Towards a General Methodology for Second-Order Science[1]

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ABSTRACT

In recent years a new science frontier emerged under the umbrella term of second-order science which creates new and challenging problems through a characteristic re-entry-operation like in pattern of patterns, learning of learning, cybernetics of cybernetics or logic of logic, which works with and on building blocks or elements of traditional or first-order scientific research and which, due to this re-entry configuration, becomes inherently reflexive.

In this article I will pursue the ambitious goal to develop a general methodology for second-order science which is needed for second-order analyses from their initial stages up to the final steps. This general methodology will be framed as a sequence of recombination operations which become the central task for a particular step in the design of second-order investigations.

Keywords: First-order science, second-order science, re-entry, science levels, reflexivity.

1 INTRODUCTION

The concept of second-order science was proposed as a radical widening and expansion of the traditional scientific landscapes and as a new science frontier with vital functions for the science system in general (Müller & Riegler, 2014). In this article a general methodology will be developed which specifies the necessary steps in second-order analyses. Moreover, two examples for a second-order study will be presented which are both situated within the social sciences and which will specify the concrete instantiations for the general methodological steps.

But before I start the tour to a general methodology of second-order science two brief outlines will be given, one on the architecture of second-order science and one on innovation processes in general which should produce the necessary guidelines and options for the subsequent steps in the general methodology of second-order science.

2 A SHORT OVERVIEW OF SECOND-ORDER SCIENCE

Second-order science is based on a new general architecture for the overall science system which is characterized by different vertical levels or, alternatively, by horizontal domains and on the long-term evolution of a three level configuration.[2] According to this construction scheme, modern science evolved, for centuries implicitly and since the end of the 19th century explicitly, in a three-layered configuration between research domains proper at a first-order level, supporting research infrastructures at a zero-order level and an area of reflexive analyses on scientific research processes and outputs at the second-order level.

- The first-order level of research can be characterized as a problem-solving operation and is designed, on the one hand, for the exploration of the natural and social worlds as well as for the construction of a technological sphere and, on the other hand, for the axiomatization and orderings of the possible worlds of logic, mathematics and related normative fields. The first-order level of research constitutes the usual area for scientific activities. Investigations on empirical themes across nature and society, on technical or technological systems or on normative issues in logic, mathematics, statistics, ethics or aesthetics fall all under the category of first-order science. Approximately 90% of scientific activities are still undertaken at the first-order level. Finally, scientific research at the first-order level can be defined as first-order science.
- The zero-order level constitutes the kingdom of research infrastructures which perform vital catalytic functions of enabling, of accelerating or of improving first-order research. These different catalytic functions are accomplished in three different forms. The first type is based on large-scale observation, measurement and experimental facilities and their production of a rich data variety which contains relevant observations, measurements and experimental data for first-order research. The second form builds and utilizes a rich coded[3] information base which is composed of bibliometric, scientometric, genomic or other encoded elements. Finally, the third type operates with the documentation and the archiving of relevant research data and through the institutionalization of permanent data archives. All three forms combined constitute the zero-order level of science landscapes and the area of zero-order science which, moreover, should increase in relevance during the next decades.
- In contrast, the fields at the second-order level operate on building blocks from the first order domain like experimental results, tests, studies, evaluations, models, methods, theories and the like with scientific means. Research at the second-order level can be organized in a multiplicity of contexts, as will be demonstrated in the subsequent sections. Second-order studies, by exploring new topics and fields at the second-order level, offer important functions for first-order research which will be developed in the course of this article, too[4].

Figure 1 summarizes, once again, the three level-configuration for contemporary science landscapes.

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1 This article is dedicated to Alexander Riegler who in recent months was very helpful and supportive to promote the new perspective on second-order science (Riegler & Müller, 2014).

2 Though this article uses a vertical level description it must be emphasized that the differentiation into three science landscapes can also be conceptualized as well as visualized in horizontal domains as well.

3 Coded objects comprise publications, gray literature or citations in the science world, but can be extended to coded genetic information in bio-technology, etc.

4 It must be added that a very small area at the second-order level or domain is reserved for second-order data and information analyses from the zero-order level or domain like meta-data compilations or bibliographies of bibliographies, etc.

Figure 1 A New Architecture of Contemporary Science Landscapes with Three Principal Levels

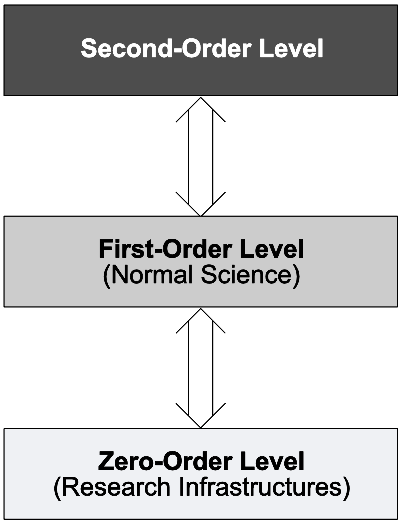
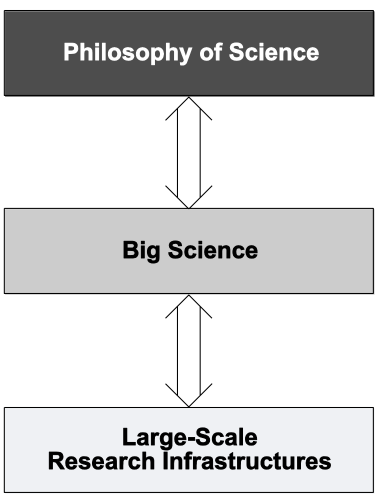


Figure 2 exhibits a stylized image of these three layers around the decades between 1940 and 1960 when trans-disciplinary approaches like systems science, cybernetics or artificial intelligence emerged.

Figure 2 Three Levels of Science-Landscapes around 1950/1960



Following Figure 2, little science entered a period of big science (de Solla Price, 1974) with high levels of production and publication levels. The dominant area at the second-order level was occupied by a small philosophy of science field and the research infrastructures at the zero-order level shifted from their small-scale into large-scale configurations. For example, CERN started its operations with a synchrocyclotron and a proton synchrotron during the 1950s, the nuclear research centre in Jülich was founded in 1956, etc.

At this point it becomes possible to introduce the notion of second-order science as the sum total of research activities that is carried out at the second-order level. Like zero- or first-order science, second-order science is, thus, bound to a specific level of science landscapes.

The next step leads to closer specifications of the second-order level and of second-order investigations. These studies at the second-order level are based on a single operation, which was originally invented by George Spencer Brown, namely on the operation of re-entries. This special operation comes into play whenever elements or building blocks from the first-order level 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)

One could add other examples by Heinz von Foerster like understanding understanding, communication of communication, goals of goals, control of control, etc. Usually, these self-referential twists are considered as a playful field or pastime for logicians, mathematicians or philosophers. But these self-applications of first-order science elements accomplish a logical closure, because these elements are not only applied in various external space-time settings, but also to themselves. Whenever such an element is applied to itself such as in understanding understanding, science writing of science writing or learning of learning, the logical realm of applications for these concepts becomes closed (Kauffman, 1987).

Aside from the closure of first-order building blocks like concepts, theories, models, methods, generative mechanisms or scientific fields, a series of arguments can be developed that these re-entries constitute also a vast new science frontier which has been weakly recognized and marginally explored so far. What was mostly ignored 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 at the second-order level.

- The first example of re-entries is focused on re-entries into normative first-order fields. 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, rule-systems of rule systems, laws of laws, etc. Usually, these re-entries into normative first-order building blocks generate new topics for second-order investigations and a normative second-order context which lead to normative approaches, frames and tools with higher generality, directed towards the foundations of normative sciences.
- A second example produces re-entries into a single, several or many first-order fields. 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 produces, 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 hybrid fields.
- The third example focuses on the output context of first-order science and leads to re-entries into 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 example is concentrated on the input context 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 or deeper generative mechanisms which are able to generate different types of generative mechanisms.

These four examples for re-entries should be considered as only a tiny fraction and as a very small set of actual re-entries in a vast number of possible re-entries. In general, re-entries can be used to generate new fields or, as a development for the near future, even new academic disciplines, new, challenging and hot topics for scientific research or more general second-order building blocks compared with their corresponding first-order counterparts.

At this point the question of the purpose and the overall goals of second-order investigations in particular and of second-order science in general must be raised. *Cui bono*? Why bother about second-order science at all? Basically, three core goals or functions can be specified for second-order science. All three goals and functions emerged when the overall science system entered the diversified stage of a three level architecture, accumulated a vast number of first-order studies and publications and was confronted with a growing need for innovation outlets, quality control and a demand for robust knowledge:

- A first goal or function for second-order studies can be specified in terms of innovative and challenging research problems. Through re-entries into first-order building blocks like concepts, theories, models, mechanisms an enormous amount of new, highly challenging and mostly unexplored research problems are generated. Thus, the first goal or function of second-order science lies in its high potential for innovations and inventions which must be fully utilized in the future.

But novelty and innovation *per se* remain a rather weak defense for second-order explorations. Briefly put, second-order studies are able to fulfill, aside from their high relevance as innovation engines, two vital functions for the sustainability of the science system as a whole.

- The second basic goal or function of second-order science lies in its capability of achieving results of higher degrees of robustness, compared to their first-order counterparts. Meta-analyses which in the new terminology become second-order analyses point to the possibility of disconfirming or confirming first-order results and of achieving, thus, higher levels of robustness (see, for example, Borenstein *et al*. 2009; Hunter & Schmidt 2004; Kulinskaya, Morgenthaler & Staudte 2009).
- The third basic goal or function lies in the integration of first-order elements. Like in the instances of theories of theories, models of models, generative mechanisms of generative mechanisms or methodologies of methodologies second-order investigations initiate a deep search to more general or fundamental forms of theories, models, generative mechanisms or methodologies.

All three goals and functions, namely higher levels of novelty and innovations, higher levels of robustness and, finally, wider integration as well as higher generality, become vital for the evolution of first-order science. As first-order science advances, second-order science provides with its three vital functions for first-order science the sustainability of the overall science system.

3 A SKETCH OF A GRAMMAR OF NOVELTY

Over the last years a general grammar of novelty (see, e.g., Müller, 2013a) was developed in close analogy to cognitive grammars which are organized as systems of linguistic elements or building blocks, schemes or templates and cognitive-linguistic production rules which distribute these linguistic elements to the available templates[5].

For a grammar of novelty building blocks are not restricted to linguistic elements alone, but can and must be extended to technological or machine components, geometric forms, musical notations, elementary dance movements, objects like flags which can be recombined and transformed into new ensembles. Schemes or templates for a grammar of novelty comprise instances like induction, analytics, i.e., the decomposition into few elements, black-box (input-output relations), analogy formation and the like.

Production rules for a grammar of novelty can be specified with a small set of recombination operators which are used in the different stages and levels of innovation processes. These recombination operators change an initial ensemble into an innovation or invention as the final outcome:

Initial → Configuration	[Transformation] → [Recombination] Operators]]	Innovative Outcome

These recombination operators, in combination with a small number of schemes or templates are capable of transforming available elements or building blocks from an initial configuration in elementary or composite ways into its innovative final stage.

Table 1 presents a list of 24 recombination operations which, however, should not be regarded as exhaustive or complete, but as a useful starting point for a specification of different recombination operations.

5 On these cognitive grammars, see especially Langacker, 2008 und 2009 und zur kognitiven Linguistik Croft & Cruse, 2004, Geeraerts, 2006 oder Geeraerts & Cuyckens, 2007.

In general, an innovative research process like the building of a new and general methodology or the construction of an integrative framework can be described as a very long sequence of recombination operations at different levels from the lowest micro-level of letters, words or sentences up to the highest macro-level of general themes which constitute the final organization of the present article.

Table 1 Primary, Elementary and Composite Recombination Operations

Primary Operations	Description of Operation
➢ PO_1	*Marking*, the differentiation of an empty space into an marked and into an unmarked space
➢ PO_2	*Unmarking*, the deletion of a marked space
Elementary Operations	**Description of Operation**
➢ EO_1	*Duplicating*, the copying or re-production of a given building block $[A \rightarrow AA]$
➢ EO_2	*Binding*, establishing a relation between two building blocks $[A, B \rightarrow AB_R]EO_2$
➢ EO_3	*Dissolving*, the elimination of a relation between two building blocks $[AB_R \rightarrow A,B]$
➢ EO_4	*Adding*, appending a new building block to a given one $[A \rightarrow AB]$
➢ EO_5	*Deleting*, the removal of a specific building block from a given unit $[AB \rightarrow A]$
➢ EO_6	*Including*, the inclusion of an autonomous building block into a new hierarchical ensemble $[A, B \rightarrow A[B]]$
➢ EO_7	*Separating*, the separation of a hierarchical ensemble into two autonomous units $[A[B] \rightarrow A,B]$
➢ EO_8	*Re-entry*, the application of a building block A onto itself $[A \rightarrow A(A)]$
➢ EO_9	*Horizontal Moving*, the horizontal movement from one building block to another one $[A \rightarrow B$ or $B \rightarrow A]$ or from a domain of building blocks D_i to another domain D_j
➢ EO_{10}	*Vertical Moving*, the vertical movement from a building block at $level_i$ to a building block at $levels_{(i+1)(i-1)}$ or from a level L_i to a level L_j
Composite Operations	**Description of Operation**
➢ CO_1	*Ordering*, re-arranging a group of building blocks to a new order: $[(CDEBA) \rightarrow (ABC\ DE)]$
➢ CO_2	*Randomizing*, the re-arrangement of a group of building blocks in a random order: $[(ABCDE) \rightarrow (DABEC)])$
➢ CO_3	*Integrating*, the blending of two or more building blocks into a single element $[A, B, \ldots \rightarrow C]$
➢ CO_4	*Breaking*, the separation of a single

Table 1 Primary, Elementary and Composite Recombination Operations (Continued)

Composite Operations	Description of Operation
	building block into two or more separate building blocks $[C \rightarrow D, E, \ldots]$
➢ CO_5	*Deepening*, the specification of a new ensemble (NM ….) at a lower level L_{j-k} which is able to account for the operations of given unit with elements (AB …) at level L_j: $[(NM\ldots \uparrow (AB\ ..C)]$
➢ CO_6	*Heightening*, the specification of a new ensemble (UV …) at a higher level L_{j-k} which is able to account for the operations of a given unit (AB…) at level L_j: $[(UV \ldots) \downarrow (AB \ldots)]$
➢ CO_7	*Widening*, the augmentation of a given ensemble or domain with building blocks from other domains or levels $(AB \rightarrow ABCFKR...)$
➢ CO_8	*Shortening*, the reduction of a given ensemble $(ABCD \ldots \rightarrow AB)$
➢ CO_9	*Selecting*, the selection of at least one building block from various ensembles: $[(ABCD)(EFGH)\ldots\ldots(WXYZ)] \rightarrow E$
➢ CO_{10}	*Inverting*, the opposite sequence of building blocks $(ABC \rightarrow CBA)$, of center (C)—periphery (P) positions, $C(A)\ \&\ P(B) \rightarrow C(B)\ \&\ P(A)$, etc.
➢ CO_{11}	*Swapping*, the exchange between at least two building blocks within two or more ensembles $[(AB\ldots)(CD\ldots) \rightarrow (AC\ldots)(BD\ldots)]$
➢ CO_{12}	*Crossing-Over*, the crossing of at least two ensembles and their merging into a new configuration $[(ABCD)(EFGH) \rightarrow (ABGH)(EFCD)]$

For the emergence of novelty or innovation the scheme or template of analogy formation plays a crucial role which puts heavy emphasis on analogical transfers or horizontal or vertical movements between different scientific domains (Coenen, 2002, Fauconnier & Turner, 2003, Hollingsworth & Müller, 2008, Johnson & Lakoff, 2011, Maasen & Weingart, 2000).

From a constructivist perspective this scheme of analogy formations AF is based on the following set of rules. [6]

The first step lies in the identification of a reference domain R which becomes conceptualized in a structural description DR^{ST} which is focused on a reduced set of relations and features which seem useful for the purpose of analogy building. The next step lies in a horizontal or vertical movement of the structural description to one or more target domains T for which the structural description becomes then DT^{ST}. The third step lies in the replacement of the elements form the reference domain and

[6] This article does not use the word metaphor, but analogy formation instead. The main reason for this procedure is due to the fact that metaphors are considered as a subset of analogy formation: „Not all analogies produce a metaphor, but each metaphor presupposes an analogy (translated by KHM).“ (Coennen, 2002:97)

their substitution with a suitable conceptual apparatus from the target domain T. An analogy formation turns out to be successful if the new descriptions DT^{ST} or DT provide new and surprising insights into the target area.

It should be added that the grammar of novelty is based on such an analogy formation, too, from a structural description D^{ST} in the reference domain R of cognitive linguistic grammars G_L $DR^{ST}(G_L)$ and its new form of a structural description of a grammar of novelty G_N in the target domain T of innovations, inventions and the like: $DT^{ST}(G_N)$. Thus the analogy formation, symbolized as ≈ with respect to a grammar of novelty can be summarized as:

$$AF: DR^{ST}(G_L) \approx DZ^{ST}(G_N)$$

In the next section I will use the list of recombination operations to develop a rule-system which can be characterized as a general methodology for second-order science.

4 AN OUTLINE OF A GENERAL METHODOLOGY FOR SECOND-ORDER SCIENCE

For a general methodology for second-order science a few general guidelines are needed which can be classified as crucial and necessary for the entire range of second-order studies. According to the list of recombination operations in Table 1 a variety of ways are available and open. While recombination operations like duplicating, inverting or swapping appear even at second glance not suitable for relevant methodological guidelines, other recombination operators like widening, heightening or integrating seem highly suited for this purpose.

3.1 First Step: Selecting a Common Theme

The initial move in a second-order analysis lies in the specification of a common or a target first-order theme which lies in the center of the subsequent explorations.. With the help of a selection operation a huge variety of possible themes can and must be reduced to a single issue or problem which forms the common basis for subsequent second-order investigations. In this article I will use two examples, one from an output analysis of social science researchers worldwide who produced articles on the basis of the data sets from the European Social Survey (ESS), and one from a theoretical concept in sociology, namely the notion of standards of living for which a large number of different specifications can be found in the sociology literature.
Basically, the common theme must fulfill two requirements, namely, on the one hand, a large number of first-order analyses and, on the other hand, a cognitive status of what Jürgen Habermas phrased, a *neue Unübersichtlichkeit*. Both requirements are fully met by the two themes. The number of ESS-analyses lies already around 3000 at the current time. And living standards have been introduced to social research since the 1930s at the latest, starting with Otto Neurath (1931, 1937) and followed by authors like Weisser (1957) or Amann (1983) in a large number of different ways.

3.2 Second Step: Re-entry Operation

The next step produces a re-entry in the common theme and its transformation to a second-order topic. Figure 3 presents the transformation from a first-order theme X to a second-order issue through a re-entry operator RE.

Figure 3 Operations with Re-Entries (RE)

Turning to the two examples, a re-entry-operation produces an ESS-based analysis of ESS-analyses as the common second-order theme for investigation. Likewise, second-order standards of living of first-order living standards become the new second-order issue for the subsequent analysis.

3.3 Third Step: Adding the Goals of Analysis

The next step requires an explicit formulation of goals of the participant researchers, regardless whether the underlying epistemology and research design follows an observer-inclusive or observer-exclusive trajectory. The goals of analysis have to specify the objectives which a second-order analysis has to reach.

In the case of the ESS-study on ESS-studies the main goals lies in the construction of three different profiles.

- The first goal lies in the creation of a comprehensive profile of ESS-utilizations. Here, an overview must be reached on highly used ESS-domains or variables and, conversely, on rarely used ESS-areas and variable groups or on the number of ESS-rounds which formed the basis for the ESS-analysis.
- The second goal can be summarized as the building up of a profile of ESS-users. With respect to the second target, a comprehensive summary must be reached on the regional affiliation of authors, their distribution across different disciplines or on their thematic preferences and on the hot topics for the scientific ESS-community.
- Finally, the third goal is aimed at the specification of a profile of ESS-publications. With respect to the third goal a general scheme must become available which shows the main types of ESS-publications or the languages of ESS-publications.

With respect to the second-order study on living standards the primary goal lies in the construction of a more comprehensive and integrative framework for living standards which is able to include the available diversity of approaches into single schemes.

3.4 Fourth Step: Widening with First-Order Building Blocks

The fourth step lies in building a sufficiently large set with first-order elements on the common second-order topic like articles, research reports, books, tests, correlations, models, theories or other first-order components. Within the fourth step the second-order theme has to be widened in order to establish a rich first-order basis of relevant building blocks for subsequent second-order explorations.

With respect to the second-order ESS-study, an intensive search was undertaken which looks for publications in journals, books, research reports, conference proceedings and the like which use the data bases of the ESS as their major source for empirical analysis. In this context Google Scholar provides a useful search instrument which offers usually a rather comprehensive overview of relevant publications. In the end, approximately 3000 articles were found which became the first-order base for further second-order investigations.

In the case of living standards one needs to assemble different specifications from, to mention only several relevant German and Austrian contributions in the 20th century in alphabetical order, Anton Amann (1983), Gertrud Backes (1997), Gerhard Bäcker *et. al.* (1980/2008), Stefan Hradil (1983, 1987, 1990), Ingeborg Nahnsen (1992), Otto Neurath (1931, 1937), Gerhard Weisser (1957, 1978) plus more recent versions which emphasize, for example, gender-specific aspects (see, e.g., Hammer & Lutz, 2002). These different specifications of systems of standards of living can be summarized in different ways, using the terminology of the respective authors. In terms of comparability, a useful way of creating a preliminary overview could be, for example, a focus on uniqueness which selects and specifies only those elements which can be found in a single specification scheme, but not in the other ones.

3.5 Fifth Step: Ordering First-Order Building Blocks

The next step is rather obvious because what is needed at this point is an ordering of the various building blocks according to a small set of order parameters. These order-parameters re-arrange the first-order building blocks and place them in comprehensive schemes or data-bases. The specification of these order-parameters is highly dependent on the second-order issue, the available first-order building blocks and the goals of analysis. The two examples used as instances for second-order analyses require significantly different order parameters and exhibit, thus, the context specificity of an appropriate choice of these order-parameters.

In the case of the second-order ESS-analysis the following order-parameters or criteria were chosen which provide basic information on the scope and the organization of a first-order analysis with ESS-data.

- Type of publication: The first order parameter distinguishes between various types of publication like a journal article, a book or a book chapter, a conference paper, a research report and the like.
- Relevant discipline(s) for journal publications: In case of journal publications the academic disciplines most relevant for a journal are to be documented.
- Language of publication
- Country affiliation of first listed author
- Number of authors
- Main ESS-domain(s): The ESS-survey is divided into several larger segments like politics, citizenship, government, immigration and nationality, inequality and the like which are documented for each publication.
- Specific Topics and ESS-variables: Each of the main ESS-domains is separated into a small number of indicators or variables and this order parameter determines the specific ESS-variables used in a publication.
- ESS-rounds used for the analysis: The ESS is organized in two year intervals and this criterion specifies whether an ESS-analysis focuses on a single round, on two or on more rounds or on all rounds so far.
- Keywords: Here the keywords listed in a publication are reproduced and each article is documented with keywords from the side of the second-order investigator.
- Methods of data analysis: This order parameter specifies the type of data analysis, ranging from basic statistics to more advanced methods like cluster or factor analysis up to multi-level modeling.
- Intensity of data usage: This order parameter differentiates between varying degrees of dependence on ESS-data, ranging from an exclusive reliance of ESS-data to only a marginal usage of ESS-data, compared to other data sources.
- Other European data sources: Finally, the last criterion refers to other European data source like the International Social Science Program (ISSP), the European Value Survey (EVS) or the World Value Survey (WVS) and specifies the inclusion of these other data sets in a given publication.

With these parameters the available first-order ESS-articles can be re-arranged in a large data base which is to become the focus for subsequent steps.

Turning to the second-order study of living standards the order parameters can be specified in the following way. Here, the criteria used require a conceptual and content analysis and a mostly qualitative coding routine, compared to the largely quantitative encodings in the case of ESS-studies.

- Goals of the different approaches to standards of living: An overview of a single or multiple goals for the construction of the various systems of standards of living
- Theoretical background assumptions
- Relevant domains for standards of living: Listing all relevant major domains for living conditions in each of the schemes for living standards
- Indicators for each domain
- Available data bases
- Methods of analysis
- Main results of empirical analyses: A summary of empirical results on empirical distributions or more theoretical relations and functions between single indicators or entire fields.

As can be seen from these two examples of second-order analysis they are specified in very different ways, even though they share the same academic discipline and even the same sub-discipline, namely empirical social research.

3.6 Sixth Step: Integrating, Deepening, Heightening, etc.

The sixth step in the general methodology of second-order science stresses the need to find new solutions which are capable of entailing all major building blocks from the set of first-order contributions. The sixth step is, once again, very much dependent on the goals, on the type of first-order building blocks and on the available basis as a result of the ordering operation. Four examples should help to clarify this point.

- With respect to a theoretical concept the sixth step performs a conceptual analysis in which the various first-order building blocks become integrated or included.
- In terms of generative mechanisms or models one needs to specify more general or basic mechanisms or models which are able to account and to tame the complexity of the available first-order approaches.
- For areas like tests, results of statistical analyses or data bases like in the case of the second-order ESS-analysis mainly advanced statistical analyses are needed for which a large quantity of methods and procedures are already available under the umbrella term of meta-analyses.
- Finally, a scientific field or an academic discipline requires mainly conceptual work in order to present an outline of a cybernetics of cybernetics (Mead, 1968), a logic of logic or a management science of management science. In this case, the sixth step produces a sketch for the main organization and tasks of a new second-order field, a discipline or a hybrid compound of disciplines.

In terms of recombination operators these different tasks can be achieved either by deepening and heightening, i.e., by a deeper or higher level of analysis, via integrating, i.e., by an integrative step which recombines the available variety into a new form of cognitive organization, by including, i.e., by the inclusion of one or several first-order building blocks in a

With respect to the second-order ESS-analysis the major work lies in an in-depth analysis of the rich data base and in statistical analyses of this data base. Here, the three different empirical profiles for ESS-utilization, for users and for publications must be generated according to the three primary goals of analysis.
The case of the second-order analysis of living standards must develop one or more integrative schemes which are able to account for the diversity of first order specifications. Here, an interesting way of integration lies in the specification of a robust and general new terminology with evolutionary stable concepts which can be used for practically all forms of human societies, past, present and, most probably, future.[7] In a recent publication an evolutionary stable terminology was created in terms of a RSO-scheme with three major components for an integrative system of standards of living, namely resources R, settings S and cognitive-emotional organization O (Müller, 2013b).

3.7 Seventh Step: Transfers and Effects for First-Order Science

The next step adds an important element especially for the relations between second- and first-order science. In this part of analysis the transfer elements of second-order investigations and their effects and impact on first-order research are to be discussed in greater detail. In general, a large number of outputs of second-order studies can be used by the respective fields of first-order science for new explorations. In the simplest instances, second-order studies question the effects of medical drugs, based on a large number of first-order clinical studies or the validity and reliability of psychological tests, again on the basis of a large quantity of first-order test procedures. In more sophisticated cases like the example of the ESS-study a second-order investigation produces new empirical insights which can be used by a variety of researchers across different fields, as will be shown immediately. More complex second-order outcomes in theory or model formations lead to further first-order explorations in new areas of applications or to new rounds of tests.
Turning to the example of a second-order analysis of ESS-articles one can point out to a large number of effects not only for future ESS-data collection processes and for ESS-based research, but for different groups outside the domain of social comparative research as well.

- First, the ESS-coordinating team receives a new and highly valuable utilization profile of ESS-data sets which becomes relevant for subsequent rounds of ESS-surveys.
- Second, social researchers become familiar with the main thematic interests of their community. Moreover, the weakly analyzed parts of ESS-data offer the possibility to initiate new ESS-analyses. Furthermore, the range of available themes can be used for recombinations and for the creation of new ESS-topics which then become the focus of analysis.
- Third, experts in the field of methods for social research get an overview of blind spots in terms of available methods of analysis. For example, a marginal number of articles can be found which use the entire spectrum of all available ESS-data from the six rounds so far. This provides a strong incentive to develop new dynamic tools of analysis which are specially constructed for a complete utilization of the ESS-data base across all rounds.
- Fourth, specialists in the sociology of science gain empirical data on the regional distribution of social research and on the thematic preferences of social researchers across time.
- Fifth, as the ESS-data production continues in its two years intervals sociologists of knowledge will be able to work with a rich data-base on shifts in thematic interests of European social researchers and relate these shifts to societal challenges and changes, economic and financial crises or political debates in the public domain.
- Sixth, researchers in the area of embedded cognition are offered a diversified and growing data source on the interpretation of data by ESS-researchers and can use these findings for laboratory studies of interactions between survey interviewers and respondents.

Due to the variety of transfers within and outside the domain of social research the example with a second-order ESS-analysis becomes a fascinating instance that second-order analysis in a seemingly narrow domain can generate results for a much wider number of first-order fields.

The final products of a second-order investigation on living standards offer more integrative frameworks for future research on living standards which can be used for new exploratory studies with new questionnaires, additional methods and

[7] On the requirements for evolutionary stable concepts, see Haag & Müller, 1992.

expanded data bases. Additionally, the new integrative second-order frameworks with their evolutionary conceptualizations can be analyzed in terms of relations, correlations and explanatory relevance. Moreover, these new integrative frameworks for standards of living enable a clearer view on existing data gaps or thematic blind spots. Finally, the new second-order frameworks can be used to re-arrange different systems of living standards across time and allow, thus, a dynamic comparative analysis.

3.8 Eighth Step: Second-Order Science ↔ Society/Environment-Relations and Dynamics

The last step in the general methodology does not belong to the core group of necessary steps, but can be added as an option. This additional step requires at least a small analysis of a particular second-order study and its outcomes on the one hand and the potential effects and consequences of this specific piece of research on the wider environment across science and society in general. Such a step might be superfluous in many instances, but could be useful especially in the case of a long-term analysis or in instances with a high political or great societal relevance.

For the two social science examples no such impact-study need to be produced because these investigations are primarily directed to relatively small segments of research groups, so the repercussions for the wider societal environments will turn out as marginal or negligible.

Nevertheless, these eight steps comprise, in essence, the basic specifications for a fully developed general second-order methodology across all scientific areas from logic and mathematics to the natural or to the social sciences.

5 A SKETCH TOWARDS A GENERAL METHODOLOGY OF SECOND-ORDER SCIENCE

The journey to the land of second-order science and its general methodology is almost finished. Recapitulating the steps in the previous analysis and generalizing them one arrives at a general methodology for second-order science studies which includes the subsequent steps for any particular building block X from first-order science like a concept, relation, theory, model, test, generative mechanism, scientific field, etc. which are summarized in Table 2.

On the left side of Table 2 one finds the necessary or optional steps for a general methodology of second-order science in terms of basic recombination operators, the second column presents a short description of these specific recombination operations.

Table 2 Core Steps for a General Methodology of Second-Order Science

Recombination Requirements Operations	Description of Specification
Selecting X	Consensus on a common first-order theme X
Re-entry X	A re-entry operation in the first-order theme and the creation of a corresponding second-order topic
Adding Goals[X] observer(s)	Consensus on the goals of the
Widening X[First-Order Building Blocks]	The compilation of a large number of first-order building blocks on the common theme
Ordering X[First-Order Building Blocks]	Applying various methods for a re-arrangement of first-order building blocks like data-bases, new conceptual schemes, etc.
X(X): {Integrating, Deepening, etc. [First-Order Building Blocks]}	The core part of second-order analysis which, in dependence from the goal set, integrates, heightens, deepens first-order building blocks and which produces a final output.
Adding [Impact X(X) → X[First-Order Science]	Generating building blocks for first-order science and assessing the effects of the final second-order outcomes for first-order research on the common theme X.
Adding [X(X) ↔-Society/ Environment-Relations & Dynamics (optional)]	An evaluation of the relations between the outputs of second-order research on X(X) or of X and the wider environment across science and society and their dynamic patterns

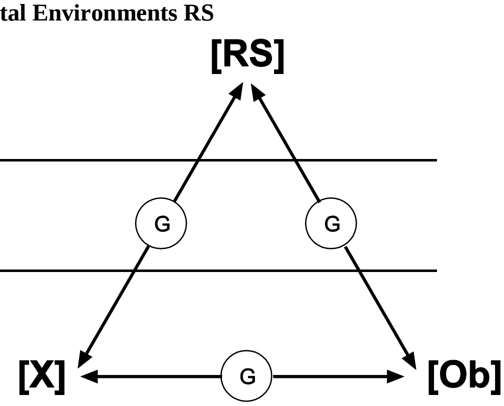
The first seven steps can be classified as necessary whereas the eighth step is considered as optional because this particular step does not change the content of X(X) but focuses at the wider relations and effects of X(X) for science and society.

These eight steps can be viewed as a sketch of a general methodology for second-order science which must be supplemented with a very broad range of special methodologies for specific disciplines as well as second-order methods for different purposes and goals.

6 THREE TYPES OF REFLEXIVITY IN SCIENCE

Finally, the new architecture of second-order science and its general methodology lead to a new configuration of reflexivity in science which distinguishes between different types of reflexivity.

Figure 4 A Triadic Configuration between an Observer Ob, a Domain of Investigation X and the wider Research and Societal Environments RS



The starting point lies in a triadic configuration between an observer Ob, her or his domain of investigation X and, finally, her or his wider research and societal environments RS where these three components Ob, X and RS generate each other (see also Figure 1.2)

In such an ensemble, reflexivity can be accomplished in three separate and strictly independent ways with respect to each of the three elements Ob, X and RS.

- Reflexivity with respect to the domain of investigation (scientific reflexivity): The first type becomes reflexive through a re-entry operation X(X) in the domain of investigation X where re-entry operations are produced with building blocks from first-order science.
- Reflexivity with respect to the observer (self-reflexivity): The second-type of reflexivity is focused on the observer Ob and includes an observer in her or his research designs and her or his scientific operations. Due to the focus on observers one can also classify the second type as self-reflexivity. The differences between observer-exclusive and observer-inclusive is beautifully summarized by the following quote from Eric Kendel who describes an observer-exclusive procedure in the following manner:

  > 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)

  Observer-inclusive or self-reflexive designs and procedures can be characterized by an inversion of Eric Kendel's quote above in the following way.

  > 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.

- Reflexivity with respect to the wider scientific and societal environment (environmental reflexivity): The third type is not based on a special re-entry operation, but simply completes the three possible sources of reflexivity. The third type focuses on the relations between elements of first- or second-order science and the wider environment RS, both within science and across science.

Aside from these three basic types of reflexivity an important point lies in the possibility of combining these three types to more complex configurations and research designs. In principle, two additional roads are open, aside from the low road of a single type. The terms of a low, middle and a high road are not used as a quality predicate, but stand for different complexity levels of research designs and research processes.

- The middle road to reflexivity: Here, two of the three reflexivity types become recombined, either by re-entering in first-order building blocks and by a re-entry in observer operations, by re-entering in first-order building blocks and adding the wider research and society relations or, finally, by a re-entry in the observer operations and by adding the observer – environment relations. All three instances are characterized by more complex research designs and production processes, compared to the three single types.
- The high road to reflexivity: In this instance a re-combination of all three reflexivity types is undertaken by a self-reflexive or observer-inclusive second-order analysis which also adds a non-trivial investigation of the eighth step in the general methodology on the relations between X(X) and the wider research and society environment RS. This recombination becomes the most demanding and most complex one and usually requires time and resources which are currently unavailable in conventional research processes.

The differentiation into three independent forms of reflexivity and their potential recombinations should become useful as a guideline for organizing higher forms of reflexivity in scientific research processes.

7 CONCLUSIONS

With the three types of reflexivity this article comes to a logical end. It might be interesting to note that this article itself, apart from this paragraph, does not contain any major reflexive elements at all because it did not deal with the typical second-order configuration of X(X), the I of the observer was mostly excluded and no environmental relations between X(X) and research and society were discussed. Thus, this article itself must be qualified as a proto-analysis, as a pre-study and as a sketch towards a general methodology of second-order science which became also the title of the paper.

Condensating its entire content into a single drop of aphorism one can summarize second-order science and its general methodology in the following way.

- First-order science: The science of exploring the world
- Second-order science: The science of reflecting on these explorations

In the long run one will most probably see the co-evolution between first-order and second-order science where first-order science continues to explore nature and society and where second-order science provides the necessary components of innovation outlets, quality control and the drifts towards more generality, integration or depth.

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