The Multiple Faces of Reflexive Research Designs[1]

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ABSTRACT

Reflexive research can be grouped into five clusters with circular relations between two elements x ↔ x, namely circular relations between observers, between scientific building blocks like concepts, theories or models, between systemic levels, between rules and rule systems or as circular relations or x ↔ y between these four components.
By far the most important cluster is the second cluster which becomes reflexive through a re-entry operation RE into a scientific element x and which establishes its circular formation as x(x).
Many of the research problems in these five clusters in reflexivity research are still unexplored and pose grand challenges for future research.

Keywords: Reflexivity, reflexive research designs, circularity, triadic configuration, observers, second-order science, Ranulph Glanville.

1 INTRODUCTION

In recent years more and more scientific approaches and designs were developed which contained aspects of reflexivity and of circular reflexivity relations. According to the Wikipedia-entry, "reflexivity refers to circular relationships between cause and effect" (Wikipedia, 2015) where x causes y and y causes x or y is a function of x and x a function of y.

Reflexive configurations can be found, for example, in the following three instances.

- A method for qualitative research was built under the name of grounded theory (Glaser/Strauss, 1967, Strauss, 1987, Strauss/Corbin, 2015) which is particularly sensitive to the role of scientific observers in the production of data and interpretations.
- Michel Foucault in his "Order of Things" (2002) concentrates on the peculiar situation that man is at the same time a knowing subject and an object of his own study.
- Feminist epistemology places special emphasis on situated cognition and on the embeddedness of researchers in socio-economic settings. (See, for example, Barad, 2007, Haraway, 1991, 1997, Jannack, 2004 or Ule/Šribar/Venturini, 2015).

All three approaches were built in splendid isolation from one another, although they are dealing with the same fundamental issues. Additionally, reflexivity plays a larger role in the work of Dirk Baecker, 2013, Ulrich Beck, 1986, 2000, 2007, Anthony Giddens, 1984, 1991, Niklas Luhmann, 1997, George Soros, 1994, 2001, 2007 or Greg Urban, 2001, to name only a few highly relevant contemporary authors.

More generally, reflexivity is characterized by a circular configuration for one single element like in the case of "functions of functions", "understanding understanding" (Heinz von Foerster, 2003) or for two or more components like in the instance of the hermeneutic circle with its reflexive relation between the whole and its constituent parts. In the present time, scientific reflexivity manifests itself not as a single approach, but in a variety of different clusters of research designs which were mostly unknown to the traditional science regime.

2 FIVE CLUSTERS OF REFLEXIVE RESEARCH DESIGNS

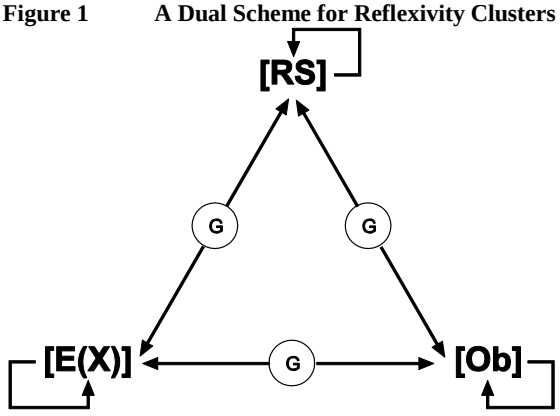
The starting point for the subsequent reflexivity explorations lies in two basic triadic configurations which are both combined in Figure 1.

On the one hand, Figure 1 shows the relations between a scientific observer Ob, a specific scientific building block X like a theory, a method, a domain of investigation, scientific outputs like tests, experiments, etc., and a set of rules and rule systems RS which become relevant for the production or transformation processes of X by a scientific observer Ob.

On the other hand, Figure 1 exhibits also the configuration of a scientific observer Ob, the wider social and natural environment E and a set of rules and rule systems RS which become relevant for the routines or practices of a scientific observer Ob.

In this basic triadic configuration in two different versions, namely as Ob ↔ X ↔ RS and as Ob ↔ E ↔ RS, the four network nodes Ob, X or E and RS generate each other, *round and round*.

Figure 1 A Dual Scheme for Reflexivity Clusters



In such an ensemble, reflexivity can arise or emerge, following Figure 1, in at least five different ways.

Observer-reflexivity: The first path is centered on scientific observers Ob, their actions, operations or routines and on the reflexivity relations of these observers with respect to other observers Ob ↔ Ob.

Building block-reflexivity: The second form of reflexivity focuses on inherent reflexivities for a scientific building block X and is typically based on a re-entry operation X(X) like in the case of models of

[1] This article is dedicated to Ranulph Glanville (1946 – 2014), magician, cybernetician of the second-order and the reflective practitioner for reflective practitioners.

models, theories of theories, explanations of explanations (Lissack/Graber, 2014), sociology of sociology, etc.

Environmental/societal reflexivity: A social or natural system or network like a social system, a financial system or a multi-level natural system can exhibit reflexivity features due to its multi-level architecture where practices or actions A at the micro-level generate an outcome O at the macro-level and this macro-element O, in turn, affects the practices or actions A at the micro-level: A ↔ O.

Rule system reflexivity: With the fourth way reflexivity is accomplished with respect to rules or rule systems RS and is constructed through a circular configuration between rules and rule systems RS ↔ RS.

Relational reflexivities: Finally, the fifth reflexivity trajectory comes about as circular relations between at least two nodes in Figure 1 and results in various different circular configurations: [Ob ↔ X, Ob ↔ E, Ob ↔ RS, X ↔ RS, X ↔ RS, Ob ↔ E ↔ RS, Ob ↔ E ↔ RS, Ob ↔ X ↔ E ↔ RS]

Moreover, these five different branches or clusters for reflexivity comprise a variety of different forms or types of reflexivity so that reflexivity can be accomplished in five clusters and different types within each of these five clusters. The next sections will describe these five clusters in reflexive research designs in closer detail.

3 REFLEXIVITY CLUSTER I: SCIENTIFIC OBSERVERS

With respect to scientific observers reflexivity can arise basically in two different forms which are strictly independent from one another.

- On the one hand, scientific observers and their routines or practices in exploring the world become the central topic of a scientific investigation by a scientific observer. Such an investigation falls under the domain of science studies, broadly conceived.
- On the other hand, the I of observers can become an inclusive element in research processes. The resulting type of science production differs wildly from the traditional approach and will lead to a basic epistemological distinction between an exo-mode – scientific research without observers - and an endo-mode – scientific research with observers included.

The first type of reflexivity within the cluster of observer reflexivity is focused on the observer Ob in her or his scientific operations or routines. As a paradigmatic example of the first reflexivity type one can refer to a laboratory study on the practices in one or more laboratories by a scientific observer (See, for example, Knorr, 1984, 1995 or 1999). Similarly, an empirical investigation of writing and presentation styles in different scientific disciplines like management science, theoretical economics, genetics and political science becomes a reflexive study because this analysis is based on a specific writing and presentation style itself. The first reflexivity type comes into play whenever a scientific observer focuses on research routines and practices of other scientific observers and produces a tangible output in the form of an article, a book, a research report, etc.

The second reflexivity type deals with reflexivity in relation to the I of an observer. This requires a radical epistemological shift from the usual exo-mode of exploration to an endo-mode. The distinction between an endo-mode and an exo-mode can be traced back to Heinz von Foerster who developed a very intriguing list of characteristic differences between two fundamentally different epistemic attitudes towards one's world or environment.

> Am I an observer who stands outside and looks in as God-Heinz or am I part of the world, a fellow player, a fellow being? (Foerster, 2014:128)

Subsequently, Heinz von Foerster provides us with the following list of distinctions which can be used directly for my differentiation between an endo-mode and an exo-mode. It must be mentioned that Otto E. Rössler published a book on endo-physics (1992) which raised considerable interest. (See, for example, Atmanspacher/ Dalenoort, 1994). However, the distinction developed here between an exo-mode and an endo-mode differs significantly from the exo- and endo-differentiation by Otto E. Roessler who assumes a two-level structure of reality.

Table 2 Dichotomies for the Exo-Mode and for the Endo-Mode

Exo-Mode	Endo-Mode
Appearance	Function
World and I: separated	World and I: one
Schizoid	Homonoid
Monological	Dialogical
Denotative	Connotative
Describing	Creating
You say how it is	It is how you say it
Cogito, ergo sum	Cogito, ergo sumus

Heinz von Foerster emphasizes especially one distinction in Table 2.

For me the most important distinction in the table is between 'Say how it is' versus 'It is how you say it.' These for me are the really fundamental differences between 'standing outside' and 'standing inside' – and here, of course, syntax fits as the set of rules you can see from the outside. Semantics, however, is like a roast that is being prepared and will soon be served. (Foerster, 2014:129)

Moreover, Heinz von Foerster specifies another distinction between the exo-mode from outside and the endo-mode from within.

This list (in Table 2, K.H.M) touches on those two areas that the linguists call 'connotative' and 'denotative'. The idea of the denotative is that you refer to something and say 'bench'; you point at something and shout 'table', etc. In this perspective, language works like Pavlov's dog: To start with, someone points at something with their finger, you hear a hissing, grunting sound, and you understand, you salivate mentally—until after however many repetitions the finger is no longer necessary, the hissing, grunting sound comes—and you've got it. On the other side there's this idea: You create sounds and hope that they trigger suitable 'semantic relations' in your conversational partner that will engage in relations with your semantics. These two worlds stand opposed to each other: Connotative versus denotative. (Foerster, 2014:128f.)

For Heinz von Foerster, the decision between an exo-mode from without or an endo-mode from within belongs typically to the undecidable questions whose charm it is that they have to be decided by us. Researchers have to decide for themselves whether they want to operate in the traditional exo-mode or whether they want to shift to the rather unusual endo-mode.

In addition to the differentiation between an exo-mode and an endo-mode another distinction can be put forward, namely the separation between an endo-sphere and an exo-sphere. The exo-sphere focuses on the world or on the environment "as it is" in an exclusive manner and tries to minimize observer-induced biases.

Eric R. Kendel provides a classical short summary of the exo-mode which attempts to eliminate scientific observers or to minimize subjective biases and which wants to establish objective knowledge.

Scientists make models of elementary features of the world that can be tested and reformulated. These tests rely on removing the subjective biases of the observer and relying on objective measurements and evaluations. (Kendel, 2012:449)

The endo-sphere concentrates on the world or the environment and on the I of its observers and links both in a triadic fashion by adding rule systems for the communicative practices of observers as a third node. The endo-sphere becomes, by necessity, more complex than the exo-sphere, due to the inclusion of the relations between world or environment and their many observers, including the I of authors.

Thus, the endo-mode includes the investigating scientific observer in the domain or the sphere of investigation. An inversion of Kendel's quotation leads to a brief summary of the endo-mode.

Scientists make models of elementary features of the world that can be tested and reformulated. These tests rely on removing the objective biases of observer-free tests and relying on observer-dependent measurements and evaluations.

This shift to the I of the observer or to the endo-mode requires profound methodological changes. As a historical note it is interesting that for a short period the most radical empirical and anti-metaphysical philosophical tradition in the 20th century, namely the *Wiener Kreis*, proposed a version of first-person science under the name of protocol-sentences which served as the observational basic statements and which had to include the name of the observer (See, for example, Neurath, 1981).

The I of the observer is, following Heinz von Foerster, "a relator … of infinite complexity". It is probably informative to quote three propositions by Heinz von Foerster on the role and function of I.

A living organism Ω is a third-order relator $\Omega = RL^{(3)}$ which computes the relations that maintain the organism's integrity (Foerster, 2003:256)
I am the observed relation between myself and observing myself. (Foerster, 2003:257)
'I' is a relator (and representor) of infinite order. (Foerster, 2003:257)

I is not only the observed relation between myself and observing myself, but holds also for any object, process, etc. I am also the observed relation between the desk in front of me and observing the desk in front of me, between my typing on the keyboard and observing my typing on the keyboard or between my writing on the screen and observing my writing on the screen. Thus, the I of the observer who produces research reports, scientific articles, books, measurements and the like, becomes not only a necessary component in the research processes, but also the closing relation between a research domain and observers.

At this point a concrete example for the endo-mode and the endo-sphere will be given which, not surprisingly

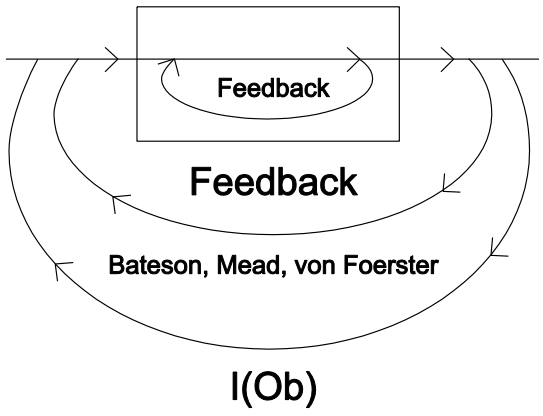
becomes highly self-referential itself since it deals with the present article. In this paper I follow a weak version of an endo-mode which is focused on the underlying goal-set and the goal behind this goal-set of an observing author, *i.e.* of myself. Here I want to present the two possible modes of exploration, namely the exo- and the endo-mode, and their designs in the production of this article.

In the exo-mode I as observer would write an article on reflexive designs, would interact with articles, books and publications by others, relevant for reflexivity designs and with the work of first- and second-order cybernetics in particular and with radical constructivism in general. Within the production process I as observer would exclude myself from the published output.

In the endo-mode I am also writing an article on reflexive designs and interact with the same number of publications from others as above. But I start this article with my goal set which I set to achieve in this work. Throughout this article I as well as a reader can observe the relations between the growing number of reflexivity clusters and their various types and my goal set as well as my goal of goals which were introduced by me in the beginning.

Figure 3 presents a sketch of my current relations as the author of this article and as I of an observer I(Ob) within the endo-sphere of I(Ob), various approaches to second-order cybernetics by Heinz von Foerster, Gregory Bateson, Margaret Mead and others and traditional cybernetics with its circular causal and feedback mechanisms.

Figure 3 The I of the Observer as the Final Closing Loop



In the endo-mode I(Ob) become the explicit relator of the highest order who selects and relates the building blocks in my endo-sphere according to an explicit set of goals and goals of goals. Thus, the endo-mode provides an inter-subjectively transparent form for relevant selection operations throughout this article. Moreover, in this article I develop the notion of an endo-mode by actually using it during its development which becomes an unusually dense form of circularity.

Thus, the endo-mode can be described as a dialogical first-person exploration and the research processes and outputs in the endo-mode can be classified as endo-science. Operating in the endo-mode within an endo-sphere constitutes an essential reflexivity type which becomes particularly relevant for the social sciences and the humanities on the one hand and, on the other hand, for complex and "wicked" (Alrøe/Noe, 2014) research problems with many teams and a large number of scientific observers across all scientific disciplines.

As a self-referential remark, I should add that this article does not operate fully in an endo-mode because important ingredients like my goal specification or the documentation of this article in terms of inter-subjective reproducibility are still missing.

4 REFLEXIVITY CLUSTER II: REFLEXIVITY IN SCIENTIFIC BUILDING BLOCKS X

The second reflexivity cluster is by far the most comprehensive one and also the backbone for the ongoing reflexivity revolution. This cluster advances reflexivity within a special domain X by re-entering this particular domain: X(X). This re-entry operation RE, as depicted in Figure 4, constitutes the vast domain of second-order science.

Figure 4 Re-Entry Operations as Generators of Second-Order Topics

The choice of research topics in the second-order domain is based on a single operation, *i.e.*, the operation of re-entries, which was originally suggested by George Spencer Brown (1969). The operation of re-entry occurs whenever elements or building blocks from first-order science are applied to themselves in the form of

computation of computation, cybernetics of cybernetics, geometry of geometry, linguistics of linguistics, logic of logic,

magic of magic, mathematics of mathematics, pattern of pattern, teaching of teaching, will of will. (Kauffman 2005: 129)

This list can be extended, following Heinz von Foerster, with "understanding understanding," "communication of communication," "goals of goals," "control of control," etc. Thesebuilding blocks are not necessarily only concepts or operations (e.g., "understanding understanding") but also theories, models and even entire disciplines (e.g., "economics of economics").

These self-applications of first-order science elements accomplish a logical closure because these elements are not only applied in various space-time settings, but also to themselves. Whenever such an element is applied to itself such as in "explanation of explanation," "science writing of science writing," or "learning of learning," the logical realm of applications for these elements becomes closed. In a more formal way a first-order science building block X with a re-entry operation RE produces X(X): X → RE → X(X).

Aside from the closure of first-order building blocks like concepts, theories, models, methods, generative mechanisms or scientific fields, these re-entries constitute also a new science domain whose potential has not been sufficiently recognized and insufficiently explored so far. What has been mostly disregarded until now is the relevance of these re-entries for the creation or production of new scientific areas of investigation.

Using re-entry operations, one can construct a very large number of new research problems and fields for the second-order level. Obviously, these re-entries can be undertaken within all scientific disciplines and sub-disciplines of the first-order level.

Following a correspondence principle between scientific disciplines and fields at the first and at the second-order level, this vast number of new second-order research problems, challenges and topics is distributed across the same range of scientific disciplines and sub-disciplines which are used for the first-order level. Here I want to list as examples four reflexivity types within the second cluster.

The first type focuses on first-order normative sciences and on re-entries in this domain. Here, second-order investigations are directed to research problems like a methodology of methodologies, research designs of research designs, a calculus of calculi, an algebra of algebras, laws of laws, etc. Usually, these re-entries in normative first-order building blocks generate new topics for second-order investigations and a normative second-order context which should lead to normative approaches with higher generality or to possible foundations of normative sciences.

A second type produces re-entries in well-established scientific disciplines and discipline groups like political science, chemistry or historiography. The social sciences of social sciences can be focused, for example, on social relations between social science disciplines, the environmental sciences of environmental sciences place their emphasis on the environmental relations of environmental science, management science of management science produces second-order management schemes for various traditions of management science, etc. and generates, thus, a new second-order area. Usually, these re-entries into first-order disciplinary domains lead to new and mostly unexplored second-order disciplines, sub-disciplines or, by selecting at least two disciplines, hybrid fields.

The third type places the outputs of first-order science in its centre and leads to re-entries in the results, products or, more generally, into the available research outputs of a single field or across many disciplines of first-order research. Here, re-entries can be focused on specific causal relations, distributions, tests, patterns, studies, articles, etc. within a first-order field or across clusters of several fields or disciplines.

The fourth type is concentrated on the input context of first-order science and generates re-entries like in theories of theories, models of models, methods of methods and the like. As a concrete example, power-law distributions and their underlying generative mechanisms can be transformed into a second-order study of generative mechanisms of generative mechanisms for power-law distributions. Here, the emphasis changes to a search for more general generative mechanisms which are able to generate different types of generative mechanisms.

These four types of re-entries for different aspects of first-order science are just a small fraction of possible re-entries. In general, re-entries can be used for quality control and for analysing the outcomes of first-order science in areas like psychological or clinical tests, to search for robust knowledge by analysing first-order frameworks or results, to generate new academic fields, new and challenging topics for scientific research or more general second-order building blocks compared with their corresponding first-order counterparts. Moreover, many of these different types of re-entries turn out to be extremely helpful for organizing and conducting new forms of trans-disciplinary research which can be qualified as post-disciplinary.

5 REFLEXIVITY CLUSTER III: REFLEXIVITY IN SOCIETIES OR ENVIRONMENTS

A third cluster becomes reflexive because a special segment of the environment, including societies, contains reflexive features. This is the case, for example, in complex multi-level systems and especially in socio-economic systems. In political elections, for example, one can observe a continuous interaction between the overall results of opinion polls at the macro-level, their effects on the individual voting behavior at the micro-level, new opinion polls at the macro-level, individual changes in voting behavior, etc. practically up to the day of the actual election. Interestingly, the general importance of this type of reflexivity was, so far, recognized by only a few authors. Two very interesting approaches were selected here as paradigmatic examples.

The first approach has been created mainly through a series of books by George Soros (1994, 1994a, 1998, 2001, 2007, 2009 or Slater, 2009, Umpleby, 2007), although Heinz von Foerster (2003) and his model of trivial machines and their interactions or tesselations turns out to be structurally similar to Soros' framework.

Soros' approach deals with basic problems of action, perception and cognition in societal systems and with the intricacies of individual and collective actions and their special forms of aggregations. More specifically, the following ingredients are needed for a reflexive modelling Soros' style (See also Haag/Müller/Umpleby, 2010).

It is highly interesting to note that George Soros comes near to the distinction between Science I and Science II since in his assessment the traditional way of science is incapable of dealing with societal domains, and one might add, with the area of living systems. In a speech at MIT in 1994 George Soros is very explicit about the need for a radical change in the general scientific approach: According to Soros, his theory of reflexivity is built from within, whereas socio-economic modeling assumes usually a position from without.

> … the way philosophy and natural science have taught us to look at the world is basically inappropriate when we are considering events which have thinking participants. Both philosophy and natural science have gone to great lengths to separate events from the observations which relate to them. Events are facts and observations are true or false, depending on whether or not they correspond to the facts. (Soros, 1994a)

As a first building block, George Soros introduces a new type of reflexive actor who, unlike the *homo oeconomicus*, is not selfish by nature or utility maximizing by necessity, but reflexive by design, *i.e.*, determined by her or his internal states. An actor within the Soros' framework is described by two functions, namely by a driving function for her or his operations and by a state function for her or his internal cognitive state. In his book "Alchemy of Finance" (Soros, 1994a), provides the following specification scheme for these two recursive functions.

The cognitive function captures the relation between the cognitive evaluations and perspectives y of a micro-actor and the macro-configuration x and its information set: $y = f(x)$. The macro-configuration x, in turn, is permanently produced and reproduced through the operations y of a large number of micro-actors, summarized as $x = \Phi(y)$. Thus, the two self-reflexive functions for the Soros' micro-macro-model become:

$$y = f(\Phi(y)) \tag{5.1}$$
$$x = \Phi(f(x)) \tag{5.2}$$

At this point it is probably interesting to note that Soros' specification scheme for micro-actors is structurally equivalent to Heinz von Foerster's functional specification of non-trivial machines. Heinz von Foerster introduces a minimal cognitive element with the help of a driving function which determines at each instant the output state, *i.e.*, the operation, given the input state and the internal state z:

$$y = f_y(x, z) \tag{5.3}$$

These operations y remain unpredictable as long as the values of z, the internal states of the cognitive element, are not yet specified. For Foerster, the most profitable specification is to define z recursively as being dependent on previous states of affairs. Consequently, one can define the state function f_z to be:

$$z = f_z(x^*, z^*) \tag{5.4a}$$

or, alternatively and equivalently

$$z' = f_z(x, z) \tag{5.4b}$$

Here, the present internal state of the machine is a function of its previous internal state and its previous input state; or alternatively and equivalently, the next internal machine state is a function of both its present internal and input states.Soros uses additional assumptions which, even at second sight, could be supported empirically and which deviate markedly from the economic mainstream literature. Full information on part of the micro-actors cannot be taken for granted nor are these assessments grouped as normally distributed deviations from a "true" configuration. Likewise, Soros

emphasizes the determining role of biased expectations and their consequences on the course of events. “Markets can influence the events that they anticipate.”Moreover, micro-actors may even increase their biases and cannot be corrected by other micro-actors involved.

The second feature in Soros’ modelling framework lies in the specification of a macro-configuration which is perpetually generated on the basis of the market biases of its micro-actors. For Soros, the relations between the cognitive assessments at the micro-level and the resulting information set on the macro-situation turn out to be complex and far from trivial. They are context-dependent and, due to the erroneous nature of micro-assumptions, likely to move far from equilibrium. Soros replaces rational expectations or the efficient market hypothesis with an alternative assumption: “Markets are always biased in one direction or the other”(Soros, 1994:49).

In fact, the implicit aggregation of the two recursive micro-functions can drift towards a multiplicity of macro-attractors. One of the macro-trajectories could lead along a long-term, but slow growth path, another macro-trajectory could lead to an unsustainable explosion, a third macro-trajectory to an equally unsustainable implosion, etc.

For Soros, the macro-configuration as an aggregation of individual biases becomes a genuine factor of its own which changes the cognitive evaluations and, through changes in the cognitive function, changes the participative function as well. In other words, markets are moved by self-fulfilling cognitive micro-biases.

George Soros uses the permanent sequences of booms and busts as a paradigmatic example for a self-reflexive mechanism Soros’ style. These booms and busts occur at irregular intervals and are of varying sizes. From the historical record it is well documented that booms are usually short-lived and only few large-scale booms and corresponding busts can be identified like the long boom-period of the 1920s and the deep bust between 1929 and 1933 or the accumulation of boom-periods and the super-bubble between 1988 and 2008 and the bust period from 2008 onwards.

Slightly generalized, the boom-bust mechanism can be characterized as a societal self-organization process without efficient local or global controls. The asymmetrical periods of booms and busts are organized in a self-critical manner and distributed in a power law fashion with a typical distribution of the frequency and the impact of booms and busts where a very large number of marginal booms or busts is accompanied by a very small number of booms with very large-scale effects and necessary deep busts.

The change from an equilibrium-seeking market to a permanent proliferation of booms and busts is far-reaching. It would well go the scope of this article to elaborate the profound consequences and implications of this new perspective on booms and busts. Just two points should be emphasized.

First, Soros’ model framework cannot predict the future in a way similar to forecasting within the Science I-contexts of majestic clockworks. Rather, Soros’ theory

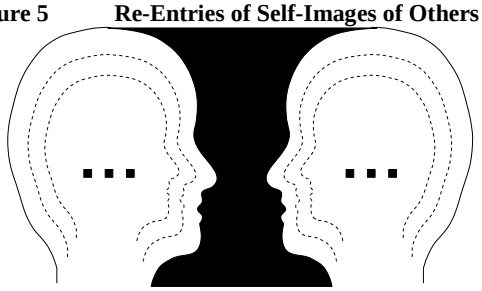
> can assert that a boom must eventually lead to a bust, but it cannot determine either the extent or the duration of a boom. (Soros, 2007:4)

Second, while impossible to predict, Soros’ approach nevertheless helps to find new ways for controlling the boom-bust cycles. While acknowledging the driving force of the developers and distributors of financial products, the building of new regulations and institutions can help to diminish the conditions for the possibility of bubbles or super bubbles to arise. Moreover, the permanent race between producers and regulators follows a pattern of catching up (regulators) and innovation (producers) which is typical for a generative, self-adaptive network.

Thus, Soros’ approach, when applied to financial markets, can best be understood as a recombination of non-trivial agents at the micro-level, of a macro-configuration in its own right and of generative linkage structures between the micro-actors and the available information on the macro-configuration.

The second approach to an intrinsic reflexivity is a classical one and can be classified, quire generally, as actor-reflexivity. Actor-reflexivity requires, as can be seen from Figure 5, a minimum of two actors A, B and the inclusion of B’s perspectives of A into A’s cognitive system and, *vice versa*, the inclusion of A’s views of B into the cognitive repertoire of B.

Figure 5 Re-Entries of Self-Images of Others



Obviously, the inclusion of how others view myself, aside from the way I perceive myself, implies both a creative and fallible widening of my cognitive system (See Lefebvre, 1982 and 2001).

Lefebvre uses Boolean algebra, with a+b equal to a or b and ab as a and b. Using the bracket notation of Spencer Brown's "Laws of Form" (1969), 0 is the void state, ‹ › stands for the marked state, ab turns into ‹‹a›‹b››, etc. (See also Kauffman, 2009:127).

The important point in a such a reflexive configuration, using the notation from Vladimir A. Lefebvre, lies in the reflexive entanglement between A's thinking of B of A and B's perspective of A of B. This configuration can be expressed as equations (5.5) and (5.6)

$$A = ‹A›B \quad (5.5)$$
$$B= ‹B›A \quad 5.6)$$

Clearly, the configuration of two actors can be extended to three actors where A is thinking of C who is thinking of B who is thinking of A or where C is thinking of A who is thinking of B who is thinking of C, etc.

$$A = ‹‹A›B›C \text{ and } C = ‹‹C›B›A \quad (5.7)$$

Finally, this reflexive configuration can be extended to a group A_1, A_2, ..., A_n where A_1 is thinking of A_n who is thinking of A_{n-1} who ..... who is thinking of A_3 who is thinking of A_2 who is thinking of A_1.

$$A_1 = ‹‹‹A_1›A_2›A_3› .... A_{n-1}›A_n \quad (5.8)$$

One of the most fascinating applications of the self-reflexive Lefebvre-system lies in the domain of international relations where Lefebvre built two different ethical systems, System I and System II with an opposite configuration of means, ends and corresponding evaluations.

In the Soviet Union a good person is one who will pursue a good end even if the means is bad, whereas in the West a good person is one who will not use a bad means to achieve a good end. (Umpleby, 1987:1)

It is surprising to see that Lefebvre is capable to elaborate on far-reaching consequences in the area of international relations, due to opposing underlying self-reflexive ethical systems, and to demonstrate the inherent conflict potentials between the United States (System I) and the former Soviet Union (System II).

6 REFLEXIVITY CLUSTER IV: RULES AND RULE SYSTEMS

The fourth reflexivity cluster is centered on the node of rules and rule-systems for the communicative behaviour of observers and is based, once again on re-entry operations. Initially, I have to emphasize that rules and rule systems must have a significant relevance for the observable behaviour of observers, otherwise these rules and rule-systems fall outside the realm of reflexivity research. An electronic coffee-machine as trivial machine can be described in elementary operational rules which, however, at least at the present time, cannot be changed into a reflexive configuration.

Here, reflexivity can be accomplished in a variety of ways like a study of rules of rules, of rule systems of rule-systems, of grammars of grammars, of norms of norms, of behavioral rules of behavioral rules, of societal laws of societal laws and the like. In the available literature one finds an astonishing number of approaches in terms of rules and meta-rules which are usually defined as rules to generate rules.

Douglass C. North's theory of economic growth (North/Thomas, 1970, North, 1994) is based, for example, on two types of rules, namely rules or property rights on the one hand and basic ground rules on the other hand. The underlying constitutional basis of property rights and basic decision rules with respect to political decision-making then become, following Douglass C. North, meta-rules or rules for making rules. Institutions are defined by Douglass C. North as collections of rules and meta-rules. And an economy as a collection of institutions is characterized by a permanent circular interplay between fast changing rules and slowly adapting meta-rules.

In linguistics, meta-rules were produced to increase the power of a grammatical formalism (See, for example, Uszkoreit/Peters, 1986). In large data-sets for sequential data one can mine for meta-rules which produce first-order rules (Cotofrei, 2005). In general, one can search in domains of first-order rules for more general principles or second-order rules which generate first-order rules which, characterizes, thus, the fourth reflexivity cluster.

7 REFLEXIVITY CLUSTER V: REFLEXIVE RELATIONS BETWEEN OBSERVERS, BUILDING BLOCKS, MULTI-LEVEL ENSEMBLES, AND RULES OR RULE SYSTEMS

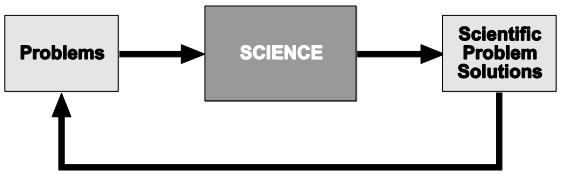
The fifth cluster contains a significant number of different relational reflexivity configurations like the relations between observers Ob and scientific building

blocks X, scientific building blocks X and society/ environment E, etc.

A first reflexivity type is based on the relations between scientific problem solutions X and societal problems in the environment E. Ulrich Beck (1986, 2007), for example, stresses the point that in more and more instances scientific problem solutions from previous periods become the sources of new societal problems. Thus, following Beck, science is confronted more and more with unintended consequences of its own expertise in the form of technologies, forecasts, scenarios, organization studies, evaluations, assessments or consulting which give rise to a new round of scientific or technological problem-solutions in the shape of new or improved technologies, socio-technical systems, revised forecasts, etc. Due to the inherent circularity in this process, these new problem solutions can become a new source of societal problems.

This relational reflexivity type between X and E can be qualified as self-infective and links the output side of the science system with the societal environment E. Due to this self-infection the science system is confronted with necessary methodological adaptations and with substantial changes in its traditional designs because science can no longer offer itself as a natural cure if at least parts of the new problems are due to an involvement of scientific procedures and outputs in the first place. At this point it should be sufficient to conclude that self-inflective designs need to be sensitive to the pre-history of a problem, to the scientific failures in the past and to new forms of risk-communication, of participation of concerned citizens and of a much wider diffusion of scientific problem solutions.

Figure 6 Relational Reflexivity between Scientific Problem Solutions and the Domain of Societal Problems



Another relational reflexivity type between observers Ob and scientific building blocks X is based on the relations of attributes of observers and the content of their theories. In particular, the theories, generated by observers, should include those attributes of observers that are necessary in order to generate or to produce these theory outcomes.
Warren McCulloch was probably the first to note the peculiarity that radical breakthroughs in physics require the invention or creation of regularities or theorems of great abstraction which, however, are usually not included in the new theory frameworks. Thus, following McCulloch,

> let us now compel our 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)

Many years later Heinz von Foerster credits Warren McCulloch as being the first to deal with "the fascinating problem of inclusion" (Foerster 1995:3).

Several other relational reflexivity types could be specified, for example the interesting heuristic advice by Stuart A. Umpleby to investigate the relations between ideas and society (Umpleby, 1990). But at this point I will close the overview on the five reflexivity clusters with their different reflexivity types.

8 COMBINING REFLEXIVITY TYPES

Aside from these five clusters of reflexivity an important point lies in the possibility of combining these clusters to more complex configurations and highly reflexive research designs. In principle, three reflexivity roads are open which are all based on the five reflexivity clusters and the various reflexivity types. In terms of classification, these roads can be categorized as low, middle and high reflexivity roads. The terms of a low, middle and a high road are not used as a quality predicate, but stand for different complexity and reflexivity levels of research designs and of research processes.

The low road to reflexivity is accomplished whenever a topic is analysed which exhibits a circular arrangement and which corresponds to one of the reflexivity types within one of the five reflexivity clusters. Any second-order analysis in the exo-mode without further reflexivity relations involved moves along this low road. More generally, reflexive investigations in the exo-mode are bound to this low road with a high degree of probability.

The middle road to reflexivity is characterized by a recombination of two or three of the five reflexivity clusters. For example, a research design can be specified for a second-order analysis in an endo-mode or by adding the wider research and society relations to a second-order study. All these instances are characterized by more complex research designs and scientific production processes, compared to the low reflexivity road of the single reflexivity types.

Finally, the high road to scientific reflexivity needs a recombination of four or five reflexivity types from four or five reflexivity clusters which results in a maximal reflexivity level. In this instance a re-combination of all five reflexivity clusters must be undertaken by an observer-inclusive, rule-reflexive second-order analysis of a reflexive system or network which also adds a non-trivial relational component. This recombination becomes the most demanding and most complex one and requires time and resources which are currently unavailable in conventional research processes. The maximum state of reflexivity can be specified, thus, in a clear way as a recombination of all reflexivity types from all five clusters.

The differentiation into five independent clusters of reflexivity and their potential recombinations should become useful as a guideline for organizing higher forms of reflexivity in scientific research processes. The possibility for recombinations of reflexivity types and clusters leads to the conclusion that the potential for reflexive designs and analyses is huge and most of these recombinations have not been realized so far.

9 ENDO-MODE, RECURSION, AND EIGENFORMS

As a final point I want to mention an interesting point with respect to the dynamics of reflexive studies in an endo-mode. The endo-mode, due to its closed operation, provides intriguing endpoints which can be classified as states of cognitive equilibrium and which are based on an important theorem which can be stated in the following way.

> In every operationally closed system there arise Eigenbehaviors. (Foerster, 2003:321)

The final form in a reflexive investigation in the endo-mode is reached when, following the quote from Heinz von Foerster, Eigenbehaviors or, more generally, Eigenforms emerge. An Eigenform EF can be an Eigenvalue in mathematical operations, an Eigentheory, an Eigenmodel, an Eigensentence[2], an Eigenfunction, an Eigenlaw, an Eigenbehavior, etc. Eigenforms are characteristic equilibrium states which reproduce themselves once they have been reached. For the operation extracting the square root of a positive number N the number 1 becomes the Eigenvalue of this particular operation and the square root of 1 generates, once again, 1. For the differential operator dy/dt *e* becomes its Eigenvalue and *e* generates *e* under a differential operation.

In addition to Eigenvalues Heinz von Foerster offers a highly interesting example of the necessity of biological Eigenlaws.

> The laws of physics, the so-called 'laws of nature', can be described by us. 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)

Moreover, 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)

Obviously, this restriction on theory formation also applies to the I of the observer so a variation of the quotation from Heinz von Foerster is needed.

> It is clear that I as a brain researcher must develop a theory of the brain: $T^I(B)$. But, of course, this theory must be written by my brain: $B^I(T)$. This means that I must build this theory in a way so that it writes itself: $T^I(B^I(T))$.

Currently, biological and brain theories are situated far from their cognitive equilibrium points of Eigentheories. But at least one can point to a promising endo-path which could reach such an area in the future.

10 OUTLOOKS

This article presented a systemic and systematic account of the realm of possible reflexive research designs, namely as

- Observer reflexivity Ob ↔ Ob
- Second-order science X → RE → X[X]
- Multilevel Configurations in Societies or Environments
- Reflexivity of Rule and Rule System RS ↔ RS
- Relational Reflexivity between these four Components

In combination, these five different clusters for reflexive research designs constitute an open and vast field of new research paths which, so far, were not explored at all and

[2] As an example for an Eigensentence, take the sentence „This sentence has .... letters" which has two solutions (thirty-one and thirty-three).

which become highly significant in shaping an emerging silent revolution in reflexivity (Müller, 2015, 2015a).

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