What is Radical about Radical Constructivism?

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This article will become an exercise in cognitive mapping of constructivist territories or landscapes. In this sense, the proposed map on different domains of constructivism *is*, by necessity, the territory. The subsequent explorations will start with Ernst von Glasersfeld's account of what constitutes Radical Constructivism (RC). The aim is to assemble a set of building blocks and fields of discourse which, in conjunction, form the core of RC Glasersfeld-style. Subsequently, a quick overview will be given on the structure and organization of Second-Order Cybernetics (SOC) as developed and proposed in the late 1960s and throughout the 1970s by Heinz von Foerster, who, together with Humberto R. Maturana, Francisco L. Varela and Ernst von Glasersfeld, formed the core-group of RC.[1] Mapping RC and SOC across different arenas, an interesting trade-off can be constructed between the radical building blocks of RC or SOC and their degree of diffusion. Towards the end, a few strategies will be outlined how RC and SOC, in conjunction, could be utilized as a radically new framework which so far has only been occasionally utilized or explored.

1 Radical Constructivism à la Glasersfeld

Ernst von Glasersfeld, in combination with Siegfried J. Schmidt (1987, 1987a), was largely responsible for the label of Radical Constructivism (RC). In 1974 von Glasersfeld wrote an article about Jean Piaget and the radical constructivist epistemology (Glasersfeld 1974). In 1981 Ernst von Glasersfeld produced the most influential article for the promotion and the diffusion of RC, namely his "Introduction to Radical Constructivism" in Paul Watzlawick's widely distributed reader "Die erfundene Wirklichkeit" or, in English, "The Invented Reality" (1984).
Analyzing these two or similar articles on RC it is interesting to note that Ernst von Glasersfeld places RC simultaneously in three different cognitive settings or landscapes. Thus, it will be useful for the cognitive RC mapping to differentiate clearly between these three arenas which comprise
- RC as an empirical research program (Area I)
- RC as a special variant in contemporary philosophy and in the history of philosophy (Area II)[2]
- RC as a meta-narrative for the post-modern condition (Area III)[3]

Normally, these three domains are only weakly inter-linked whereas RC à la Glasersfeld establishes strong connections between them. And it is probably due to the permanent re-

1 See especially Schmidt 1987 where S.J. Schmidt introduced RC to the German speaking world as a new paradigm and a novel form of interdisciplinary discourse (Schmidt 1987a), with the four RC-musketeers Maturana, Varela, von Foerster and von Glasersfeld.

2 Here, the cognitive environment consists of the state of the art in areas like epistemology, ontology, truth-theories, and of authors like Robert Brandom 2000, 2004, Mario Bunge 1977, 1979, 1983a,b, Daniel C. Dennett 1991, 1995, 2003, Karl R. Popper 1965, 1975, 1982a, 1982b, Nicholas Rescher 1994, 1998, 2001 and many, many others.

3 Area III is composed of contemporary discussions on postmodern conditions in a wide variety of fields mostly outside the domains of philosophical sub-disciplines. As typical authors for Area III one can name Zygmunt Bauman (2000), Judith Butler (1995) or Jean-Francois Lyotard (1984).

combination of these three arenas that RC has meant and still means so many different things to different people.

Initially, one can show that Ernst von Glasersfeld plays on these three different locations simultaneously even within a single article. His "Introduction to Radical Constructivism", for example, starts in Area III and introduces RC as a counter-program to and as a radical departure from common sense assumptions on knowledge and reality. RC is characterized as a radical alternative which stresses the importance of being responsible and the constructive nature of our experience. In the first section of the article Ernst von Glasersfeld still plays mostly in Area III and introduces a fundamental dichotomy[4] between metaphysical realism as a philosophical tradition of *très longue durée* on the one hand and RC on the other hand. Metaphysical realism is associated with catchwords like objective reality, (iconic) correspondence between objective reality and knowledge or truth and with operations like discovering or detecting whereas RC is linked with actively constructed subjective realities, with viable knowledge structure and with operations like inventing or producing.[5] Ernst von Glasersfeld then turns to Area II and discusses the differences between a viable knowledge organization and its close relationships with evolutionary thinking. In evolutionary theory too, one cannot establish degrees of correspondence between the fitness of organisms and the structure of the environment, but only a negative relation between species or mutations and their irreproducibility or non-viability. The second section of the article plays in Area II as well and turns to the history of philosophy, stressing the importance of a small counter-movement, with Giambattista Vico as one of its core-representatives, to the dominant realist epistemology. In the third section of his article Ernst von Glasersfeld turns to Area I and offers a few glimpses of RC as an empirical research program. Introducing the work of Jean Piaget, Glasersfeld provides a sketch of the theoretical core of RC. Towards the end of the article Glasersfeld returns to Area III and characterizes, once again, RC as a radically new world view which is in the process of overcoming and replacing metaphysical realism which has dominated the philosophical theater not for centuries, but for millennia.

Especially in his widely recognized papers on the design and the content of RC Ernst von Glasersfeld operates predominantly in Area II and Area III. For the subsequent mapping operations, the territories of RC Glasersfeld-style will be laid out in greater detail.

Turning to Area I of the cognitive map, RC à la Glasersfeld is organized as an empirical research program with all the necessary ingredients of research programs. Figure 1 shows the typical modules or building blocks for empirical research programs like a theoretical core (TC), a set of methods, models and mechanisms (MMM), linked to the theoretical core, the embeddedness of TC and MMM within a wider background-knowledge BK as well as a class of paradigmatic examples, *i.e.*, applications of TC and MMM on observable or actually observed processes. [6],

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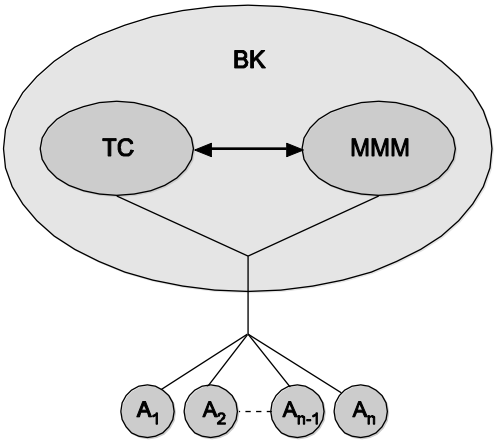
4 It should be added that one of the prime operations in Area III lies in the construction of a basic dichotomy, differentiating between a dominant tradition à la "metaphysical realism" (preferably > 1000 years, possibly > 2500 years, including Greek philosophy), ranging at least across the Western world (again, if possible, globally) and a very small, but highly promising out-group with increasing importance à la RC. From this primary operation many sub-operations can be added like a history of ideas-operator, an identity operator for this specific out-group, an incentive system for insiders within this out-group and for outsiders to become insiders, etc.

5 Some of the features in this dichotomy are also captured in Karl R. Popper's distinction of searchlight and bucket theories of knowledge. On this separation see Popper 1975:341pp.

6 As a relevant selection from the philosophy of science literature, see Balzer/Moulines/Sneed 1987, Curd/Cover 1998, Bunge 1998, 2002, 2003, Donovan/Laudan/Laudan 1988, Ludwig 1990, Schurz/Weingartner 1998, Salmon 1998, Sneed 1991 or Stegmüller 1981.

Figure 1 The Building Blocks of Empirical Research Programs



Shifting to the theoretical core, the main building blocks are adapted mostly from Jean Piaget. Basically, RC in Area I uses Piaget's action scheme approach with assimilation and accommodation as the two main dynamic operations. The class of relevant methods, models and mechanisms of RC reflects this theoretical core and comprises a series of Piaget-models for the cognitive formations of fundamental concepts like time, objects, identity or moral judgements. Moreover, the MMM-class contains instruments for conceptual analyses which have been developed by Ernst von Glasersfeld in his cooperation with Silvio Ceccato. Turning to the application side one can find, most probably, three paradigmatic examples for RC à la Glasersfeld, namely chimpanzee communication and the construction of Yerkish language, the formation of numerical concepts in children and, finally, the concept formation in the education of physics.[7] RC in Area I took place mostly between the 1960s and the 1980s, after Ernst von Glasersfeld entered the United States, although his earlier work with Silvio Ceccato served as an essential preparatory or latent phase for RC as a research program. Table 1 lists several important building blocks for the theoretical core as well as for available models and methods.

Table 1 The Main Building Blocks for Glasersfeld's Radical Constructivism in Area 1

Module	Main Characteristics
Conceptual Analysis	Operational analysis of concepts Comparative operational analysis across different languages
First-Order Models	Models of the observer (scientist)
Second-Order Models	Models for the behaviour of observed groups
Piaget-Theory (Static)	Equilibration of schemes
Piaget-Theory (Dynamic)	Assimilation and accommodation of schemes

[7] These three paradigmatic examples have been extracted from Glasersfeld (1997a) which presents a short autobiographical sketch.

One of the most interesting elements of the RC-program lay in the specification of research designs which contained models of first-order as well as models of second-order. Leslie P. Steffe, a close friend and collaborator of Ernst von Glasersfeld within the IRON-project on number-formations, draws the following distinction between first and second-order models.

> Glasersfeld produced his model of units and number by using mental operations to analyze his own conceptions of units and number. So, I refer to his analysis as a first-order analysis. The goal of a first-order analysis concerns specifying the mental operations that produce particular conceptions of the analyst … When the goal is to explore operations by means of which human beings construct mathematics … we construct second-order models which are models an observer constructs of the observed persons' knowledge in order to explain their observations. (Steffe 2007:45p.)

Steffe continues that the interplay between first-order and second-order models lies at the heart of RC as a research program:

> The reciprocal relationship between first- and second-order analyses is basic in radical constructivist research programs because it illustrates that researchers and their ways and means of operating and observing constitute the research programs. (Steffe 2007:46)

Area II consists of two large segments, one being the history of philosophy, and one being contemporary philosophy, composed of areas like epistemology, ontology, philosophy of science, logic, ethics and the like. With respect to the history of philosophy, Ernst von Glasersfeld associates RC with a small philosophical tradition which includes various forms of scepticism, due to its negation of an "objective reality" or "objective knowledge", variants of idealism (Berkeley, Kant), because of the active involvement of the human mind or single thinkers like David Hume or the Neapolitan Giambattista Vico who is applauded for the acknowledgement of the active role of the human mind in structuring experiences.
Proceeding to the right hand-side of Area II in Figue 2, RC can be characterized as a negative ontology and as another variant of an evolutionary epistemology. More specifically, the RC-theory of knowledge rests on two theoretical assumptions.

> Knowledge is not passively received but built up by the organizing subject.
> The function of cognition is adaptive, and serves the organization of the experimental world, not the discovery of ontological reality. (*Ibid.*)

Table 2 lists some of the important building blocks of RC as a philosophical Area II-approach.

Table 2 Principal Components for Glasersfeld's Radical Constructivism in Area II

Module	Main Characteristics
Theory of Knowledge	Against "objective reality" and correspondence; for an active, though largely unconscious world-making of subjects
Validation	Viability as core element (instrumentalism,

	pragmatism and evolutionary epistemology as RC-neighbours) Fitness and coherence
History of Philosophy	Pre-Socratics, Vico, Berkeley, Kant *et al.* as RC-forerunners

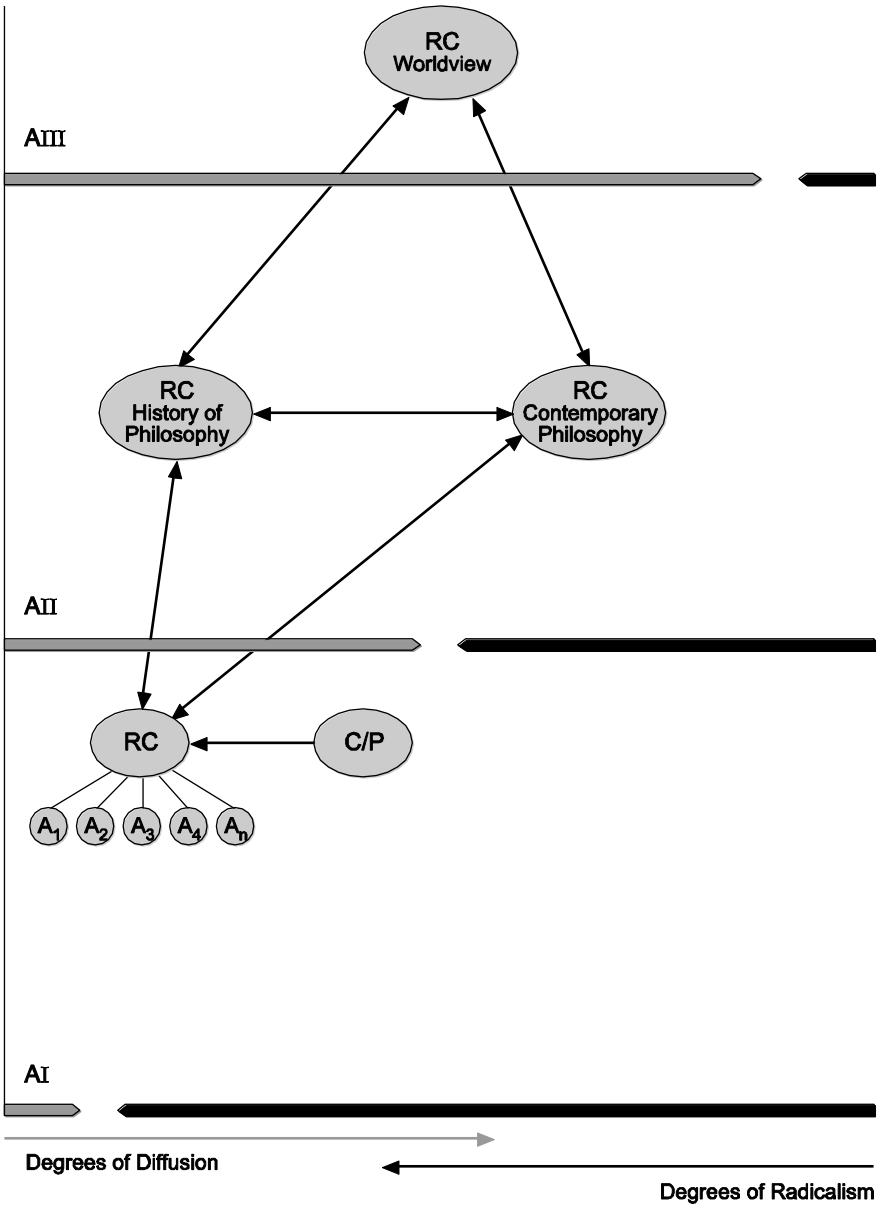
For RC Glasersfeld-style Area III has become increasingly important over the last two decades. Here, RC sees itself as an intellectual avant-garde which tries to accomplish what David Hume provoked in Immanuel Kant, namely an awakening from dogmatic slumber or, more specifically, from realist daydreams. Table 3 assembles a small number of constructs which are commonly associated with RC in Area III.

Table 3 Core Building Blocks for Glasersfeld's Radical Constructivism in Area III

Worldview	Themes
Individual	Radically new role model as world-constructor, Iconoclastic attitude towards common sense realism and common sense-theory of knowledge;
Ethics	Responsibility, autonomy, etc.
Culture	Pluralism, tolerance, etc.
Society	Self-organization

Figure 2 summarizes the overall organization of RC across three different areas. In Area I, RC has been placed in the upper left-hand corner which was due to the fact that Area I of the map has two implicit dimensions, a vertical one for micro-macro levels and a horizontal one for degrees of formalization. The vertical dimension differentiates between micro-analyses at the level of the neural organization and macro-studies of the observable behaviour of actors. The horizontal dimension separates between research programs with relatively low degrees of formalization (left) from approaches with a high degree of formalization and modelling (right).
It should be added that each of these areas in Figure 2 is characterized by different dimensions respectively. Aside from Area I with the dimensions micro/macro and low/high degrees of formalization Area II exhibits a 0/1-dimension only, differentiating between the history of philosophy (left side) and contemporary philosophy (right side). Area III contains, once again, a political left-right dimension (horizontal) and a low/high theoreticity dimension (vertical). Thus, RC in Area III has been mapped with a medium degree of theoreticity and a with a politically centrist position far away from either explicit left-wing or right wing orientations.

Figure 2 A Map for Radical Constructivism Glasersfeld-Style



Towards the end of this section a short remark must be added that these three RC-arenas need not be strongly inter-linked. For example, RC can be used as an empirical research program in Area I and combined with a more sophisticated realist epistemology far away from iconicity and a passive de-picturing of a singular objective reality. Furthermore, it is questionable at best to see radical forms of scepticism only directed against off-springs of metaphysical realism. Rather, radical scepticism could be turned powerfully against a viable RC-theory of knowledge as well. Finally, RC as *Weltanschauung* and postmodern *Lebensgefühl* can be maintained in the absence of Area I and even of Area II. In fact, the popularity of RC among management consultants, coaches and therapists of various persuasions lies mainly in the reception and acceptance of RC as a viable post-modern view on communication, understanding, autonomy, individual responsibility or self-organization irrespective of its sub-structures in Area II, let alone in Area I.

2 Heinz von Foerster's Second Order Cybernetics (SOC)

During the late 1960s and 1970s Heinz von Foerster developed a vision for a new type of living research on living systems under the heading of Second-Order Cybernetics (SOC)[8]. More specifically, in 1979 Heinz von Foerster presented SOC as a new research program and as a fundamental paradigm change which, moreover, was not attributed, as Thomas S. Kuhn suggested, to the power of crucial experiments and to the emergent defectiveness of the older paradigm, but to its very flawlessness (Foerster 2003:284). Interestingly, Heinz von Foerster mentions two profound instances for self-elimination by success, the first one the Copernican Revolution and "the novel vision of a heliocentric planetary system" (Ibid.) irrespective of the fact that "the Ptolemaeic geocentric system was to its height as to the accuracy of its predictions" (Ibid.). The second instance for Heinz von Foerster was the hegemonic scientific method[9] en bloc with its "flawless, but sterile path that explores the properties seen to reside within objects" (Ibid.) Instead, a radically new paradigm was proposed which focuses, as suggested already by the definition of second-order cybernetics in Foerster *et al.* 1974, on the observers of these objects, including observing scientists themselves. In 1988, Foerster compares the attempted *coup d'etat scientifique* with an unusual form of reverse demolition:

> Everywhere, also in the United States, the oldest and most beautiful houses are nowadays demolished and instead steel and glass-skyscrapers with 36 stories are being constructed. I want to emphasize the reverse process. I start with a 36 story steel and glass-skyscraper and demolish it. But I am not building a baroque castle instead, but something completely different: maybe a cockchafer, maybe an ant colony, maybe a family. (Foerster 1988:20)[10]

In short, the established scientific method with its emphasis on laws, physics and logic or, metaphorically, on glass and steel, is to be replaced by a *Scienza Nuova* of living systems and an associated philosophy of living science.
More specifically, Heinz von Foerster points to two new elements which lie in the centre of SOC and which are needed to bring about this fundamental paradigm change, namely a new type of logic as well as new forms of algorithmic or formal description-devices.

> It is most gratifying for me to report to you that the essential conceptual pillars for a theory of the observer have been worked out. The one is a calculus of infinite recursions; the other one is a calculus of self-reference. With these calculi we are now able to enter rigorously a conceptual framework which deals with observing and not with the observed. (Foerster 2003:285)

In line with the proud announcement of an inventor, SOC apparently constituted a radical breakthrough in the history of science, comparable in its impact and its revolutionary content

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8 Following Heinz von Foerster the term "cybernetics of cybernetics" goes back to the year 1968 where this concept was invented jointly by Margaret Mead (Foerster 2003:302).

9 Heinz von Foerster characterizes the scientific method with the postulate of objectivity: "The properties of the observer shall not enter the description of his observations" (Foerster 2003:285). However, he adds two more rules which lie in the core of the scientific method:
(i) Rules observed in the past shall apply to the future. This is usually referred to as the principle of conservation of rules …
(ii) Almost everything in the universe shall be irrelevant. This is usually referred to as the principle of the necessary and sufficient cause (Foerster 2003:203)
Heinz von Foerster goes on to conclude that the scientific method is "counter-productive in contemplating any evolutionary process, be it the growing up of an individual, or a society in transition." (*Ibid*:204p.)

10 This section has been translated from its German original by the author.

only to the Copernican Revolution. Moreover, SOC as a *Scienza Nuova* implied a radical farewell to the cluster of established scientific practices, methodologies and philosophies and a shift or even a phase transition to a distinctively new set of scientific routines, methodologies and philosophies, including a different form of logic for living objects and a new kind of observer language which compels, for example, a

> physicist to account for himself as a part of the physical world. In all fairness, he must stick to his own rules and show in terms of mass, energy, space and time how it comes about that he creates theoretical physics. He must then become a neurophysiologist … (McCulloch 1988:73)

Heinz von Foerster credits Warren McCulloch as being the first to deal with "the fascinating problem of inclusion" (Foerster 1995a:3). SOC was designed to become an inclusive framework and a living form of research, capable of writing itself.

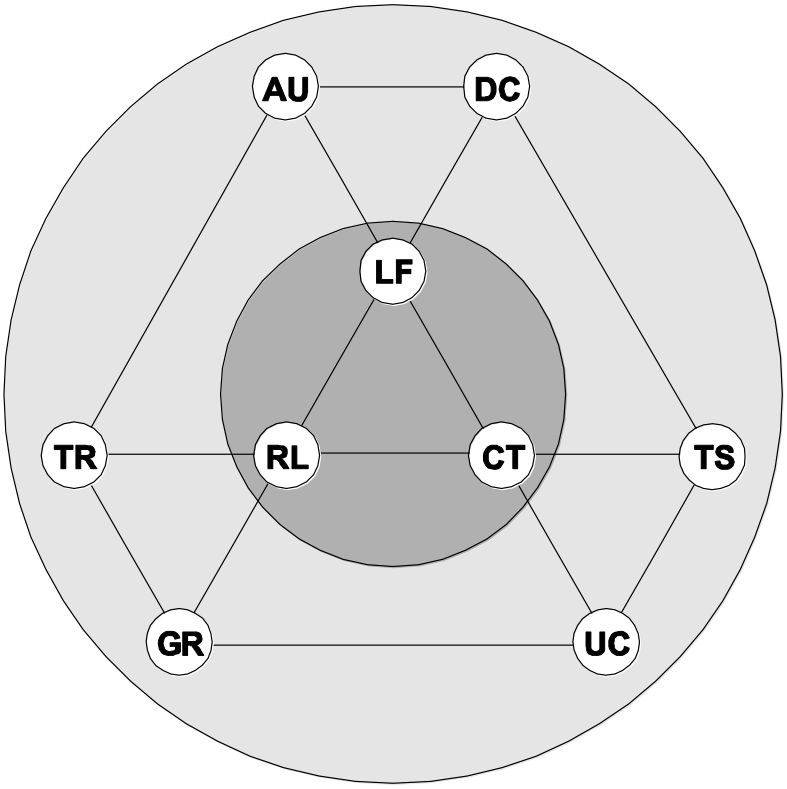
> The laws of brain functions – or even more generally – the laws of biology, must be written in such a way that the writing of these laws can be deducted from them, *i.e.,* they have to write themselves. (Foerster 2003:231)

Thus, a theory of the brain has to write itself and be able to account for its own operations in being able to write a theory of the brain.

> It is clear that if the brain sciences do not want to degenerate into a physics or chemistry of living – or having once lived – tissue they must develop a theory of the brain: T(B). But, of course, this theory must be written by a brain: B(T). This means that this theory must be constructed in a way as to write itself: T(B(T)). (*Ibid*:195)

Figure 3 summarizes the main building blocks for SOC which can be distributed across the three groups: core modules, theory of cognition and research designs.

Figure 3 The Main Building Blocks of Second-Order Cybernetics



Research Designs	**Core-Modules**	**Theory of Cognition**
GR: Generative Relations	RL: Recursive Language	UC: Unity of Cognition
TR: Triadic Closure	LF: Laws of Form	TS: Tesselations
AU: Autology	CT: Cognitive Tiles	DC: Double Closures

According to Figure 3, the core modules consisted of a new type of logic, a new form of language and a minimal cognitive machinery especially suited for the study of One Brain-Problems. With respect to the domain of logic, Heinz von Foerster referred to Gordon Spencer Brown's "Laws of Form" which, in contrast to earlier versions by Gottlob Frege, Bertrand Russell and Alfred Whitehead or Rudolf Carnap, was not primarily based on propositions, predicates or truth-values, but on indications, distinctions and self-referentiality.[11] For Heinz von Foerster, the main attractions of the new logic by Spencer Brown or its extensions lay, on the one hand, in its higher degree of generality and abstraction. On the other hand, "Laws of Form" opened up a viable path for the paradox-stricken concept of self-referentiality. In the Laws of Form-framework self-referentiality appears no longer as an entry to the land of inconsistencies, paradoxes and contradictions, but, according to Spencer Brown, a re-entry into its own domain produces and requires – time.

Spencer Brown tackles the problem of infinite expressions by allowing an expression to re-enter its own space. This calls for trouble, and one anticipates now the emergence of anomalies. Not so! In his notation the classical clash between a simultaneous Nay and Yea never occurs, the system becomes 'bi-stable', flipping from one to the other of the two values as a consequence of previous values and thus generates time! Amongst the many gems in this book, this may turn out to be the shiniest. (Foerster 1969:1)

[11] In 1975 Francisco J. Varela extended "Laws of Form" to a "Calculus for Self-Reference" (Varela 1975) and between 1976 and 1980, together with Joseph Goguen and Louis H. Kauffman, revised the original version to "The Arithmetic of Closure" (Goguen/Varela 1979, Kauffman/Varela 1980, Varela 1976a, Varela 1979, Varela/Goguen 1977).

Shifting from a new logical calculus for self-reference to the specific descriptive language for SOC, the final breakthrough occurred most probably in the early and mid 1970s when Heinz von Foerster had assembled all the ingredients for presenting a new and highly general form of descriptions. The new SOC-language can be characterized as a recursive mode of description and as a drift towards *Eigenforms* which follow almost naturally from the recursive language-design. In his article on occasion of Jean Piaget's 80th birthday, namely in "Objects: Tokens for Eigenbehaviors" (1976), Heinz von Foerster used a formal demonstration for the necessary emergence of and for the unexpected operational attributes inherent in *Eigenforms*. These Eigenforms, because of their self-generating nature, imply topological closure or circularity and topological closure produces *Eigenforms*.

> This result, that there emerge Eigen-values, is the only thing we can rely on. *It rests upon a theorem*. Among the many variants and paraphrases of this astonishing theorem I've picked Francisco Varela and Joseph Goguen's version (1979), for I believe I see an affinity here with sociological vocabulary. "In every operationally closed system there arise Eigen-behaviors." (Closure Theorem) (Foerster 2003:316)

Aside from a new logic and a new description mode, SOC contained a minimal machinery for the study of cognitive processes. This machinery was based on finite state machines and appeared, following Heinz von Foerster, in different names like non-trivial machine, minimal cognitive system, a cognitive element, or, alternatively, a cognitive tile, due to its combinability to form whole mosaics or tessellations. The various components of a cognitive tile comprise an external sensory input, an output of the system as seen by an outside observer for whom this elementary component appears as a "through-put" system. However, because of its internal organization, a cognitive tile has a more complex structure than a stimulus-response mechanism with a fixed transfer function.
So far, SOC has been characterized with three core modules, namely by its new logic, its new language and its new machinery. Shifting to theoretical core-assumptions on cognition a particularly challenging guiding hypothesis can be characterized, following Heinz von Foerster, as the Unity of Cognition-Theorem. This grand theoretical vision underlying a science of observing living systems in general can be found explicitly across several publications, for instance in the article "What is Memory that it May Have Hindsight and Foresight as Well?" from the year 1969. In "What is Memory …" Heinz von Foerster starts by distinguishing a number of cognitive faculties like perceiving, memory and inference-making (Foerster 2003:105). Simply by inductive reasoning, this list can be enlarged to faculties like learning, communicating, moving, evaluating, imaging, etc. (Foerster/Müller 2003) In normal cognitive science, so Heinz von Foerster, these faculties are studied as self-contained and autonomous domains, a procedure, against which Heinz von Foerster advocated his very strong unification thesis. Attempts of functional, local, genetic or epistemological isolation[12] of these faculties will lead to serious errors and misconceptions because

> if the mechanisms that are responsible for any of these faculties are to be discovered, then the totality of cognitive processes must be considered. (Foerster 2003:105)

[12] In the article "What is Memory that it May Have Hindsight and Foresight as well?" (1969), Heinz von Foerster argues only against the functional separation. But from several conversations – and by the power of inductive logic – local, genetic and epistemological separations can be added as well.

Another important theoretical guideline on cognition is related to the composition of the minimal cognitive machinery or, phrased differently, to the tessellations of cognitive tiles. Although a cognitive tile consists, as it was pointed out earlier, of various components covering an astonishing range of cognitive functions the entire tile can be treated as a unit and, more specifically, as an elementary computer. In this way, a cognitive tile T_i can be combined with other tiles T_j, and may form a mosaic of tiles – a computational or cognitive tesselation. Information exchange between tiles can take place on all interfaces, however, under observance of transmission rules.
Another guiding hypothesis on cognition is related to the generative compositional dynamics and to its emerging *Eigenforms*. Following insights already put forward by Warren McCulloch, neural networks of observing living systems advance to a state of double closure between their external sensory-motor and their internal secretoric-neural circuits. In other words, double closure becomes a central feature of observing living systems across humans or animals. Thus, double closures can be considered as the *Eigenform* of recurrent tessellations.

> Here, two systems – the sensory-motor system and the inner-secretoric neural system – control one another reciprocally: the operational functions of the one system become functions of the other: two recursive functors. Functors operate on a function and produce a function. Functors, too, have Eigen-values like the exponential function $y = e^x$ of the differential operator and on account of the extraordinary relationship of the exponential function to the trigonometric functions sin and cosin, sin and cosin are the Eigen-functions of the differential operator iterated fourfold. (Foerster 2003:124)[13]

Turning to SOC-designs as the third area in Figure 3 the first important ingredient lies in the closed organization of relations into which SOC-research on observing systems, the observing scientist included, can and should enter. In SOC, the new minimal research configuration is not a single domain which is to be studied in itself like in the conventional scientific method, but is built in a triadic fashion, with the observing scientific system as one node, the domains under observations as another node and with a final intermediate element linking and closing these two nodes to a triadic ensemble. In short, SOC-research is to be built in its minimal form not with one, not with two but with three components.[14]
Turning, once again, to the programmatic announcement of an imminent second Copernican Revolution from the year 1979, Heinz von Foerster re-conceptualizes a human observing system by introducing two additional domains which must be co-present, namely a specific language L and a minimal societal context S. Thus, an observed system changes into a triadic configuration of observers, language, and society.[15] In a small, but visionary contribution, in "Computing in the

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[13] It should be added that one doesn't have to restrict oneself to mathematical expressions for Karl Menger developed these ideas for logical functions (1962) as well.

[14] See also the paper from 1976 by Francisco J. Varela where he starts from the usual dualistic suspects like observer/observed, subject/object, describer/described, operator/operand and the like and continues:
It is very obvious, however, that these poles are not effectively opposed but rather moments of a larger whole which sits in a metalevel with respect to both terms. (Varela 1976:65)

[15] At several points, Heinz von Foerster stresses the importance of being or becoming triadic:
Let me repeat the three concepts that are in a triadic relation connected to each other. They are: first, the observers; second the language they use; and third, the society they form by the use of their language. This interrelationship can be compared, perhaps, with the interrelationship between the chicken, and the egg, and the rooster. You cannot say who was first and you cannot say who was last. You need all three in order to have all three. (Foerster 2003:284)

Semantic Domain" (1971), Heinz von Foerster introduces, for example, the term "environment" which he distributes across three different domains.

'Environment' appears in three distinct domains: in the domain of the 'real world' (W), in the domain of 'cognitive processes' (C), which provide an organism with an internal representation of his surroundings; and in the domain of an organism's 'descriptions' (D) of his world. Environment is the triadic relationship E(W,C,D) between these domains. (Foerster 1971:239)[16]

With triadic configurations a radical shift occurs with respect to the types of relations within SOC because the new science of observing living systems operates with productive or generative relations, in contrast to the generalized causal relations of the traditional scientific approach. Table 4 offers some guidelines of what generative relations are and which types of outputs they produce.

Table 4 Causal and Generative Relations

Causal $A \rightarrow B$	Generative $A \overset{C}{\Pi} B$
Asymmetrical in time	Symmetrical in time
Separation into cause and effect	No causes and effects
Cause is necessary, sufficient or both	Mutual dependence
Observers excluded	Observers included
Non-recursive	Recursive
Openness	Closure
Generalizations	Eigenforms

The most striking difference between generative SOC-relations and causal relations of normal science lies in their organization and in their dynamics. Due to their triadic closure, due to the recursive description devices and due to the Closure Theorem,[17] generative relations, by necessity, lead to *Eigenforms*, broadly conceived whereas causal relations lead to viable or spurious generalizations.

[16] As a largely ignored corollary of the triadic configuration Heinz von Foerster is very explicit that the scientific disciplines also should be organized in accordance with triadic configurations. Again in "Computing in the Semantic Domain" von Foerster offers a sharp criticism of the ill-fragmented form of the disciplinary knowledge bases of his times. Referring, once again to triadic relationships which "have only recently been discovered" (*Ibid*:239), he goes on to assert that in normal science
… it is only descriptions, D, of a single domains in isolation, the 'major disciplines', as 'physics' D(W), 'psychology' D (C), linguistics' D(D), and so on, to which the scientific community is accustomed to addressing itself, and for which powerful analytic formalisms have been developed. (Foerster 1971:239)

[17] For another version of proving the Closure Theorem, see the exchange between Lou Kauffman and Ranulph Glanville in Kauffman 2005.

Using the same type of reasoning which Heinz von Foerster developed against disciplinary isolationism of the form D(W), D(C) or D(D), one can put forward a similar attack against causal isolationism, for it can be argued that in normal science

… it is only causal relations C of a single domain in isolation, which are used by the 'major disciplines', as 'physics' C(W), 'psychology' C(C), 'linguistics' C(D), and so on, to which the scientific community is accustomed to addressing itself, and for which powerful analytic formalisms have been developed.

A final SOC-component in the heuristic MMM-domain of research designs deals with a new type of investigation which is based on self-referentiality. Autology as a genuine SOC-topic has been expressed in several articles like "Understanding Understanding" or in examples like "explanation of explanation", "functions of functions", "goals of goals", "operators of operators", etc.[18] Autology as a special SOC-arena fulfils a special role since self-referential re-entries become the necessary step in closing domains of investigations. Thus, any presentation of SOC would not be complete unless cybernetic tools are used for an overview of cybernetics or its key concepts are allowed to close onto themselves.

Thus, SOC, as it was proposed in the 1970s, plays almost exclusively in Area I as a new alternative to the scientific approach *sans phrase*.[19] Surprisingly, SOC took a similar course to RC in the sense that in subsequent years SOC was placed more and more in Area II or Area III where SOC as a theory of knowledge or a postmodern *Weltanschauung* for the postmodern mind held similar or identical positions to RC-Glasersfeld style. From the 1990s onwards, SOC was presented largely in Area III and many lectures and talks by Heinz von Foerster supported the impression that SOC was another philosophical variant of RC in Area II or an additional element under the umbrella of RC in Area III.

3 Degrees of Radicalism in Radical Constructivism à la Glasersfeld and Second-Order Cybernetics Foerster-Style

As already noted, the three areas of the RC and SOC map underwent a similar development process. Figure 4 exhibits the overall cognitive map for RC and SOC and summarizes the discussion so far on the three different areas in which RC or SOC have been constructed. In Area I, RC is placed on the upper-left corner, due to its emphasis on macro-problems[20] and a low degree of formalization whereas SOC is located in the lower right field because of its emphasis on neural organization, neural networks and a high degree of formal modeling.

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18 For the SOC-perspective of autology, an essential contributor has been Lars Loefgren, especially Loefgren 1968.

19 Following Heinz von Foerster the research projects at the BCL especially during the crucial period from the late 1960s to the early 1970s were organized in a triadic pattern, operated massively parallel in three different, but inter-linked areas and included

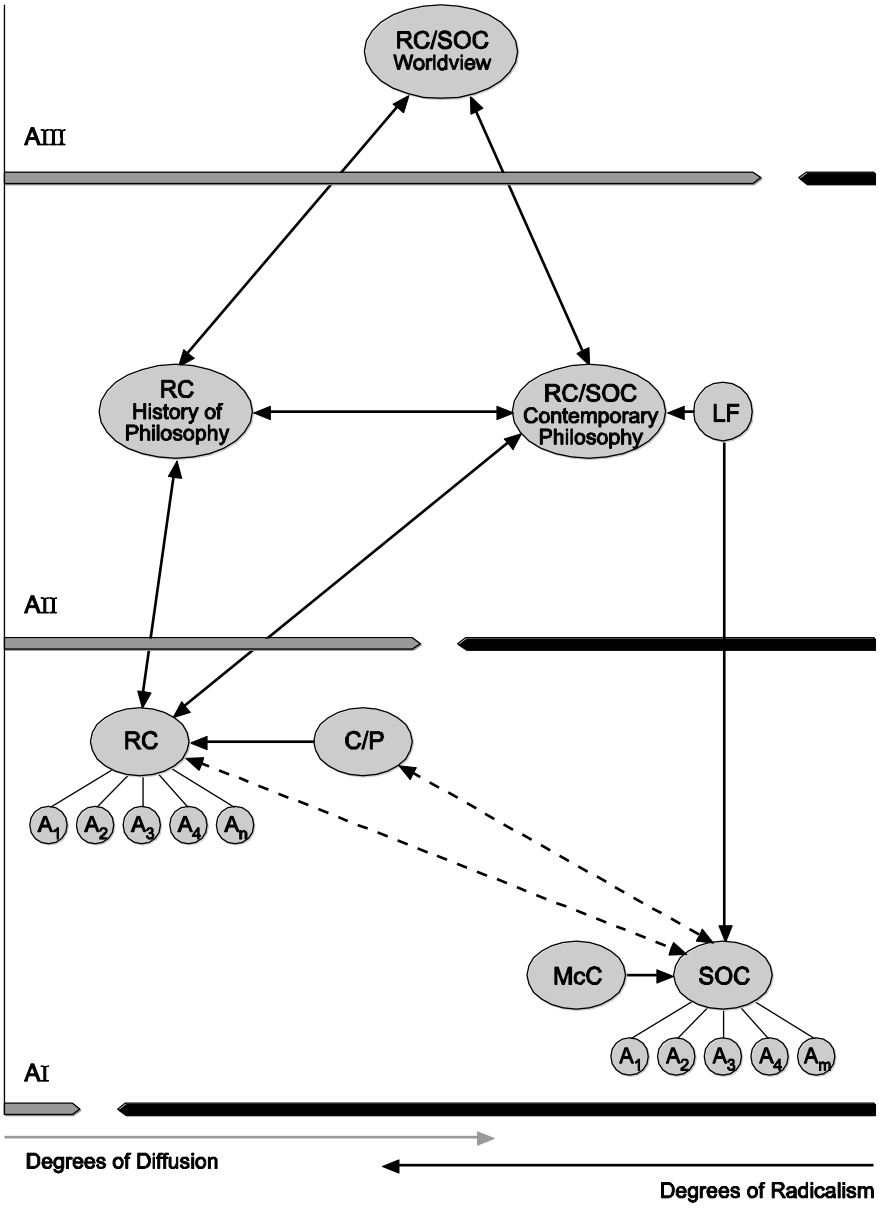
an epistemology of cognitive processes which has as a goal a rigorous penetration of the logic of descriptions, of the concept of self-references and of the emergence of sensory modalities

theoretical investigations of cognitive processes in terms of mathematical models of complex regulatory and control systems

experimental studies in electrophysiology of neural activity along sensory channels, in higher nuclei and in motor control areas … in as much as they are commensurate with the needs of the epistemological and theoretical investigations. (Foerster 1969:7p)

20 In cognitive science it is convenient to distinguish between micro-levels, comprising neurons and the neural organization and macro-levels which include primarily the observed behaviour of actors or, alternatively, of living systems.

Figure 4 A Combined Map for Radical Constructivism Glasersfeld-Style and Second-Order Cybernetics Foerster-Mode



C/P: Ceccato, Piaget

McC: Warren Mc Culloch

LF: Laws of Form

Figure 4 shows also an interesting trade-off between degrees of diffusion and degrees of radicalism across Areas I to III. As it turns out, RC and SOC, although situated in different cognitive territories of Area I as research programs, share a common pattern with respect to their levels of radicalism. In domains, where RC and SOC were and still are highly radical, namely in Area I, one finds rather little diffusion or reception. In the fields where RC or SOC have become very popular and widely recognized, namely in Area III, they have lost their radical impetus and have effectively stopped being radical. Here, RC as well as metaphors from SOC are circulated as a new common-sense philosophy for postmodern life-styles, an all-purpose pocket guide for postmodern (re)-organizations or a postmodern travesty of the limits of science .

4 Towards RC &SOC as a Recombinant Radical Research Program for the Future

Following the cognitive mapping so far, it will be shown that RC or SOC in full operation within Area I can bring about radical re-designs in conducting research in the life-sciences, in the cognitive sciences or in the social sciences.

According to Figure 4 RC and SOC within Area I can be viewed as complementary frameworks with different domains of applications and a common philosophical core. Thus, it should be possible to link RC and SOC to a broader RC&SOC-framework which shares a common epistemology and which is located in different territories of Area I, RC being largely macro-oriented and equipped with a theory of schemes and dynamics of schemes whereas SOC has a strong formal focus and is centered predominantly on the One-Brain Problem and its neural constitution.

Turning, thus, to RC&SOC as a powerful new research symphony rather than a philosophical serenade in the field of postmodern *Weltanschauung* or of contemporary epistemology and ontology, RC&SOC-research can be organized as a vital trans-disciplinary research program across the entire spectrum of the study of living systems. RC&SOC-work will be widely separated from conventional scientific practices, methods and approaches. In this section some of these profound and radical changes across the entire group of relevant life-science disciplines will be outlined.

As a starting point, RC&SOC-designs are characterized by including researchers in an explicit way. Heinz von Foerster, for example, used to refer to "the truism that a description (of the universe) implies one who describes (observes it). (*Ibid*:247) This, in turn, led him to demand that

> what we need now is the description of the 'describer' or, in other words, we need a theory of the observer. Since it is only living organisms which would qualify as being observers, it appears that this task falls to the biologist. But he himself is a living being, which means that in his theory he has not only to account for himself, but also for his writing his theory. This is a new state of affairs in scientific discourse, for, in line with the traditional viewpoint which separates the observer from his observations, reference to this discourse was to be carefully avoided … Life cannot be studied *in vitro*, one has to explore it *in vivo*. (*Ibid*:247p.)

These statements were never meant to be aphoristic or metaphorical. Given the overall structure and organization of RC&SOC, as shown in the cognitive map of Figure 4, a theory of the brain, laws of evolutionary forms, patterns of cognition or regularities societies, past and present, have to be generated in a triadic configuration where observing scientists are but one node of a triadic generative network and where the research process should be organizing itself so it can drift towards its stable *Eigenforms*. It is through these triadic recursive interactions *in vivo* that the laws or patterns of biology and brain research emerge.

The radical difference that makes the characteristic difference between RC&SOC-designs and traditional social science approaches can be seen in Figure 5. Here, one finds a triadic configuration with generative relations between an observing scientist S, observing observers O and an intermediary unit linking S and O.[21]

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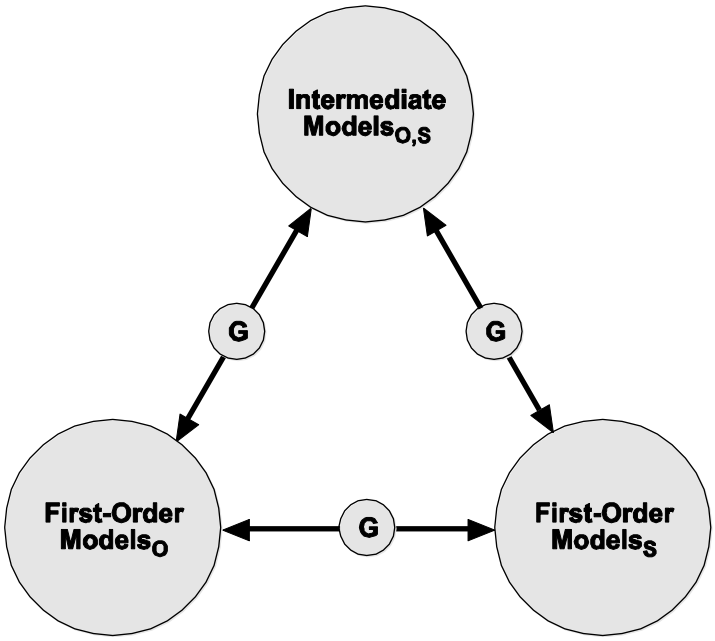
[21] It must be noted that Steffe's distinction between first and second-order models fits well for Figure 5. The second-order models in the Steffe and von Glaserfeld framework are the first-order models$_O$ in Figure 5, the first-order models for Steffe or Glasersfeld become the first-order models$_S$ and a Piaget-model of learning was present as an intermediary ensemble as well.

Figure 5 Basic RC&SOC-Designs for Area I



Towards the end of this section, a few outlooks and hints will be given that operating with RC&SOC in Area I is not a sentimental or nostalgic affair, but still urgently needed and required. After all, the cognitive status of RC&SOC remains one of an unfinished revolution of an unfinished revolution.[22] Three broad areas, namely biology, the cognitive sciences and, finally, the social sciences, of a living science for living systems will be discussed.

From the 1970s onwards one was able refer to a paradigmatic instance for the viability of the new RC&SOC approach. And this paradigmatic example was the new Chilean biology which was propagated by Humberto R. Maturana, Francisco J. Varela or Ricardo Uribe and others (Maturana/Varela 1980, Varela 1979a). In a way, RC&SOC could be interpreted as the generalization of the autopoietic approach to a trans-disciplinary framework for observing systems in general.[23]

Shifting from biology to the cognitive sciences, RC&SOC can still act as a catalyst and as a radically new perspective especially within the contemporary cognitive science landscapes. By and large, the Unification Theorem, the tessellation mechanisms or the double closures of living systems have only been marginally explored so far. Moreover, RC&SOC continues to remain a necessary and persistent critic to current developments in Artificial Intelligence or the cognitive sciences, including linguistics. The research designs for semantic computing or for living and learning observer-machine inter-actions constitute viable, albeit radically different research trajectories, compared to the normal cognitive science practices.[24] For even today's models of embedded cognition as they been advanced over the last years would need to cross a large cognitive distance in order to proceed in a RC&SOC compliant fashion, namely in a triadic as

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22 For more details see Müller 2007a.

23 Despite its initial successes the autopoiesis program, too, moved gradually from Area I to Area II or Area III. While Francisco J. Varela continued with his experimental work, Humberto R. Maturana turned more in the direction of a philosopher of biology in Area II or III and Ricardo Uribe worked in domains outside of autopoiesis.

24 For a more recent version sufficiently close to the former BCL-perspectives in the field of semantic computing, see Krieg 2005.

well as a generative configuration which includes the observing scientist as an integral element within an operationally closed configuration.
Turning, finally, to the social sciences in general one can specify two design features which would be necessarily present in RC&SOC-research and which are typically absent in today's normal social science investigations.
On the one hand, the RC&SOC-designs are organized recursively, drifting towards *Eigenforms* like patterns of social patterns, functions of economic functions, models of anthropological models, etc. This implies that the RC&SOC-designs cannot be limited to descriptions or analyses of a single social domain only, but have to assemble a variety of studies of first-order processes which are to be solved recursively within a second-order mode.
On the other hand, the observing social scientist becomes an integral part of a triadic research process where processes under observation are analyzed in a closed and generative configuration. For example, attitudes of observers *qua* social researchers have to play a significant role in attitude research. Normally, attitudes are always seen as the attitudes of others and the attitudes of social scientists are not considered as part of an inter-active research-design. In the RC&SOC context, the main emphasis does not lie in the fact that specific attitudes of researchers could have an adverse or negative effect on the interpretation of observations, but the point to be made is far more profound and of more general nature. Any theory of attitudes, for example, cannot be considered as complete as long as the attitudes of observing systems, studying attitudes, are not part of the investigation. This incompleteness simply means that it cannot be decided whether the attitudes of researchers are commensurate with the attitude theory in construction.
Thus, also the theories of sociology, political science, or the social sciences in general have to follow the RC&SOC-imperative of "Write thyself":

> It is clear that if the social sciences do not want to degenerate into a science of group interactions they must develop a theory of actions or attitudes T(A). But, of course, this theory must be written by a social scientist, acting on actions or with the attitude of writing about attitudes A(T). This means that this theory must be constructed in away as to write itself: T(A(T)).

Thus, the trans-disciplinary unity of observing living systems, so strongly advocated within the RC&SOC framework has to wait until the traditional sciences of living systems have implemented these drastic and necessary changes.

Conclusions

In this article a comparative cognitive mapping of RC Glasersfeld-style and SOC Foerster-mode has been undertaken. In doing so, RC and SOC could be weakly combined to form a comprehensive research program with a still very radical theoretical core and radically different sets of heuristic rules and research designs. This re-combination and re-focusing of RC &SOC as a largely unfinished trans-disciplinary agenda for empirical research still has an enormous, but currently un-utilized potential and a high relevance for today's research in biology, cognitive science, medical research or the social sciences. A few promising hot spots in the RC&SOC-designs were provided where the Foerster-Glasersfeld program could act as a powerful feature detector, as a radical problem deflator and, above all, as a distinctly new way for organizing

research with and of living systems. And here, after all, lies the primary domain where RC or SOC-radicalism should be measured, assessed and, if necessary, deepened.

Abstract

Purpose: The article pursues four aims. First, it wants to summarize Ernst von Glasersfeld's main theoretical as well as methodological building blocks which, according to him, justify the viability of the claim of being radically constructive. In a second move, Second-Order Cybernetics, as it has been developed by Heinz von Foerster in the late 1960s and 1970s, will be presented as another variant of a radically new research program for the study of cognitive processes in one-brain-, two brain-, multiple brain- and global brain-settings. Third, a map for the two approaches by Heinz von Foerster and Ernst von Gaserfeld will be outlined which will show the cognitive similarities as well as the distances between Radical Constructivism (RC) Glasersfeld-style and Second Order Cybernetics (SOC) in its Foerster-version. Fourth, it will be proposed that the RC/SOC approach contains some radical, albeit nearly unexplored features far away from later self-descriptions and self-definitions of radical constructivists themselves. **Design/Structure**: The article is analytical in nature, identifying building blocks and linkages between Radical Constructivism and Second-Order Cybernetics. **Findings**: The main finding lies in a re-focusing and re-orientation of radical elements of RC or SOC to the domain of research-designs. **Conclusions**: The article wants to contribute to a re-invention and re-construction of the period of the late 1960s and 1970 when RC and SOC developed radically new designs and enabled new forms of research. **Key words**: History of Philosophy, Philosophy of Science, Radical Constructivism, Second-Order Cybernetics, self-referentiality, viability