Grandesso, 2011).

It is also important to highlight the contribution of Edgar Morin to the development of Cybernetics. From the 1980s on, he dedicated himself to studying complexity and proposed to evaluate the applicability of this theory to the anthropo-social systems, thus recognizing the advances and limits of Cybernetic Theory. According to Vasconcellos (2010, p. 245), Morin states that "Cybernetics, in addition to not having developed the principle of complexity, subordinated communication to command, becoming a science of organizational control and leading to technocentric, technomorphic and technocratic practices". Thus, Edgar Morin proposes an overstepping movement to rescue and integrate all the moments and aspects of first-order cybernetics, giving rise to a new look that considers the notion of reciprocal obligation between the parties. The new proposal is named by Morin of Sy-Cybernetics, whose prefix *si*, from the Greek preposition *sun*, means to be with, to be together (Vasconcellos, 2010, 2012).

Cybernetics has become an epistemology by including the observer in the systems he observes, "dealing with the limits and possibilities of knowledge" (Grandesso, 2011, p.136). The epistemology of Sy-Cybernetics, or *new-paradigmatic* Cybernetics, also assumes the three epistemological assumptions distinguished by Vasconcellos (2010) as defining of the *new-paradigmatic* ST, namely, complexity, instability and intersubjectivity.

The Communication Theory

The communication theory involves a vast field of theories and researchers. For this reason, it is necessary to emphasize that this text, by its didactic character, briefly presents the work of a group of researchers, initially coordinated by Gregory Bateson (1904-1980), an English biologist and anthropologist, without the pretension of exhausting the subject. A detailed description of the broader context of the researches on human communication can be found in the book of Ives Winkin, *The new communication: from theory to fieldwor*k.

According to Winkin (1998) the objective of Bateson "was not the improvement of therapeutic methods, but rather a general theory of communication, derived from the ideas of cybernetics" (p. 43), a proposal presented in the book *Communication: the social matrix of Psychiatry*, published in 1951, in collaboration with the psychiatrist Jurgen Ruesh. For these researchers communication involves all human activities.

From 1952 to 1962, Bateson coordinated a research group that focused on the paradoxes of human communication. The group worked at the Veterans Hospital in Palo Alto, Calif., and concentrated efforts on communication in families with a schizophrenic member and postulated the *double-bind* hypothesis and its implications on interpersonal relationships among its members (Haley, 1979; Winkin, 1998).

The researchers in this group have broadened the limits of investigation of phenomena and included the context in which they occur, as well as the relationships between the parts of a system and the circularity of the communicational patterns. Thus, the group of Bateson broadened the disciplinary boundaries of ST, applied to clinical psychology, in the early years of systemic family therapy (Grandesso, 2011).

Bateson acknowledged the influence of Cybernetics on his scientific researches (Winkin, 1998) and thus elaborated a new concept of mind, stating that the mind is not in the brain but in relationships (Vasconcellos, 2010). His primary interest was in the study of the pattern that binds all creatures, having as fundamental thesis that there is a meta-pattern, that is, a pattern of patterns (Bateson, 1986).

With the end of the project of Bateson, due to non-renewal of research grants, one of his collaborators, the psychiatrist Don D. Jackson, founded the *Mental Research Institut*e (MRI), also in Palo Alto and invited him to participate, but Bateson declined the invitation (Haley, 1979). The research focus of the MRI group were the bonds and interaction processes in families with a schizophrenic member. Several people who had had contact with the Bateson project and his ideas about *double bind* were part of the MRI team and continued to develop his postulates (Winkin, 1998).

MRI became a center of reference in clinical care for families and in the development of researches. Paul Watzlawick, Janet Helmick Bevian and Don D. Jackson, published the Reference Book *Pragmatics of Human Communication*. *A study of the patterns, pathologies, and paradoxes of interaction*, whose fist edition dates from 1973. The book deals in particular with the behavioral effects of human communication, from the interaction and effects of behavior in which each person affects and is affected by others persons (Watzlawick, Beavin, & Jackson, 2007).

The MRI group postulated five basic axioms on the process of human communication (Watzlawick et al., 2007):1 - it is impossible not to communicate - it refers to the fact that the human being communicates all the time, whether with gestures, tone of voice, postures, looks and even with silence; 2 - all communication has an aspect of content and an aspect of communication - the second classifies the first and is therefore a metacommunication, because it transmits data and informs how this communication should be understood, aspects that may be congruent or incongruent; 3 - the nature of a communication depends on the communicative sequences between communicating individuals – alludes to the interaction between communicators and the message exchange sequence, whose dilemma lies in the claim that there is a beginning; 4 - humans communicate digitally and analogically - digital communication is characterized by words, the way objects are named, whether through writing, speech or drawing and analogical communication refers to all non-verbal communication; 5 - all communication exchanges are symmetric (based on equality) or complementary (based on difference) – it specifies relationships based on equality and minimization of difference and interactions based on difference and its maximization.

According to Capra (1996)**,** Gregory Bateson and Humberto Maturana elaborated innovative conceptions influenced by Cybernetics and focused their interest on how living beings know, although there is a fundamental difference between the contributions of the two authors. Bateson claims the impossibility of objectivity, however, maintains belief in a reality independent of the observer by referring to objective characteristics of the world and the impossibility of representing it adequately (Bateson, 1986; Capra, 1996). As for Maturana, the distinctions of a living organism create a world (Maturana & Varela, 2001), as will be detailed in the next session.

Thus, it is considered that communion theory is aligned with two assumptions of *new-paradigmatic* science, when considering the complexity and instability of phenomena. However, it does not seem to integrate the assumption of intersubjectivity, when assuming a reality independent of the observer.

The contributions of Humberto Maturana to the advancement of postmodern science

The neurobiologist Humberto Maturana, Ph.D. in Biology from Harvard University, with postdoctoral degree at MIT, was born in Chile in 1928. He became a professor at the Faculty of Sciences of the University of Santiago and gained international academic prominence from the beginning of the 1960s.

The Biology of Knowledge or biology of cognition, epistemology developed by Maturana and Franscisco Varela, in biological research laboratories, presents important contributions to science as a

scientific theory about how humans know. It has been used for the interpretation of phenomena in several areas, such as science, philosophy and everyday life, because it addresses the complexity of the phenomena experienced by human beings through the recursive use of the explanatory mechanism that constitutes its basis (Maturana, 2014b).

The researchers were interested in the study of the nervous system, in particular by the phenomenon of perception. The starting point for the construction of this theory was the search to answer the question: how do living beings know? Thus, they have performed several experiments and present concrete evidence that perception is a mode of operation of the nervous system, characterized as a cyclical system, operationally closed and of internal correlations (Maturana & Varela, 2001; Maturana, 2014a, 2014b). In this way, the Biology of Knowledge is characterized as an epistemology, as a reflection on knowing and knowledge, and as a broad reflection on human relations and experience.

Autopoiesis is the primordial foundation of Biology of Knowing and has brought important contributions to science, being considered one of the scientific notions of greatest impact for science in the 20th century (Capra & Luise, 2014). The term was created by Maturana to designate the type of organization peculiar to all living beings, "which create the necessary components to maintain their own organization" (Grandesso, 2011, p. 135). *Auto* means "self" and refers to the autonomy of self-organizing systems and "*poiesis*" means "making", so autopoies alludes to "self-making" (Capra & Luise, 2014).

The autopoietic organization is what characterizes living beings as self-organizing systems in continuous production of themselves, operationally closed, but in continuous interaction with the environment (Maturana & Varela, 2001; Maturana, 2014a, 2014b). Autopoiesis demonstrates the autonomy and dependence of the living being, that is, it is able to maintain itself, but it needs interaction with the environment.

The process of interaction between the living being and the environment, termed by structural coupling researchers, produces recursively continuous structural changes in the living being. However, these structural changes are the result of the internal dynamics of the living being, triggered by the interaction with the environment, but always determined by the structure of the living being, at that moment (Maturana & Varela, 2001; Maturana, 2014a).

The fact that living things in general and human beings in particular are determined by their structure does not mean that they are predictable. Phylogenetic history participates but does not determine its ontogenetic structure since "every living being is where it is in its present as a result of that history, in a continuous transformation of its present from its own present" (Maturana, 2014a, p. 238). The assumption of instability appears in the consideration of contingency, of eventuality, that is, of the possibility that something may or may not happen.

Thus, at the base of the Biology of Cognition is the consideration that the phenomenon of knowing is invariably tied to the human structure and not to something that is outside and is captured by the mind. Thus, the researchers place *objectivity between brackets* and evidence the need to consider the subjectivity of the observer and how he experiences what he observes, which is what makes possible what emerges in the description (Maturana, 2014b; Maturana & Varela, 2001). In this way, the assumption of the intersubjectivity of the ST and the fundamental contribution of Maturana to the advance of postmodern science is evidenced.

The researchers say that there is a continuous coincidence between being, making and knowing, which reveals the impossibility of separating the histories of the human beings from their biological and social actions, given that it is from them that the world emerges (Maturana, 2014a). The aphorism *all doing is a knowing and all knowing is a doing* expresses the circularity between action and experience of the whole life of the human being (Maturana & Varela, 2001).

Therefore, every distinction of an observer is related to his structure at that moment, and it is not possible to describe the experience of another human being, because this will always be an act of distinguishing of an observer. Human beings and the world share the vital process of each other and establish an interconnection between themselves, and it is not possible to understand them separately (Maturana & Varela, 2001; Maturana, 2014a). Thus, the assumption of the complexity of the systemic thinking is evidenced, in view of the proposal of an explanatory model that goes beyond disciplinary

barriers and assumes the three principles of this assumption, namely, the dialogical principle, the principle of recursion and the hologramatic principle described above.

Humberto Maturana retired from the University of Santiago in 1999 and began working with Ximena Dávila Yáñez in the development of Cultural-Biology, which is characterized as an epistemological understanding of human living and coexisting. In 2000, they founded Matríztica, a school of reflective, scientific and philosophical thinking, seated in Santiago, Chile, and currently they continue to teach courses and conferences in several countries, including Brazil. In 2015, they launched the book *El Arbol del Vivir*, in which they present work and joint reflections, conducted since the year 2000.

Cultural-Biology was configured by understanding the biological-cultural nature of human living (Maturana & Yáñez, 2015). It is based on the foundations of the Biology of Knowing and proposes the expansion of these investigations to the different domains of realization of the human being.

This expansion includes the consideration that every living thing has an *ecological niche*, that is, an environment that makes it possible. Thus, the history of a living being is the history of transformations of the *organism-niche* ecological unit in the realization of living (Maturana & Yáñez, 2015).

Final considerations

This article aimed to present an introduction to the historical and epistemological development of ST in the 20th century, and the main contributions of Humberto Maturana for the advancement of postmodern science. For this, he presented the paradigm shift from traditional science to postmodern science and the basic assumptions that characterize them. He proposed the use of a graphic representation (Figure 1) to understand the interconnections between researchers and theories that contributed to the development of ST and presented some of the main concepts of systemic theories with recognition and visibility in the scientific community, namely, the General Systems Theory, Cybernetics, the Communication Theory, as well as Biology of Knowledge and Cultural-Biology.

It is considered that this study presents two important contributions. The first one refers to the didactic systematization of a very broad and complex context, which may favor the understanding of professionals and researchers from different areas, interested in knowing the ST. The second contribution concerns the graphic representation of the spiral (Figure 1), whose purpose was to show the recursive influence between theories and researchers involved with the development of ST throughout the 20th century.

Regarding the limitation of this study, we highlight the use of one of the possible versions for the understanding of the development of ST in the 20th century. In this way, new studies could include the perspective of other researchers on the subject.

Finally, the importance of the understanding of the epistemological principles of ST for the production of researches and systemic interventions is emphasized. This is a challenge found in undergraduate and postgraduate courses in different areas.

References

Bateson, G. (1986). *Mente e Natureza*. A Unidade Necessária. Rio de Janeiro: Francisco Alves.

Capra, F. (1996). *A Teia da Vida. Uma nova compreensão científica dos sistemas vivos*. São Paulo: Cultrix.

Capra, F. & Luise, P. L. (2014). *A visão sistêmica da vida: uma concepção unificada e suas implicações filosóficas, políticas, sociais e econômicas*. São Paulo: Cultrix.

Gomes, L. B., Bolze, S. D. A., Bueno, R. K., & Crepaldi, M. A. (2014). As Origens do Pensamento Sistêmico: Das Partes para o Todo. *Pensando Famílias, 18*(2), 3–16.

Grandesso, M. A. (2011). *Sobre a reconstrução do significado* (3a ed.). São Paulo: Casa do Psicólogo.

Grzybowski, C. T. (2010). Por uma teoria integradora para a compreensão da realidade. Psicologia Em Estudo, 15(2), 373-379.

Haley, J. (1979). Psicoterapia Familiar. In *Psicoterapia Familiar: um enfoque centrado no problema* (Interlivro). Belo Horizonte.

Kasper, H. (2000). *O processo de pensamento sistêmico: um estudo das principais abordagens a partir de um quadro de referência proposto*. Dissertação de mestrado, Programa de Pós-graduação em Engenharia de Produção, Universidade Federal do Rio Grande do Sul, Porto Alegre, RS.

Maturana, H. (2014a). *A Ontologia da Realidade* (org. C. Magro, M. Graciano, & N. Vaz. 2. ed.). Belo Horizonte: Editora UFMG (Humanitas).

Maturana, H. (2014b). *Cognição, Ciência e Vida Cotidiana* (org. e trad. Cristina Magro, Victor Paredes. 2. ed.). Belo Horizonte: EditoraUFMG.

Maturana, H. R. & Varela, F. J. (2001). *A Árvore do Conhecimento. As bases biológicas da compreensão humana* (9a ed.). São Paulo: Palas Athena.

Maturana, H. & Yáñez, X. D. (2015). *El arvol del vivir*. Santiago, Chile: MVP Editores.

Morin, E. (2011). *Introdução ao Pensamento Complexo*. Porto Alegre: Ed. Sulina.

Najmanovich, D. (2002). El lenguaje de los vínculos. De la independencia absoluta a la autonomía relativa. In E. Dabas & D. Najmanovich (Orgs.), *Redes: el lenguaje de los vínculos: hacia la reconstrucción y el fortalecimiento de la sociedad civil* (p. 33-76). Buenos Aires: Paidós.

Schmidt, B., Schneider, D., & Crepaldi, M. A. (2011). Abordagem da violência familiar pelos serviços de saúde: contribuições do pensamento sistêmico. *Psico, 42*(3), 328–336.

Vasconcellos, M. J. E. (2010). *Pensamento Sistêmico. O novo paradigma da ciência* (9a ed.). Campinas, SP: Papirus.

Vasconcellos, M. J. E. (2012). Pensamento sistêmico novo- paradigmático: Novo-paradigmático, por quê? In J. G. Aun, M. J. E. de Vasconcellos, & S. V. Coelho (Orgs.), *Atendimento Sistêmico de Famílias e Redes Sociais: Fundamentos teóricos e epistemológicos* (3a ed., pp. 97–109). Belo Horizonte: Ophicina de Arte & Prosa.

Watzlawick, P., Beavin, J. H., & Jackson, D. D. (2007). *Pragmática da Comunicação Humana: um estudo dos padrões, patologias e paradoxos da interação* (18a ed.). São Paulo: Cultrix.

Winkin, Y. (1998). *A nova comunicação: da teoria ao trabalho de campo.* São Paulo: Papirus.

Received: Oct. 19, 2016
Approved: Jun. 22, 2017

Joyce Lúcia Abreu Pereira Oliveira: Psychologist, Pedagogue, Specialist in Individual, Family and Couple Therapy, Master in Psychology and Ph.D. student in the Department of Psychology at Universidade Federal de Santa Catarina (UFSC).

Maria Aparecida Crepaldi: Psychologist, Specialist in Child Psychology Clinic, Specialist in Therapeutic Psychodrama, Specialist in Family and Couple Therapy, Master in Psychology, Ph.D. in Mental Health, Postdoctorate at Université du Québec à Montréal and Postdoctorate at Ribeirão Preto Clinical Hospital (USP), and Professor contributor in the Department of Psychology at Universidade Federal de Santa Catarina (UFSC).