Selection and Variation: Criticism and a First Selectionist Metamodel for the Growth of Knowledge in Management Science

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The President:

Prof. Ernst Mohr, PhD
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The creation of this dissertation parallels its own topic: a continuous process of trial and error. The ability to run trials requires freedom of thought, the will to question any supposed acquired knowledge, the confidence to propose novel ideas, and the recognition of change and diversity. Additionally, error elimination requires rigorous thinking and severe criticism. In this section, I want to mention just the most direct influences for the growth of knowledge summarized in this trial called a “dissertation”.

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I dedicate this work to my parents and to my sister.
# TABLE OF CONTENTS

## ABSTRACT

## 1. INTRODUCTION

## 2. REFLECTION ON THE CURRENT FOUNDATIONS OF MANAGEMENT

### 2.1. Current Practices

#### 2.1.1. Methods as Starting Point

#### 2.1.2. Epistemological Issues

### 2.2. The Problem with the Current Foundations of Management Science

#### 2.2.1. The Intrinsic Problem Attached to the Method

#### 2.2.2. Costs Attached to the Paradigm

### 2.3. The Challenge to Uniformity: Evolutionary Thought

## 3. EVOLUTIONARY KNOWLEDGE

### 3.1. Evolution Revisited

#### 3.1.1. Variation and Selection

#### 3.1.2. From Instruction to Selection

#### 3.1.3. Selection: The Driver of Change

### 3.2. Evolutionary Knowledge

#### 3.2.1. Growth of Knowledge Through Nested Inter-Playing Selective-Retention Processes

#### 3.2.2. Scientific Knowledge

### 3.3. Critical Rationalism (Non-Justificationism)

#### 3.3.1. Instruction: A Jail for Epistemology

#### 3.3.2. A Search for Balance: Critical Rationalism

#### 3.3.3. Selection via Criticism

#### 3.3.4. The Basis for a Selectionist Epistemology
4. EVOLUTIONARY WORLD ............................................................... 117
   4.1. Knowledge and a Real World ................................................ 118
       4.1.1. Presentationalism and Representationalism .......... 119
       4.1.2. A Narrow Science ................................................. 124
   4.2. Ontological Commitments ..................................................... 127
       4.2.1. From Things to Processes ..................................... 128
       4.2.2. Evolutionary Ontology ............................................ 140
   4.3. Evolutionary Thought Meets the World ................................. 147

5. VARIATION ..................................................................................... 151
   5.1. A Trial ................................................................................ 152
   5.2. The Metamodel .................................................................... 158
   5.3. Remarks ............................................................................. 183

6. OUTLOOK ........................................................................................ 193

REFERENCES ...................................................................................... 198
ABSTRACT

This dissertation starts from a central diagnosis: the distressing state of unreliability of management science regarding its standard methods as proper channels for the growth of knowledge of the discipline. The dissertation emphasizes that in spite of the current proposed analyses and discussions about the apparent diversity of main approaches and methods, most of management science is rooted in one single—and seemingly invisible—paradigm, holding assumptions borrowed from other fields and anchored in the current standard view of science that was established in the 20th Century. This paradigm can be labeled as a restricted and narrow empiricism, which comes from an unnoticed idealism and an incorrigible anthropocentrism. The dissertation develops this assessment and, furthermore, indicates that idealism is inherently inadequate for conducting research because it entails a uniform world. Consequently, this study proposes a different foundation articulating diverse traditions that converge in a coherent methodological framework for doing sound research in the domain of management science, which is characterized by change and diversity. The alternative is based on evolutionary thought, with special emphasis on the evolving character of knowledge, which is also consistent with factual biology. Apart from this distinctive criticism of the methods of management science, which is hardly found in current scholarly and academic literature, the main result is the development of a selectionist metamodel, i.e., a consistent template for developing explanations and generating theories. This dissertation is actually the introduction to a broad research agenda for management science.
Esta disertación tiene como punto de partida un diagnóstico central: la poca confiabilidad de la ciencia organizacional en cuanto a sus métodos como canales apropiados para promover el crecimiento del conocimiento en la disciplina. La disertación enfatiza que a pesar de las discusiones y análisis actuales sobre la aparente diversidad de enfoques y métodos, la mayoría de la ciencia organizacional parte de un solo—y aparentemente invisible—paradigma el cual se basa en supuestos tomados de otros campos y en la concepción estándar de ciencia que fue establecida en el siglo 20. Este paradigma se puede identificar como un empirismo reducido y rígido el cual proviene de un idealismo y de un antropocentrismo que no se cuestionan. La disertación desarrolla esta valoración e indica que el idealismo es inadecuado para adelantar investigación debido a que supone un mundo uniforme. En consecuencia, este estudio propone unas bases diferentes por medio de la articulación de diversas tradiciones que convergen en un marco metodológico coherente para desarrollar investigación firme en el dominio de la ciencia organizacional el cual se caracteriza por el cambio y la diversidad. Esta alternativa se basa en el pensamiento evolutivo y con un especial énfasis en el carácter evolutivo del conocimiento lo que además resulta ser consistente con la biología. Aparte de esta crítica a los métodos de la ciencia organizacional, la cual es difícil de encontrar en la literatura académica, el resultado principal es el desarrollo de un metamodelo seleccionista, i.e., un esquema coherente para desarrollar explicaciones y generar teorías. Esta disertación es realmente la introducción de una amplia agenda de investigación para la ciencia organizacional.
1. INTRODUCTION

Motivation

There is a particular paradox entailed by the legacy of David Hume, perhaps both the most influential and the most ignored philosopher in the history of science. On the one hand, his empiricism was the chief philosophical inspiration of the logical positivists, who in turn gave shape to science as we know it today—that is, the belief that our experience determines the sources, validation, scope, justification, and confirmation of knowledge. On the other hand, his very destruction of empiricism with his formulation of the problem of induction, and his criticism of causation, have been widely ignored by scientists. Thus, the method used in science has seldom been revised: we still want to believe that we can learn by observation—that is, we hold that we are instructed by our environment. This epistemology, the epistemology of Hume, was embraced by Kant, and hence was somehow "legitimated", and then propelled in the realm of physics by Mach, and afterwards diffused by the logical positivists, from Carnap and Ayer to Reichenbach and Wittgenstein. It happens to be the epistemology defended by Jean-Baptiste Lamarck as well. It is the view of science that favors the observer who is supposed to learn using his sensorial apparatus as an authoritative source, regardless of our recognition of the limitations of such a device. Our current standard textbooks on the philosophy of science and epistemology have as a starting point the question of the justification of knowledge, any discussion regarding methodologies is just a quest to acquire supposedly better ways of observing, measuring, validating, and confirming: essentially, better ways to justify knowledge. In general, almost any learning process that we deal with, both at the individual and at the collective level (e.g., science, organizations, etc.), is conceived of as a process that involves some transference of knowledge from the environment to the organism.
What about the alternative view, which does not depend on observation to validate knowledge? This other view, in which the source and the justification of knowledge do not constitute a relevant epistemological question, has been widely overlooked by scientists and philosophers of science in general. However, this is the epistemology of the most influential scientists of our time, such as Newton, Darwin, Planck, and Einstein. This epistemology has also been delineated by evolutionary epistemologists, mainly Karl Popper and Donald Campbell. It happens to be the same epistemology present in the system proposed by Darwin: “learning” by selection. This epistemology is sharply opposed to the standard view mentioned above, and it has a particular characteristic: it is consistent with what we know about man as a product of a biological evolutionary process.

The driving force of Hume (1740) was epistemology. His Treatise of Human Nature starts from the assumption that science and the questions of knowledge and knowing should include what we know about the nature of man (hence the title of this influential book). However, our current view of the growth of knowledge by selection instead of instruction is rather new. It is only now that we are finally recognizing that human beings, and seemingly every process that involves the growth of knowledge, may better proceed if one follows a selectionist logic. The criticism of the narrow and standard view, which not only contradicts biology but which also happens to be very restrictive, is the driving theme of this dissertation.

We are observers, and it is through observation that we have developed our theories, both as individuals and as a society. How do we develop these theories? We develop them with further assumptions that perhaps we do not acknowledge: regularities and uniformity. Hence, as individuals, after some successful observations, we proceed with our inner “machine” of confirmations with which we favor the evidence that confirms our previous observations; we tend to ignore, many times unconsciously, the evidence that
contradicts our theories. So, in this way, we have a theory. This theory is, inescapably, a causal theory. We think that there are some causes behind the changes that we observe; preceding events become candidates for causes, and events that follow become candidates for effects. Moreover, this cause-effect relation is timeless. We believe that if conditions are similar, then these events will happen again. This process of generalization in space and time based on observation, i.e., induction, is exactly the same method suggested (and mostly followed) by current science. Although Hume already showed that this is a naive and untenable position for generating knowledge, we have nevertheless developed a science anchored in these assumptions: learning by observation, induction, generalization, causality, confirmation, validation, and justification. Indeed, we have several methods of making these observations. We have devised sophisticated qualitative schemas for observing particular cases, and we have also devised sophisticated tools, so-called quantitative methods, for observing larger samples of cases.


The level of inquiry: Science of Management

The reciprocal relationship of epistemology and science is of noteworthy kind. They are dependent upon each other. Epistemology without contact with science becomes an empty scheme. Science without epistemology is — insofar as it is thinkable at all — primitive and muddled. However, no sooner has the epistemologist, who is seeking a clear system, fought his way through to such a system, than he is inclined to interpret the thought-content of science in the sense of his system and to reject whatever does not fit into his system.

Albert Einstein
Cited by Holton (1969)
The quote above originally appeared in the book properly entitled "Albert Einstein Philosopher-Scientist," a compilation that is part of the famous Schilpp series "Library of Living Philosophers". The brilliance of Einstein as a scientist is only equaled by his lucidity and explicitness as a philosopher. These characteristics are also shared by the other two main influential scientists of modern times: Newton and Darwin. And although these three great minds differed with regard to ontological issues, they shared the epistemological basis upon which their theories were proposed. Such an epistemology, which can be labeled as *realism*, has been neglected and abandoned by the science of the 20th century. It has to be said that epistemological reflection in current science is simply nonexistent or, at best, very limited. However, for many scientists, especially in the social sciences, there is a supposed element of philosophical reflection. The neglect of epistemology, in many cases unconsciously, since for numerous researchers there is no such neglect, has engendered a naive and inadequate type of science that dominates almost every scientific practice, a type of science that assumes empiricism as the essential process for generating theories and for validating and justifying knowledge. This is the foundation that was rejected by Newton, Einstein and Darwin.

This introduction presents the background, motivation, and level of inquiry of this dissertation. The framework suggested by John van Gigch (2003) emphasizes the importance of epistemology for a scientific discipline and the need to include it in every attempt to create any artifact produced by human intervention. The output of this type of inquiry feeds the way in which science and academic research are understood, a kind of reflection that, surprisingly enough, is missing in current management research. This dissertation builds on the framework of van Gigch, which will be introduced next.

The relationship between epistemology and science is critical. Perhaps the growth of knowledge can be studied best if one examines the growth of
scientific knowledge, as Popper (1968) suggests;\(^1\) van Gigch (2003), in his work about epistemology and the foundations of knowledge in scientific disciplines, identifies the “neglect of epistemology” as the lack of concern by scientists for epistemological issues. He criticizes such an attitude, especially in management science, which he labels merely as “normal science”. In the traditional Kuhnian sense, this expression refers to the processes of puzzle-solving—for any particular paradigm, explaining it and expanding it (Kuhn, 1962), i.e., producing and attaining more accurate estimates of existing knowledge. In his own words:

> Unless a science searches for new inspiration in its epistemological foundations, it will wither or remain, at best, a technical specialty, comprised of a series of tools and methods, which does not renew itself… Most, if not all, management scientists are engaged in producing Normal Science. They proceed to solve problems, produce theories, conduct investigations and, in general, carry out investigations within the norms of the established paradigm. In the last few years, several signs seem to indicate that the discipline is not as innovative as it once was. If real, this apparent decline bodes ill for the future of the discipline. (van Gigch 2003, pp. 224-225)

This situation is evident in the literature and in the reasoning of mainstream management research, as this dissertation will demonstrate. Despite clear symptoms of inadequate assumptions in research practice that lead to poor “solutions”, and also regardless of fundamental problems concerning the sources of knowledge for management science, it is hard to find scholars or academic work dealing directly with the problem that van Gigch states.

\(^1\) Although this aim was initially his central concern, he later widened this view to link epistemology with evolution processes in general, e.g., Popper (1974b) emphasized: “the main task of the theory of knowledge is to understand it as continuous with animal knowledge and to understand also its discontinuity—if any—from animal knowledge “ (p. 1061).
The framework proposed by van Gigch helps to situate the type of inquiry that this dissertation develops for the management discipline. In order to cope with general human intervention, van Gigch (2003) suggests various systems of inquiry “devoted to the creation, acquisition, production and dissemination of knowledge” (p. 3). These systems are located at different levels of logic, all of them necessary for shaping how problems are formulated, how decisions are made, and how actions are implemented. Concerning scientific disciplines, three levels of logic are of particular interest here—see Figure 1.

**Figure 1**

Three levels of logic of the management discipline, as suggested by van Gigch (2003)
Level 1 is concerned with the immediate “real world”; typical problems here include time schedules, cost targets, budget constraints and similar demands. This is the task of applied science and daily management. This first level is fed by a second one, which is concerned with what Kuhn labeled as “normal science”: the act of solving everyday problems of science without questioning the paradigm that serves as the basis for such activities; typical outputs of this level are models, theories, and solutions to scientific problems; these types of tasks seem to cover most of current scholars’ activities in mainstream management research, including "major" works and doctoral theses. The third level is concerned with meta-modeling and epistemology; it corresponds to the type of activities neglected today. The tasks at this level are to identify the sources of knowledge and to guarantee the adequacy of the methods of reasoning and methodologies used in the lower levels; in the words of van Gigch, this has to do with establishing the epistemology of a system.

This dissertation is placed at level 3 of logic; its main goal is to feed the lower level of normal science by questioning its sources and the type of knowledge that it represents; this dissertation also provides a meta-design based on epistemological foundations, which is why it can be identified as a meta-inquiry: “An investigation (at the metalevel) about the system’s organization” (van Gigch 2003, p. 5) in which the “system” is at level 2: Normal science in management. Consequently, Van Gigch makes a distinction; on the one hand, the task of Management Science is to solve everyday scientific problems of normal science; on the other hand, the task of the Science of Management (a meta-science) is to deal with the epistemological issues of the management discipline, e.g., reflection upon its own reasoning methods and sources of knowledge. This dissertation addresses first and foremost these latter kinds of meta-issues placed at Level 3 of Figure 1. In other words, this dissertation can be stated as having a meta-design that aims to dissolve conflicts at the lower level of normal management science by re-conceptualizing them at the meta-level, “where diametrically opposed polarities are, absorbed, dissolved, and/or
constrained” (van Gigch 2003, p. 234). It is a dissertation that contributes to the *Science of Management*.

The next section introduces the issue to face, i.e., the presence of an unnoticed, single, and inappropriate paradigm in mainstream management research; these ideas are developed in detail through the second chapter of the dissertation.

**The research problem: Management research as mere and flawed normal science**

The whole enterprise of management research is uncertain. This declaration may sound astounding considering the popularity of the subject. However, such an evaluation is clearly reasonable in some sectors of academia (although not necessarily for the right reasons). For instance, Zald (1993) makes an overall analysis that can be summarized here:

> Organizational studies could be a powerful applied discipline if the scientific base of the field was strong. Since it is not, organizational studies follow the ratings, responding not only to academic fads, but to the whims and foibles of academic hucksters and the problem definition of corporate executives. (p. 514)

Although this statement was made some time ago, it is still relevant. The quotation is symptomatic and illustrates one of the present concerns in a field that has apparently fallen into a “fragmentation” trap described by Knudsen (2003) and Zald (1996). McKelvey (1997) also denounces the post-positivist situation of “unbounded multiparadigmaticism” because, according to him, the “current organization science method does not foster easy refutation of false paradigms, due to subjectivist epistemology and lack of testability…[based on] a truly archaic eighteenth century view of science, a worst case scenario really, in that it is a linear deterministic Newtonian mechanics epistemology *without*
the power of mathematics” (pp. 353, 357, emphasis original)². Public administration faces a similar panorama; Hill and Lynn (2004) reviewed public management research published in more than 70 academic journals from 1990 to 2001 in order to evaluate whether and how findings cohere across diverse sources. They identified more than 800 studies that specify relationships between at least two levels in the logic of governance. The conclusion of the survey sounds astonishing: “Our review indicates that although the empirical literature on governance reports extensive positive findings, most of these findings are contingent: Few if any generic management principles are directly confirmed” (p. 8)³. In general, scholars argue for deep-rooted change in organization and management studies. For example, Zald (1993) urges a re-examination of fundamental assumptions, McKelvey (1997) proposes a “quasi-natural” science looking in the direction of complexity theory, and Wicks and Freeman (1998) declare the need for a deep and fundamental reshaping of

² The concern is legitimate given the state of disarray in the field. But this dissertation will show that the quoted argument is mistaken. Several issues can be criticized in such a typical assessment, for instance, the expression "Newtonian mechanics" should denote ontology and not epistemology, but the quoted author indicates the opposite; indeed this dissertation will show that Newtonian epistemology, i.e., realism, has been neglected by science. The quoted author is right when he affirms that the dominant epistemology is subjectivist. But this subjectivism also includes so-called "quantitative methods". Nevertheless, the customary identification of qualitative methods with "subjectivism" and quantitative methods with "objectivism" is one of the most pervasive, widespread, and unfortunate assessments found anywhere in literature. This dissertation will also show also that the mentioned "power of mathematics" is usually confined to a narrow conception that equates it with statistics. This state of affairs, where simplistic analyses, naive dichotomies, and the inversion of terms are the rule and not the exception, is described and rejected in this dissertation.

³ A related issue is the extensive poor quality and the minimal contribution of doctoral research to public administration, which in turn is linked to the general problem of knowledge and theory development in the field (White, Adams, & Forrester, 1996). In particular, Adams and White (1994) identify in doctoral research what they call a widespread "mindless empiricism"; with this expression, they denote the elevation of technique over all other considerations. Such a fascination with technique refers to the customary acquisition of some data, either quantitative or qualitative, and the corresponding analysis following the prescribed canon of the methodology but without any relevance to any theory, or even to practice.
organizational studies suggesting a new pragmatic approach. Lynn (2003) also claims new foundations for public administration research.

Naturally, there are different answers to the problem depicted above. The first natural answer is to defend current methods in order to look for integration and common lines; this option is pictured by Callahan (2001), who calls for shared research agendas in a fragmented academic community—see also (Rainey, 1994). The opposite typical answer relates to the endless debate that has been traditionally conceived of as quantitative vs. qualitative methods, or positivism vs. case studies; this is an over-simplification that will be criticized and rejected in this dissertation—see an example of this typical position in the work of Riccucci (2001). However, this dissertation proposes a different appraisal. A central point to develop is that most management research is established based on the very same paradigm, one that is rooted in the philosophy of physics, essentially idealism (presentationalism) and justificationism. Furthermore, this dissertation asserts that these assumptions are not acknowledged by most researchers; the epistemological situation of the field is seen as being shaped by different colliding paradigms engaged in a struggle. The discussions vary only in their theories around the kind of struggle at play, which some scholars perceive as a diverse field of different and valid ways to approach to social issues, while other researchers see it as the conflict of one “better” paradigm trying to overcome its “minor” rivals in a typical Kuhnian universe. This dissertation makes a different judgment. It asserts that, first, most management studies are grounded in the same shared assumptions; second, that these assumptions are a flawed basis for conducting scientific research; third, that this grounding is not noticed by researchers; and fourth, that these assumptions are even more challenged, i.e., more contradicted, in the realm of social science. Some of these statements taken separately are not entirely new, but if one articulates them along with existing traditions that converge around various topics, mainly around evolutionary thought, it is possible to establish adequate methodological bases for conducting research.
Research questions and approach

The motivating question follows the concern of van Gigch (2003): “How should the epistemology of a scientific discipline be formulated in order to design and implement artefacts which are devoid of the detrimental features and dysfunctional consequences that often trouble present-day systems?” (p. 2). In the context of the situation introduced in the preceding paragraphs, the central research question can be stated this way:

What kind of epistemological basis for management research can be suggested if one wishes to deal successfully and consistently with current methodological challenges?

Given that most of current answers seem to be inadequate, at least in the field of management as it was outlined above, this dissertation aims to develop a proper path, a path that articulates a variety of traditions based on evolutionary thought.

How should knowledge be approached? This is the very question that this dissertation addresses. It is reasonable to expect that a work grounded on evolutionary epistemology should be consistent with its discourse—essentially, the means of reasoning and the approach constituted by such epistemology must define the method followed in this study. This discussion is not trivial. In short, following the path of inquiry of this dissertation, the answer (or better, the attitude) proposed is based on Critical Rationalism (CR), the philosophical tradition that underpins the proposal of this dissertation at the logic of the research level, i.e., evolutionary epistemology. That is, such a line of inquiry has two functions here: to fuel the contents of the logic of research for the benefit of the methodological framework that is proposed through this dissertation and, at a second self-referential level, to provide the lines of reasoning that will facilitate the development of that framework, i.e., the
methodology of this dissertation. Given the emphasis and dominance of justificationism in the methodologies and philosophy of science (indeed, a "methodology" section in any paper is a requirement for the justification of knowledge), the use of CR—which is opposed to such logic—demands a full exposition that will form an important part of the dissertation. For now, it is possible to sketch some general principles for approaching knowledge, the logic of reasoning, and the sources of knowledge to be employed here. A brief explanation of means of achieving answers in the context of CR is necessary, i.e., the rationality of means. But the full argument will be clear only through the complete dissertation, which depicts, in essence, a way to approach knowledge.

In short, justificationism is rooted in the question, *When is it rational to accept a particular theory?* The expected answer is: *When it has been verified or probabilified to a sufficient degree* (Radnitzky, 1987). This position supports most of Western thinking regarding what science should be. The fallacy of such an approach—closely related to the problem of induction—will be fully developed in the second chapter of this dissertation. For now, CR’s answer is to abandon the search for justificationism (or certainty), and the question is different: *When is it rational to prefer a particular position over its rivals?* Its answer: *If and only if it has so far resisted criticism better than its rivals did* (Radnitzky, 1987).

By developing criticism of traditional methodologies, this dissertation builds a meta-model for Management Science unifying a body of knowledge; this conceptual-theoretical work will provide a meta-design for epistemological foundations. It is an argumentative discourse. Therefore, the next question is how to develop this meta-design (in the sense of van Gigch). Because it is placed at a different level of logic, the meta-modeling process occurs at a different level of abstraction, i.e., the meta-level (see Figures 1 and 2); or in other words, it concerns a methodology about methodologies. Here, the practice of meta-modeling has several strategies based on the logic of
epistemology (van Gigch, 2003). A summary developed by Vollmer (1987) is a helpful guide here. Epistemology starts with specific questions concerning knowledge: "We begin right in the midst of everyday situation, usual knowledge, household language, naive questions" (p. 182). Examples include *What do we know? And how do we know?* Particular motivating questions here in the realm of management research were stated above. Next, the task is *analysis*. We turn to the object of investigation, which in this case is management research; following Vollmer again, "We try to analyze it, to classify, to structure, to systematize, to give definitions, explications, derivations, proofs, to find (at least necessary) criteria of adequacy,… of demarcation, or rationality… [via] reflecting, controlling, criticizing, correcting, sharpening, cleaning, restricting, rejecting" (pp.182-183). The main generic source concerning the object of investigation is management research practice as reported by academics. These processes form a feedback process that turns out to be the practice of meta-modeling as suggested by van Gigch (Figure 2).

**METAMODELING**

![Image of a diagram illustrating the self-reflexive loop of meta-modeling between Management Science and Epistemology. Based on van Gigch 2003.](image-url)
Regarding sources, the main support comes from two fields of inquiry: on the one hand, Epistemology and Philosophy of Science; on the other hand, evolutionary thought, in particular, Evolutionary Economics and Evolutionary Epistemology. With respect to the object of investigation, the focus is on management research with a special emphasis on the methods and assumptions that can be seen in current normal science practice, both in works that treat the subject directly and in those that apply the methods traditionally used in empirical research.

Summary of the argument and structure of the dissertation

The logic of the main argument to be developed in this dissertation is as follows.

1. **Current mainstream management research is flawed because it is grounded in inadequate assumptions about the nature of scientific research.** These assumptions form a single, unnoticed, and inappropriate paradigm whose roots can be found in presentationalism and justificationism.

This statement confronts most of the discussions in literature that suggest, on the contrary, diverse struggling and suitable paradigms; furthermore, management scholars do not seem to recognize such common assumptions framed in a narrow view about the nature of science and research.

2. **The mentioned paradigm brings with it unresolved epistemological problems** such as: the proliferation of views and programs, the problem of the growth of knowledge in a particular research field, the problem of induction, the deceiving search for confirmation and verification, the view of causality as
the only and valid way to explain phenomena, and the exclusion of time in a dynamic non-uniform world.

Furthermore, it seems that scholars do not recognize the link between a single paradigm (the one they are immersed in) and some of these problems. What's more distressing is that most current management researchers do not even seem to recognize most of the mentioned problems.

Chapter 2 develops these two previous theses.

3. In order to dissolve such problems, they will be re-conceptualized at the epistemological level through the introduction of various constructs that cope successfully with them and that will help to build an adequate methodological framework for conducting management research. “Adequacy” means “coherence” with the non-uniform nature of organizations and social systems in general.

This re-conceptualization is based on evolutionary epistemology as the main guide shaping the logic of the research. The purpose of chapter 3 is not only to present viable alternatives to the criticism presented above but also to develop the conceptual apparatus needed to portray a theory of evolving knowledge.

4. The evolutionary view is not only epistemological but also ontological. To understand the world as a complex arrangement of evolutionary entities gives one the pillars necessary to develop a system for theory development in management research.

Chapter 4 briefly depicts an ontological grounding based on process philosophy and evolutionary realism in order to develop the metadesign consistent with the evolutionary theory of knowledge.
5. Chapter 5 **builds the meta-design in the form of a formal framework.** It uses the main results of the assessment developed through the dissertation. In order to have a consistent level of scope and abstraction (i.e., level 3 in Fig. 1, extraordinary science / epistemology / meta-modeling), the meta-model is developed with the help of set theory. Apart from the criticism developed of management science, which is hardly found in current scholarly and academic literature, this meta-design is the main outcome of this dissertation.

6. The final chapter presents a summary of main contributions.

*What this dissertation is and what it is not*

As it is presented, the range is broad. But mainly, this wide scope is provided by the rather high level of abstraction, which implies a larger capacity for representation. Nevertheless, the dissertation is placed at neither of the extremes in a spectrum of general inquiry. It is not a case study pretending to answer particular questions about a single case anchored in time and space. It is also not a metaphysical system of speculative philosophy trying to develop background in which every experience can be interpreted. Somehow, it is halfway between them, although it includes elements of both. By articulating various traditions in the theory of knowledge, it develops a methodological system adequate for conducting management research regarding both individual specific cases and more wide-ranging views by guiding our understanding so that we can face new cases in different times and/or spaces. Essentially, this dissertation is a methodological proposal in the broad sense of the word, signifying the explicit inclusion of assumptions and the development of the type of knowledge expected to be addressed.
Summary of main objectives

According to the previous exposition, a number of main results to achieve can be identified:

I. To develop a critical assessment of mainstream management research methodologies. That is:
   - A literature review of main methodologies in management science.
   - Critical revision of assumptions held and examination of major epistemological difficulties.
   - Development of the claim that management research rests on one single - and unnoticed - paradigm for a uniform world (and therefore that this is an unsuitable foundation).

II. To outline a meta-design, i.e., from the meta-level perspective, of a distinctive kind of knowledge for management science. Ontological assumptions and epistemological premises have to be developed explicitly in order to set up the grounding for theoretical propositions. This re-conceptualization aims to dissolve the epistemological problems found, and it provides the basis for conducting research. The conceptual apparatus is anchored in evolutionary epistemology.

III. To build a meta-design, (a methodological framework) for management research using the proposed re-conceptualization of knowledge. This includes the assumptions in which it is
located, the sources of knowledge, the logic of research, and possible methods of reasoning. The meta-design is formed by assumptions, categories, and a formal specification.
2. REFLECTION ON THE CURRENT FOUNDATIONS OF MANAGEMENT

Also those modern empiricists who substitute 'law' for 'causation' fail even worse than Hume. For 'law' no more satisfies Hume's tests that does 'causation'.

Alfred North Whitehead, 1929.

*Process and Reality*

Few things are more ironic than for a self-styled 'empiricist' openly to repudiate philosophy, when he himself has unconsciously adopted the philosophical views of Comte, Mill, Mach, or Carnap and unconsciously repudiated the scientific practice of anti-positivists such as Lavoisier and Dalton in chemistry, Lyell and Darwin in biology, Galileo, Newton, Plank, and Einstein in physics who all assumed the reality of a physical world beyond sensory appearances and who thought that the primary task of science was to understand that trans-empirical world (i.e., 'elements' and 'atoms' were not observable, geological and biological history are not observable, the real motion of the planets is not observable, and the absolute speed of light in a vacuum is a constant whether observable or not). In other words, 'anti-philosophical' empiricists are commonly the victims of the most anti-scientific of all philosophies, namely the phenomenalism and subjective idealism of Berkeley and Hume, who aimed above all else to restrict the scope and importance of science as had earlier phenomenalists even as far back as Pyrrho the sceptic.

John Blackmore, 1979

*On the inverted use of the terms 'Realism' and 'Idealism' among scientists and historians of science*

Introduction

The expression “philosophy of science” might be misleading because both terms, “philosophy” and “science”, denote ways of approaching knowledge.
Philosophy prefers reflection, while science prefers observation. This chapter, in fact, is a reflection on the observations made in science; in this sense, it is about 'philosophy of science' as a part of a single ongoing inseparable process (in fact a process, by principle, is not separable). Unfortunately, “Science” seems to be prevailing to the detriment of “Philosophy”. That is, observation seems to be more popular than reflection, which this might be problematic, both at the individual level and at the scientific level.

Aristotle is someone for whom such a distinction did not make sense. Indeed, it is meaningless to discuss whether Aristotle was either a scientist or a philosopher. Some of the topics to be found in his texts include aesthetics, anatomy, astronomy, biology, corruption, economics, education, embryology, ethics, foreign customs, geography, geology, government, justice, literature, meteorology, metaphysics, music, physics, poetry, politics, psychology, rhetoric, theology, and zoology. The ideas of Aristotle that focused on “philosophy” are mainly found in the book Metaphysics. The rumor is that three centuries after Aristotle's death, Andronicus of Rhodes was editing a collection of works by the master. He found, regarding a particular group of works, that there was no easy word for their contents as a set; because of their location in the compilation (after the works on 'physics'), the book received that label—i.e., the book happened to be beyond (next to, after, meta) 'physics'. It would be even more appealing to believe that the librarian also understood that the book was 'about' (meta) physics: a reflection on physics. And seemingly, in a very simplified account of the story, what we know as “science” has preferred to use that book of physics — for some reasons that are ostensibly understandable, since it was practiced by people concerned with apparent material, static things. At a later point in the story, it is told that we seemingly forgot to look back, and that we now use this “science” — that book of physics — for issues related to animated and living things, including humans. This “scientific” approach still persists, with the approaches of some biologists and social scientists posing an exception. Shortening the story further, people mainly treating the topics of the “meta-physics” became the
“philosophers” (*the ones who reflect*), and the people handling the contents of the book of “physics” became the “scientists” (*the ones who observe*). When we draw distinctions, we may learn, but we may also unlearn. Those works of *physics* of Aristotle treated “the world of change”. This chapter introduces a particular irony of this story by reflecting on that notion of “change” in science; in short, it became a science that excludes the notion of “time”. Current discussions of science seem very limited; this dissertation suggests a broader debate. We are locked into *observing* the world, but *reflection* seems to be ignored, this has had consequences.

The quotation of Blackmore (above) is not only a sort of moral lesson. Indeed, it describes the current state of affairs in most of what we know as “science” today. The chapter that follows is nothing more than a systematic reflection. But it should not be labeled either as “scientific” or “philosophical” because it is *both*. Yet, by the end, the reader will likely believe that this chapter was *either* about science *or* about philosophy, perhaps depending on which side the reader is on—that is, if the reader happens to be characterized as a philosopher, then certainly this chapter, and this dissertation, might be about science; and if the reader happens to be what we know as a practitioner, or a scientist, then for him this chapter might be about philosophy. Naturally, there are exceptional readers for whom that difference does not make sense.

The main purpose of this chapter is to depict the current foundations of management science and to show various inconveniences, not only because of intrinsic flaws but also because of the inherent commitment to a uniform world. The first section describes the current practices by examining the standard research methods. It shows that a central assumption across these methods is the method of sourcing and validating scientific knowledge via *observation* (empiricism). This statement confronts most of the discussions in literature that suggest, on the contrary, diverse struggling and suitable paradigms; this section also articulates the corresponding epistemological premises when science is committed to observation as a source of knowledge:
Reflection on the Current Foundations of Management

presentationalism, justificationism, lawhood, and uniformity. The second section claims that these foundations are inherently defective as a result of the problem of induction. The final section highlights the fact that the commitment to induction and uniformity excludes the possibility of addressing change; it also points towards an alternative that is inspired by biology, as it is the discipline that meets a domain full of diversity and change: the living world.


A frequently employed strategy used to address the philosophical roots of a particular scientific practice is the technique of looking at the history of that practice and seeing its historical connections with philosophical thinking. This chapter follows a different strategy because of the necessity of attempting a direct connection with practitioners and scientists. In addition there is another motivation. A historical inspection might suggest some sort of authority arising from the philosophical ideas that have shaped our current notion of science. However, if we carefully examine the current practices, then we can highlight major aspects and difficulties. Therefore, in order to depict the ground on which management science stands, we must take as our starting point the direct consideration of its methods, since by inspecting their use, we may examine assumptions that lie beneath regarding the conception of knowledge and ways to approach it.

2.1.1. Methods as Starting Point

This section presents an overview of the methods of management science and highlights the subjects that are common to most of them.

Since the particular qualitative/quantitative demarcation will be mentioned in various parts of the text, given that it is widely assumed by researchers as the main source of the supposed paradigmatic differences, a brief note on this distinction follows. Perhaps a crude first approximation has to do with the
characteristics of the core data that the researcher manipulates; quantitative research uses numbers and magnitudes, i.e., quantities, and qualitative research uses words, pictures and any other media that permit the representation of properties, attributes, characteristics, etc. – qualities. The preferences for particular types of methods entail some assumptions held by the researcher regarding their use, usefulness, and suitability for the questions he seeks to address. A variety of techniques are available. For instance, regarding qualitative approaches, Smith notes, as cited by Miles and Huberman (1994), that “the terms ethnography, field methods, qualitative inquiry, participant observation, case study, naturalistic methods, and responsive evaluation have become practically synonymous” (p. 1). A wide overview of these approaches can be found in the standard Handbook of Qualitative Research by Denzin and Lincoln (2000); these authors offer a generic definition:

Qualitative research is a situated activity that locates the observer in the world. It consists of a set of interpretive, material practices that make the world visible. These practices transform the world. They turn the world into a series of representations, including field notes, interviews, conversations, photographs, recordings, and memos to the self… [It] involves an interpretive, naturalistic approach to the world. This means that qualitative researchers study things in their natural settings, attempting to make sense of, or to interpret, phenomena in terms of the meanings people bring to them. (p. 3)\(^4\)

Regarding quantitative methods, these are usually understood as statistical analyses—e.g., the application of a survey design provides numeric

\(^4\) It is interesting to note that qualitative researchers emphasize their "naturalistic" approach as being distinctive and closer to social life in order to understand human action; the irony is that "naturalism" is usually understood as the belief that the social sciences should and can employ the methods of natural sciences (Rosenberg, 2000), a position that is habitually rejected by qualitative researchers without their noticing the contradiction (within their own discourse). Yet, to be fair, there is no contradiction; they indeed follow the assumptions of the natural sciences, in particular physics, as this chapter describes, but they do not seem to notice it.
descriptions of trends in a population by analyzing a sample. Indeed, Black (1999) entitled his popular book *Doing Quantitative Research in the Social Sciences: An Integrated Approach to Research Design, Measurement and Statistics*. This approach focuses on the collection of numerical data in order to produce and verify theoretical relationships in large samples based on probability theory and statistics.\(^5\)

However, beyond “words/pictures vs. numbers”, these research methods share several aspects. A short characterization of this common ground follows.

**The 'empirical basis', science by observation**

One of the defining premises is usually the “empirical basis” that undergirds the source of knowledge”. It is widely taken that *the* way to generate theories is from empirical data, from observation. Before starting, a remark is in order: 'empiricism' is not a proper epistemological term. For example, observation can be stressed without considering a particular epistemology; however, it can be also related to the issue of knowledge, as usually is done in science. Blackmore (1979) summarizes: "Granted, that if one means by 'empiricism' not just an extensive and careful concern with empirical evidence but restricting reference or knowledge or both to sensory appearances, then there are indeed epistemological implications. One has become an epistemological phenomenalist or subjective idealist, or if you will, a positivist" (P. 130, 5 For example, in the broad survey made by Peng, Peterson and Shyi (1991) which addresses quantitative methods in cross-national management research, all the methods studied in the report are based on probability theory and statistics; the most prominent ones are correlation, multiple regression and ANOVA analyses. All these types of techniques are taken as encompassing quantitative methods. The general text of Creswell (2002) on research design is also another example of such a prevalent view. The quantitative approaches in Operations Research and Operations Management that use mathematics to address management-related issues are usually excluded, since they tend to be attached to specific problems without involving the development of social theory; some of these methods are summarized by Wacker)—mathematical programming and optimization, discrete-event simulation, and system dynamics are examples of these approaches.
emphases original) — see chapter 4. This quotation is a first hint of the core of the main argument to be developed in this chapter, that management science can be characterized within a restricted view of empiricism or “empirical basis” that constitutes a prevalent epistemological principle regarding what science should be and how it should proceed.

Regarding qualitative methods, the empirical basis and observation are defining principles given their naturalistic emphasis, as it is claimed by practitioners (e.g., Miles & Huberman, 1994). For instance, field research proceeds via direct and participant observation, interviews, surveys and archival analysis (Snow & Thomas, 1994). Case study research relies on empirical data as the source of patterns and shaping and building theories (Eisenhardt, 1989; Yin, 1998). In general, qualitative methods seek to collect data in order to interpret, understand, and/or construct statements and build theories; Denzin and Lincoln (2000) state: "Qualitative research involves the studied use and collection of a variety of empirical materials - case study; personal experience; introspection; life story; interview; artefacts; cultural texts and productions; observational, historical, interactional, and visual texts - that describe routine and problematic moments and meanings in individuals' lives" (p. 3). Such collections of data are the source of knowledge that drives research. As for quantitative approaches, Black (1999) also stresses the nature of empirical research in his well-known text: “Empirical indicates that the information, knowledge and understanding are gathered through experience and data collection...Such an approach is usually described as scientific because of its systematic approach and goal of producing replicable studies...At the foundation of the process of trying to understand events and their causes are observations” (pp. 3, 4, 6, emphases original).

Carlile, Christensen, and Sundahl (2003) characterize a "theory of theory building" in order to offer a general account of what theory-building research for management is and how it should be done—beyond qualitative/quantitative differences. They summarize: "Scholars seem to agree that the process of
building good theory proceeds in three stages. In the first stage the best that researchers can do is to observe phenomena and to carefully describe, measure and record what they see… With the phenomenon observed and described, researchers classify the phenomena into categories in the second stage… In the third stage, researchers articulate theories to explain the phenomena observed” (p. 5).6 It can safely be said that the previous affirmation characterizes in broad terms the tendency of what is understood as the way to make science in management research. Such an account summarizes what can be labeled the framework of the empirical basis. This emphasis is part of the traditions of Locke, who gave the first modern account of an empiricist epistemology (Rogers, 2000), Hume, for whom experience is the sole source of all meaning and knowledge (Newton-Smith, 2000), and, in the 20th century, the ideas of the logical positivists of the Vienna Circle and the logical empiricists—for instance, Carnap, who emphasized the phenomenalist basis (underlining what arises out of direct experience), or Reichenbach and his physicalism (Ray, 2000; Salmon, 2000). These assumptions have permeated the ideas that we have regarding science and knowledge. Various topics in concordance with such a view arise for management research from that assumption; they are described in the following section.

The prominence of the reliable observer

Naturally, if science is based on observation, then the role of the observer and how he accomplishes his tasks become the point of reference. For instance, one of the leading issues in qualitative methods has to do with meaning, interpretation and the active role of the researcher. Consider the definition of Denzin and Lincoln (2000): "Qualitative research involves an interpretive,

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6 In their work, Carlile, Christensen, and Sundahl (2003) cite Popper as one of those scholars who, according to these authors, agree on the process of building "good" theory as summarized by them (see quoted text); this is a very common misinterpretation of Popper. The position of Popper is exactly the opposite: he is against induction and against building theories from observation as a canon, e.g., (Popper, 1968, 1974a).
naturalistic approach to the world. This means that qualitative researchers study things in their natural settings, attempting to make sense of, or to interpret, phenomena…” (p. 3). The interpretation made by the researcher is central to this approach — which in turn provides a method of sense-making\(^7\) for him and also for the people involved in the study; the researcher also influences the research process and the results (for example, because of his or her presence and because of his or her observation and communication of biases). In a similar way, quantitative approaches place the weight of the source of knowledge on the ability to make systematic observations. For instance, Black (1999) emphasizes, "If the observations that underpin a theory are not systematic and replicable, the theory will develop in an erratic manner" (p.7). This process relates to careful sampling and cautious survey designs.

Hence, the skills necessary to make *good*, or at least *reliable*, observations are the cornerstone needed to build theories, regardless of the quantitative/qualitative distinction. The researcher should be able to be consistent with his own assumptions and criteria, which inform him about whether or not he is making reliable observations; these criteria indicate how he can distinguish the flaws or possible defects and effects associated with the observations, e.g., interpretation and impact on the situation observed, the correct analysis of surveys, the adequate design of general measurement artifacts and instruments, etc. As long as the researcher can take into account, minimize, or even eliminate the observational flaws, then the processes of research and theory-building are supposed to be *safe and sound* because they rest on what has been observed and on the correct way in which it has been observed and, moreover, because there is a sense of awareness of the possible shortcomings of this observational process.

\(^7\) An illustration of the concepts of *sense-making* and *sense-giving* can be found in the work of Gioia and Chittipendi (1991).
An essential facet of an empiricist orientation - and indeed one that is the core of current science - is the dependence on inductive procedures and the building of theories based on empirical data. The method of induction relies on examining *events* or *instances*, which, after all, are the only things we can observe.\(^8\)

The approach of induction forms the groundwork for the methods in management research that seek to build theory. In relation to qualitative methods, Miles and Huberman (1994) underline the “focus on naturally

\(^8\) A note on induction should be introduced here. The method seems quite simple: the process of inferring a general law or principle from the observation of particular instances (Simpson & Weiner, 1989). This method has been studied since Aristotle; the main source text is ‘Posterior Analytics II’, and an introduction to this work can be found in the paper by Watson (1904). The discussion was continued much later – concerning scientific inquiry – by Bacon, who promoted it in the *Novum Organum* as the main inference method for the natural sciences (Milton, 1987). A preliminary, basic discussion on induction and modern science can be found in the work of Thilly (1903) and certainly in almost every book labeled as “philosophy of science” or the like. The idea of induction shows why it is so crucial to establish whether observational data can give us reasons to infer and/or accept hypotheses, i.e., the issue of *confirmation* or, i.e., confirmatory evidence in scientific inquiry (cf. (Howson, 2000a). There is *enumerative* induction, in which a generalization is inferred from evidence about instances of the generalization; in *hypothetical* induction, a hypothesis is inferred as the best explanation of the evidence (Harman, 1992) – this non-deductive approach is usually known as *abduction* and is claimed as an alternative to both enumerative induction and deduction (R. Fumerton, 1992) that tests hypotheses against experience; the logic of abduction was developed by Peirce in order to decide if a hypothesis is worth testing (at a particular stage), with the following line of reasoning summarized by Lipton (2000): “Explanatory considerations are a guide to inference… Scientists infer from the available evidence to the hypothesis which would, if correct, best explain that evidence”(p. 184). This is what is also known as “inference to the best explanation”, which refers to the process of forming an explanatory hypothesis and to the criterion for choosing between various competing hypotheses (Hookway, 1992; Misak, 2000). A typical example: suppose that Peter observes several apples and all of them are green. With an enumerative induction argument, Peter concludes that *all* apples are green. A hypothetical induction could be based on the hypothesis that Paul has been hiding all the apples that are not green. As expected, the main objection against the abductive argument is its self-validating characteristic (Leplin, 2000).
occurring, ordinary events in natural settings, so that we have a strong handle on what 'real life' is like. The confidence is buttressed by local groundedness, the fact that the data were collected in close proximity to a specific situation… The emphasis is on a specific case” (p. 10). This is why qualitative studies are also understood as case-study research. They are associated with one or a limited number of singular unique events. In a similar way, the influential "grounded theory" approach is defined as the discovery of theory from data systematically obtained (Glaser & Strauss, 1967), with an emphasis on inductive procedures: “Generating a theory from data means that most hypotheses and concepts not only come from the data, but are systematically worked out in relation to the data” (p. 6).9 Likewise, in case study research, the analysis of case-based data is the source from which theoretical propositions can be developed—for example, via pattern-matching and/or by establishing causal links – known sometimes as logic models — in order to explain a phenomenon (Yin, 1998). More concretely, concerning typical procedures, Yin (1998) suggests: “You may begin by taking the data you have collected for a single case and attempting to see whether they converge over a logical sequence of events (chronologically) that appears to explain your case’s outcomes” (p. 252). Also, Eisenhardt (1989) underlines the inductive character of theory-building in qualitative studies: “The interest here is…theory generation from case study evidence” (pp. 535-536). This way of thinking is so entrenched that Glaser and Strauss (1967) affirm that the procedure itself indicates criteria for judging a theory: “The adequacy of theory for sociology today cannot be divorced from the process by which it is generated. Thus one canon for judging the usefulness of a theory is how it was generated – and we suggest that it is likely to be a better theory to the degree

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9 Strauss (1987) later tries to reject this emphasis, arguing that “all three aspects of inquiry (induction, deduction, and verification) are absolutely essential” (p. 12). For him induction refers to the actions perpetrated to discover a hypothesis and deduction refers to the drawing of implications from hypotheses for the purpose of verification (pp. 11-12). Strauss does not notice the contradiction between verification and deduction. The inductive nature of grounded theory method is unmistakable not only in its very definition (i.e., “theory from data”) but also in actual research practice, in which models and theories are indeed induced from data.
that it has been inductively developed for social research” (p. 5). Induction is also essential in ethnography\textsuperscript{10} (van Maanen, 1983) and in field research (Snow & Thomas, 1994).\textsuperscript{11}

Similarly, quantitative methods are firmly based on induction. Black (1999) underlines: "Theories...usually have been developed through \textit{induction}, a process through which observations are made (possibly casually at first), data are collected, general patterns are recognized and relationships are proposed” (p. 8, emphasis original). The assumption is that statistical inference is possible, as Kyburg (1985) summarizes: "\textit{To suppose} that...is possible to take a sample from a population, and to conclude from the sample, with appropriate probability (or confidence, or practical certainty) something about the distribution of quantity in the population sample" (p. 20, emphasis added).

In summary, in a broad paper about general research methodologies in management—including, as the title says, "current practices, trends, and implications for future research”—Scandura and Williams (2000) underline the process of formal theory-building: "Theory often involves an inductive process... A generalization that starts from the data points that observations produce..." (p. 1250). This is the statement to highlight here, as it indicates the current inductive \textit{nature} of management research, regardless of particular methods.

\textsuperscript{10} Areas such as ethnography are usually placed on a level of description, for instance cultural description (van Maanen, 1982). If the theoretical aim is to establish causal relationships, then description is taken as the identification of constructs and variables (Snow & Thomas, 1994). But an ethnographic study can be also used with the aim of developing explanatory theory, e.g., as in the work of Hargadon and Sutton (1997). Generally, this kind of work involves other qualitative approaches such as field work, case studies and grounded theory.

Generalization and prediction

In a process of research based on induction, the capacity to generalize and predict is expected. That is, it is expected that these theories should apply for new instances, i.e., cases in different settings/places, in the past and in the future. Attached to an inductive mode of thinking is the aim of generalizing from particular instances to generalities established on principle. The term theory denotes this aim, as a theory is expected to hold on a more general basis beyond what was observed.

How are these goals addressed by current methods? In qualitative studies, it is argued by researchers that it is possible to conduct analytic generalization: to use single or multiple cases to illustrate, represent, or “generalize to a theory” (Yin, 1998). Miles and Huberman (1994), in order to defend the strength of qualitative data, affirm that "we underline their strong potential for testing hypotheses, seeing whether specific predictions hold up" (p. 10). The same aim is present in statistics: to generalize from evidence to a universe. Furthermore, this condition is taken as a source of validity: "External validity refers to generalizing across times, settings, and individuals" (Scandura & Williams 2000, p. 1252). Regarding quantitative methods, prediction is also the objective: “The value of a theory is in its ability to allow us to explain and predict outcomes” Black (1999, p. 7). Verification also becomes important as the way for the theory to gain acceptability: for example, one might ask, “Can the process be replicated by someone else such that the same results are produced?” (Black 1999, p. 20)—see “Confirmation and verification” below.

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12 This ‘generalization to a theory’ refers to the comparison of emergent concepts with existing literature. Eisenhardt (1989) defines it: “Tying the emergent theory to existing literature enhances the internal validity, generalizability, and theoretical level of theory building from case study research...Literature discussing similar findings is important as well because it ties together underlying similarities in phenomena normally not associated with each other... The process is directed toward the development of testable hypotheses and theory which are generalizable across settings.” (pp. 544, 545, 546).
It is easy to see that these methods - both qualitative and quantitative approaches - share the same assumptions in trying to build theories. Generalization and prediction are taken as elements of good theory-building. This point is underlined by Wacker (1998) in his broad research guidelines for theory-building methods: as long as a theory can provide answers to questions like Could a specific event occur?, Should a specific event occur?, or Would a specific event occur?, then we have a theory: "Good theory-building research's purpose is to build an integrated body of knowledge to be applied to many instances by explaining who, what, when, where, how and why certain phenomena will occur" (p. 371.). To sum up, Weick underscores that "a good theory explains, predicts, and delights" (Sutton and Staw, 1995, p. 378).

How are these generalizations and predictions stated? They are stated in the form of causal theories that aim to develop explanations, as is introduced next.

**Theories and explanations as causal relationships**

The notion of scientific explanation, strongly held in management science, is clear: *to have an explanation, we must have causal connections*. Indeed, at the core of management science is a tendency to find no more than *causes*. For example, Sutton and Staw (1995) take causal explanations to be the way to answer *why* questions and the essence of a theory. Likewise, Carlile, Christensen, and Sundahl (2003) state: “A theory is a statement of what causes

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13 Sutton and Staw (1995) show the propensity of authors to present merely isolated references, data, variables, diagrams and/or hypotheses without further commitments, which constitutes, according to them, a sort of insufficiency if one wishes to have a theory. In order to overcome this problem, they argue, “Authors need to explicate which concepts and causal arguments are adopted from cited sources…Observed patterns like beta weights, factor loadings, or consistent statements by informants rarely constitute causal explanations…the reporting of results cannot substitute for causal reasoning….Just like theorists who use quantitative data, those who use qualitative data must develop causal arguments to explain why persistent findings have been observed if they wish to write papers that contain theory…Theory emphasizes the nature of causal relationships, identifying what comes first as well as the timing of such events” (pp. 373-378).
what and why” (p. 5). This propensity is manifest in most papers that aim to build theories; the goal is to explain a number of variables, constructs, events, behaviors, etc. as caused by other variables, constructs, events, behaviors, etc. The essential basis for explanation and theory-building is the causal relationship between constructs and variables. This principle holds for both qualitative and quantitative methods.

Regarding qualitative studies, to explain a phenomenon is to stipulate a set of causal links about it (Yin, 1998). Also, Miles and Huberman (1994) emphasize their characterization of explanation with the “causal description of the forces at work” (p. 4, emphases original). Likewise, Snow and Thomas (1994) underscore: “With explanation as a research objective, the investigator must address the issue of causality among variables” (p. 467). Moreover, what is known as internal validity rests on a well-supported relationship between constructs (Eisenhardt, 1989). In quantitative studies, an explanatory answer also aims to establish causal relationships between variables. For instance: "To provide a more complete explanation of events in our lives, theories—models and explanations that elaborate on why events have occurred—are devised to describe causal relationships between actions and/or events" (Black 1999, p. 7). Also, the criterion for internal validity is based on these cause-effect relationships (Scandura & Williams, 2000). All of these principles are strongly held in papers and reports on theory-building.

The causality-based explanation in management research usually addresses single variables/constructs, and it aims for an explanation based primarily on causal connections between them. The typical question concentrates on the final state or level of one or a limited number of constructs or variables Y₁, Y₂,...,Yₙ strictly in terms of other causes, variables, or constructs X₁, X₂,...,Xₙ, joined by a type of direct unidirectional causal link: that is, one or more Xᵢ influence (causally) one or more Yᵢ. See Figure 3.
This characterization is somewhat vague, since a proper treatment of what is assumed to be a causal relationship is not easy to find in management literature, i.e., the discussion on the nature of the causal relations. For instance, it seems that events, properties, propositions, objects, behaviors, and variables/constructs in general can play the role of causes and effects. In any case, the principle of building theories in this way is at the core of most theory-building procedures. Some examples taken from management literature can show typical types of questions: What are the determinants of power? (Finkelstein, 1992). What are the factors for successful inter-partner learning? (Hamel, 1991). What are the determinants of absorptive capacity? (van den Bosch, Volberda, & de Boer, 1999). The search for causes is already embedded in these questions.\textsuperscript{14}

\textsuperscript{14} Another illustrative example is the statistical-based analysis of Coles and Hersterly (2000), in which they investigate the relationship between board composition and the independence of the board chairman; they conclude: “Our results suggest that the independence of the Chair is a strong determinant of how the market views the adoption of a poison pill. The market takes a favourable view of firms that adopt a poison pill when they have an independent Chairman” (p. 211). This sentence illustrates the notion of causal explanation.
To sum up, the causal relationship is the source of explanatory power—i.e., the *explanans*, that which does the explaining—and furthermore, it is a validity criterion and is taken as the way to state theories.

**Confirmation and verification**

Given the reliance on the "empirical basis" (observation), we then see arise the problem of how to trust knowledge acquired in this way; in other words, how can we trust these theories?

The conjunction between generalization/prediction goals and inductive processes leads us to confirmation and verification. The fundamental question in a theory of confirmation is: *Under what conditions is a theoretical hypothesis confirmed by a piece of evidence?* (Edidin, 1988). For example, regarding qualitative approaches, there is the common principle of “theoretical saturation” as a criterion for when to stop adding new cases (i.e., the empirical evidence of the theories), that is, “theoretical saturation is simply the point at which incremental learning is minimal because the researchers are observing phenomena seen before” (Eisenhardt, 1989, p. 545). Yin (1998) also underlines the importance of replication: "Analytic generalizations may be strengthened because the multiple cases were designed to 'replicate' each other - producing corrobatory evidence from two or more cases... Generalizations may be broadened because the multiple cases were designed to cover different theoretical conditions, producing contrasting results, but for predictable reasons" (p. 240). Within quantitative methods, this premise is not different: "Theories are the basis of research studies and can be thought of as formal statements of explanations of events, expressed in such a way as to allow their investigations, confirmation and verification" (Black, 1999, p. 8).

Additionally, the search for confirmation is taken as a criterion for guiding research; for instance, regarding case study research, “[t]he goal of theoretical sampling is to choose cases which are likely to replicate or extend the
emergent theory" (Eisenhardt, 1989, p. 537). In the same way, Carlile, Christensen, and Sundahl (2003), within their general framework of management research, underline: "Researchers use theory built upon on a thorough categorization scheme to guide what phenomena they will observe under a variety of circumstances. If the theory accurately predicts what they actually observe, this 'test' offers one specific confirmation that the theory is useful under the circumstances in which the data or phenomena were observed" (p.6, emphases added).

Indeed, the concept of confirmation is tied with the notion of validity and “true” knowledge - at least justified knowledge. A quotation by Miles and Huberman (1994) synthesizes this view, which presupposes confirmation and verification as a source of the validity of knowledge and theories:

Verification may be as brief as a fleeting second thought crossing the analyst’s mind during writing, with a short excursion back to the field notes, or it may be thorough and elaborate, with lengthy argumentation and review among colleagues to develop ‘intersubjective consensus’, or with extensive efforts to replicate a finding in another data set. The meanings emerging from the data have to be tested for their plausibility, their sturdiness, their ‘confirmability’ – that is, their validity. (p. 11)

To summarize, Wacker (1998) matches prediction with verification (meaning here empirical support) with the purpose of testing the “model by criteria to give empirical verification for the theory” (p. 368). In general, theories are valid as long as they are confirmed by different and future observations—that is, by induction.
Summary: the method

The strength of the influence of Mach and the Vienna Circle can be seen where the defining characteristic of all scientific statements is the possibility of observational and/or experimental verification—namely, the principle of verification (see, e.g., Ray 2000) or the method of induction. The sketch above is a broad overview. This principle is taken for granted by management scientists; in management research literature, it is hard to find discussions objecting to this inductive grounding, which is customarily taken as the definition of what scientific practice should be. In short, the process of building theories is based on a method that starts from particular cases or data with the aim of observing repeated instances, i.e., confirmation; this is the methodological pillar of management research, which aims to develop predictive theories based on statements in the form of causal connections; science should have an empirical basis as the source of knowledge, which is thus approached via observation and later on confirmed with repeated observations that allow us to generalize with valid predictive statements.

2.1.2. Epistemological Issues

The previous section underlined core aspects of major methods of management research regarding its approach to knowledge. That ground might be summarized in this way:

*The empirical basis is the source of knowledge; here, the role of the observer is prominently positioned, since knowledge depends on - takes as its sources - sense observations. Induction is the way to build theories that are stated as confirmed causal relationships in order to make generalizations and predictions.*

This section introduces basic assumptions required for such a commitment.
Presentationalism

Perhaps it is appropriate to start with the attitude behind an empiricist epistemology, which is possibly the broader aspect distinguished in the preceding section. It can be suggested that a major defining posture is what has been labeled as presentationalism, given the natural disbelief of a world beyond the senses, which is the pillar of the empiricist epistemology depicted above. In the words of Hunter (1992): “As a result of their constraints on knowledge and meaning, empiricists tend to be skeptical of necessary truths that are independent of mind and language, and of putative eternal abstract entities” (p. 110). This posture is usually linked to the idealism of Berkeley, which can also be identified with terms such as “phenomenalism”, “neutral monism” or “subjective idealism” (Blackmore, 1979), or presentationalism. A good summary is made by Chapin-Jones (1941): "Anything in time or space, anything than can be known by the human mind, is phenomenal" (p. 146). In particular, Bartley (1987a) defines the term as follows:

Presentationalists see the subject matter of science not as an external reality independent of sensation. The subject matter of science is our sensory perceptions. The collectivity of these sensations is renamed 'nature'… The aim of science is seen not as the description and explanation of that independent external reality but as the efficient computation of perceptions…[It] became the dominant twentieth-century philosophy of physics. (p. 11, 16, emphasis original)

This position is the pillar of the prevalent conception of science, which has been fueled by physics (for instance, in the interpretation of quantum mechanics associated with Bohr and Heisenberg) and backed by influential names like Mach, Russell, Wittgenstein, Ayer, Lewis, Carnap (Bartley, 1987a).
**Justificationism**

Within a presentationalist worldview, the search for confirmation and verification is nothing less than the search for the justification of knowledge where the intellectual authority lies in sense experience. From a presentationalist account, it is straightforward to have a justificationist approach that lies behind the effort to confirm and verify theories:

> Preoccupied with the avoidance of error, they suppose that, in order to avoid error, they must make no utterances that cannot be justified by - i.e., derived from - the evidence available. Yet sense perception seems to be the only available evidence… The claim that there is an external world *in addition* to the evidence is a claim going *beyond* the evidence. Hence, claims about such realms are unjustifiable. Worse, many presentationalists argue that they are intrinsically faulty: they are not genuine but pseudo-claims; they are indeed *meaning-less*… Crucial to the presentationalist argument are, then, two things: the desire to give a firm foundation or justification to the tenets of science, and the construal of sense experience as the incorrigible source of all knowledge. (Bartley, 1987, pp. 12-13, emphases original)

Justification philosophy, understood as the search for epistemic authorities, has been the dominant style of Western philosophy\(^\text{15}\) and looks for "well-grounded" knowledge (Campbell, 1987b). The central problem to address based on this epistemology—as succinctly formulated by Radnitzky (1987)—can be summarized as follows:

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\(^{15}\) For instance, in the customary view of knowledge as *justified true belief*, e.g., (Russell, 1912, 1948) - as the result of a systematic analysis of our sensory experience of a knowable external reality (Spender, 1996).
"When is it rational or, so to speak consistent with one's intellectual integrity, to accept a particular position?" The formulation suggests the direction in which the answer is to be sought: "When concerned with a statement, a theory, etc., accept those and only those statements, theories, etc., which not only are true but whose truth has been established" (p. 282, emphasis original).

The goal of justification is intrinsically entrenched within the method of induction where every new repeated observation is a confirmation that validates - justifies - the theoretical statement.\textsuperscript{16} Its appeal can be explained also because it looks to avoid relativism, since not all positions are equally good or bad, and because it suggests that one looks for something beyond blind belief (Radnitzky, 1987).

In short, given a justificationist logic, it is rational to accept only those positions that have been justified according to the rational authority—which, in the case of presentationalism, is sense experience.

\textit{Lawhood}

As introduced earlier, the core of a theory in management research is a statement that details causal relationships confirmed and justified by the evidence available. In general, the goal of these theories is to give an account of observed generalities whenever those theories are "just facts expressed by contingently true, universally quantified, spatiotemporally unrestricted, material conditionals" (Vallentyne 1988, p. 598).\textsuperscript{17}

\textsuperscript{16} Even with weaker conditions, the method of reasoning is the same; for instance, in the ideas of Ayer, strict verifiability is seen as an overly rigid criterion, and thus he introduces confirmability to some degree instead of complete and conclusive verifiability (Salmon, 2000).

\textsuperscript{17} The origins of the idea of laws can be traced back to Berkeley, who in 1710 "proposed to account for the fact that there are all sorts of regularities in the world as we observe it... From his theology he took the notion of the rules that God prescribes for himself in thinking the world and
On the most general level, it is expected, "1. That there should be a regular concomitance between events of the type of the cause and those of the type of the effect; 2. That the cause event should be contiguous with the effect event; 3. That the cause event should necessitate the effect event" (Harré, 2000, p. 216). Then it follows that "All F's are G's", or:

$$ (\forall x) (Fx \supset Gx) $$

where "F" and "G" are purely qualitative in nature—that is, in the sense of Hempel and Oppenheim (1948): they do not require "reference to any one particular object or spatiotemporal location" (p. 156).18

Naturally, strict universality is not met in practice; even in physics, truly universal laws hardly exist—see, for instance, the discussion of Rynasiewicz (1986). An alternative is the suggestion by Dretske (1977, pp. 251-252), who offers a restricted notion of law by drawing a distinction with the concept of universal truth:

Many philosophers have argued that the distinction... [is] a difference in the role some universals statements played within the larger theoretical enterprise... It is merely a symptom of the special status or function that some universal statements have. The basic formula is: law = universal truth + X. The 'X' is intended to indicate the special function, status or role that a universal truth must have to qualify as a law. Some popular candidates for this auxiliary idea, X, are:

thinking us and our experiences. It is these rules that account for, and are reflected in, whatever regularities we perceive in nature" (Harré, 2000, p. 213).

18 Some examples provided by Hempel and Oppenheim (1948) of predicates purely qualitative in character are referred by the terms 'soft', 'green', 'warmer than', 'as long as', 'liquid', 'electrically charged', 'female', 'father of'.
(1) High degree of confirmation.
(2) Wide acceptance (well established in the relevant community)
(3) Explanatory potential (can be used to explain its instances)
(4) Deductive integration (within a larger system of statements)
(5) Predictive use.

Therefore, in this restricted account of law, there is a further epistemic,
pragmatic, or systemic requirement, e.g., “highly confirmed” or “widely
accepted” (Vallentyne, 1988). We are obligated to do that if we are going to
distinguish between universal truth and law. A further alternative that tries to
justify exceptions is the weaker condition constituted by normic laws, where
"As are normally Bs" (Schurz, 2001).

In any case, a particular aspect must be highlighted: consistent with an
empiricist tradition, these laws depend on what humans have observed and
confirmed (Vallentyne, 1988). Thus, and coherent with the discourse of the
previous sections, either in a universal or in a constrained sense (restricted
regularity, probabilistic - see below -, normic, etc.), the archetype of theory
that management science looks for has a (causal) law-like form. This
aspiration is strongly defended in social science by some authors arguing in
favor of the same type of laws used in physics, which is taken explicitly as
example of 'good' science; for instance, Kincaid (1988) argues that the
restricted generalizations of social science—e.g., in the form of the ceteris
paribus clauses—are examples of 'good' and 'respectable' science because they
are basically empirically based causal restricted generalizations and follow a
confirmatory and inductive process in order to predict for different space-time
regions, as in physics (for example, Newtonian laws are indeed restricted
generalizations).

Summarizing, there is no ambiguity in the law-like form of theories in
management science that look to explain observed regularities where some
general conditions might (or should) be applicable in different space-time
circumstances and that are confirmed by evidence. The perfect theories have
the form of laws, although sometimes researchers are reluctant to admit it or to
recognize it, yet sometimes this assumption is acknowledged explicitly, e.g.
(Black, 1999; Wacker, 1998). To come to the point, this type of research
follows the traditional empiricist principle "[t]o know causes is to know the
existence of a law" (Byerly 1990, p. 553), and in particular, laws (or law-like
statements) are essentially built on summaries of observations. Furthermore, a
uniform world is needed for law-like statements. This uniformity is introduced
next.

**Uniformity**

How can induction be justified? And what are the assumptions behind the law
framework depicted above? Basically, to look for confirmatory evidence
requires that such repeated evidence be somehow possible, to some extent at
least; otherwise, induction makes no sense. In fact, to rely on induction implies
that one assumes some type of uniformity and lack of variance in the universe.
Furthermore, such an assumption allows one to search for predictive theories,
one of the main goals of a “good” theory in management research literature as
it was presented above.

Such assumptions were plainly and explicitly stated by Mill: "What happens
once, will, under a sufficient degree of similarity of circumstances, happen
again, and not only again, but as often as the same circumstances recur"
(Gotshalk, 1932, p. 141). Such a principle implies that the regularities
observed are invariable with respect to location in space and time (Schlesinger,
1990). Furthermore, if there is an observed change, then it can be explained
because of the different space or the different time in which the observation is
made and not because of changes in the nature of the things observed. That is,
in a causal relationship where A causes some B, then "A → B" is always "A → B",
and if there is a change observed in such a relationship, then it can be
explained by the circumstances in which the observation of "A → B" is made,
since the causal relationship is invariable to location in space and time; i.e., changes in space and time are causally irrelevant.\textsuperscript{19}

This is a traditional assumption in science, as for instance in this quotation by Keynes: "A generalisation which is true of one instance must be true of another which differs from the former by reason of its position in time or space" (O'Neill, 1989, p. 123).\textsuperscript{20} Indeed, this is a core principle of current science, since "if difference in date or position alone could make particulars unalike, then inductive reasoning, based on the belief that like things behave alike, would have no application" (Schlesinger 1990, p. 529).

Moreover, within a uniform world, when a different observation appears, then it can be stated that it is "genuinely different" since it is not a confirmatory piece of evidence; in this way, the particular inductive theory is protected, and the method remains safe as well. The difference can also be explained as an observational imperfection: "In fact, examining any of the seeming counter-examples to the principle of uniformity of nature, will lead to the conclusion that in the past no violation of that principle had ever taken place and the appearance of violation can always be shown to have been the result of the wrong application of the inductive method" (Schlesinger 1990, p. 531-532, emphasis added). Indeed, if the principle of induction is to be guarded, then whenever and wherever observations are not as expected, it can always be

\textsuperscript{19} Dretske (1977) specifies:

\begin{quote}
To say that it is a law that F's are G's is to say that [the expression] 'All F's are G' is to be understood (in so far as it expresses a law), not as a statement about the extensions of the predicates 'F' and 'G', but as a singular statement describing a relationship between the universal properties F-ness and G-ness. In other words… is to be understood as having the form: 'F-ness $\rightarrow$ G-ness' …To conceive of it as a law is to conceive of it as expressing a relationship between the properties (magnitudes, quantities, features) which these predicates express (and to which we may refer with the corresponding abstract singular term" (pp. 252-253).
\end{quote}

\textsuperscript{20} Indeed, O'Neill (1989) does not try to challenge the traditional view of science; he affirms that this is not really a problem because this uniformity of nature is where science starts from. The customary prevalent view of science seems to prevail. This dissertation questions this assumption.
argued that either the new case is truly novel (and thus that it does not belong to the regularities to be observed and expected) and/or that it is a problem of observation—with familiar different labels such as “sampling problem”, “inadequacy of the selected cases”, “survey design defect”, “measurement problem”, “acceptable error”, “bias”, and so on.21

Current science seems to be obsessed with observational problems and keeps on embracing a uniform and static world instead of recognizing change. This is inherently attached to the empiricist tradition and its methods.22

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21 An example of this point can be illustrated with the Kyburg (1985)’s concern in addressing the problem of confirmation of quantitative laws:

We need never suppose we make mistaken observations. We are free to do this, but the cost would be high. We would have to reject the most elementary common sense generalizations. In particular, the generalizations on which measurement depends would have to be rejected. To have measurements at all, we must allow for error. To have quantitative laws, we must have measurement. To allow for error, we must have at least a rough, quantitative, statistical treatment of error - what I have been calling a theory of error…The interplay among quantitative laws, observations, and the theory of error is complex, and depends in important ways on what we are warranted in accepting as 'practically certain'. Some quantitative laws (for example the additivity of length) are so fundamental to measurement that any deviations automatically become data for the inferred distribution of errors. Others are so isolated, and come so late in our accumulation of knowledge, that any deviation can be taken as refuting (within the limits of practical certainty) the putative quantitative law. Small and systematic deviations may lead us to speak of an 'approximate' or 'ideal' law. But many cases are intermediate: deviations are taken to contribute data to the theory of error, until the data put too much of a statistical strain on the theory of error. (p. 19)

The cited author is locked into problems of observation. Further examples - for both qualitative and quantitative studies - are everywhere.

22 Indeed, this empiricist tradition is so firmly upheld that Schlesinger (1990), for example, states: "We would only give up our assumption about uniformity if it always turned out to be false, in which of course we would have to abandon the entire scientific enterprise" (p. 533, emphasis added).
Uniformity means that things do not change. Why? First, a preliminary distinction has to be made. Following Aristotle, we could conceive that "the essential properties of a thing are those on which its identity depends. They are the properties of a thing which it could never have lacked, and which it could not lose without ceasing to exist or to be what it is. Accidental properties of a thing are properties which that thing could either have had or lacked" (Bigelow, Ellis, and Lierse 1992, p. 374). Within the uniformity described above — expressed in laws or law-like statements — the essential properties of entities do not change. This sort of essentialist thinking can be summarized in this way:

The statement that an object follows a law involves the presumption that there is some informant agency that makes an object to behave in a certain way and not to behave in any other way. The term 'inform' conveys here the idea that a 'form' is 'in' an object… [it] means that there is something that is in a certain way and that it is not in any other way. If there is only one informant agency, for all objects of a kind in all time, we call it a law (Dopfer, 2005, p. 9, emphases original).

A deterministic conception of the world is involved in such a view; a quotation by the physicist Wigner perfectly pictures this intertwined schema of observation, induction, and [static] laws: "It is…essential that, given the essential initial conditions, the result will be the same no matter where and when we realize these… If it were not so…it might have been impossible for us to discover laws of nature" (Schlesinger, 1990, p. 529). The goal of

23 In the words of Harré (2000): "For Aristotle there is a necessity in causal relations that comes from the fact that they derive from the essential characteristics of material things" (p. 218).
prediction makes total sense in this phrase. The neglect of endogenous change is intrinsically attached to these assumptions, for instance, in the words of Dopfer (2005): "The events the law describes also do not change endogenously unless an exogenous force is introduced into the system. The model is universally deterministic. Given complete information about the initial and subsidiary conditions, the law allows us to retrodict events precisely on to the past and to predict them to precisely on to the future." (p. 10).

Thus, an empiricist view entails a deterministic and uniform world. We can start to label this stance as a “non-evolutionary view” that excludes the notion of time. Why? Bergson, in his text Creative Evolution, which emphasizes the essential unreality of intellectual discoveries, states: "Induction rests on the belief that there are causes and effects, and that the same effects follow the same causes... Induction therefore implies first that ... time does not count" (Gotshalk, 1932 , p. 142). Whitehead (1978), in his major work "Process and Reality", which introduces modern process philosophy (a worldview grounded on change), made a reflection that condenses the picture of science depicted above:

On the whole, the history of philosophy supports Bergson's charge that the human intellect 'spatializes the universe'; that is to say, that it tends to ignore fluency, and to analyse the world in terms of static categories. Indeed Bergson went further and conceived this tendency as an inherent necessity of the intellect. I do not believe this accusation; but I do hold that 'spatialization' is the shortest route to a clear-cut philosophy expressed in reasonably familiar language. (p. 209)

Spatialization is the shortest route, but it is not necessarily the best route.
2.2. The Problem with the Current Foundations of Management Science

Following the last section, the paradigm of management science can be labeled as restricted *empiricism* (e.g., subjective idealism in the sense of Berkeley)—that is, the idea of “science by observation” as the defining character of the scientific enterprise: induction, presentationalism, justificationism, causality, and uniformity. This is taken for granted by the management research community regardless of its awareness that it does so; furthermore, it is hard to find a criticism of this groundwork held by management science.

But what is a paradigm?

It is a prejudice.24

Yet, the last two sentences may sound strange—to say the least—for a number of scientists. After all, we say sometimes that science is a way to fight our prejudices (and based on this belief, we make/support very important decisions). Science is the tool for avoiding prejudices. How can it act in a prejudiced manner?

*Prej·u·dice:* From Middle English and Old French (13c.), and from Latin *praefudicium* (from præ- "before" + *judicium*).

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24 It must be underlined that the goal here is not to present an essay on the concept of “paradigm”; the notion of “prejudice” might be sufficient. Moreover, Masterman (1970) notes and counts the use of the term by Kuhn himself in no less than twenty-one ways. She finally categorizes this Kuhnian mixture into three main groups: *metaphysical or metaparadigms* - as set of beliefs, myths, organizing principles governing perceptions, maps, and so on; *sociological paradigms* – for example, in the form of universally recognized scientific achievements or political institutions, among others; and *artifact paradigms* or *construct paradigms* that include more concrete entities such as text books, or tools, along with other meanings. Besides, this chapter can be interpreted as the presentation of Management “normal science” (in the Kuhnian sense) as *empiricism*, that is, subjective idealism, or positivism (see a discussion on these terms in the work of Blackmore (1979)).
"judgment"), meaning "damage", "an unfair and unreasonable opinion or feeling, especially when formed without enough thought or knowledge."

This section discusses particular problems with the current paradigm of management science, which fits the previous definition of “prejudice”, i.e., an unfair and unreasonable opinion.

### 2.2.1. The Intrinsic Problem Attached to the Method

In the previous sections, a prevalent paradigm (prejudice) of research was outlined, along with various deeper commitments within that view, since it is grounded in the empiricist tradition. Management science provided a source of examples. This section will discuss various intrinsic problems attached to methodological matters that seem to be ignored, underestimated, unnoticed, or neglected in standard management research practices. These problems of methodology are relevant not only because of their questionable consistency but also because they reveal important deeper commitments that seem to prevail and that are questionable as well.

The predominant method of induction will be the starting point.

**The problem of induction**

Above, the approach to research in management science was shown to be induction. It must be underlined that repeated instances of (observed) phenomena are taken as the essential source of knowledge. Popper (1974a) summarizes this approach: “Induction was a process of establishing or justifying theories by repeated observations or experiments” (p. 62). This inductive position and the principle of verification were the driving forces of the influential ideas of the Vienna Circle (Ray, 2000).
The fundamental assumption underlying the principle of induction is that “the future will resemble the past, or, somewhat better, that unobserved cases will resemble observed cases” (Bonjour, 1992, p. 391), a supposition that aims for a preconception of a given uniformity (as it was previously introduced) and that draws attentions to the old Humean problem of induction.25 David Hume, as cited by Howson (2000b), summarized this problem with the question of whether there is anything “in any object, considered in itself, which can afford us a reason for drawing a conclusion beyond it... We have no reason to draw any inference concerning any object beyond those of which we have had experience, even after the observation of their frequent or constant conjunction” (p. 181).

The problem of induction does not have a solution but still produces a variety of discussions among philosophers of science—see, e.g., (Bonjour, 1992; Glennan, 1994.; Lipton, 2000; Maxwell, 1993; Newton-Smith, 2000). Perhaps the best and simplest way to picture it is with a traditional example: a strong and long-lasting prevalent "theory" (until the 17th century) was that “all swans are white”, inferred from uncountable repeated observations (for centuries) of white swans in Europe. Indeed, until that century, it was not a theory but a truth. Then, the black swans of Australia were "discovered" in 1698. The theory happened to be very "wrong", and for a very long time. This seems the simplest way to illustrate the problem.

As was presented earlier, we can always present/invent additional information to protect the method. For example, reflecting a little bit more on the example of the swans, we can see a possible first attempt at a counter-argument based on (as per usual) either the relativism of the evidence or a reformulation of the theory. Taking the first option, for instance, we can demarcate: "The relevant

framework is Europe", or "We do not care about black swans", or "We have only observed a few of them", or "They can be neglected; after all, they do not look like 'normal representative swans' ", etc. The second choice—that is, to reformulate the theory *creating* a new fixed class—is not better: "It could be argued that the black swans are another different *kind* of swan." Now, we have two kinds, “white swans” and “black swans”, although it is difficult for us to dispense with the class “swan”—after all, “They look so similar!” And then, after a while, what do we do if there are thousands of *kinds* of different-colored swans that we start to observe? We proceed with the same argument. At the end, perhaps we can never say anything general about "swans" (the color is only one detail here that now we can label as a “property”; it could be size, particular behaviors, etc.); we can talk only about the white swans, the red swans, the pink swans, and so on. In addition, we will never know how many different kinds of swans exist. Furthermore, based on observation, it becomes difficult to say anything about what a “swan” is (apart from seemingly coming in different colors). Moreover, we are assuming that every individual (say white) swan is equal to every other one. Are they equal?

Management Science seems another perfect example of this situation. The paragraph above reflects most of the discussions held currently, where we commit to the idea of learning by observation with the aim of making any type of general statement that pretends to go beyond what we already observed. This is when our creative mind enters and we start to create diverse instruments to guard the method (e.g., properties, relevant frameworks, new constrained definitions, observation guidelines, etc.). For Hume, it was clear that it was not possible to have such inductive reasoning; being an empiricist, he recognized the problem and argued that the only thing of which can be sure is “constant conjunction”. Any further general statement beyond that - including *any* additional condition, say 'causality' for instance - is, as he said, merely "a psychological propensity" (Howson, 2000b).
Within an empiricist tradition, "we must work with what we are given, and what we are given (the observational and experimental data) are facts of the form: this F is G, that F is G, all examined F's have been G, and so on" (Dretske, 1977, p. 249). However, induction is the way laws—or law-like statements—are built. Probabilistic affirmations do not help either. To illustrate this point: "It may be a law that there is a 90% chance that anything with property P will also have property Q, and yet, as a matter of fact 80% (or any other percentage other than 90%) of Ps are Qs" (Vallentyne 1988, p. 599, emphasis added). Any idea of an "empirical" law seems to be flawed unless further assumptions are made—of uniformity or invariance, for instance. Howson (2000b) summarizes the problem: “For one property which characterizes without exception the members of any sample is, of course, that of belonging to that sample. But it is clearly false that this property will belong to any individuals not yet sampled” (p. 182).

A point to underline is that, therefore, the aspirations of confirmation and verification cannot hold, in principle, if we are going to take the problem of induction seriously. It is not possible to confirm a generality based on particular evidence, as that would be an affirmation that intrinsically goes beyond the evidence. The aspect to stress here is the flawed perspective of looking for confirmatory evidence to support statements that aspire for some sort of generality (as theories do, for example). A foundational issue has to do with the mentioned questionable assumption that the “explanatory power” of a theory is assumed as evidence of its truth, i.e., the premise of abduction—that is, to assume that if the theory explains, then the theory is true. To picture this point clearly, we can return again to the example of the white swans, where the theory used to assert that “all swans are white”. Until the 17th century, the explanatory power of this hypothesis was undeniable (indeed, it was a truth). It can be said that it had reached the “principle of saturation” used in management research. But it is also obvious that it is an erroneous statement.
Stroud (1992) underlines that confirmation theory requires one to solve the problem of induction: “The task of confirmation theory is therefore to define the notion of a confirming instance of a hypothesis and to show how the occurrence of more and more such instances adds credibility or warrant to the hypothesis in question. A complete answer would involve a solution to the problem of induction” (p. 264). Since it cannot be solved, the need arises to justify knowledge, and we are locked into justificationism or induction.

Non sequitur

It might be necessary to emphasize that the problem of induction cannot be solved. To generalize via induction entails a fallacy (non sequitur, "it does not follow"). The conclusion can be either true or false, but this is irrelevant, since the argument is a fallacy: the conclusion does not follow from the premise. It is not an argument.

For instance, with the help of predicate calculus, O'Neill (1989) remarks that the problem of induction is strictly a logical problem, which can be stated as:

\[ \text{No finite set of singular statements: } F_{a_1} \rightarrow G_{a_1}, F_{a_2} \rightarrow G_{a_2} \ldots F_{a_n} \rightarrow G_{a_n}, \text{ entails a universal statement } \forall x(Fx \rightarrow Gx) \]

O'Neill (1989) tries to find an alternative within such logic, relaxing the domains of the quantifiers (that is, he seeks a restricted notion of law, as presented in the previous section). Yet, the problem is the logical validity of the argument. For instance, in terms of basic propositional calculus, modus ponens (“mode that affirms”) is a valid argument: If \( P \), then \( Q \). \( P \). Therefore, \( Q \). The well-known logical fallacy of affirming the consequent shows the problem of induction unmistakably; the assumed inference goes: "If a Hypothesis (H) implies an observation statement (O) and if (O) is true, then (H) is thereby confirmed." Such “inference” is invalid. Furthermore, it is weaker if we express the conclusion as a probabilistic term: “then, (H) is more
probable”; it does not follow (e.g., it can be seen as another way for relaxing the relevant domains or another way of stating sophisticated laws). There is no valid argument—*non sequitur*; (H) cannot be “confirmed”. Eriksen (1989) summarizes the idea flawlessly: "It is quite odd to consider them as general hypotheses. In fact, they are hypothetical singular statements. Hence asking what their confirming evidence is, constitutes a category error. What is relevant is truth or falseness, not confirmation or disconfirmation" (p. 687). In short, the method of induction, in any form, is non-demonstrative\(^2\); it is not an argument, since the conclusion does not follow.

The “argument” of confirmation, so to speak, is pervasive. Perhaps the amusement of verification can be understood based on our natural inclination as human beings to search for confirmatory evidence\(^2\). Indeed, ideas like “the principles of saturation”, verification, or “analytic generalization” are strongly suggested in management research as methodological principles, as was

\(^2\) Not to be confused with the method of mathematical induction, which is demonstrative.

\(^2\) Based on the phenomenon known in cognitive psychology as *confirmation* bias (our propensity to seek confirmatory evidence for our prior beliefs) and *belief* bias (our propensity to evaluate evidence in such a way as to favor prior beliefs), Evans (2002) shapes a suggestive discussion linking these aspects with scientific inquiry and our natural seeming predilection for induction. Confirmation via observation does not hold, but we, as humans, tend to generalize via induction. And yet, for instance, we say that “all men are mortal”, though such a generality cannot be strictly stated empirically. For example, if one were an empiricist, what would be one’s source of knowledge in asserting that all humans are mortal? It would be the observation of all humans, from the first born to the last to die. In fact, setting aside the problems of observation and considering that there have been around 106.5 billion people on the planet since the beginning of human history, and that now there are about 6.2 billion alive, then there are still approximately 6% of cases not supporting the hypothesis, a non-negligible amount. Naturally, it would be worse to affirm that "men are normally mortal" or that "the probability of dying is close to 0.94"! (see Haub (2002) for the calculation of population numbers). But then, why can we affirm that “all men are mortal”\(^?” To advance to an idea from the later chapters, we can appoint out the possibility of *conjecture* or *speculation*: "all men are mortal,” and it does not matter where this theory comes from—i.e., the source of knowledge is not important here. The point is that such a conjecture has not been empirically refuted and that for now it seems to work. What must be noticed is the radically different *way of reasoning*. 
presented above. But the fact is that confirmation and verification as guidelines are misleading, and yet we seem to embrace them firmly. This perplexing situation was underlined by Hacking, who finds ‘the success of the verification principle amazing... for no one has succeeded in stating it!’ (Ray, 2000, p. 250).

To finish this section, we should remember that Popper (1974a) took seriously the problem of induction without skepticism; indeed, he denied the need for inductive inference: “There is no induction: we never argue from facts to theories, unless by way of refutation or falsification. This view of science may be described as selective, as Darwinian” (p. 68). This attitude is basically one of the core ideas of the next chapters, which have to do with the approach to research and the evolution of knowledge in general. The “empirical basis” is valuable for the in-depth study of single cases; in fact, as was mentioned earlier, sometimes the terms qualitative studies and case studies are used interchangeably. And if the research goals are restricted, for instance to enhance capabilities, reflection, intellectual emancipation, etc., then perhaps the concern disappears. The problem is the contradictory aspiration or pretense to go beyond empirical observations in order to affirm a more general statement of any kind based on such evidence.

To generalize via induction is a contradiction in terms. The discussion above should suffice. Aristotle reminds us: "No one can reject the principle of non-contradiction and still engage in meaningful discourse" (Barnes, 1995, p. 29). However, the problem of induction seems to have been ignored. Howson (2000b) notices this: "If this is true, then science stands on no surer evidential foundation than the crudest superstition" (p. 181). The fact is, as Popper (1974a) states, that “induction is a myth” (p. 118).
2.2.2. Costs Attached to the Paradigm

Given that we want to embrace a diverse, dynamic, non-uniform world via observation and induction (which is in principle impossible, as has been presented), management science might become an inconsistent enterprise, an enterprise whose spirit, we usually say, should be guided by a minimal acceptable level of consistency. It is sufficient to recall that theory-building processes, explanatory power, guiding criteria, claims, and alleged validity rely entirely on induction, i.e., science by observation, as was presented. It was also indicated that this approach implies a commitment to presentationalism, justificationism, lawfulness, and uniformity.

Proceeding via induction and struggling for consistency, we have to assume costs that can be summarized as each fitting one of two types:

(1) **To explicitly assume some sort of [restricted, of any type] uniformity of the universe using sophisticated observational devices.**

**Examples:** Neoclassical economics; quantitative approaches used in management.

(e.g., equilibrium criteria, representative agent, rational choice, etc.)

**Difficulties:** To have a sort of induced-uniform-human-static-predictive-social world. *Non sequitur.*
(2) To add auxiliary information, restrictions, multiple theories, etc. in order to propose coherent statements about new observations related to observed ones.

Example: Management/Organization Science
(e.g., “multiparadigmatical” scientific enterprise, huge collection of single unrelated case studies, relativism, etc.).

Difficulties: The impossibility of working with “unique” cases via induction. But research reports end up stating theories beyond observed events. Non sequitur.

Thus,

(I) Should we accept an inconsistent enterprise assuming a static, uniform world (1), (2)?

or

(II) Should we follow the path of Pyrrho the skeptic? 28

28 Pyrrho expressed the major principle of his thought in the word acatalepsia, which expresses the impossibility of knowing things in terms of their own nature. The argument follows. First, against every statement the contradictory statement can be advanced with equal reason. Secondly, it is necessary in view of this fact to preserve an attitude of intellectual suspense, since no assertion is more valid than another; this attitude leads to a state of equilibrium, but it also leads to refusal to speak and to non-committal silence. Thirdly, these results are applied to life in general. Then, Pyrrho concludes that, since nothing can be known, the only proper attitude is imperturbability (ataraxia). "The impossibility of knowledge, even in regard to our own ignorance or doubt, should
To challenge uniformity, (I) seems more promising. Besides, it is hard to accept that we, as scientists, have failed to meet diversity.

2.3. The Challenge to Uniformity: Evolutionary Thought

The way that management science develops theories could be described as follows. Relying on observation, researchers propose general statements via induction. Causality is ascribed to observed regularities in the form of law-like statements that are confirmed with further evidence. This view entails a world that is assumed to be uniform.

The exclusion of change

When new observations do not fit, then we have two options: either to add further auxiliary hypotheses (or additional "explanatory" information) or to assert that "this observed item is truly different and does not belong to the set of expected observations." Or in other words, in a uniform world, novelty means that the thing in question "is from a different [static] class", but "uniform classes (must) remain"—i.e., "It is not conceivable for us to dispense with the idea of a fixed class"—that is, "It is not conceivable for us to dispense with uniformity".

29 This persistence is pictured by Graves (1974):

When mankind made its first inductions, there was neither the possibility of nor the recognised need for any justification. People simply made them, whether from natural instinct or Humean habit. Gradually, we became aware of the fact that inductive predictions were remarkably successful in a wide variety of cases, and that our inductions could be organised in a hierarchy of increasing generality. Suppose we observe an additional black crow, having seen black but never having seen any non-black crows. This confirms the hypothesis that all crows are black. But it also confirms that all crows have the same colour, that all crows have some properties in
The firm assumption of uniformity is hardly challenged in management research literature. Uniformity, closely tied with causal essentialist thinking (see above), excludes the possibility of addressing change. Why? In short, because it is a re-affirmation of a principle of identity. Gotshalk (1932) summarizes this argument:

Uniformity, if anything significant, is a relation between a genuine diversity. But the causal theory, as set forth, actually applies to no genuine diversity. We raise no question of the theory's abstract truth; the theory, as stated, is abstractly true enough; the same cause, under similar conditions, no doubt should produce the same effect, again and again… It merely states (in sum) that A is always A, and fails, so far as experience goes, to state a relationship between real diversity. In short, it amounts to a true but trifling proposition, and is not a significant statement of uniformity at all (Gotshalk 1932, p. 142-143).

Immutable substances are entrenched in any sort of causal law-like statements, which makes sense when one is searching for predictive theories. We can assume static entities interacting through time, but we should then be aware that this position represents an explicit neglect of diversity and a re-affirmation of a uniform nature. The particular point is that time is left out. Why? In short, a re-affirmation of identity is a re-affirmation of the immutability of fixed substances, which in this case refers to the following idea:

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30 Actually, the concern of Gotshalk (1932) is still pertinent:

The principle of uniformity, although sometimes dismissed as irrelevant to science, is more usually asserted to be the basis not only of scientific but of all induction… But few have adequately noticed the unsatisfactoriness of accepted statements of the principle, and fewer have made plain the very great difficulty in attaining a satisfactory statement (p. 141).
A stuff endures by virtue of its inertness; its endurance is conceived to be the retention of its self-identity… [which] is irrelevant to any temporal passage; the stuff is what it is quite irrespective of any transition…it means that stuff cannot endure… it is eternal… For if all substance be eternal, what then is duration? What is time? An ontology of eternity can in the end only explain duration as an appearance and thus as illusory (Leclerc 1953, pp. 227-228, 229).

The ontology of eternity is that of the physical world: "Stellar evolution is a transformational evolution of a system composed of immortal objects; organic evolution is variational and its objects, individual organisms, are mortal" (Fracchia and Lewontin, 1999, p. 64). Thus, it could be affirmed that the ontology of management science is also timeless. When one excludes time, its current causal and/or law-like theories belong to an ontology of eternity. But the domain of management is the social world, a living world characterized by change and diversity. What we would like to understand is why A is not always A, and not why A is always A. With the current grounding, diversity cannot be addressed using management science methods.

The next step seems to be to challenge the strict dependence on our senses as incorrigible sources of knowledge, i.e., science by observation. Where do we start? It seems fitting to question the exclusive dependence on observation. This dissertation suggests that we reflect on the assumption of presentationalism (the subjective idealism of Berkeley, justificationism, etc.) so as to question the standard conception of science embedded in management research. On this basis, the first natural choice seems to be to consider the attitudes known as re-presentationalism (which looks to dispense with the exclusive dependence on the senses), and critical rationalism (which eliminates justificationism in knowledge processes).
Looking Ahead

This chapter presented particular problems that arise when observation is the exclusive approach to scientific knowledge, in particular the neglect of diversity and change. The next chapter explores the distinct character for the logic of research that develops this scientific knowledge in order to address change; this different stance is inspired by biology, the discipline that addresses the living world, which is characterized by continuous change. To close this chapter, a quotation from the biologist Ernst Mayr (1969, pp. 201-201) summarizes perfectly the degree of reframing that is suggested:

Much of science has long been dominated by a conceptual framework derived from Plato and Aristotle. This is what the scholastics called realism, it is what Popper calls essentialism, and what biologists usually call typology. It is an interpretation of the observed variety of phenomena in terms of a limited number of universals, each of them well-defined, fixed, unchangeable, and separated from others by clear-cut gaps. Philosophers place great emphasis on differences in the views of Plato, Aristotle, and other essentialists, but to a biologist they seem very unimportant, in comparison to the drastic difference between essentialist and nonessentialist interpretations. The rather static typological approach of the essentialists has been entirely replaced in evolutionary biology by what is called "population thinking". Phenomena are now described in terms of variable populations of which the statistics (mean, standard deviation, etc.) can be determined. The difference between typological and population thinking is complete. In one case the underlying eidos (or essence) is considered that which has reality and the variation as irrelevant if not imaginary (Plato's shadows on the cave wall). In the other case variation is considered the reality while the statistics and in particular the mean values of samples and populations are the abstraction. An extraordinarily high number of
biological problems are entirely differently interpreted by the topologist and the populationist. Natural selection is meaningless for the typologist and so is gradual evolution. Race for him becomes an all-or-none phenomenon, indeed all racist generalizations are based on essentialist thinking.

Addendum

As was formerly introduced, if the reader of this dissertation is usually labeled as a “philosopher”, then maybe for him, this chapter seemed to be mainly about science—whereas if the reader happens to be what we know as a “scientist” or a practitioner, then perhaps this text seemed to be about philosophy (and maybe meaningless, though hopefully not). Such a distinction is deceptive. If the reader made that distinction, even in the slightest way, then the reader might possibly be divided, with the world of his mind full of static categories that are reinforced with any “new” evidence, every day and everywhere—a world where “philosophy” and “science” are two different and static things that exist among many other spatializations, some of them possibly more harmful than others.
3. EVOLUTIONARY KNOWLEDGE

It was inevitable that such a self-refutation of rationality should be followed by a great outburst of irrational faith. The quarrel between Hume and Rousseau is symbolic: Rousseau was mad but influential, Hume was sane but had no followers. Subsequent British empiricists rejected his scepticism without refuting it …German philosophers, from Kant to Hegel, had not assimilated Hume's arguments. I say this deliberately, in spite of the belief which many philosophers share with Kant, that his *Critique of Pure Reason* answered Hume. In fact, these philosophers - at least Kant and Hegel-represent a pre-Humean type of rationalism, and can be refuted by Humean arguments. The philosophers who cannot be refuted in this way are those who do not pretend to be rational, such as Rousseau, Schopenhauer, and Nietzsche. The growth of unreason throughout the nineteenth century and what has passed of the twentieth is a natural sequel to Hume's destruction of empiricism. It is therefore important to discover whether there is any answer to Hume within the framework of a philosophy that is wholly or mainly empirical. If not, there is no intellectual difference between sanity and insanity.

Bertrand Russell, 1945

*History of Western Philosophy*

**Introduction**

Current and prevalent western epistemologies, with foundations that rest on the subjective experience of man, remain unchallenged (Bartley, 1987a). Sense observations are taken as the exclusive and authoritative source of knowledge, and the consequence is an obsession with justifying such knowledge. The introduction of this dissertation promised a re-conceptualization at the epistemological level (level 3 in the schema developed by van Gigch) of normal science in management research; the second chapter paved the way by showing its inconsistent grounding. Furthermore, the implication was underlined: that of a uniform and timeless world. The previous chapter
presented how these two suppositions pervade management research. It also showed the prevalent assumptions that inform management research, which can be depicted with terms such as presentationalist (idealist, subjectivist), science by observation, justificationist, positivist, anthropocentric, phenomenalist, determinist and static (within a timeless ontology for a uniform world). This chapter presents an available, fair, and respectable answer to the challenge of induction, a reply provided by evolutionary thought. It rejects the claims of positive knowledge of any sort; this is what the term "conjecture" will denote. This dissertation belongs to a quest to include time and abandon certainties; this leads to a different and consistent ground that can be labeled as representationalist (realist), selectionist, cosmocentric, non-justificationist, indeterminist, and as including time and, most importantly, recognizing the uniqueness and creativity of human beings.

In short, this chapter delineates an evolutionary epistemology, namely, a theory of evolving knowledge. The first section provides an introduction to evolutionary theories, approaches that seek to explain change in diverse settings; two main lessons are underlined. (i) Evolution is fundamentally a two-step process, that of variation and selection; the prevalent misunderstandings regarding variation (commonly mistaken for a simple random process) and the process of selection (usually ignored) are emphasized as well. (ii) Regarding knowledge processes, a logic of selection contradicts a logic of instruction; the pervasiveness of instruction as the way we conceive of almost every knowledge process will be criticized; the difference against selection is absolute and epitomizes the epistemological opposition already introduced, that of realism vs. idealism. The second section presents a selectionist (evolutionary) theory of knowledge; here, knowledge is a growing process and is conceived of as a stored program for organismic adaptation in external environments that follows a selectionist logic, one of variation and selection. Several knowledge processes follow that same logic in nature and in several other environments; in particular, the description of the process related to species evolution illustrates the theory, and not only as an example but also
because: (i) Description and logic match, and (ii) Human and scientific knowledge belong to this process. A hierarchy of knowledge processes, running under variation and selection, is presented; also, the notion of substitute functioning and flexible controls in this integral schema is emphasized; moreover, (Neo)-Darwinism is assumed, and with it the implication of a continuum where human (individual, social, scientific, etc.) knowledge processes follow a selectionist logic; the understanding of this continuous character is necessary, so we will briefly follow the growth of knowledge from a paramecium to Einstein; both are part of the same process. The section underlines that it is impossible to address human rationality while ignoring fundamental aspects as instincts, thoughts, habits, language, etc. Human knowledge is an evolved and evolving process. Scientific knowledge also belongs to this continuum, which allows one to clarify the implications that should start to inform level 2 of "Normal Science"; in short: scientific knowledge is demarcated: it follows a selectionist logic, it can act as a substitute functioning for other knowledge processes (e.g., rituals, habits, instincts, etc.), its method is variation and selection, it is conjectural, it is uncertain, it is unjustified, it is objective (this adjective has to be re-examined as well), the question of the source of knowledge is irrelevant to it, and it looks to encounter a real world. The final section underlines the consequences of placing science within the evolutionary continuum for our conceptions of rationality; this discussion delivers a clarification of the method, including its relation to the problem of induction; moreover, the standard theories of rationality are identified as permeated by the logic of instruction; they are unnecessary and inadequate for the theory of knowledge processes presented here and are therefore abandoned. Epistemology is not confined to positivism or, essentially, to instruction.

The first chapter asked about the consequences of neglecting epistemology in management science; the second chapter showed the prominence and also the difficulties of the customary methodological assumptions as related to those epistemologies; this third chapter shows why an evolutionary position truly
different. The claim is that we can achieve epistemologies consistent with a non-uniform and real world so as to drive the growth of scientific knowledge.

3.1. Evolution Revisited

Evolution is perhaps the central organizing concept in biology. It is also one of the "latest fads" outside biology. It has become fashionable in various fields, and with the distortion scientism, it has entered several disciplines; one of the problems with fads is a pervasive analogical, metaphorical or even direct applicability of one field to another; such an exercise, usually posed based on dissimilar assumptions, is simply defective; Mayr (1969) makes the warning regarding the unfortunate growth of pseudo-biology. A preliminary process of clarification is necessary. Yet, the first place to look is biology, the discipline that deals with the study of life. We will see that we can learn in several ways regarding its assumptions and its methods. This is its special character, its grounding or foundations. We can consider as introduction and motivation a famous quotation from Mayr, echoing our story from the previous chapter regarding the books of Aristotle:

I have some five or six volumes on my book shelves which include the misleading words ‘philosophy of science’ in their title. In actual fact each of these volumes is a philosophy of physics, many physicist-philosophers naively assuming that what applies to physics will apply to any branch of science… When it comes to philosophical questions that specifically relate to man, his well-being and his future, it is the science of biology that will be more suitable a starting point… We need far more consideration in philosophy of the significance of unique phenomena and unique events, we need far more consideration of historically evolved programs of information and of the properties of complex systems. We need less numerology and less typological logic. We will not be able to achieve a well rounded philosophy of science, until the important conceptual contributions made by biology in the last
100 years are adequately considered and fully integrated with the concepts derived from the physical sciences” (1969, pp. 197, 202).

It is challenging to establish an outline of general evolutionary theories. Evolutionary concepts have begun to re-emerge as a source of inspiration and application in many disciplines (Metcalfe, 2005). However, although most people have some idea about the meaning of the term evolution, the fact is that it is a confusing, muddled word that is usually used in broad academic circles to denote “development”. A general framework for the concept will be indicated.

The word “evolution” derives from “evolve”, whose first definition is "to unfold, roll out, unroll" – year 1622 - from the Latin term ēvolvĕre: "unroll"; this term itself is derived from ĕ: "out" and volvĕre: "to roll" (Simpson & Weiner, 1989). The first author to coin the term in a scientific sense was Bonnet in 1762, who used it in his hypothesis of embryonic development from a pre-existing form (Simpson & Weiner, 1989). Later, the word "evolution" was associated in its more popular sense with Darwin’s theory, although he never used the word in his main work, preferring to use the expression “descent with modification”, in part because the previous utilization by Bonnet included a sense of "progress” (not in line with Darwin's theory), because of the ambiguity of the word based on usage at that time, and also because

31 Certainly it is older than the term "biology" — introduced in the 18th century. Moreover, "variation" is from the 14th century at least, from Old French and, in turn, from the Latin word variationem (nom. variatio) "a difference, variation, change". And "selection" dates from the 16th century at least, from Latin selectus, pp. of seligere "choose out, select," from se- "apart" + legere "to gather, select" (Simpson & Weiner 1989). This is not only a point of etymological interest. It serves to point out that the discussion of these and other terms in this dissertation is not confined to biology, and that it does not mean to support the application of biological theories in social science, either; following Dopfer (2005), these terms are used here in their general sense unless a specific domain is implied by the context. "It would not be permissible to transfer their theoretical content along with these terms, as if we were simply riding the same horse along a common disciplinary road" (p. 18). In fact, such common epistemological jumps are currently part of the problem, in particular with many so-called "evolutionary theories".
Darwin did not want to be confused with speculation (Gayon, 2003). Ultimately, the term *evolution* refers to development and change, change through time—and this is the point. This distinction sounds trivial, but it is not. Time is an aspect that is widely neglected in science (sometimes explicitly, as, for instance, in static equilibriums in physics or social descriptive approaches such as some ethnographies); this shortcoming is also frequent and unnoticed in management research, as the previous chapter presented. It was also shown that any causal theory with underlying uniformity intended to generalize (via induction) leads to a timeless view of the world. Modern science has often denied *time* a significant role (England, 1994).

An evolutionary stance seeks to explain *change*. This represents a general inquiry\(^3\). Nelson (1995), for example, proposes a wide framework regarding the conditions necessary for an evolutionary theory, expanding the scope beyond natural biology; he advocates the focus of attention on one or more variables changing over time with the goal of understand the process behind that change. Specifically, he defines evolutionary theories, models, or arguments as having three characteristics: “First, their purpose is to explain the

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\(3\) One of the most common misconceptions with regard to evolutionary theories is the automatic connection that is usually made with Darwin, which represents a very narrow view. What then follows is the identification of the theory of evolution with the origin of life — even today, some creationists follow this line of attack. The fact is that this was not the aim of Darwin, though perhaps the title of his *magnus opus* (The "Origin" of Species) might have something to do with it; still, a minimal reading of the book would suffice. Maybe "The Origin of Diversity", or similar, would have saved readers some trouble. Nevertheless, even to check the complete title (*On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life*) or to read the very first line of the preface should be revelatory:

> I will here give a brief sketch of the progress of opinion on the Origin of Species. Until recently the great majority of naturalists believed that species were immutable productions, and had been separately created. This view has been ably maintained by many authors. Some few naturalists, on the other hand, have believed that species undergo modification, and that the existing forms of life are the descendants by true generation of pre-existing forms." (Darwin, 1859, preface)

Afterwards, he proceeds with what we call now an executive summary of the contemporary literature on the subject: how to explain the different forms of life.
movement of something over time, or to explain why that something is what it is at a moment in time in terms of how it got there…Second, the explanation involves both random elements which generate or renew some variation in the variables in question, and mechanisms that systematically winnow on extant variation. Third, there are inertial forces that provide continuity of what survives the winnowing” (Nelson, 2001, p. 169).

Following this general characterization, Campbell (1987b) underlines that evolution is frequently proposed as "the universal non-teleological explanation of teleological achievements, of ends-guided processes, of fit" (pp. 54-55). In general, natural selection constitutes a basic general principle, since it can be framed by different, subsidiary assumptions (Mayr, 1984); for instance, Metcalfe (1994) sees competitive selection as a universal principle not related exclusively to biology; he later sets up a framework of evolutionary concepts that define any evolutionary dynamic and that have nothing inherently to do with biology and related disciplines based on the ideas of development, selection, variation, fitness and adaptation (Metcalfe, 2005). All of these characteristics are included in the meta-design to be presented here grounded on an evolutionary theory of knowledge as initially proposed by Popper (1972; 1974a) and further developed by Campbell (1987a; 1987b). Evolution is not confined to biology; indeed, this chapter presents a broader view that assists one in understanding the scope of evolutionary thought.

### 3.1.1. Variation and Selection

The question of what is essentially an evolutionary theory is not resolved (Barnett & Burgelman, 1996). This section presents a broad summary. Two fundamental distinctions will be underlined. On the one hand, we will consider the general depiction of evolution as a process that consists fundamentally of two steps: variation and selection; on the other hand, we will examine the perspective evolutionary thought that is taken up in this dissertation: it is seen fundamentally as a selectionist logic for explaining the growth of knowledge,
as opposed to the instructional logic that is attached, again, to the problem of depending on observation; this logic of "learning by instruction" describes the assumptions of management science. Karl Popper and Donald Campbell are perhaps the main proponents of the view of evolution as a knowledge process, where organic evolution is just one case used as an illustrative example; they will be the main guides to the evolutionary view presented here.

Behind the creative force of evolutionary change, two major steps must be distinguished: variation and selection.

Regarding the variation process, the provider of the ‘raw material’, it was already clear for Darwin that variation should be generated in copious and dependable amounts and that it should be undirected (Gould, 2002). Campbell coined the expression blind variation, preferring it over the term “random” as used by Ashby in his Homeostat; “blind” essentially denotes that "variations are produced without prior knowledge of which ones, if any, will furnish a selectworthy encounter" (Campbell 1987a, p. 92). Here, "blind" does not mean the strict equiprobability of alternatives; it just underlines that the probability distributions of variations are independent of previous experiences, potentially successful trials or targeted goals. Campbell emphasized three conditions: (i) The variations emitted are independent of the environmental conditions of the occasion of their occurrence; (ii) The occurrence of individual trials is uncorrelated with the solution—specific correct trials are no more likely to occur at any point in a series of trials than another, nor than specific incorrect trials; (iii) The rejection of the notion of a "correcting" process between variations—that is, a variation subsequent to an incorrect trial is not a "correction" of an earlier one. The direction of evolutionary change is granted in the second step, in the form of selection, which works upon variation, as is presented next.

Selection occurs due to the elimination of unsuccessful forms by the environment and through a hierarchy of plastic controls, the term coined by
Popper (1972). The general logic of problem-solving is trial and error-elimination through this hierarchical system of flexible controls. Or more specifically, the error-elimination process may proceed either through the elimination of unsuccessful forms or through the evolution of those controls; this last point is central and frequently ignored. Along the same lines, Campbell (1987b) remarked that general knowledge processes involve several mechanisms at different hierarchical levels of substitute functioning; at each level—a type of template—there is a kind of selective retention process acting as a plastic (flexible) control. He identified for biological and social evolution ten levels ranging from the most primitive non-mnemonic problem-solving layer, to higher levels like habit, instinct, visually and mnemonically supported thought, and imitation, to levels such as language, cultural cumulation, and science. Before this hierarchical schema is described, an important comment will be underlined: what we mean by “selection” here and why is important to demarcate it.

3.1.2. From Instruction to Selection

**in·struc·tion:** from Latin *instructus*, pp. of *instruere*  
"arrange, in-form" from *in-* "on" + *struere* "to pile, build, assemble" — related to *strues* "heap".

The old debate usually labeled as Lamarckism vs. Darwinism defines the way in which information processes are characterized, in particular adaptation and learning processes. Lamarck's theory of transformational evolution is no longer accepted today in biology, having been replaced by Darwin's theory. The debate concerned the mechanism of inheritance, which is introduced next.

A Lamarckian position in biology involves the possibility of inheriting phenotypic acquired traits, i.e., the idea that organisms might be slowly transformed during evolution through the inheritance of characteristics acquired during each lifetime (Mayr, 1997). Here, function precedes form, and
learning occurs by *instruction*—as opposed to *selection*—by the environment, through a relatively passive process of combination, accumulation, repetition, and induction (Bartley, 1987a). Knowledge is expanded stage-by-stage via cumulative inductive achievements (Campbell 1987a). There is a corrective logic to this process based on partial truths or partial knowledge; hence, there is a defined notion of ‘progress’. In the words of Gould: "Lamarckism represents the quintessential theory of directed variability. Variation arises with intrinsic bias in adaptive directions either because organisms respond creatively to ‘felt needs’ and pass acquired features directly to their offspring, or because environments induce heritable variation along favoured pathways" (Gould, 2002, p. 145). In the broader view of Popper (1974b): "Lamarck explained adaptation as the result of more or less direct instruction (through repetition) by the environment to an aim-seeking organism" (p. 1023). *Instruction* matches in principle the notion that criteria can be developed for conceiving of progress. It also matches the common notion of *adaptation* as a process in which the organism adapts to (responds to) the environment based on its acquired knowledge and based on a process of progressing correction; *the organism is instructed by the environment*. Notice also that this common view of (Lamarckian) adaptation denies the fact that variation is blind. The final blow for this position was due to the findings in molecular biology establishing that the information in proteins (phenotype) cannot be transmitted to the nucleic acid (genotype) — see, e.g., (Mayr, 1997). Inheritance is Mendelian, not Lamarckian.

In contrast, a Darwinian position, recognized by biologists as the explanation of evolutionary change, emphasizes blind variation and the fact that adaptation and selection are driven by the environment according to the fitness of organisms. Originally, Darwin did not reject the idea of the inheritance of acquired traits; after all, he knew little about the mechanism of variation. However, in its most restricted form, the currently accepted neo-Darwinian synthesis (in short, an integration of Darwinism and Mendelian genetics) denies the possibility of the inheritance of phenotypic traits by organisms;
Evolutionary Knowledge

inheritance operates only at the genetic level (Mayr, 1984, 1997). Therefore, learning and adaptation are conceived of differently; instead of repetition or a cumulative process, what takes places is trial and error-elimination for unsuccessful responses. Exploration goes beyond the limits of foresight or prescience. In this sense, it is blind (Campbell 1987a). "Adaptation" is explained as the result of selection instead of as Lamarckian instruction (Popper, 1972).33

Human beings have a strong propensity to favor instruction, which perhaps seems more intuitive to us; this is also a natural indication of our dependence on observation. The examples of various knowledge processes might help to illustrate this. The scope and significance of a shift from instruction to selection might be better summarized in the words of Nobel laureate Niels Jerne:

Looking back into the history of biology, it appears that wherever a phenomenon resembles learning, an instructive theory was first proposed to account for the underlying mechanisms. In every case, this was later replaced by a selective theory. Thus the species were thought to have developed by learning or by adaptation of individuals to the environment, until Darwin showed this to have been a selective process. Resistance of bacteria to antibacterial agents was thought to be acquired by adaptation, until Luria and Delbrück showed the mechanism to be a selective one. Adaptive enzymes were shown by Monod and his school to be inducible enzymes arising through the selection of preexisting genes. Finally, antibody formation that was

33 The advantage can be enjoyed not only as a result of particular characteristics but also as a result of higher reproductive success. For instance, we can see regarding adaptation of a species in biology, the following: "An individual may be more successful not by having superior survival attributes but merely by being more prolific reproductively" (Mayr 1997, p. 192). This issue in particular is commented on at the end of this chapter regarding evolutionary economics and Gould’s theory of punctuated equilibrium.
Evolutionary Knowledge

thought to be based on instruction by the antigen is now found to result from the selection of already existing patterns. It thus remains to be asked if learning by the central nervous system might not also be a selective process; i.e., perhaps learning is not learning either. (1967, p. 204)

Indeed, all the cases mentioned by Jerne are nothing more than knowledge processes. The instructional view has permeated our assumptions regarding knowledge. But now Darwin has won the battle over Lamarck with the development of genetics; several fields are finally recognizing that selectionism is perhaps a more accurate way to describe certain processes. Thus, several examples of selectionist processes are now at hand. The functioning of the brain and the nervous system is better described as a selectionist system (Calvin, 1989)—as opposed to the Lamarckian position, which takes the functioning of the nervous system as a learning process with correction and directed progress via feedback adjustment; this was the way that scientists have tended to depict the brain, as an instructional system. We actually know that the immune systems of vertebrates are also Darwin machines (Calvin, 1987; Jerne, 1967). Even a goal-directed movement like target selection in complex visual scenes is driven by the selective facilitation of chosen eye movements before their execution (Basso & Wurtz, 2002). The evolution of human language and the specialization of grammar have been also explained as selectionist processes (Pinker & Bloom, 1990). At the computational level, the most prominent examples are known as Darwin automata (J. L. Krichmar & Edelman, 2003). Many of these instances will be indicated below when this chapter covers the continuum of the growth of knowledge.

3.1.3. Selection: The Driver of Change

The shift from instruction to selection is significant; it means that the growth of knowledge is not a progressive process of correction based on partial truths.
The Lamarckian postulation suggests directed and constrained generation guided by a corrective logic. A Darwinian stance emphasizes copious, undirected blind variation. The particular conception of variation generation affects not only the characterization of the production of alternatives but, in general, the conception of learning and adaptation processes, thus framing our notion of control and the corresponding role of organisms. Based on a typical instructional logic, the generation of variations is conditioned by externalities and by previous efforts; there is intended progress, instruction, restriction, rectification; the environment takes the leading role, and the organisms follow the changes by adapting to their milieu. On the other hand, according to a selectionist logic, the exploration process is constrained neither by any previous result nor by foresight. The organism is an active agent instead of being a passive responder. Popper underlined that the method of trial and error-elimination is not completely based on chance-like or random trials, since the organism "establishes controls which suppress or eliminate, or at least reduce the frequency of, certain possible trials" (Popper, 1972, p. 245). Nevertheless, the point is not the source of variation; the point is the extent to which the variational process is conditioned by the environment. Blind variation consists of independent trials within hierarchies of (selective) templates; this is the meaning of "vicarious" (indirect) selection. Still, every trial is independent: it is not a correction of previous efforts. The templates vicariously direct variation generation and are arranged in nested hierarchies that form the evolution of increasingly specific selection-criteria, but generation is still blind; there is no partial truth, and the generation of alternatives is kept blind within those templates. There is no conditioned direction. This also means that adaptation and change are not subordinated exclusively to control mechanisms, e.g., feedback processes; rather, the

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34 Biology provides the example: "the crucial difference between Darwin's and Lamarck's mechanisms of evolution is that for Lamarck the environment and its changes had priority. They produced needs and activities in the organism and these, in turn, caused adaptational variation. For Darwin…the variation was not caused by the environment either directly or indirectly" (Mayr, 1982, p. 354).
converse is the case, where control mechanisms contribute to error elimination and become part of a broader selectionist logic that drives adaptation and in which possibilities of survival are maximized and change is not restricted by the past. Selectionist systems do not work based on partial truths; no prior knowledge of the environment or any information transfer from the world is necessarily needed to propose variations or directing adaptation. These systems do not depend on processing information from the milieu; instead, adaptation is related to the profuse generation of possibilities and the selection of successful ones. New aims can be always invented and controlled through variation and selection. As mentioned, we now know that this logic works for the immune system, perhaps the best defense mechanism of which we have knowledge. It also works for the nervous system, which is perhaps the most advanced known type of control machinery. And it is also the way that we explain knowledge growth and survival within the most creative process of which we can conceive: the development of life on earth.

Campbell remarks that the rejection of blind variation means an objection to the theory of natural selection in biological evolution (Campbell 1987a). After all, the way biological adaptation is achieved is currently explained using Darwinian theory, Mendelian genetics, and our understanding of RNA and DNA (Gould, 2002; Mayr, 1997); in short: "There is blind variation, which may be attained through gene mutation or random recombination of the genetic material, and which also may be attained by variation in behaviour leading to the selection by the organism of a new niche. This is followed by duplication or invariant reproduction, and by natural selection" (Bartley, 1987a). However, a particular comment must be made, since Darwinian theory is often mistakenly understood as a theory of pure chance (Dawkins, 1996), with critics failing to recognize that it is a two-step process. Variation is blind; it provides the material for change via mutations and genetic recombination. But selection—the second step—is essentially non-random; selection is, in fact, ‘natural’, i.e., driven by the environment. Nature ‘decides’ so to speak, though the expression is misleading given that it suggests a sort of selecting agent or
force; more accurately, selection is the *non-random elimination* of most variants through a *multi-layered evolving system of plastic controls*, which leads to the survival of better-adapted individuals; this will be presented in the next section. In biology, this Darwinian logic is no longer challenged today; that is, it has been established that evolution is due to genetic variation and (natural) selection, and that both are necessary. Current controversies are centered on particular topics *within* such principles, e.g., the characterization of the units (or better, ‘targets’) of selection, whether genes, whole individuals, or even entire populations (Mayr, 1997).

The idea of the process of blind variation and selective retention as a general problem-solving strategy and explanation for adaptation seems at first hard to accept; after all, biological evolution is not a conscious process as such. Yet, the definition of a “problem” is a late addition. For example, Popper suggests that "the evolution of the eye solves the problem of giving a moving animal a timely warning to change its direction before bumping into something hard. Nobody suggests that this kind of solution to this kind of problem is consciously sought" (1972, p. 246); Popper emphasizes that here a “problem” emerges from hindsight; furthermore, this problem-solving strategy inherently assures expansive creativity and extensive innovation.

Regarding social science in particular, it is not hard to find in the literature the rejection of Darwinism based on erroneous grounds that are mainly related to issues such as teleology, a supposed exclusion of human intentionality, an alleged denial of self-organization, or the view of evolutionary discussions as mere (and futile) analogies. These positions are now recognized as mistaken and ungrounded. Apart from the works of Popper and Campbell, the interested reader may consult, for instance, (Berninghaus, Güth, & Kliemt, 2003; Dopfer, 2004, 2005).
The two-step process of evolution was depicted along with the significance of its selectionist nature as opposed to that of instruction. The next section introduces a selectionist (evolutionary) theory of knowledge.

3.2. Evolutionary Knowledge

Bartley (1987a) introduced the origin of evolutionary epistemology, acknowledging the foundations set up by Popper: "[He] has found in biology and evolutionary theory, and particularly in the comparative study of animal and human cognition, a new argument for objectivism and realism - an argument against presentationalism and for representationalism" (p.18). Donald Campbell seems to be the first one to have coined the term "evolutionary epistemology" (Popper 1972), which finds its origin in biology, based on the recognition of man as a result of biological and social evolution. Evolution here is a knowledge process that follows the logic of natural selection; the increments of knowledge in that process involve not only the development of the species but also other epistemic activities such as thought and science. This epistemology has been neglected in the dominant philosophical traditions. Additionally, it must be underlined not only that it is analytically consistent but also that it is a descriptive epistemology of man as knower according to contemporary science; that is, analysis and description happen to agree (Campbell 1987b).

The term knowledge is used here with great significance:

This extended usage of "knowledge" is a part of an effort to put "the problem of knowledge" into a behaviouristic framework which takes full cognizance of man's status as a biological product of an evolutionary development from a highly limited background, with no "direct" dispensations of knowledge being added at any point in the family tree... Suffice is to say here that the position limits one to "an epistemology of the other one". The "primitives" of knowledge can not
be sought in "raw feels" or in "phenomenal givens", or in any other "incorrigible" elements. While man's conscious knowledge processes are recognized as more complex and subtle than those of lower organisms, they are not taken as more fundamental or primitive. In this perspective, any process providing a stored program for organismic adaptation in external environments is included as a knowledge process, and any gain in the adequacy of such a program is regarded as a gain in knowledge (Campbell 1987a, p. 92, emphasis added). 35

Therefore, evolution is conceived of as a process "in which information regarding the environment is literally incorporated...in surviving organisms through the process of adaptation. Adaptation is, for Darwinians, an increment of knowledge" (Bartley, 1987a, p. 23). Variation is generated, selected, and maintained/propagated through evolutionary cycles. The schema follows a nested hierarchy of selective-retention processes including, in particular, various human and social processes like that associated with scientific knowledge. The use here of the term "knowledge" is based on the full appreciation of man as part of a continuum36 of biological and social evolution. Given this element of continuum—i.e., the fact that there is no injection or transference by instruction in a different kind of knowledge—it is a process of growth where higher knowledge processes are addressed as part of the progression. For example, scientific knowledge acts as a substitute in terms of function for other processes such as habits and other cultural accumulations—

35 The expression "epistemology of the other one" refers to the commitment to an organism-environment dualism, or more specifically, the dualism of an organism's knowledge of the environment against the environment itself; that is, the study of the relationship of an organism's cognitive capacities and the environment they are designed to cognize. Naturally, this position assumes a real world to be known, and a central question becomes the fit between knowledge and the world (see Campbell, 1987b).

36 The term "continuum" refers here to the notion that man is a product of selectionist neo-Darwinism. It does not refer to the process of Darwinist evolution as such, which is better described as variational evolution (as opposed to Lamarckian transformational evolution, which resembles a continuum on an arrow of progress).
e.g., rituals. The continuum in particular denotes the place and the logic of particular knowledge processes that we are interested in addressing in this dissertation: scientific knowledge, whose evolved and evolving character we end up ignoring if we address it analytically as separate and as built on self-contained categories. Accordingly, these processes follow a selectionist logic and hence knowledge, including scientific knowledge, is conjectural, unjustified, and objective (i.e., real, representational, though imperfect)—not learned by instruction. This affirmation holds for animal knowledge, human knowledge, social knowledge, and scientific knowledge; it is developed through the continuum that is described next.

3.2.1. Growth of Knowledge through Nested Inter-Playing Selective-Retention Processes

The brief description of this hierarchy helps one to understand the way evolutionary epistemology is postulated; this schema is based on the works of Campbell (1987a; 1987b) and Popper (1972). Basically, here we see presented an updated version using the same framework but illustrating it with relevant examples (most of them taken from contemporary biology) and with particular emphases added. This account follows the same classification and order presented by Campbell (1987b). Today, almost half a century after Campbell’s contribution (the original article on blind variation and selective retention was published in 1960, and its full development was published in 1974; both were reprinted in 1987), these ideas should be reinvigorated given the latest advances in biology, neuroscience, and related disciplines. It should be also emphasized that this is not an application of evolutionary biology to knowledge theories (a common misreading). In fact, it is the other way around, so that the recognition of biological evolution is a specific case of a broader stance that explains processes of growth of knowledge. But, first and foremost,
it is a theory of (human) knowledge with a *logical character*, and this is the main interest for this dissertation\(^{37}\).

Evolution is conceived of here as a growing hierarchical system of *flexible* controls; the controlled subsystems make trial and error movements that are partly suppressed and partly restrained by the controlling systems (but they are not "replaced" by the higher levels), and yet, the search is kept blind as it was defined above. Moreover, the hierarchy is not rigid but is rather flexible — there exists considerable overlapping and interplay.

(I). **Non-mnemonic problem-solving.** A blind locomotor search constitutes the most direct exploration. A good example is the paramecium: blind variation in locomotor activity takes place until a nourishing place is found, at which point the solution is then retained through stopping movements; i.e., there are no more variations. When the food supply is exhausted, then blind variation is again generated (i.e., movement), but there is no memory involved, no re-use of previous successful solutions.

(II). **Vicarious locomotor devices.** Spatial exploration via locomotor trial and error can be substituted for by higher functions. A distance receptor such as radar is a good example of these indirect devices. The echolocation mechanisms of bats follow the same principle. The walking stick that a blind man uses in a new environment serves a similar search process.

Vision as included at this level is just another vicarious function, and it is also indirect because it is a substitute for the more costly blind locomotion; it is also indirect in the sense that the radar is, because both are very imperfect mechanisms of *representation*, *like any other sense*; this is the place to

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\(^{37}\) In words of Popper (1972): "We epistemologists can claim precedence over the geneticists... I contend that the leading ideas of epistemology are logical rather than factual; despite this, all of its examples, and many of its problems, may be suggested by studies of the genesis of knowledge" (pp. 67-68).
underline that perception acts as another vicarious function with a blind search component; it does not have a privileged status for epistemology. Furthermore, as is true of every knowledge process considered here, vision works based on trial and error; indeed, we now recognize that even human vision follows a selectionist logic, as was already suggested by Campbell: "the multiple photocell device, or the eye, uses the multiplicity of cells instead of a multiplicity of focusings of one cell, resulting in a search process equally blind and open-minded, equally dependent upon a selection-from-variety epistemology" (Campbell, 1987b, p. 60).

(III). Habit. Along with the next level, habit selects or terminates visual search and trial-and-error learning. Furthermore, learned adaptive patterns that are discovered by trial and error learning may precede instincts; habit provides "a selective template around which the instinctive components (see below) could be assembled" (Campbell 1987b, p. 61).

38 One of the first explicit challenges to presentationalist studies of perception and cognition claiming the role of evolution in epistemology, i.e., that knowing is an evolved function after all, can be found in the work of Shimony (1971).

39 Campbell develops this idea in detail in a paper with the suggestive title "Perception as Substitute Trial and Error" (1956). Yokoyama and Yokoyama (1996) show how our 125 million photoreceptor cells in the retina of each eye have evolved, e.g., the mechanisms involved are the same among vertebrates, etc. On the specific process of vision, the up-to-date debate is not settled regarding what occurs first, recognition or selection; the theory holding that selection is prior to recognition dates back to the work of Donald Broadbent (1954; 1958), who also studied hearing processes based on the same hypothesis. But what is clear now is that vision is an indirect process that involves internal competition regardless of the moment in which selection occurs; furthermore, the "early selection" theory appears to hold largely, e.g., given that visual stimuli compete for limited neural resources, the Posterior Parietal Cortex seems to help visual selection by exerting a top-down influence on information processing (Hung, Driver, & Walsh, 2005). Bundesen et al. (1997) show evidence that the initial allocation of attention to items in a visual display is independent of any contact between stimulus and entries. Similarly, target selection during saccadic eye movements in complex visual scenes seems to be driven by the selective facilitation of chosen eye movements before their execution (Basso & Wurtz, 2002). That is, these processes follow not instruction but blind variation and selection.

40 Naturally, not all habits are convenient, though we may not notice it. A perfect example is the method of induction, which is merely a habit that seems to be taken for granted, as the last chapter
It is important to notice that habit seems to have been removed from many cognitive and rational theories as a meaningful and relevant process, as Baldwin (1988) underlines. However, habit is another knowledge template that must be included in any attempt to understand and address human knowledge; habits function as templates, and new habits can also be generated and further selected.

(IV). Instinct. For Campbell, the hierarchical order between habit and instinct is not clear, since they are closely interconnected, e.g., instinct also selects visual searching. But in any case he summarized: "In the habit-to-instinct evolution, the once-learned goals and sub-goals become innate at a more and more specific response-fragment level" (1987b, p. 62).

Presented. Creed (1940) delivers this point, concluding that induction is just another human habit; though she is trapped by the problem of justification as well (another closely connected habit), she still addresses the question of how to justify induction. However, evolutionary thought can take another path (a more consistent, more rational one) to the challenge of Hume: to abandon justification (see below); that is, higher levels (e.g., human thought) may suppress variations at lower levels and new habits can be re-generated. More recently, and similarly in the context of science, Margolis (1990) uses a Kuhnian framework in order to explain paradigmatic changes in the function of what he calls "habits of mind", which he defines as "scenarios or templates or patterns that guide intuitions in the automatic, non-conscious, hard-to-change way characteristic of physical habits" (p. 432). In the schema presented here, science is a higher selective-retention process of knowledge and can substitute for lower processes (like habits) acting as a flexible control.

Baldwin (1988) in particular criticizes the excessively preference in sociology for cognitive models of the human actor, e.g., the rational actor of exchange theory, game theory, or the incessant reflective actor of symbolic interactionism and interpretive theories. (Many of these models are also used in Economics and Management Science.) For Baldwin, this is an "overly cognitive view of man" (p. 36) that has produced "a narrow and distorted view of human behaviour and society" (p. 53); he calls for including habits in these analyses, as this dissertation also suggests.

The association of instinct as a form of knowledge is not new either, though the idea has encountered strong resistance. For instance, Lighthall (1930) made a strong defense with his article entitled "The Knowledge that is in Instinct". In the first half of the 20th century, when evolutionary ideas were just starting to inform philosophy, this position was revolutionary because
Similarly as with habit, *instinct* seems not to be properly recognized as part of human knowledge processes, a point that is also rejected in this epistemology but that has found a very strong opposition, perhaps best explained through our traditional belief in the radical separation of the evolutionary continuum. For example, Arnhart (1994) takes up this discussion of instinct in order to link it with political science and a very old controversy. On the one hand, we have the ideas of Hobbes, who assumes a separation between animal societies (for him founded exclusively on instinct) and human societies (for him founded on social learning); this argument leads to support a common modern view of culture as the unique realm for *social* learning. Of course, this thesis is now strongly challenged by contemporary biology (again), which shows that non-human animals have a capacity for learning and teaching that allows for cultural traditions. On the other hand, there is the old claim by Aristotle that there is no division between animal instinct and human learning; he believed that animals have instincts for social learning enough to live as social and political animals, which today is far more easily recognized in so-called social animals such as lions, killer whales, ants, chimpanzees, etc. A full exposition of this debate for the context of political science, and for that of the social order in general, is found in the paper by Arnhart (1994).

during the strong tendency to separate instinct from intelligence and relate the former with animals and the latter exclusively with man; see, e.g., Dunlap (1922) for a summarized exposition of the debate and its relationship to the question of acquired habits. Lighthall (1930) finished his statement in this way: "In our pride of intellectual forms, we should keep in mind that there is deep knowledge in Instinct (including function); that warnings of ‘common sense’ should never be lightly dismissed; that the trust of the infant is founded on a hidden reason; that the voice of conscience comes out of a larger world… We who claim to be intellectuals are *not* exclusively ‘the people and wisdom will *not* die with us’" (p. 501, emphases original). In the evolutionary continuum of knowledge, there is no such dichotomy between instinct and intelligence; these are not mutually exclusive categories but are instead interplaying processes.
In the evolutionary epistemology presented here, the position held on this particular point can be identified as Aristotelian (to use the previous example); there is no division, as instinct is a knowledge process in the same way that language, thought, and culture are; these are further levels in this integral selective-retention hierarchy of knowledge (see below) and constitute flexible controls over other levels.

(V). Visually supported thought. Campbell summarizes this level as follows: "With the environment represented vicariously through visual search, there is a substitute trial and error of potential locomotion in thought" (1987b, p. 62).

A simple and illustrative example borrowed from Cziko (1995) illustrates this substitute function in human thought and may suffice to make the point:

Imagine attempting to rearrange the furniture in your living room to accommodate an upright piano. In looking over the room as currently furnished, you could readily imagine other possible arrangements. You might think, "The sofa could be moved from the back wall to under the window, freeing up wall space for the piano, and the two chairs currently under the window could be moved to the empty corner." Of course, this plan may not prove to be the most acceptable if you then realize that the piano would block access to the built-in bookcase, but other arrangements could easily be imagined as you observe the room's current configuration and contents. Once a decision is made, however, you could implement it directly, without having to try out physically each of the arrangements you considered and then rejected in your thinking. (p. 146)
This function is found in non-human animals, too; for instance, Campbell (1987b) mentions problem-solving strategies in apes that require the support of a visually present environment\footnote{The issue of animal thought might not be free of controversy. Just two examples will be mentioned along the lines of non-human knowledge. (i) The matter of \textit{conceptual representation} and vision is tightly linked in animals. For example, Gil-da-Costa et al. (2004) recently found for rhesus macaques that conspecific vocalizations elicited activity in higher-order visual areas, including regions in the temporal lobe associated with the visual perception of object forms and motion and in storing visual object information in long-term memory; they underline that such neural circuitry corresponds to the network shown to support representation of conspecifics and affective information in humans. They conclude the paper with this sentence: "This system may have served as an important substrate for the subsequent evolution of language in humans." (p. 17521). Language is a higher template in the schema presented here which matches this hypothesis (see below). (ii) Even more sophisticated knowledge processes in non-human animals can be mentioned which are also supported by vision stimulus. Hauser (2005), in an article with the suggestive title "Our Chimpanzee Mind", presents what he calls "folk" mathematics and "folk" psychology; that is, these are operations in the absence of education or other acquired experiences, part of what is known as the brain's core knowledge. For instance, folk mathematics refers to chimps' representation, in parallel, of small numbers of objects or events; he underlines that this sense of number is evident in several non-human species in contexts like foraging, group hunting, food sharing and intercommunity warfare. Hauser also suggests that perhaps the computation that enables unique human abilities is related to language.}\footnote{Memory plays a definitive role in the knowledge processes of non-human animals as well; to name just one illustrative example, it has been found that memory helps to increase seed foraging efficiency in particular species of ants (Johnson, 1991).}.

\textbf{(VI). Mnemonically supported thought.} Instead of through visual representation, the environment can be \textit{indirectly represented} in memory; blindly emitted thought trials are selected by a vicarious criterion substituting for an external state of affairs (Campbell, 1987b).\footnote{Memory plays a definitive role in the knowledge processes of non-human animals as well; to name just one illustrative example, it has been found that memory helps to increase seed foraging efficiency in particular species of ants (Johnson, 1991).}

Campbell underlines the evolutionary logic at this level and its consequences: "The net result is the ‘intelligent’, ‘creative’, and ‘foresightful’ product of thought, our admiration of which makes us extremely reluctant to subsume it under the blind-variation-and-selective-retention model" (1987b, p. 62); such a view of this general trial-and-error creative process is illustrated by him with
reference to a wide range of areas and thinkers, including Ashby and his Homeostat, Hebb, Riggs, and Platt on vision, Bain on the psychology of creativity, Souriau on innovations, and Poincaré on mathematical inventions, among many others (Campbell 1987a). Several years after Campbell's first proposal, Calvin (1987) acknowledged his contribution when he affirmed that "it has been recognized that even the highest-known biological function, human thought, involves random generation of many alternatives and is only shaped up into something of quality by a series of selections" (p. 34). Still, the idea of trial-and-error creative thought has not been assimilated; this is perhaps connected with our entrenched view of learning as a Lamarckian process of instruction consistent with an anthropocentric worldview. Questions regarding this belief follow.

Psychology is one area that is contributing to the confrontation of the Lamarckian view. For instance, Simonton (1999), inspired by the work of Campbell, shows how psychology research in the last forty years largely matches this evolutionary conception, not only referring to introspective reports of recognized creators but also based on experimental evidence (on human creativity and computer creativity), psychometric tests (creativity tests and personality assessments), and historiometric evidence (related to talent development, professional careers, stylistic development, and sociocultural environment) regarding creative individuals; in all of these cases, he shows how blind variation and further selection is the core concept for understanding and explaining human creativity. Furthermore, he finishes with a broad assessment:

The psychoanalysts, the Gestalt and humanistic psychologists, the behaviourists, and the cognitive scientists all have their separate opinions about how creativity works... The variation-selection process may subsume all the alternative accounts as special cases of the more general process... All hypothesized mechanisms and processes can effectively operate on at least at some occasions... In a sense, each
rival theory of the creative process becomes a ‘metavariation’, where each metavariation is given the chance to solve the problem at hand… Because the variation-selection model can encompass such a diversity of processes, at some profound level creativity must be Darwinian. In both cultural and biological evolution, it may constitute the single most important explanation for creative innovations. (Simonton, 1999, p. 322)45

Furthermore, the very internal process of thought seems to follow trial-and-error, a conception that has challenged our previous view of the nervous system46 and that was unknown to Campbell when he published his work on blind variation and selective retention. The fact is that our image of the brain has dramatically changed in the last two decades; this shift is perhaps the biggest change in the way we understand learning, and it has implications for any area that seeks to understand human knowledge processes.

45 This broad position of Simonton can be supported by the evolutionary epistemology presented here as long as selective-retention levels can be related to those diverse theories (e.g., psychoanalysis, Gestalt theory, etc.) for explaining particular creative strategies. The issue of Psychological Inquiry where the article of Simonton (1999) appears includes a full discussion by other nine commentators on that targeted paper with, naturally, diverse reactions; that whole discussion shows how defiant is evolutionary thought for standard epistemologies and customary assumptions.

46 For example the prominent field of cybernetics must be mentioned here. Thinkers like Wiener, Ashby, McCulloch and von Neumann led to conceive the brain as a computing system following an instructional logic for producing adaptive behaviour via goal-seeking feedback that aims to warrant homeostatic behaviour, e.g., (Ashby, 1958, 1960); in particular the work of von Neumann has been fundamental for our modern conception of instructional, stored-programs computers, that is, a sequential processor with a repertoire of instructions known as a von Neumann machine; a typical view of this influential idea in the second half of the 20th century is depicted in the paper by Weisert (1965); naturally the best resource is the direct source—von Neumann (von Neumann, 2000), whose work was originally published in 1948. A general overview of the contribution of von Neumann in the context of the history of computer science is found in the work of Goldstine (1977). A criticism to organizational cybernetics from a selectionist point of view is developed by Olaya (2009).
The book by Calvin (1989) entitled "The Cerebral Symphony" pictures this radical shift: in short, the brain is not an instructional hierarchical machine anymore; it better resembles an orchestra with neurons producing the most amazing symphonies. The Nobel laureate Gerald Edelman coined the expression "Neural Darwinism", meaning that the brain is now seen as being closer to a Darwin "Machine" (as opposed to the classic von Neumann Machine) that selects among stochastic sequences; here noise is not an obstacle but is instead an opportunity to explore new paths and to be creative. The idea of a quest for error correction is not an accurate characterization any more. For example, feedback pathways are inadequate to match many situations—too slow in rapid series of moves; see Calvin (1987; 1989; 2004). It is (again) selection and not instruction that characterizes this knowledge process. Instead of using information from the milieu to direct progress, the selectionist system differentially reproduces the fittest objects from a big, changing population.

The selectionist view is also replacing the old (and almost standard) reductionist conception that ascribes specific functions to activities in specific regions of the brain; this is summarized by Edelman and Tononi (2000): "Since a dynamic core is a unified whole, mutual interactions among its constituent neural elements will bring about certain global states of the core that automatically preclude the simultaneous occurrence of certain other global states at any given time" (p. 146, emphases added). Notice that this temporal nature of knowledge processes is a central characteristic of the position

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47 Lerner (1999) summarizes the metaphor: the dominant model of the brain had been one of hierarchical organization modeled on digital computers following von Neumann’s machines principles (see previous note), just with neurons replacing transistors: supposedly, single neurons operated by detecting features in the environment, e.g., in the optic region of the brain, the neurons would detect features like lines and edges; in turn, higher-order neurons, linked to hundreds of lower-order neurons, would detect more sophisticated features, and at the highest level, cardinal neurons would integrate sensations to recognize concepts; this was consistent with the traditional neuron doctrine and state-machines analyses. But now, the favored current view opposes such dated descriptions: the increasing consensus indicates a model of cooperative networking in which information in the brain is stored and processed only when millions of neurons work together.
presented in this dissertation. An overview of this latest shift (from functions and regions to network) is found in the book "Cortex and Mind" by Fuster (2003). He identifies the root of the discrepancy: selection vs. instruction: "Selectionists maintain that cortical representation is the result of the competitive selection of neural elements…the constructivists emphasize the idea that cortical representation is the result of growth and combination of neural elements that develop in the cortical structure promoted by experience" (p. 37); the latter position is the characteristic Lamarckian approach to knowledge processes: the organism is imprinted (instructed) by sense-perception and follows a passive process of adaptation via correction and feedback. Yet, the selectionist view matches in a better way what we now know of the physiology of the brain. A brief explanation follows:

Cognitive information is represented in wide, overlapping, and interactive neuronal networks of the cerebral cortex…Such networks develop on a core of organized modules of elementary sensory and motor functions, to which they remain connected…The cognitive code is a relational code…Any cortical neuron can be part of many networks, and thus many percepts, memories, items of experience, or personal knowledge…A network can serve several cognitive functions…The same cortical networks can be used in perception, attention, memory, intellectual performance, and language…cognitive functions per se have no definite cortical topography. (Fuster, 2003, pp. iv-xii, 15)\footnote{Fuster opens his book with a passage of \textit{Huckleberry Finn}, alluding to a memory of Huck’s that can be explained either with an instructional or with a selectionist description. The author of this dissertation believes that Twain was one of the best examples of what we can call "selectionist thinking"; indeed, the mentioned passage suggests the dynamic and holistic nature of what we call "memory", in this case the memories of Huck.}

The brain, then, is not depicted as a computer that processes information following programmed instructions; it does not produce preordained outcomes.
but instead follows a selectionist logic that, through pattern recognition, arranges things in ever-new ways; variation and selection mechanisms in neural populations determine crucial functions of the brain, affecting, for instance, cortical function, sensorimotor control, or perceptually based behavior (Edelman 1993). This selectionist picture also fits the now recognized ability of the brain to renew itself, including the generation of thousands of neurons every day within memory and learning processes, something unthinkable a few years ago (Gage, 2002). This condition has also been suggested as the explanation for the considerable variation among individuals given the recently discovered variability in the neuronal genome (Muotri et al., 2005; Ostertag & Kazazian, 2005). The implications are straightforward: our "higher" functions are now best explained with selectionist models. For example, the aforementioned book by Fuster (2003) connects with the processes of perception, memory, attention, language, intelligence, and consciousness; the last topic is one that usually provokes more resistance (mostly out of neuroscience), yet, for instance, as related to physiology, "It is reasonable to assume that the conscious awareness of a cognit coincides with the temporary activation of its cortical network while it is being retained in working memory…the seat of consciousness has eluded several generations of neuroscientists because consciousness is an epiphenomena of activity in a shifting neural substrate" (Fuster, 2003, pp. 254, 256, emphases added).49

Campbell (1987b) also included the topic of computer problem-solving as a particular area; this is one of the areas that have grown rapidly since the publication of his articles. A first direct area that comes to mind is the development of evolutionary algorithms as optimization methods, e.g., genetic algorithms, genetic programming, evolution strategies and evolutionary programming; an evolutionary algorithm usually starts with an initial set (population) of alternative solutions (individuals)—usually randomly

49 Several neuroscientists now give a coherent view of this prospect, i.e., consciousness and selectionism; apart from the recognized works of Fuster (2003) and Edelman (1993), further comprehensive overviews can be found, e.g., (Calvin, 1987, 1989, 2004; Seth & Baars, 2004).
generated and restricted to the region of interest in search space—and via the iteration (generation) of mechanisms of replication, variation and selection, it develops new solutions (children, offspring) until a final solution is achieved according with a termination criterion (fitness); direct applications are related to traditional problems addressed in operations research, e.g., resource management in production systems, scheduling, networks, facility management, inventory management, traffic management, etc.; see, e.g., (Biethahn & Nissen, 1995). A general summary of evolutionary computation is made by Mitchell and Taylor (1999). In robotics, brain-based devices are designed as selectionist systems that consist of changing populations of variant repertoires that are differentially amplified to yield responses to unpredicted or novel events—they are starting to be called "thinking robots" (Krichmar & Edelman, 2003). In particular, over the last 15 years, these machines known as Darwin automata have been shown to develop perceptual categorization, invariant visual object recognition, forms of learning, and adaptive behavior, among others (Krichmar, Nitz, & Edelman, 2004). This revolution in robotics might be summarized in this quotation by Calvin (1989): "I will also bet that we'll solve problems such as robot locomotion not by a mathematical analysis and careful engineering of robots, but rather by shaping up a robot brain via much the same trial and error that children go through — the robot will first thrash around (as a fetus does in utero), then crawl, then stand, then walk, then run, and only later ride a bicycle successfully" (p. 325).

Although we are now using the selectionist model to design robots, indeed the main impact of these developments is the other way around, that is, to advance our knowledge of the functioning of the nervous system. This was the point that Campbell (1987b) delivered when he associated computer problem-solving with this particular hierarchical layer; he emphasized such computational processes that, "like thinking, [require] vicarious explorations of a vicarious representation of the environment, with the exploratory trials being selected by criteria which are vicarious representatives of solution
requirements or external realities" (p. 66). We have had to wait several decades to finally start to appreciate the scope of the ideas of Campbell.

A final remark on this level follows; although the knowledge process at this layer is a typical example of the human "higher" condition, it is imperfect and indirect anyway: "The vicarious representations involved — both environmental realities and potential locomotions being represented in mind-brain processes — are discovered contingent relationships, achieving no logical entailment, and in fine detail incomplete and imperfect" (Campbell 1987b, p. 66).

(VII). **Socially vicarious exploration: observational learning and imitation.** Social life entails a fundamental advantage: "The trial-and-error exploration of one member of a group substitutes for, renders unnecessary, trial-and-error exploration on the part of other members" (Campbell 1987b, p. 67).

A typical example is scouting, both in animals—e.g., migrating social insects—and in human exploration groups. Moreover, the observation of the consequences of others’ actions indicates suggestions regarding behaviors to follow or to avoid. Imitation in animals is part of this indirect exploration as well; an illustrative example of this substitute functioning within the broader hierarchy of evolving knowledge is found in the study of Weigl and Hanson (1980) on the feeding behavior of red squirrels and imitation: "While feeding techniques may develop by trial and error, observational learning (for example from a parent or other conspecific) is more efficient in terms of energy and time and may be crucial to the safe and rapid exploitation of new foods and habitats" (p. 213).

It must be emphasized that even here, there is no "learning by instruction" or "learning by observation". There is no "transmission"—instead, trial-and-error is the logic behind this knowledge process:
There is no "direct" infusion of transference of knowledge or habit, just as there is no "direct" acquisition of knowledge by observation or induction… What the child acquires is a criterion image, which he learns to match by trial and error of matchings. He hears a tune, for example, and then learns to make that sound by a trial and error of vocalizations, which he checks against the memory of the sound pattern… Studies of the learning of bird song confirm and elaborate the same model. (Campbell, 1987b, p. 68)

(VIII). Language. This layer significantly overlaps with the previous two levels. Substitute functioning means here that, for instance, the scout can communicate the findings of the exploration to the followers; thus, the scout does not have to imitate, or even more, the scout does not need to have a representation of the relevant environment.

This topic requires a slightly longer exposition, since it is a central point in the current discussion on the continuum of evolution. The traditional debates on language reflect our anthropocentrism, which is more entrenched that we realize, but this is just a Lamarckian assumption where the observer is instructed by the milieu. With respect to language, Campbell contrasts such assumptions with the dance of bees (which expresses, for example, messages about direction and distance) and the use of pheromones in ants and termites. Today, it is claimed that language has evolved by natural selection as well, e.g., (Pinker & Bloom, 1990), and this idea involves the overwhelming recognition of language in non-human animals\(^50\). Moreover, in the

\(^{50}\) The issue of animal language cannot be discussed in this short space, but a few illustrative cases will be mentioned. Apart from traditional and famous studies on the skills of primates, especially chimpanzees—for instance, regarding symbolization (Cangelosi, 2000), the formation of mental concepts, the attachment of signs to those concepts, and the communication of specific ideas concerning those concepts via purely symbolic means (Schoenemann, 1999)—perhaps it is worth mentioning the celebrated and extensive work of Herman on language and the cognitive system of dolphins, undertaken in Hawaii over a span of 30 years. Since his ground-breaking and polemic paper from 1984 (Herman, Richards, & Wolz, 1984) on the comprehension of sentences, up until
evolutionary continuum, the potential for language comprehension preceded the appearance of speech by several million years at a minimum (Savage-Rumbaugh et al., 1993). Bates, Thal and Marchman (1991) present a Darwinian framework based on the continuity of the mechanisms, motives, and representations that underlie the evolution and development of language, i.e., the continuity of language from other cognitive systems constructed out of old components; even a sophisticated mechanism like word learning, for example, is not exclusively human. In general, the difference between animal and human language seems to be only a matter of degree and not of kind; yet, this is the latest debate, a discussion that is increasingly shifting to selectionism. These issues are briefly commented upon next.

For human language in particular, the logic of this layer is the same: selectionism. Campbell clearly experienced the necessity of having both a Popperian model of language-learning for the child and a model of language-development for the race. These models were unavailable at the time of his related articles; yet, Campbell suggested this view with the next example:

now there has been an increasing recognition of this sophisticated language. An updated overview (Herman, 2002) addresses suggestive functions and capacities like memory, rule learning, the development of abstract concepts, the processing of both semantic and syntactic information, linguistic references and symbolic representation, and even the interpretation of television scenes and self-awareness. Other noticeable and perhaps less famous examples are found in non-vertebrate species. For instance, the study conducted by Reznikova and Ryabko (2001) on the numerical competences of farming red-wood ants; this work emphasizes their capacity to memorize and transmit messages concerning a sequence of turns towards a hidden trough of syrup and to use the simplest regularities to compress information; the use of numerical co-ordinates in their communication is also underlined.

51 On the one hand, because various specific mechanisms underlying word learning are not specific to language; also, the ability to link novel arbitrary noises to some referent is quite general among several vertebrates (e.g., chimpanzees, parrots, dogs); there are also several related traits that overlap with language without being specific to it, like fact-learning, vocal imitation (e.g., among birds, frogs), and musical abilities (e.g., among whales); see (Fitch, Hauser, & Chomsky, 2005).
Regarding the child, this would emphasize that word meanings cannot be directly transferred to the child. Rather, the child must discover these by a presumptive trial and error of meanings, which the initial instance only limits but does not determine. Rather than logically complete ostensive definitions being possible, there are instead extended, incomplete sets of ostensive instances, each instance of which equivocally leaves possible multiple interpretations, although the whole series edits out many wrong trial meanings. (1987b, p. 69)

Now Campbell’s wish to have Popperian models of language learning (for both child and race) has been fulfilled. Apart from the selectionist program carried out by neuroscience, as mentioned above, there is currently a growing favored view of conceiving these processes with variation and selection. For example, language acquisition by a human individual can be best described as a selectionist model of populations with competing grammars; selection is made possible by the variational properties of individual grammars, a view that also has empirical matching in child language development in which a "learner" is best modeled as experiencing multiple grammars in co-existence and competition (Yang, 1999). And a trial and error logic of hypothesis testing and selection can depict our process of word learning as well, as in the previous quotation by Campbell. In this area, there has also been important advancement concerning specific points, e.g., a typical trial-testing concern is the problem of matching a word with one hypothesis that is informationally consistent with it out of a large number of hypotheses; solutions related to constraining the search space in order to rule out incorrect hypotheses, or the

52 Another example is found in the report of Nowak, Komarova and Niyogi (2001). They model a selectionist competition between different universal grammars, calculating the conditions under which natural selection favors the emergence of rule-based, generative grammars that underlie complex language. And within the same boundaries as this dissertation, Yang (1999) also delivers strong and consistent criticisms against both (i) the popular Chomskyan theory of innate universal grammars and (ii) the popular empirical statistical learning models of language acquisition in which the child is seen as a progressive inductive data processor. The instruction vs. selection divide is pervasive and covers every approach related to knowledge processes.
use of mutually exclusive object categories, have been proposed (Au & Glusman, 1990; Hollich et al., 2000). This type of selectionist view is also consistent with research regarding the huge degree of variability in children regarding learning language processes, e.g., differences in the rate of development during the passage from first words to grammar. These significant, individual differences cut across specific ages and content domains like phonology, vocabulary, grammar, see Bates, Dale and Thal (1995).53

The knowledge process of language is particularly debated due to its implications for the biological continuum. Currently, the deeply rooted view of innate language or any other particular "jump in kind" is being heavily reconsidered. The idea of an “innate grammar” would imply the breaking of the evolutionary continuum, i.e., the claim that universal features of grammar are unique human traits. However, Christiansen (2000) addresses word order universals (positions in sentences), which can be explained in terms of non-linguistic constraints rather than as a product of innate linguistic knowledge; in his article, the position of Chomsky (i.e., detailing the biological adaptation of learning mechanisms to fit linguistic structure) is contradicted by the evidence that adaptation of linguistic structure fits pre-existing sequential learning mechanisms. Moreover, consider the "learnability problem", that is, the common argument for Chomskyan innateness that comes from the apparent lack of negative evidence that children receive from their linguistic environment—i.e., children are not consistently corrected for speech errors. In this regard, Schoenemann (1999) proposes an alternative selectionist logic:

Thus, children would still be creating and testing hypotheses, but they would be using, in effect, a general parsimony principle to greatly limit

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53 They finish their report with perhaps the most relevant and strongest affirmation of all: "One conclusion seems uncontroversial: The Average Child is a fiction, a descriptive convenience like the Average Man or the Average Woman. Theories of language development can no longer rely on this mythical being. Any theory worth the name will have to account for the variations that are reliably observed in early language learning." (p. 140).
their search (note that this principle is not a part of syntax, per se). That is, they would have to notice that certain forms are not used, even without being explicitly told. Such a model circumvents the learnability problem... [and it] can be operationalized using a neural network designed to learn the meanings of basic spatial terms. The learning algorithm uses the concept of “mutual exclusivity,” wherein positive evidence for the meaning of one spatial word (e.g., “outside”) is taken as weak negative evidence for the meanings of other spatial words (e.g., “on”, “above”, “off”, etc.)... [The] model correctly learned the meanings of such spatial words when trained only with positive examples. Thus, it simply is not the case that if there is an absence of negative evidence during learning, there must therefore be innate structures specifically defining those exact features (p. 338).

Schoenemann (1999) also remarks that a number of other general cognitive features facilitate language acquisition, typically imitation, which was already presented as part of the evolutionary knowledge process.

To recapitulate, an integrative and interplaying schema includes a plausible explanation for the richness of human knowledge, a type of knowledge that is part of a continuum in the evolution of species following sequences of variation and selection at different layers, from primitive blind locomotion to language and social life.

**(IX). Cultural cumulation.** This chapter is presenting a theory of knowledge, not an application of Darwinism to social science. Here, the evolution of species is just one instance of a more general selectionist hierarchical logic of knowledge processes that naturally finds its place in any knowledge process (biological species, immune system, nervous system, etc.). Man and social culture are taken indeed as part of the evolutionary continuum of knowledge, but, as has been emphasized, the process is indirect, vicarious and also highly conjectural. For instance, instead of there being supposed cultural evolving
traits that are somehow "transmitted", here the process is no different from the
other ones presented above: cultural cumulation is another embedded
evolutionary process, culture is understood as a form of knowledge, and it is
another substitute functioning layer. The difference is definitive. What does
this mean? Campbell explains how cultural cumulation acts as a type of
knowledge and as a selective level:

In sociocultural evolution there are a variety of variation and selective
retention processes leading to advances or changes in technology and
culture. Most direct, but probably of minor importance, is the selective
survival of complete social organizations, differentially as a function of
cultural features. More important is selective borrowing, a process
which probably leads to increased adaptation as far as easily tested
aspects of technology are concerned, but could involve adaptive
irrelevance in areas of culture where reality testing is more difficult.
Differential imitation of a heterogeneity of models from within the
culture is also a selective system that could lead to cultural advance.
The learning process, selective repetition from among a set of temporal
variations in cultural practice, also produces cultural advance.
Selective elevation of different persons to leadership and educational
roles is no doubt involved. Such selective criteria are highly vicarious,
and could readily become dysfunctional in a changing environment.
(1987b, p. 70)

That is, traditions, rituals, customs, technologies, and science (see below) are
just forms of knowledge that follow a variation and selection schema. An
illustrative example for the quotation from Campbell, as borrowed from Cziko
(1995), will be mentioned. Cziko studies the process of rice cultivation in Bali.
The use of flooded fields or terraces, the planning of the timing for the
movement of water down the terrace slopes, and the coordination among
individuals have developed through variation and selection. Cziko quotes the anthropologist John Reader: "The farmers who founded and refined the wet-rice system and maintained its high levels of production for centuries knew nothing of nitrogen cycles and oxygen transportation in plants. They worked purely by trial and error. In the process, however, they acquired a sound appreciation of just what made the system work, and of how to keep it working" (Cziko, 1995, p. 156). Such cultural knowledge substitutes for other knowledge processes, e.g., individual thought.

The development of technologies is also a typical aspect of cultural cumulation. For example, Vincenti (1995) shows how engineering design becomes far less restricted and more effective when viewed as a variation-selection process; he illustrates this idea with the development of Edison's lighting system, where he underlines the importance of re-inventing "the-state-of-the-art" whose constraints should not just be taken for granted—in the case of Edison, with gas lighting, or in another article concerning trials and variation in air-propeller tests. In another work (Vincenti 1979), he also mentions the trials made by Edison where he grew 6000 vegetables in his search for a filament for the incandescent lamp. Vincenti also gives a full, detailed description of the process of trial and error in the innovation of flush rivets in American Airplanes (Vincenti 1984).

54 The process has been guided by a particular cultural aspect: religious beliefs; rice is grown in Bali according to the norms of temples and the rice goddess. It also is worth noticing that any etymological dictionary shows that "agriculture" comes from agri (a field, from acre) and culture (cultura, tend, guard, cultivate, "the tilling of land"), which in turns comes from cult (cultus, care, worship, cultivation). We also associate "culture" with intellect, e.g., the cultivation of individuals by "acquiring" knowledge.

55 But it should be noted that for Vincenti, this process of trial-and-error means "the absence of science" (the lack of a partial truth that otherwise would guide the process of innovation, "Lamarckian science", we would say). Contrary to that position, the position defended in this dissertation is that science might follow trial-and-error in a truly selectionist process of growth of human knowledge and as part of a blind-variation and selective-retention multi-layered process; indeed science is just another aspect of cultural cumulation just as technology is as well.
In general, cultural cumulation has several facets or different types of knowledge: rituals, customs, traditions, technologies, and science, among many others, all interact as substitute selective functions and are all conjectural. A particular aspect of cultural cumulation is the central interest in this discussion: science. This tenth level in the Campbell’s schema will be introduced next.

**Science.** Popper is most recognized for his contribution and emphasis on this particular knowledge process. Campbell remarks that science is just another kind of social speculation like all the previous ones. Indeed, it is an aspect of cultural cumulation, but with some differences: knowledge claims should be tested, and there are mechanisms for selection that are more than “social”, since they involve deliberate contact with the environment through experiments that can be designed in such way that the outcomes can be independent of the preferences of the investigator. Popper (1987) also remarks on another two important differences: human language is argumentative, which makes criticism possible, and this characteristic is objective (Popper’s *World 3*). Campbell does not mention these points, but they have to be included, as will be shown.

### 3.2.2. Scientific Knowledge

The exposition of the previous knowledge processes suggests how scientific knowledge—as part of such a schema—is conceived of here. The aggregated schema of processes in this theory of knowledge can be summarized this way. Evolving selection criteria are nested in a flexible hierarchy: "What are criteria at one level are but ‘trials’ of the criteria of the next higher level, more fundamental, more encompassing, less frequently invoked level" (Campbell, 1987b, p. 56). Furthermore, "the controlled subsystems make trial-and-error movements which are partly suppressed and partly restrained by the controlling system" (Popper, 1972, p. 245). Unsuccessful trials are eliminated, but, "if successful, they increase the probability of the survival of mutations..."
which ‘simulate’ the solutions so reached, and tend to make the solution hereditary, by incorporating it into the spatial structure or form of the new organism" (p. 245). Here, there is no direct transference of cumulative knowledge, e.g., via observation or induction, what takes place is *vicarious* selection, an indirect process where success is driven by the environment—representing discovered ‘wisdom’ about it\(^{56}\).

Relevant interconnected points will be indicated as an explicit summary of implications for management science.

\(^{56}\) As mentioned above, this theory of knowledge takes biological evolution as just one case. We are in position now of making this point more explicit. A preliminary suggestion, borrowed from Popper, might be:

I also regard Darwinism as an application of what I call "situational logic" ... [which] can be understood as follows. Let there be a world, a framework of limited constancy, in which there are entities of limited variability. Then some of the entities produced by variation (those which do ‘fit’ into the conditions of the framework) will ‘survive’, while others (those which clash with the conditions) will be eliminated. Add to this the assumption of the existence of a special framework — a set of perhaps rare and highly individual conditions — in which there can be life, or more especially, self-reproducing but nevertheless variable bodies. Then a situation is given in which the idea of trial and error-elimination, or of Darwinism, becomes not merely applicable, but almost logically necessary. This does not mean that either the framework or the origin of life is necessary... Even in a situation without life Darwinian selection can apply to some extent: atomic nuclei which are relatively stable (in the situation in question) will tend to be more abundant than unstable ones; and the same hold for chemical compounds. (Popper 1974a, p. 134)

Several other contexts in which selectionism takes place have been enumerated through this dissertation: the nervous system, the immune system, Darwin automata, etc. The development of species is just a prominent example; this schema is formalized to develop management research in the fifth chapter. This dissertation aims to indicate that several inconsistencies of management science (mentioned in the introduction) are related to the fact of holding a reduced and inadequate epistemology: instruction, the belief of learning by observation, the presentationalist reduction of the world to perception and the subsequent generalization and confirmation-seeking processes of causal theories.
• The previous presentation makes explicit the place of (management) science in the nested hierarchy of knowledge processes. It is an aspect of cultural cumulation and acts as a substitute functioning for other levels in order for one to gain knowledge, a knowledge that can also fulfill selective functions on other lower levels (e.g., habits, instincts, social norms, etc.).

• This dissertation underlines the consequent method to be used in management science: blind variation and selection. This logic is also known as "the critical method", a real non-positivist method for science: "The difference between the amoeba and Einstein is that, although both make use of the method of trial and error elimination, the amoeba dislikes to err while Einstein is intrigued by it: he consciously searches for his errors in the hope of learning by their discovery and elimination" (Popper 1972, p. 70). But this method of bold conjectures (trials) and the attempts to refute them (error-elimination) are absent in management science; on the contrary, the previous chapter showed the prevalence of justification, validation, and confirmation, i.e., the opposite method.

• Thus, scientific knowledge should be conjectural. "Conjecture" means simply that there is no positive knowledge, ever; it is the direct contradiction of the influential ideas of the logical positivists. We try to refute it with the most severe criticism (as this dissertation also attempts to struggle against the "partial" truth we live now: the obsessive empiricism of science). As long as we do not succeed, then knowledge remains unchallenged, yet uncertain. That is why the condition of falsifiability is prominent; it provides the only way to eliminate errors and to keep on posing new trials—see, e.g., (Popper, 1963, 1974a). These blind trials should not be conditioned by observation or by previous results. Moreover, the concern regarding the origin of such trials does not exist; it is irrelevant, i.e., variations
can be freely generated with the help of any procedure, or sourced merely from reason or with the help of computers, or just based on our imagination, or as instincts, etc. *It does not matter*; this is, as expected, also connected with the irrelevance of questions of *validity, confirmation* and *justification*.

- Naturally a mere conjecture does not need justification, in the same way that a trial (in any knowledge process in the presented schema) is never justified, a mutation is not justified. The trials made in our vision system are not justified either, nor were any of the 6000 attempts that Edison made as he sought to find his filament justified, etc. As underlined in the previous chapter, the problem of induction already showed the intrinsic inconsistency of attempts to justify observations or, in general, the futile effort to proceed via generalization. But the problem of induction has been overlooked and has created a particular human-centered (observer) world, a world in which knowledge must be justified somehow, a world full of methods of validation and truths (partial or restricted truths included), the world of the idealists, the world that exists in our mind and comes from our senses. Such popular positions are rejected in this dissertation. After all, habits are also knowledge processes and are not unquestionable truths.

- This dissertation endorses the concept of objective knowledge in the sense of evolutionary epistemology: "In this context, *knowledge* refers to the objective products of certain evolutionary processes, ranging from the endosomatic cognitive structures of men and animals to the most abstract scientific theories" (Bartley, 1987a, p. 21). But a special note should be made regarding human knowledge. Subjective knowledge is recognized, but it is not taken as the border of the world—Popper (1972) labels it as "organismic knowledge", since it consists of the dispositions of organisms. But objective
knowledge specifically consists of "the logical content of our theories, conjectures, guesses (and if we like, of the logical content of our genetic code)" (Popper, 1972, p. 73, emphases added). The development of descriptive and argumentative language is unique to humans, and here it is recognized as such. In fact, this capacity is what makes science different from other cultural cumulations (e.g., rituals, traditions, etc.); the use of this knowledge process constitutes the very possibility to distinguish science from other social institutions, since it is with the logical character of a rich, descriptive and argumentative language that scientific knowledge is possible and, thus, argumentation, comparison, testing, criticism, can take place.

- An important consequence of a selectionist theory of scientific knowledge, as part of the evolutionary continuum, is that such knowledge is not sourced exclusively through observations (or any other indirect mechanism of representation of the world); these are only imperfect aids, and there is no transmission of any kind. Knowledge is not acquired through instruction. This is a direct contradiction of the presentationalist stance that permeates methods and assumptions in management science. The organism (the scientist) in general becomes far more active; s/he is not “imprinted” by sense observations but actively runs blind trials Conjectures are generated by variation (essentially, this idea is no different in logic than exploration via the blind locomotor activity of the paramecium, and it is different neither from the way we use vision nor from the way we generate creative thought; it is also not different from language development, etc.). They are selected (as conjectures) as long as they are not refuted. Empiricism, as was presented in the previous chapter, is rejected, i.e., observation is not "the" source of knowledge. The question of source is irrelevant. This rejection of instruction and presentationalism points to a representationalist position that transcends the senses.
• Related to the last point, it is also underlined that there is an imperfect representation of an external world created through the nested hierarchy of levels; such a world contains what we perceive and seemingly much more. The assumption of realism (representationalism) is also a consequence of following this continuum of knowledge. Besides, without an external world as a point of reference, evolution could not have taken place; it is needed to understand and match the development of species, and there is no reason to believe that a special break occurred in the rise of man. Naturally, all the objections presented to management research methods (as detailed in the previous chapter) constitute also motives for at least considering a representationalist position.

The next section summarizes a rational grounding for the methods of management science: critical rationalism. In short, critical rationalism follows an evolutionary (selectionist) regime, as any other knowledge process indeed does.

3.3. Critical Rationalism (Non-Justificationism)

To affirm that the question of the justification of knowledge is irrelevant and such that an effort is rejected, including through the rejection of the concerns regarding the origin of knowledge, might still sound strange to say the least, given our apparent identification of science with what has been labeled as "empiricism" (previous chapter). Apart from considering the stand of evolutionary epistemology as a non-justificationist theory of knowledge, a further brief note might be needed regarding this element and, particularly, the concepts of rationality that this theory discards. Perhaps the main author synthesizing this theory is William Bartley III; he will be a main guide here. This section also underlines that the logical character of the fallacy of induction can be answered with a logical argument.
3.3.1. Instruction: A Jail for Epistemology

The previous chapter underlined that a major implication of presentationalism is the need to justify knowledge. This view is challenged by evolutionary epistemology as has been presented. Bartley (1987a) summarizes the argument:

Evolutionary epistemologists contend, simply, that (exosomatic) scientific knowledge, as encoded in theories, grows and develops according to the same method as (and is indeed adaptationally continuous with) the embedded (endosomatic) incarnate knowledge…in [biological] organisms, including man. In the second case there is an increasing fit or adaptation between the organism and its environment when its stored templates model stable features of the environment. In the first case there is an increasing fit or adaptation between theory and fact. (Such theory grows and develops according to the same method; of course it is transmitted somewhat differently)… Human knowledge appears to develop similarly. The highest creative thought … is the product of blind variation and selective retention - or, to use Popper's phrase, through conjecture and refutation. Science is, on this account, utterly unjustified and unjustifiable… The question of its justification is irrelevant: it is as irrelevant as any question about whether a particular mutation is justified… There is no justification - ever. The process that began with unjustified variations ends in unjustified survivors. (p. 24, emphases original)

Considering the previous section, this assertion can be appreciated in its full dimensions and with its different character based on the established grounds of rationality. To explain why, one must take a brief look to theories of rationality. In short, a non-justificationist approach contradicts the grounding of management science, and in fact, most of our current conceptions of
Evolutionary Knowledge

science, as Western epistemologies, embrace justification as the central question in the advancement of knowledge. This author knows of no attempt to develop a minimal research framework for management science (e.g., ontological or epistemological premises)—let alone methods or theory-building arguments—based on the discussion and the criticism developed up until now. The academic community, being informed by those epistemologies, has as a starting point a grounding built on justification, confirmation, verification, validation, observation, etc. And what are conceived of as epistemological discussions and research method development become proposals for holding those justificationist assumptions.

The common standard view advocates that "the concept of justification may be the most fundamental in epistemology. On what became the dominant view in the twentieth century, knowledge is to be understood, at least in part, through our understanding of justification" (Fumerton, 2002, p. 204). Furthermore, epistemology itself is regularly taken primarily as the question of the justification of knowledge. To give just one example, consider the general treatise in epistemology compiled by Michael Huemer (2002), who takes the subject of inquiry as both the theory of knowledge and the theory of justification as his necessary and sufficient primary bases.57 The core question of epistemology is formulated by him in the standard way:

Under what conditions does a subject, S, know that p (where p is some proposition)? There is a general agreement among epistemologists on two basic conditions, with disagreements on what further conditions are required. The core of agreement is that in order for a person to

57 This 'wide-ranging' book has three large parts, namely: I. Sources of justification and knowledge. II. The structure and growth of justification and knowledge. III. The nature and scope of justification and knowledge. Justification is inherently taken as part of epistemology; the compilation includes authors like Locke, Berkeley, Hume, Reid, Russell, Kant, Ayer, Carnap, Goodman, Sextus Empiricus, BonJour, and Descartes, among others. In short, to dispense with justification is not even considered, let alone discussed.
count as knowing that \( p \), the person must at least believe that \( p \), and it must be true that \( p \). (Huemer, 2002, p. 435)

However, based on an evolutionary theory of knowledge, both conditions (the ones that supposedly constitute "the core of agreement" among epistemologists) are rejected. Furthermore, even the core question, i.e., the first line of the quotation above, is discarded as such. Such a question—which is in short, "how do you know?"—does not arise in evolutionary epistemology. However, this has been the central task of modern and contemporary epistemology and methodology in Western culture. And management science just keeps on following the current.

This is why most of the current discussions in such areas are irrelevant to an evolutionary theory of knowledge and are of little use here. Moreover, those views are rejected; epistemology itself is also trapped in instruction.

3.3.2. A Search for Balance: Critical Rationalism

What is rationality? "To be rational is to be guided by reason" writes Cohen (1992, p. 415) in establishing an overview of rationality. This position is shared here. But immediately after that sentence, Cohen proceeds to cover "at least nine types of rationality, or roles for the faculty of reason, [that] seem to be commonly recognized in Western culture" (p. 415). This "exhaustive" list

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58 The nine broad types of rationality covered by Cohen (1992) are: conformity with the laws of deductive logic, correct mathematical calculations, meanings of words, ampliative inductions that conform to appropriate criteria, correct assessments of mathematical probability, inferences that are licensed by an accepted factual generalization, pragmatism in action consistent with the goals of agents, moral judgement, and successful linguistic communication. In fact, all of these roles address the question of 'correctness' or 'validity' in order to justify a claim of knowledge, the position that is rejected by an evolutionary theory of knowledge. The assumed need for the justification of knowledge is so pervasive that, for example, when Lemos (2002) discusses "non inferential foundational knowledge", he cannot help but to assert that "a basic or 'foundational' belief is one that has some level of epistemic justification that does not derive from nor depend
does not include the abandonment of justification, and it is a good list of current epistemologies that inform science at the present time. This restricted position can be labeled as *comprehensive rationality*, following Bartley (1987b), a position that "dominates traditional philosophical approaches, and remains today the most common account of rationality… and combines two requirements: a rationalist accepts all and only those positions that can be justified by appeal to the rational authority" (p. 206). The two current options for such authority are intellectualism (reason) and empiricism (sensations). A second position, which gained prominence in the twentieth century, is labeled by Bartley (1987b) as *limited rationality*; in short, it looks for bounding justification according to diverse criteria, for instance subjectivism (relativism), or relevant frameworks; here, we find very popular authors like Kuhn, Feyerabend, and also the notions of linguistic communities, e.g., Wittgenstein and followers. The issue of relevant frameworks within the problem of induction was briefly commented on in the previous chapter. Some of these limited rationalities take *description* as the only alternative to justification, which is a self-defeating and objectionable attitude; either everything is assessed regarding the pertinent framework (i.e., relativism) or justification is seen as a vain attempt and the only goal then is merely to describe. These two positions—*comprehensive rationality* and *limited rationality*—encompass most of the current views of how knowledge is assessed, and they inform management science. An actual non-justification stance, that is, a non-foundational account of knowledge, is not even discussed in management research literature, let alone explored or used.

What are the bases of Critical Rationalism? The basic premise, already indicated, is that we can only have conjectural knowledge but never certainty. positively on one's other beliefs. It has some level of justification that is independent of the justification, if any, that it might derive from its logical relations to, or its cohering with, one's beliefs" (p. 492). But genuine non-justification is not even considered. In fact, it is hard to find texts, books, or papers in general epistemology or general science that "dare" to doubt justification. Radnitzky (1987) develops in detail why the program of justification is not realizable; see also Popper (1972) and Bartley (1987b).
We do not look for confirmation, validation, or verification: "No theory of knowledge should attempt to explain why we are successful in our attempts to explain things" (Popper, 1972, p. 23). As was presented, the problem of induction cannot be solved—it is strictly logical in character and unsolvable. Popper notices that this has been widely overlooked.\textsuperscript{60} It must be said that the problem can be dissolved, that is, it is induction itself that is rejected. In spite of being early stated in 1934,\textsuperscript{61} it is surprising that the alternative of the non-justification of knowledge has not been considered. Critical Rationalism, in a nutshell, "abandons all justification whatsoever. It sees criticism, not description, as the alternative to justification… Not only do we not attempt to justify the standards; we do not attempt to justify anything else in terms of the standards. We do not think that there is any such a thing as 'well-founded belief' anywhere in the 'system' " (Bartley 1987b, pp. 211-212). This is the central premise: instead of "well-founded belief", rationality is now located in criticism. This issue is introduced next.

\textsuperscript{60} For example, Popper addresses the positions of Russell and Kant regarding Hume:

> The fundamental schema of the traditional problem may be stated in various ways; for example: Tr1: How can Induction be justified (in spite of Hume)? Tr2: How can a principle of induction (that is, a non-logical principle justifying induction) be justified?... I think that Kant's problem 'How can synthetic statements be valid \textit{a priori}?' was an attempt to generalize Tr1 or Tr2. This is why I regard Russell as Kantian, at least in some phases, for he tried to find a solution for Tr2 by some \textit{a priori} justification… From my point of view, all these problems are badly formulated. (And so also are the probabilistic versions such as the one implicit in Thomas Reid's principle of induction…). Their authors do not take Hume's logical criticism sufficiently seriously; and they never seriously consider the possibility that we can, and must, do without induction by repetition (1972, pp. 27-28).

\textsuperscript{61} For instance, Popper remarks that "I stressed, for example, at the Congress in Prague in 1934: 'Scientific theories can never be "justified", or verified. But in spite of this, a hypothesis A can under certain circumstances achieve more that a hypothesis B…). I even stressed very early that questions of truth or validity, not excluding the logical justification of the preference for one theory over another (the only kind of 'justification' which I believe possible), must be sharply distinguished from all genetic, historical, and psychological questions" (1972, p. 67, emphases original).
3.3.3. Selection via Criticism

The previous section introduced (management) science as part of a continuum of knowledge processes. That is, (i) it follows a two-step process of variation and selection, (ii) it follows a selectionist logic of growth of knowledge (no instruction), and (iii) it serves as substitute functioning for other knowledge processes. In particular, selection, the driver of change, is accomplished via criticism. What does this mean?

As was previously presented, the problem of induction is logical in character. In short, it is a fallacy to generalize via induction. Popper’s answer, frequently misunderstood, is also logical: it is modus tollens, the "mode that denies". This answer is an argument in the strict logical sense. The difference between argument (falsification: it necessary follows) and fallacy (induction: it does not follow) is definitive. Popper situated this argument at the heart of his line of reasoning. In this way, a general hypothesis can be falsified by a single negative instance. Modus tollens is a form of indirect proof, and the familiar argument follows: If P, then Q. Q is false. Therefore, P is false. That is, if a Hypothesis (H) implies an observation statement (O) and if (O) is false, then (H) is false. It is not possible to question the conclusion. The goal of the quest is not justification (i.e., confirmation, verification, validity). The goal is falsification. The logic is the opposite. The purpose of testing must be to falsify, not to confirm. Nothing is confirmed unless we accept positivism. And if (H) cannot be falsified, then it still remains what it is, a conjecture, uncertain. The theory is only corroborated, meaning that it has been subjected to tests and it has not been falsified (Popper, 1963, 1974a). This does not mean that the hypothesis is confirmed—surely it is a general statement of some sort, but there is no generalization; (H) just remains as such, as a hypothesis, a trial. Indeed, formally speaking, it is a deductive argument; there is no claim of generality, and the conclusion does not surpass the premises.
This distinction is fundamental; it is a distinction that looks trivial but certainly is not. In fact, it defines the logic of the growth of knowledge: it is the choice between instruction and selection, the difference between certain truths and conjectural knowledge, the real separation between positivism and anti-positivism, the distinction between biased variation and blind variation, and a choice between fallacy and argument. However, this line of reasoning is overlooked or misunderstood by many management scientists and historians (philosophers) of science. Consider, for example, typical instances of authors quoting Popper in the name of "verification" and the methods they use in which their theories are “confirmed via falsifiability”. Critical Rationalism is simply a method of trial and error. And this is why one of the primary well-known characteristics of a theory is—in the tradition of Popper—falsifiability or testability, which becomes the criterion that demarcates science (Popper, 1974a) and not only a mere requisite of a theory. The criterion of demarcation of Bacon (i.e., induction) is rejected. In the words of Popper (1974b):

Scientific knowledge is essentially conjectural or hypothetical… There is no need any longer to be disturbed by Hume’s negative results, since there is no need any longer to ascribe to human knowledge a validity derived from repeated observations…Our conjectures are our trial balloons, and we test them by criticizing them and by trying to replace them – by trying to show that there can be better or worse conjectures, and that they can be improved upon. (p. 1016)

Criticism becomes the task and falsification the goal. Furthermore, the core question of epistemology is shifted and widened; it is not about justification, i.e., it is not about "how do you know?" The core question now concerns the growth of knowledge processes.

Popper (1972) also labels his proposal as a theory of preference: "All that can possibly be 'positive' in our scientific knowledge is positive only in so far as certain theories are, at a certain moment of time, preferred to others in the light
of our *critical* discussion which consists of attempted refutations, including empirical tests" (p. 20). In other words, the question is not about when it is rational to accept a theory (the question of the justificationist). Acceptance is exchanged for preference:

When is it rational to prefer a particular position (statement, view, standard, etc.) over its rival(s)? The answer suggested is along the lines: "It is rational to prefer a position over its rivals if and only if it has so far withstood criticism - the criticism relevant for the sort of position at stake - better than did its rivals." (Radnitzky, 1987, p. 288)

How do we understand "relevance" here? Radnitzky (1987) suggests different types of non-justificational criticism of theories, guided by the next types of questions:

* Check the problem: Is the theory relevant to the problem at hand? Does it potentially offer a solution to it?
* To what degree can the new hypothesis be empirically criticizable? (Prior to testing)
* Is the new theory a more accurate description of the relevant aspects of reality than are its rivals? (After testing)

The method of science, from the point of view of critical rationalism, is quite straightforward: "the method of bold conjectures and ingenious and severe attempts to refute them" (Popper 1972, p. 81). This method is again a two-step process: generation of blind variation of trials and to put pressure on hypotheses—criticism—following a process of natural selection where the questions regarding the justification, viability, or origin of a new theory are meaningless. This is why Critical Rationalism is consistent with the hierarchy of knowledge processes presented in the previous section. If science is taken as part (and result) of the evolution of man, i.e., as another knowledge process, then Critical Rationalism follows.
3.3.4. The Basis for a Selectionist Epistemology

To summarize, the traditional epistemological core question to address from this stance has changed. The current foundational questions of epistemology, which inform management research methods—"How knowledge is justified" or "how do we know"—are discarded. Instead, the central question of epistemology can be broadly suggested as follows:

How can our lives and institutions be arranged so as to expose our positions, actions, opinions, beliefs, aims, conjectures, decisions, standards, frameworks, ways of life, policies, traditional practices, etc. - whether justifiable or not - to optimum examination, in order to counteract and eliminate as much error as possible? (Bartley 1987b, p. 213)

A research framework that takes into account such a view of knowledge in order to develop methodologies and theories of management science is lacking. It is surprising that the recognition of Darwin’s theory as a theory of evolution of knowledge has been overlooked. It is hard to understand evolutionary thought without discarding justificationism. As Bartley (1987b) remarks: "Why, it may be asked, have twentieth-century professional philosophers, who have known and often advocated Darwinian theory, not already adopted such an approach? Not for want of trying. The problem is that it is impossible, within a justificationist approach, consistently to work out a truly Darwinian epistemology" (p. 214, emphases added).

The contributions of a selectionist theory of rationality presented above, i.e., critical rationalism, coincide with the view of evolution as a process of evolving knowledge addressed by the evolutionary epistemology presented. Indeed more than a coincidence, this match is a fitting consequence of various aspects: (i) Man as a result of evolution, which includes human knowledge as part of such a process; (ii) The recognition of science as just another epistemic
activity alongside other ones that integrate an organism where several processes interact, ranging from non-mnemonic problem-solving to representational cognitive devices, and other knowledge processes like learning, thought, etc. (iii) The recognition of the processes of variation and selection for characterizing the growth of knowledge; and (iv) The premise, as Campbell (1987b) remarks, is that at no stage has there been any transfusion of knowledge from the outside, nor of mechanisms of knowing, nor of fundamental certainties, as biology and neuroscience increasingly show.

To sum up, this chapter started with a broad view of evolutionary theories as inquiries seeking to explain change. The emphasis on a two-step process of variation and selection, alongside the contradistinction against the pervasive assumption of instruction in learning processes, was emphasized. The rejection of a passive role for organisms that are assumed to be imprinted by the senses and the questionable logic of adaptation—understood as correction and progression conditioned by the environment—was also examined. A selectionist (evolutionary) theory of the growth of knowledge was presented. This epistemology entails several implications for the way we conceive of human knowledge and scientific knowledge. For instance, the inclusion of instincts, habits, thought, language, cultural cumulation, and several other processes as compulsory for understanding human action and human knowledge, and the role of science in such a context and the way to proceed consistently, i.e., criticism and refutation, were also highlighted, including the dismissal of positivism, justification, induction, verification, and all related assumptions. All of these characteristics have to be included in the meta-design announced in the introduction to this dissertation.

The conjectural nature of knowledge is deeply linked to the gap between our imperfect mechanisms of representation (our senses) and a real world beyond them. What assumptions about such a world can we hold consistently with this view? This is explored in the next chapter.
4. EVOLUTIONARY WORLD

The fact that something is left out of a particular mode of representation gives no license to conclude that it is not there.

W.W. Bartley, III, 1987

*Philosophy of Biology versus Philosophy of Physics*

An evolutionary approach addresses foundational issues: it invites not only an exploration of new theoretical vistas but also a rethinking of the paradigmatical-ontological premises on which they are based.

Kurt Dopfer, 2005

*Evolutionary Economics: a Theoretical Framework*

**Introduction**

The second chapter identified management research’s reliance on observation in sourcing and validating knowledge. Such an assumption is the standard basis for building theories that follow inductive methods and entail strong assumptions about the world; in particular, the assumption of uniformity that lies behind that worldview was underlined. The consequent inconveniences were emphasized: the unacceptable status of inconsistency (the myth of induction), the fact that knowledge is assumed to be “grounded” in what has been (imperfectly) sensed, the typical relativism linked to any epistemology attached to an observer, and the implications of addressing a uniform world that is supposedly explainable with causal theories. The previous chapter developed an articulation of related streams of evolution, science, epistemology and rationality; this depiction was also updated and inserted into the context of the tradition of management science. Yet, there are areas in which the previous theory of knowledge might fall short. A major requirement
is, for example, that of specific ontologies that may provide conditions for the contents of the theories to be generated, e.g., types of entities, categories, relations, etc. This chapter will complement the discussion with various necessary distinctions, particularly around issues related to realism and the inclusion of time.

This chapter develops a brief ontological reflection that is suggested by the previous epistemological discussion. The first section draws the distinction between presentationalism/representationalism so as to underline that representational realism is consistent with the theory of the evolution of knowledge. It also comments on the pervasive idealism that has even driven ontological discussions in science. The second section explores ontological commitments tied to the necessity of having an explicit and consistent ontology with the character of knowledge as a process, an evolving entity. In particular, two programs are indicated: the metaphysical process program of Whitehead and the evolutionary ontology of Dopfe—and a further redefinition is introduced: knowledge adoption is conceived of as reproduction. The third section remarks on the importance of a consistent combination of an ontology with the evolution of knowledge, since the main interest of this dissertation is to have a framework in which consistent theories for management science can be generated within an evolutionary foundation for the growth of scientific knowledge.

4.1. Knowledge and a Real World

The distinction between idealism and realism is full of misleading debates and interpretations (Blackmore 1979). For the final part of this dissertation, the terms “presentationalism” and “representationalism” will be preferred. As a first step, these notions will be briefly demarcated so as to indicate representational realism as a natural ground for the theory of the evolution of knowledge.
4.1.1. Presentationalism and Representationalism

Presentationalism has already been introduced. We can identify it with Lamarckism in the sense that it assumes the acquisition of knowledge by instruction in which the organism is imprinted by the environment, and we call these *impressions* "knowledge". Given the limitation of our senses, presentationalism postulates that nothing more can be known beyond our sensory apparatus. For a presentationalist, the world is not re-presented, since we do not have access to it; the world is just what is presented to our senses: the world as we experience it happens to be the world itself. This stance is summarized by Bartley (1987a):

> Almost all traditional epistemologies are *Lamarckian* in their accounts of the growth of knowledge. This is conspicuously true of presentationalism, almost all adherents to which maintain an inductivist, justificationalist account of knowledge growth, according to which knowledge is constructed out of sensations (as building blocks or elements) by a relative passive process of combination, accumulation, repetition, and induction. This is a process of learning by *instruction*, rather than adaptation and *selection* by the environment.

(p. 25, emphases added)

As it has been presented in this dissertation, idealism is not endorsed. But empiricism (i.e., not "epistemological empiricism" but "empiricism" as such) in its most basic sense is not rejected. Blackmore (1979) also reminds us that, strictly speaking, neither "rationalism" nor "empiricism" is a properly epistemological term at all. To clarify, up until now we have been using the term "empiricism" as synonymous with knowledge sourced from observation. But Blackmore remarks on important restrictions regarding the use of terms: "Granted, that if one *means* by 'empiricism' not just an extensive and careful concern with empirical evidence but *restricting* reference or knowledge or
both to sensory appearances, then there are indeed epistemological implications. One has become an epistemological phenomenalist or subjective idealist, or if you will, a positivist" (1979, P. 130, emphases original)\(^{62}\).

The natural alternative to idealism is \textit{realism}. Because of the widely inverted use of such terms\(^{63}\), it seems critical to demarcate both of them. Regarding realism, a standard definition seems a good starting point:

\(^{62}\) The inverted use of the term "positivism" in management science is a widespread practice, too, but the problem is not about terms and words. So-called anti-positivists does not notice their positivism, and they end in inconsistency as well—not linguistic inconsistency but rather epistemic inconsistency that in practice materializes in contradictory claims—or else they end up falling back on relativism. On the other hand, the so-called positivists do not notice either that they are idealists or hence that they are victims of their own presentationalist stance. A recent example follows. "The Academy of Management Journal" presents an article by Suddaby (2006) on the popular "grounded theory" (second chapter), clarifying what the author calls "confusion regarding alternative epistemological approaches" (p. 633). Consider this statement: "[Grounded theory] was… a reaction against the extreme positivism… Instead [the authors that invented grounded theory]… argued that scientific truth results from both the act of observation and the emerging consensus within a community of observers as they make sense of what they have observed" (p. 633). The last sentence reflects plain positivism, though the paper presents a position that is a reaction against positivism. Furthermore, positivist ideas regarding holding a notion of minimal confirmation or validation are endorsed through the paper (e.g., the notion of "saturation). The cited paper also claims a rejection of induction: "Pierce [sic] recognized that pure induction and pure deduction are necessarily sterile. New ideas result from a combination of these fundamental approaches, which he termed ‘abduction’ " (p. 639); deduction is apparently understood according to the idea that "whenever researchers conceptualize data, [they are engaging in deduction]" (p. 639). This is the redefinition of “deduction” made by Peirce. For a critique of the original intrinsic ambiguity in the redefinitions of Peirce, see, e.g., (Frankfurt, 1958). The notion of “abduction” is also misdirecting, since it is actually a type of induction—see the second chapter.

\(^{63}\) Rescher (1992) illustrates typical examples of the confusing use of terms in literature: "The three positions to the effect that real things just exactly are things as \textit{philosophy} or as \textit{science} or as \textit{commonsense} takes them to be - positions generally designated as \textit{scholastic}, \textit{scientific} and \textit{naïve} realism, respectively - are in fact versions of epistemic idealism exactly because they see reals as inherently knowable and do not contemplate mind-transcendence for the real" (p. 187). See also (Blackmore, 1979).
'Realism'…is used for the view that material objects exist externally to us and independently of our sense experience. Realism is thus opposed to idealism, which holds that no such material objects or external realities exist apart from our knowledge or consciousness of them, the whole universe thus being dependent on the mind or in some sense mental. It also clashes with phenomenalism, which, while avoiding much idealist metaphysics, would deny that material objects exist except as groups or sequences of sensa, actual and possible. (Blackmore 1979, p. 126)

Apart from the particular emphasis on material objects (as opposed to Berkeley's ideas) in the quotation above, another point already mentioned is that realism defends a cosmocentric thesis—as opposed to the observer-centered view. The plain assumption of realism cannot be refuted, i.e., the existence of a real world beyond sense data.64

The position in which this proposal is assembled can be labeled as representational realism; it is not only a consequence of the assumptions and the argument of evolutionary epistemology but also an attitude toward the world with all its practical implications for practical scientific research. Representational realism is representational in that sensory images represent aspects of external objects but are not those objects or aspects themselves; it is a form of realism in that neither the process of perception nor consciousness determines the reality or character of the object perceived (Blackmore 1979), and in that it is also concerned with empirical examination (testing): it is interested in meeting a real world, and the error-elimination of evidence drives the growth of knowledge in this position.

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64 But it must also be underlined that realism does not imply that knowledge is achievable, that it does not imply that the world is a perfect clock, that it does not imply determinism, and that it does not imply that there can be correspondence between theories and this real world.
Most (if not all) of the methods in management science discard representational realism, as has been shown. For scientific research, the representationalist position demarcates a different attitude. It has been mentioned that the limitation of our senses does not have to imply the constraint of our world by them. We can also assume a world beyond our sensorial perception and assume that a real world is just imperfectly represented by them. Within this assumption, the position of science, which is where evolutionary epistemology rests, can be summarized:

Representationalism maintains that the *subject matter* of science (and of seeing) is the external world *as it is*, independently of human (or animal) perceptions and descriptions of it. The *aim* of science, for a representationalist, is to attain increasingly accurate accounts of this world in language. To accomplish this, one *uses* sense perceptions as aids; and these sense perceptions or sensations are themselves only more or less accurate symbolic representations of external reality formed through the interaction between that external reality and organs of sense. (Bartley 1987a, p. 10, emphases original)

In consistent harmony within a *realist*—and hence cosmocentric—position, "Ignorance is possible, because normally it is possible that human subjects lack contact with certain regions of the independent reality in question. Error is possible, because normally it is possible that human subjects are only imperfectly attuned to the regions with which they do make contact" (Pettit, 1992, p. 421)\(^65\). This very possibility of error is fundamental to embracing the

\(^{65}\) Compare with the anthropocentric (presentationalist) position, which holds that "with certain substantive propositions within the discourse in question - with a certain number or with certain specific cases - there is no possibility that specified individuals or groups could be in ignorance or error. The anthropocentric may deny the possibility of a certain error or ignorance by taking the interpretationist line that the objects posited by a discourse are whatever objects participants are mostly right about; this will put limits on error… She may do it by going the verificationist or anti-realist way of refusing to acknowledge that propositions for which we lack adjudication procedures have a determinate truth-value; this will put limits on ignorance… She may do it
evolution of knowledge within the stance of Critical Rationalism and the theory of knowledge introduced in the previous chapter, but the attitude toward error is different: instead of there being a partial truth in which errors are progressively corrected following a Lamarckian process (moreover, idealist-perceived errors), here real errors are just an opportunity to be creative and to run further trials. Error-elimination is the driver of change in the knowledge processes presented above. These assumptions regarding error and ignorance underpin the realist position, the gap between a real world and our senses (or our imperfect representations of that world). As has been indicated above, the first important implication is that observation is not the exclusive defining method of sourcing knowledge. The anthropocentric and empiricist view of “science by observation” is abandoned. The primary role of the observer is revised. That is, the prime source of knowledge is not sensory perception, which is instead only an aid to be used; it is other knowledge processes belonging to the schema of the previous chapter.

Representational realism is consistent with evolutionary epistemology. In particular, we are interested in addressing, if possible, a real world of evolving, real, and uncertain scientific knowledge. We are interested in developing a research framework for management science consistent with the criticism developed here up until now, avoiding the current and pervasive contradictory position that places all of the weight on (epistemological) empiricism. We still need to make explicit various assumptions about the world and knowledge. The following section summarizes the criticism developed on this point by making a reflection that paves the way toward bridging epistemology and ontology: the rejection of the naive and insidious philosophy of science of the 20th century, i.e., ontological Newtonianism under epistemological idealism.

through becoming a relativist and increasing a group's chances of hitting the truth by moving the target nearer: by defining truth, in the relevant sense, as truth relative to that group. Or she may take any of a variety of other approaches" (Pettit 1992, p. 422). The second chapter showed how such options are carried on within management science.
4.1.2. A Narrow Science

Epistemology should drive the design of the scientific world instead of letting Epistemology be a derivation (or an afterthought) of the scientific world. (van Gigch 2003 p. 2)

One of the consequences of the wave of idealism has been the wide diffusion of positivism, thanks largely to influential thinkers like Berkeley, Bacon, Locke, Kant, and, more recently, Mach, Carnap, Wittgenstein, and Kuhn, among many others. Furthermore, epistemology has been reduced to a naive and unaware subjective idealism, and we have relabeled it with several names, predominantly "science". (Perceived) phenomena are currently the only relevant information, the "real world". In fact, the term \textit{phenomenon} is now synonymous with \textit{thing}; we use, contradictorily, expressions like "real phenomena" and "objective phenomena". The term \textit{metaphysics} refers to theories of reality. In fact, this subjective idealism became the metaphysics of 20\textsuperscript{th}-century science. We forgot that epistemology is far broader than mere subjective idealism. But, trapped in this realm of metaphysics, we have built an anthropocentric view where, paradoxically, the dynamic features of a real world and the uniqueness of instances have been ignored. And we source our scientific knowledge exclusively from perceptions; thus, we need to confirm it or validate it to justify our claims around the positive knowledge that we say we can achieve. This metaphysics is hidden under several different names beneath almost every method in management science that pretends to "build theory".

The matter of ontological commitments is not straightforward. And the relationship with epistemological assumptions is critical; we can point out a specific example in terms of the way epistemological presentationalism (idealism) has \textit{informed} ontology. Alam (1978) states,
In fact, the Vienna school now takes physics as a prototype and has developed the doctrine of physicalism. This doctrine which is of a more exact but more narrow and static nature, denies history, as it does not contain the possibility of returning to the past through the medium of an immediate experiment. History is merely the immediate experience that we can draw from past facts...This [critical] attitude [of positivism] is therefore essentially critical, analytical, and static. It is more suited for adjusting the balance of acquired knowledge, for clearly formulating the structure and content of that knowledge, than for indicating how to extend or renew it; more suited for pointing out difficulties than for resolving them. It allows for the elimination of ideas or theories, the denunciation of problems and affirmations that are without meaning, but it does not permit us to formulate the basis for the construction of new ideas or theories. The critical attitude is thus valuable in preparing the way for the constructive attitude but, is insufficient in itself. The positivist or logician may dissect the content of a doctrine, but he has not means of developing, of constructing, of making an actual synthesis within this doctrine. Thus it is necessary to go beyond that attitude. (p. 72, emphases original)

The quotation above points at the inherent neglect of time carried out by presentationalism. The criticism can be re-stated as the problem of incoherence among some ontological assumptions, the methodologies and epistemologies employed, and the claims derived from such relationships. No doubt the researchers who utilize the so-called quantitative methods appear to have very different ontological assumptions than the ones who defend the so-called qualitative methods; however, both parties have the same underlying epistemology, idealism, i.e., presentationalism. Why do (social) scientists seem to be blindly led to hold idealism as an epistemological position, so far as to identify epistemological empiricism, i.e., idealism, as science itself? Surely, this is related to the influential positivist thinkers of the 20th century, like Wittgenstein, Ayer, Carnap, etc., who propelled the Machian epistemology so
that it became the dominant philosophy of physics that we know today (in spite of the opposition of Planck, Einstein, and others). This position became largely the dominant philosophy of science.\textsuperscript{66} The misleading words "philosophy of science" actually cover nothing more than the "philosophy of physics", or to be even more accurate, the "philosophy of (idealist) physics". This "philosophy of science" is, in short, the conjunction of \textit{ontological} Newtonian mechanical thinking with the \textit{epistemological} idealism of Mach, a stance that, surely, Newton himself would have rejected (on epistemic grounds)—and, naturally, Darwin as well (based on both \textit{ontological} and \textit{epistemological}\textsuperscript{67} grounds). In the meantime, the philosophy of biology was almost buried alive\textsuperscript{68}, not to mention the social sciences.

\textsuperscript{66} Bartley (1987a) details this process, and indeed, his explanation is sound: "The logical positivists, including Carnap, who formed their famous group around Moritz Schlick in Vienna—the "Vienna Circle"—named themselves the "Ernst Mach Society", even though not all were presentationalists. And with the mass exodus of philosophers of science from Austria and from Hitler's Germany immediately before the Second World War, phenomenalist, presentationalist philosophy or science—under various names: operationalism, positivism, instrumentalism, and so on—spread around the world, firmly establishing itself in the universities of the English-speaking countries, where it remains dominant today" (pp. 16-17).

\textsuperscript{67} Yet, a strong common misconception is to believe that Darwin’s method was related to idealism (induction). Mayr (1982) warns: "Francis Bacon (1561-1626) was the chief promoter of inductivism, though he never applied this method consistently in his own work. Darwin, who boasted that he was following ‘the true Baconian method’, was anything but an inductivist. Indeed, he made fun of this method, saying that if one did believe in this method, ‘one might as well go into a gravel pit and count the pebbles and describe the colours’. Yet, in the philosophical literature Darwin has often been classified as an inductivist" (p. 28).

\textsuperscript{68} Only recently is what is known as "philosophy of biology" entering the debate; a chief promoter of this inclusion is Mayr, e.g., (1969; 1997). It is interesting to notice that the first instinct of 18\textsuperscript{th}-century biologists was to embrace the philosophy of Newtonian mechanics (e.g., on principles, properties, and powers); naturally, this attempt was quickly abandoned. Those first attempts are documented by Hall (1968), who underlines that both the reflection and the explicitness of Newton’s stating his philosophical assumptions were fundamental elements to be dismissed by those biologists:

The answer lies partly (but only partly) in the fact that, in the \textit{Principia}, Newton has led his readers step by step, omitting no relevant argument as he reasoned from his initial statement of the Laws of Motion to his culminating picture of the solar system orbiting in grand obedience to the Law of Gravitation. He was able to do this (again, partly) because
As presented in the first part, the concern, the criticism, and the products of this dissertation have an epistemological character. We can already extract several implications for management science. For example, within the schema of van Gigch (introduction), we can inform Level 2 of normal science regarding methods and sources of knowledge. For instance, as management scientists, what kinds of questions should/could we pose? What kinds of questions are restricted? What kinds of questions are forbidden? With which types of methods should we try to answer the questions that we can indeed entertain? Answers to these inquiries could now be suggested as arising from the discussion conducted up until now. Yet, some minimal assumptions about existences and that real world, consistent with the epistemology presented here, have to be made explicit; some of these assumptions have been delineated. Ontological reflection is necessary as a further knowledge process. What kind of ontological commitments can be consistent with evolving knowledge?

4.2. Ontological Commitments

Coming back to the inclusion of time, this dissertation will directly consider natural candidates that recognize the inclusion of time: process philosophy

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he had been ingenious enough to hit upon a real if mysterious commonality in the systems he undertook to explain, a behaviour common to all bodies of considerable mass and (with qualifications that Newton carefully noted) independent of their individual organization. "No such commonality characterizes the varied behaviors that the physiological properties and powers were supposed to illumine. Had a step-by-step analysis been essayed, to show the working-out of such properties and powers in physiological systems, the analysis would have failed because behavior is dependent, in them, on complexities of organization that differ from system to system and render the search for common causes futile". It was this weakness that critics of this mode-of-thinking had in mind when they asserted that, in endeavoring to explain everything, it succeeded in explaining nothing. (p. 25).

69 It is unknown to this author other works in management research literature making these distinctions based on evolutionary thought.
(Whitehead, 1978) and evolutionary realism (Dopfer, 2005; Dopfer & Potts, 2004). We will keep in mind that epistemology needs consistent ontological assumptions, and vice versa. This concern is addressed next.

4.2.1. From Things to Processes

Philosophers have worried themselves about remote consequences, and the inductive formulations of science. They should confine attention to the rush of immediate transition. Their explanations would then be seen in their native absurdity. (Whitehead 1978, p. 129)

We have emphasized the power of a narrow epistemology. A good example is the Machian idealism and the positivist wave that pervaded and defined the notion of science in the 20th century. But a narrow ontology can be also very powerful. Here, a top example might be the attempts in biology to characterize the ontology of species and living beings without abandoning essentialism. Mayr (1969; 1997) strongly advocated anti-essentialist thinking in biology; for him, it was clear that the proposal of Darwin was a new kind of theory, not just a new theory.

For example, consider the question of species and their identity and persistence through time, i.e., the question of "natural kinds". This old question is simply intractable if we do not renounce our preference for objects. Splitter (1988), for instance, poses the inquiry in terms of objects; he opens his paper stating this question to be answered: "Suppose that an object, \( A \), divides at \( t \), to become (as we would naturally say) \( B \) and \( C \) at \( t_1 \) (\( >t \)). How should we describe the relation, vis-à-vis identity, between \( A \) on the one hand, and \( B \) and \( C \) on the other?" (p. 323). Starting from such a platform, the discussion becomes very complicated in his article, which is natural if we want to address the question of what a species is based on the notion of an object. In his paper, Splitter ends by rejecting the notion of natural kinds of species. Indeed, it is the notion of identity that is challenged by biology. The notion of "object" is
suitable for discussion based on issues of identity, natural kinds, etc. But what happens when the necessity of having a constituent definition is removed, as population thinking and evolutionary theory entail? This should be a preliminary hint for us in our examination of what is the very "nature" of those essences. How can identity be related to change? The exploration of this question follows.

The second chapter delineated why idealism entails a timeless approach to the world. It also indicated the connection with uniformity—that is, objects are eternal. Idealism (presentationalism) follows this essentialist thinking regarding things that behave according to law-like statements. Induction assumes that there are causes and effects and that the same effects follow the same causes. Then, for instance, repeated observations (in different times and/or spaces) can "confirm" such statements. To put it simply, time does not count, as what has been observed will occur again and again. Following

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70 This point is made by Sober (1980), who develops the argument of how evolutionary theory contradicts the essentialism of Aristotle, i.e., the Natural State Model. He also draws an interesting parallel with the destruction of the concept of absolute simultaneity made by Einstein. And even more appealing is how he notices the pervasiveness of the model of Aristotle in culture and society. This is closely connected with our tendency, criticized here, to make generalizations, i.e., induction, in every knowledge process. And if we are instructed by the environment, as Lamarck suggested, i.e., by our senses, then the addition of an essentialist theory of reality introduces a definitive limit to our capacity to recognize and meet diversity. The epistemological problem of method was mentioned earlier in this dissertation in relation to diverse issues of our most basic knowledge processes. Sober makes this parallel discussion related to ontology:

In addition to the influence that the Natural State Model continues to exert in scientific thinking, perhaps even more pervasive is the way that notions of naturalness have had, and continue to have, an influence in politics and in popular culture. Political theorists of both the left and the right have appealed to something called "human nature". Political optimists see human nature as essentially good; the evil that human beings have done is to be chalked up to interferences on the part of civilization, or of the state, or of particular economic institutions. Pessimists, on the other hand, see in human beings a natural tendency towards evil, which the restraints made possible by civilization can perhaps correct. The common presupposition here is that each human being has a particular dispositional property—a natural tendency—whose manifestation is contingent. (p. 378)
Dopfer (2005): "The events the law describes also do not change endogenously unless an exogenous force is introduced into the system. The model is *universally deterministic*. Given complete information about the initial and subsidiary conditions, the law allows us to retrodict events precisely on to the past and to predict them to precisely on to the future" (p. 10). The essential properties of things assure the supposed effectiveness of the causal explanation. But therefore, the possibility of endogenous change is left out and the world is deterministic and uniform. A stuff is inert and does not "endure" as such, since it retains its self-identity, its essence—A is always A, this is an ontology of eternity, and duration is illusory. Nothing changes.

Then, the question of how to include time becomes evident. A plausible way seems to be to include *duration* in the very character of substances—that is, "it must be the nature of substance to be in passage, in transition" (Leclere, 1953, p. 230). Thus, the further option would seem, then, a shift from static to changing entities—for instance, *to conceive of entities as units of sequential stages*, the common notion of "process". Indeed, Whitehead (1978) suggests that *process* can become a fundamental notion as we view our world (see below). Here, the spatial scale becomes confronted with a more important temporal scale where "higher levels reproduce themselves over longer durations than lower levels" (Gare, 2002, p. 9). These modifications might also promise that related questions on *novelty* and *change* can be sufficiently addressed.  

However, the process of reframing ontological commitments is not straightforward. Consider these two famous fragments of Heraclitus, from ca. 500BC:

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71 A revision of the notion of “emergence” in Complexity Science, as related to the questions of novelty and change, has been made elsewhere (Olaya, 2006).
The river where you set your foot just now is gone –
Those waters giving way to this, now this.

Just as the river where I step is not the same, and is,
so I am as I am not.

The river is and is not. It is an ever-changing stream, like us. We are equal, and we are unique individuals, but we are also different from yesterday, from tomorrow, and from each other. The current foundations of management research do not allow for such a view, given the commitment to Western metaphysics—which, since Aristotle, has been anchored in things or (static) substances (Rescher, 2002). Yet, a fundamental shift can be delineated. Following Rescher (2002), a basic description of process might be conceived of in its usual sense: a sequentially structured sequence of successive stages or phases, condensed with the following three statements:

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72 Whitehead (1938) notes: “The development of western philosophy has been hampered by the tacit presupposition of the necessity of static spatio-temporal, and physical forms of order. The development of scientific knowledge in the last two hundred years has completely swept away any ground for the assumption of such necessity. But the presupposition remains even among men of science” (p. 120).
- A process is a complex - a unity of distinct stages or phases. A process is always a matter of now this, now that.

- This complex has a certain temporal coherence and unity; processes accordingly have an ineluctable temporal dimension.

- A process has a structure, a formal generic format because of which every concrete process is equipped with a shape or format.

This notion of *process* is a foundational shift. All that exists now becomes conceived, originated, sustained, and characterized by processes. *Change* is the principle. It seems almost unattainable: verbs instead of nouns, the puzzle of universals, the rejection of fixed identity, the difficulty of characterization, etc.73 Within a process worldview, notions like contingency, novelty, and

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73 Illustrative pieces can be found in the works of the Argentinean writer Borges. Two examples follow: (I) In the story "Tlön, Uqbar, Orbis Tertius", he refers to a fictional world called Tlön:

The world for them is not a contest of objects in space; it is a heterogeneous series of independent acts. It is successive, temporal, not spatial. There are no nouns in the conjectural *Ursprache* of Tlön, from which the "current" languages and the dialects come: there are impersonal verbs, modified by monosyllabic suffixes (or prefixes) with an adverbial value. For example: there is no word corresponding to the word *moon*, but there is a verb that in English would be *to moon* or *to moonate*. *The moon rose above the river is hlör u fang axaxaxas mlö*, that is, in the same order: *Upward, behind the onstreaming, it mooned* (Borges, 1956, p. 21; apart from the terms *moon*, *moonate* and the last sentence, which are originally in English, the quotation is a translation from the Spanish by the author.)

Notice the *conjectural* character given by Borges to the language of Tlön—in Spanish: "conjetural". Borges also discusses, afterwards, the sciences and philosophy as they exist Tlön. (II) In "Funes The Memorious" (*Funes el memorioso*), Borges depicts a young man who remembers everything, literally *everything*; the world around him changes constantly, and he is aware of this:

Locke, in the 17th Century, proposed (and rejected) an impossible language in which each individual thing, each stone, each bird and each branch would had an individual name; Funes once conceived an analogous language, but he rejected it since it was too general for him, too ambiguous. In effect, Funes not only remembered every leaf on every tree of every wood, of every hill, but even every one of the times he had perceived or imagined
creativity become fundamental categories of metaphysical understanding (Rescher, 2002).

Given the central concern of our theory of knowledge, i.e., that of explaining change, the connection with an ontology committed to change seems almost automatic—something recognized, as expected, by process philosophers like Whitehead and Rescher. Nevertheless, the challenge of developing an ontological reframing is enormous given our current foundations. Apart from the ideas of Heraclitus, perhaps the first formal comprehensive attempt was made by Whitehead. Without a detailed treatment, we will just sketch some of his notions that might assist us in thinking in terms of processes without entering into ontological criticism.

The Philosophy of Organism

The “philosophy of organism”, the metaphysical program proposed by Whitehead, particularly in his major 1929 work 'Process and Reality', can be a starting point for approaching process thought more formally. His proposal looks for a reflection on our best-established assumptions. As an introduction, it. He determined to reduce all of his past experience to some seventy thousand recollections, which he would later define numerically. Two considerations dissuaded him: the thought that the task was interminable and the thought that it was useless. He thought that by the hour of his death he would not have finished classifying even all the memories of his childhood… It was not only difficult for him to understand that the generic symbol dog embraced so many unlike specimens of differing sizes and different forms; he was exasperated by the fact that a dog at three-fourteen (seen in profile) should have the same name as the dog at three-fifteen (seen from the front). His own face in the mirror, his own hands, surprised him on every occasion… Funes continuously distinguished the tranquil advances of corruption, of caries, of fatigue. He noticed the progress of death, of moisture. He was the solitary and lucid spectator of a multiform world which was instantaneously and almost intolerably precise (Borges, 1956, pp. 129-131, translated by the author).

Both stories are included in a work properly called by Borges as "Fictions". But, what is fiction? That is precisely the criticism of Borges.
along the same lines as the criticism of explanation put forth in the first part, Whitehead criticizes the consequences of essentialism, i.e., what he calls scientific materialism:

By an unfortunate application of the excellent maxim, that our conjectural explanation should always proceed by the utilization of a vera causa, whenever science of philosophy has ventured to extrapolate beyond the limits of the immediate deliverance of direct perception, a satisfactory explanation has always complied with the condition that substances with undifferentiated endurance of essential attributes be produced, and that activity be explained as the occasional modification of their accidental qualities and relations. Thus the imaginations of men are dominated by the quiet extensive stone with its relationships of positions, and its quality of colour — relationships and qualities which occasionally change. The stone, thus interpreted, guarantee the vera causa, and conjectural explanations in science and philosophy follow its model... We are now approaching the limits of any reasonable certainty in our scientific knowledge ...There is evidence that the concept may be mistaken. (1978, p. 77-78)

But his proposal goes beyond epistemology. The aim of Whitehead was broader; he looked "to frame a coherent, logical, and necessary system of general ideas in terms of which every element or our experience can be interpreted. By this notion of ‘interpretation’ I mean that everything of which we are conscious, as enjoyed, perceived, willed, or thought, shall have the character of a particular instance of the general scheme... in respect to its interpretation, applicable and adequate. Here ‘applicable’ means that some items of experience are thus interpretable, and ‘adequate’ means that there are no items incapable of such interpretation" (1978, p. 3).

The program of Whitehead is best categorized as a sort of idealism similar to the one depicted previously—though we have been emphasizing the
epistemological aspect of such a term, here we can think of "absolute idealism". But Whitehead was not pursuing such absolute idealism, as we can see here: "Indeed, if this cosmology be deemed successful, it becomes natural at this point to ask whether the type of thought involved be not a transformation of some main doctrines of Absolute Idealism onto a realistic basis" (1978, p. xiii). 74 This particular position, connected with the method, is derived from his criticism of the inconsistency of Locke and the restricted frames of Hume75 and Kant76, which he could not accept. He traced the problem back to Aristotle. For instance, when Whitehead criticizes, rejects, and then reforms what he calls both the subjectivist and the sensationalist principles,77 he questions:

74 This particular metaphysical idealism of Whitehead is addressed by Mills (2002), who underlines that this is indeed a distinct proposal; he concludes:

Instead of an absolute subject, self, mind, will, or pure thought thinking itself and the world into existence from a purely subjective ground, he shows how objectivity is the necessary precondition for every subjective form of creative pulse to materialize and thrive. This is the foundation of his transcendental realism: actual occasions arise out of nature and surpass themselves as immortal fact. His acceptance of a revised subjectivist principle is embodied in his doctrine of prehensions; thus whatever is actual experiences. Yet for Whitehead, experience is the experience of objects whose experience is constituted by the inclusion of otherness that is "immanent" within their own interior constitutions. But because he situates the drive toward novelty and objective immortality within a purposeful, valuative self-feeling subject that desires to complete itself through unity with the complex totality of cosmic process, his underlying idealism is representative of many Modern philosophies of the will. Indeed, Whitehead's philosophy of organism is a dynamic self-articulated complex holism, a metaphysics few idealists could ever aspire to surpass (p. 48).

75 Whitehead (1978) underlines that the philosophy of Hume has as its starting point "impressions of sensations" (p. 159). The problem of induction indeed arises there, intrinsically attached to such empiricism.

76 That is, the Kantian idealism where the doctrine of the objective world is a construct from subjective experience (Whitehead, 1978, pp. 152, 155-157, 190). More precisely, Kant rejected the sensationalist principle but accepted the subjectivist principle (see the next note).

77 Whitehead demarcates: "The subjectivist principle is, that the datum in the act of experience can be adequately analysed purely in terms of universals. The sensationalist principle is, that the primary activity in the act of experience is the bare subjective entertainment of the datum, devoid
The history of modern philosophy is the story of attempts to evade the inflexible consequences of the subjectivist principle, explicitly or implicitly accepted. The great merit of Hume and of Kant is the explicitness with which they faced the difficulty…The subjectivist principle follows from three premises: (i) The acceptance of the 'substance-quality concept as expressing the ultimate ontological principle. (ii) The acceptance of Aristotle's definition of a primary substance, as always a subject and never a predicate. (iii) The assumption that the experient subject is a primary substance… This is the famous subjectivist bias which entered into modern philosophy through Descartes. In this doctrine Descartes undoubtedly made the greatest philosophical discovery since the age of Plato and Aristotle. For his doctrine directly traversed the notion that the proposition, "This stone is grey", expresses a primary form of known fact from which metaphysics can start its generalizations…Primitive men were not metaphysicians, nor were they interested in the expression of concrete experience. Their language merely expressed useful abstractions, such as "greyness of the stone". But like Columbus who never visited America, Descartes missed the full sweep of his own discovery, and he and his successors, Locke and Hume, continued to construe the functionings of the subjective enjoyment of experience according to the substance-quality categories…In contrast to Hume, the philosophy of organism keeps "this stone as grey" in the datum for the experience in question. (1978, pp. 157, 159, 160)

of any subjective form of reception. This is the doctrine of mere sensation" (1978, p.157, emphasis original). Whitehead notices that Locke accepted the sensationalist principle but that he was inconsistent regarding the subjectivist principle—sometimes he accepted it, but most of the time he rejected it. As a further note: compare the subjectivist principle with the Borges story "Funes The Memorious" (in a previous note).
A central part of the proposal put forth by Whitehead is perhaps best summarized by Leclerc (1953) in direct contrast to the Aristotelian grounding: "For Aristotle substance is ‘informed’ matter; for Whitehead, substance or actual entity is ‘informed’ activity" (p. 242). More graphically, Whitehead, referring to the example of Heraclitus, pictures it as such: "We have transformed the phrase all things flow into the alternative phrase, the flux of things" (1978, p. 208).

The original words of Whitehead (1978) will be used in order to underline foundational aspects at play here:

**Principle:**

"The ultimate metaphysical principle is the advance from disjunction to conjunction, creating a novel entity other than the entities given in disjunction…The 'production of novel togetherness' is the ultimate notion" (p. 21).

**Entity:**

"The 'substance-quality' concept is avoided…morphological description is replaced by dynamic process…The notion of 'substance' is transformed into that of 'actual entity' "(pp.7, 19).

"An actual entity is a process and is not describable in terms of the morphology of a 'stuff' " (p. 41).

"Two descriptions are required for an actual entity: (a) one which is analytical of its potentiality for 'objectification' in the becoming of other actual entities, and (b) another which is analytical of the process which constitutes its own becoming. The term 'objectification' refers to the particular mode in which the potentiality of one actual entity is realized in another actual entity" (p. 23)
Process:

"Each ultimate unit of fact is cell-complex, not analysable into components with equivalent completeness of actuality… Each actual entity is a cell with atomic unity. But in analysis it can only be understood as a process; it can only be felt as a process, that is to say, as in passage. The actual entity is divisible; but is in fact undivided" (pp 219, 227).

"Every actual entity is in its nature essentially social… there is a growth from phase to phase; there are processes of integration and of reintegration" (pp. 203, 283).

"The same entity, be it actual entity or be it eternal object, cannot be felt twice in the formal constitution of one concrescence" (p. 227).

"The ultimate attainment is 'satisfaction'. This is the final characterization of the unity of feeling of the one actual entity… An actual entity is a process in the course of which many operations with incomplete subjective unity terminate in a completed unity of operation, termed the 'satisfaction' (pp 166, 219).

Explanation:

"How an actual entity becomes constitutes what that actual entity is; so that the two descriptions of an actual entity are not independent. Its 'being' is constituted by its 'becoming'. This is the principle of process" (p. 23).

"The primary character of this process is that it is individual to the actual entity; it expresses how the datum, which involves the actual world, becomes a component in the one actual entity. There must therefore be no further reference to other actual entities; the elements available for the explanation are
simply, the objective content, eternal objects, and the selective concrescence of feelings whereby an actual entity becomes itself." (p. 153).

**Summary of Central Ideas**

Without entering into a discussion or attempt to develop Whitehead's philosophy, we can catch a first useful glimpse of various premises:

- *To act* is to exist.
- Being is *becoming*.
- Substances are processes of activities.
- Agency is constant transition.
- Actual occasions (unique entities) are addressed in a primary place and are fundamentally the actualization of potentialities.
- To understand the becoming of a dynamic process is to explain it as such.
- *There are no essential causes*; entities exist in flux and are social by nature. Durations, activities, and phases take place identifying an operating unit ('satisfaction' achievement).
- Novel togetherness is a principle, not a derivative. But *there is no morphological analysis of static categories*, although processes indeed can be characterized; morphological description is replaced by (dynamic) process description.
- A foundation of processes of activities underlines the primacy of *acting individuals* (agents), that is, their individuality and uniqueness.

Now we will develop a brief overview of an explicit ontology for evolutionary processes that is founded on knowledge processes.
4.2.2. Evolutionary Ontology

Dopfer proposes an ontological framework for evolutionary economics based on a criticism of mechanical thinking (the Newtonian ontology). The core of this ontology, inspired by Darwinism, will be summarized in this section (Dopfer, 2001, 2005).

Three axioms regarding existences form the platform of the framework:

1. **Bimodality**: Existences are bimodal actualizations of matter-energy and information.

2. **Association**: Existences are structured based on (i) informational relations and (ii) matter-energy connections

3. **Process**: Existences are processes in time, structured as knowledge (endogenous change).

Various propositions are stated from the previous axioms:

- **Ideas** specify informant agencies, i.e., they in-form objects ("a form is in object" so it behaves in a certain way and not in another)—that is, the physical

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78 The specific proposal for economics takes as part of its justification the emphasis on empirical validity, and it is inductively generated. And what follows is called a process of decontextualization of terms (general meaning) and a further recontextualization within economics. This ontology is also defensible on its own terms based on the discussion up until now regarding the problem of the absence of the notion of time in research methods and the inadequacy of other ontologies in dealing with a non-uniform world.

79 Unless stated otherwise, this subsection is based on these two works.

80 Here the term "idea" does not refer to the sense of Berkeley and idealism. However, it is not far from it, either, if we recall how Berkeley’s idea has in-formed science. Russell (1912) summarizes the core of the philosophy of Berkeley, for whom "sense-data" only exist "in" the mind and, furthermore, for whom sense data became the only things he could "know". Blackmore (1979) develops this notion of an “idea” in the context of idealism:
actualization of objects (Bimodality). This bimodality rejects Cartesian dualism; there is no *a priori* (given or perfect) idea, but rather this becomes only through actualization. An idea is "any imagination that is brought about by a human thought process" (Dopfer, 2001, pp. 8-9).

- **Variety**: one idea is actualized in *different* objects that constitute a population.

- **Variation**: every idea changes; change of *variety* over time.

- **Relations**: structure of *ideas* that constitutes *semantic information*.

- **Connections**: structure of matter-energy existences

- **Selection**: distinction of *association* from its complement, i.e., structure is not an exhaustive set and not every relation is possible.

- **Retention**: the selected informant variant endures, i.e., meta-stability.

It is called "idealism" because Berkeley called physical objects ‘ideas’, a term which he used to include sensations and feelings as well as thoughts. For him and later phenomenalists such as Hume, Mill, and Mach physical objects are "groups of sensations". Neutral monism refers to the attempt of Mach, James, and even Russell to argue that phenomenalism was "neutral" between realism and idealism and was not merely a sub-variety of idealism. Subjective idealism is most commonly understood as restricting what can be "known" to the conscious impressions of an individual self or subject (epistemological solipsism). Many phenomenalists deny that they are either subjective idealists or solipsists on the ground that they deny that there is an individual subject or ego, which for realists simply proves that they are more subjective and solipsistic than ever, denying not only the "knowability" of an external world but even of the self which would do the "knowing". Objective idealism on the other hand would treat everything as part of a universal or "objective" consciousness. This and what many people call "inter-subjectivity" suggest different forms of what might be called “epistemological pantheism" (p. 127).
- An evolutionary regime is the sequence variety-variation-association-selection-retention. Evolution is the constant transition between regimes.

With this schema, and turning to economics, this ontology delineates various levels. At the microeconomic level, *Homo sapiens oeconomicus* (HSO) is taken as the unit of analysis (as opposed to the traditional *Homo oeconomicus*). HSO is conceived as a rule-user and rule-making animal in economic contexts—see also (Dopfer, 2004). The first distinction is the emphasis on studying the creation, selective adoption, and the adaptation and retention of problem-solving rules. This level of analysis is the generic level, i.e., generic cognition and generic behavior, and it is contrasted with the operant level (operant cognition and operant behavior), which has to do with economic operations (production, consumption, transactions). This distinction is fundamental and parallels the geno/phen distinction held in biology.

With these elements, a trajectory for an economic process can be identified in the microscopic layer (one individual):
- Rule origination (exploration, creativity).
- Rule adoption (internal selection, learning and inclusion of the rule in the knowledge base).
- Rule retention (memory, recurrent rule activation manifest at the operant level).

The macroscopic level is related to a multi-agent setting. Each agent is a carrier of information, and knowledge is demarcated as carried information. This multi-agent environment gives rise to the distinctions related to the axioms of association and process. An example is the social unit: the *firm* and, as such, the trajectory for the growth of the knowledge of the firm can be identified: (i) The exploration of economic opportunities, (ii) The social process of selective knowledge adoption, and (iii) The stabilization and retention of the knowledge base (organizational *routines*). This trajectory is extended to a fundamental part of the proposal by Dopfer, the meso-analysis—
that is, the study at the macro domain of many rule populations. A meso-trajectory is then conceived as:
- Rule origination: innovation, primacy of adoption.
- Rule adoption: macroscopic adoption in a population, replication, path dependence.
- Rule retention: adoption dynamics exhausted, stabilization of a rule in a population.

Moving to macroeconomics, this level refers to interrelated rules and interconnected populations that generate two layers:
- Deep structure: interrelated rules.
- Surface structure: interconnected populations; the actual carriers of rules.

Since at the structural level, the main issue is the coordination process (i.e., the trajectory of a rule affects the structures involved), the macro-trajectory can be conceived of, at both deep and surface levels, as:
- Rule origination that brings about macro de-coordination (disturbance).
- Rule adoption that brings about macro re-coordination.
- Rule retention that brings about macro-coordination (meta-stability re-achieved).

It is emphasized that any macro explanation should involve all the multi-level dynamics introduced above. After all, this is also an evolutionary continuum unfolding through time. It is an integral framework that, unlike what occurs in the naivety of neoclassical economics, includes both (i) the nature of man and (ii) time. The references mentioned (Dopfer, 2001, 2005) include contributions of diverse authors on different aspects of evolutionary economics.

To finish this sub-section, a re-definition is suggested that can assist one in handling the notion of adoption in our evolutionary framework. This is commented upon next.
The Role of Reproduction

Evolutionary economics places the emphasis on the study of the generic level. However, there is an important process carried about at the operant level, and a particular re-definition is suggested next, using the previous framework of evolutionary ontology.

Regarding the meso-level, Dopfer (2005) introduces a distinction that is fundamental and that we did not discuss in our selectionist theory of knowledge. He presented the term adoption of rules identified as "partial selection", as was shown above. A good example in economics and in managerial environments is the diffusion of innovations when a novelty has been partially adopted; this can generate the well-known path dependence behavior. In short, after small changes at the beginning of the history of the system, it shifts to a particular direction (the rate of adoption becomes a differential advantage above that of other competitors). Propelled by positive feedback that drives the growth of the adoption of the innovation, the process grows, and this can lead to a locked-in condition—in fact, this behavior is usually called path dependence because it grows as a consequence of its own history.81

In particular, given the bimodality axiom and the distinction between variation and variety, e.g., the difference between heredity and reproduction in the domain of biology, it is suggested in this dissertation that the process of

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81 The basic example is a Polya process where the growth of a system is driven by positive feedback ("increasing returns" for economists); these reinforcing processes drive and dominate this growth. For instance, using a System Dynamics simulation, Sterman (2000) develops several path-dependence simulation models based on several positive feedback processes that affect corporate growth (e.g., advertising, word of mouth, economies of scale, process improvement, network effects, complementary goods, product differentiation, etc.). An example of certain dynamic aspects of competition that lead to path-dependence, related to innovation networks in the biotechnology sector and the growth of their knowledge base, was developed in a simulation model by Olaya and Ruess (2004).
adoption be conceived of as reproduction. A specific idea is reproduced, and the population (phenotypes) grows. Indeed, each entity is a duple-entity; hence, there are as many objects as (idea-actualization) pairs; every actualization or every adoption of an existing rule "gives birth" to a new entity (in biology, a new phenotype). There is no selection of a "new" rule here, and there is no transmission, either (consistent with the evolutionary schema of the third chapter). There is the actualization of an existing idea (rule) and the growth of a given population. In particular, a given idea can be intensively actualized, e.g., with exponential strength given the positive feedback included. This development can be understood as differential reproductive success. This distinction underlines that the unit of selection is the idea, not the individual. Ideas can be selected, and they can be reproduced—actualized by further carriers so that they birth to new duple-entity idea-carriers; the latter process does not represent a change in the idea but instead represents a survival advantage in a selectionist schema. This is commented upon next.

Dopfer (2001) remarks that the diffusion of an innovation can be described by the Bernoulli equation as "the change in relative frequency of adopters and non-adopters in a population" (p. 34). It is the same process followed by the SI and SIR models of infectious diseases in populations, e.g., the spread of a virus. These notions have been applied in economics and management, starting, for instance, with the classic Bass model of the "infection" of innovations, see, e.g., (Sterman, 2000). Populations of duple-entities can engage in competition in a certain environment (a niche), and reproduction becomes a decisive factor. In biology, this corresponds to the idea of "reproductive success"—related to what Darwin called "sexual selection": "an individual may be more successful not by having superior survival attributes but merely by being more prolific reproductively" (Mayr, 1997 p. 192). Ultimately, natural selection can be understood merely as the differential reproduction of individuals "that differ unique in their adaptive superiority" (Mayr, 1982, p. 57). This distinction is not obvious; indeed, the difference between heredity and reproduction is constantly remarked upon by biologists.
As Dawkins (1996) likes to state, "You can have reproduction without heredity" (p. 88).

As an additional point, we can indicate a broader suggestion for the debate around the theory of punctuated equilibrium of (Gould, 2002), a theory focused on the evolution of phenotypes—he extended previous ideas suggested by Mayr, who always underlined the role of reproduction, which had been relatively overlooked in biology. At the heart of the proposal is exactly the same logic that economists have identified as "path dependence"—that is, if we hypothetically were to use the same ontology for both cases, then the evolutionary economists would lean the debate in favor of Gould. In short, he uses the expressions "reproductive drive" via "dominant relative frequency" to characterize "directional speciation as an important and irreducible macroevolutionary mode separate from species selection" (p. 724). This idea is summarized here:

When we consider the second category of reproductive drive (biased production of offspring that vary in a given direction from parents), we encounter one of the chart's most striking disparities — a crucial, yet almost entirely unrecognized and unexplored difference in basic pattern between micro- and macroevolution...suppose that a strong bias exists in production of offspring, so that 80 percent arise with smaller bodies than their parents...suppose also that this pattern continues from generation to generation. This driving process would generate a strong trend to decreased body size in the population at the organismal level; and to species with smaller average body sizes within the clade at the species level... Reproductive drives of this kind can occur at the organismal level, and a variety of names for such process exist, including mutation pressure and meiotic drive... However, when we move to the species level, the analogous driving phenomenon of directional speciation suffers no constraint or suppression — and may
represent one of the most common modes of macroevolution. (Gould, 2002, pp. 724-725)

To recapitulate, *Homo sapiens oeconomicus* as such is a "universe" of duple-entities, as many as the number of rules he uses. Moreover, the human being in this case can be conceived of, as presented in chapter 3, as an organism associated with multi-layered processes in a substitute-functioning schema of evolving knowledge; since it belongs to the biological continuum, in every event that involves a growth of knowledge, the interplay of indirect mechanisms of representation, habits, instincts, language, thought, etc. play their role in the actions of the individual. In one final remark, as a further redefinition, it should be noted that in the theory of knowledge presented, we did not explicitly address the process of reproduction; in fact, neither Campbell nor Popper made the explicit distinction; yet, the layer of "cultural cumulation", with all of its different facets, is essentially social knowledge and is a form of reproduction of knowledge among individuals. Dopfer addresses this, and we suggest that "adoption" can be conceived of as "reproduction"; this will also be clarified and formally demarcated in the next chapter, which presents a meta-design (see the introduction) in the form of a formal schema using the discussion presented up until now.

4.3. Evolutionary Thought Meets the World

A final and short reflection inspired by the example posed by evolutionary economics that confronts what we have taken for granted in economics, and in particular regarding its particular notion of rigor, will close this chapter.

As evolutionary economics authors suggest, the naivety of neoclassical economics is very much related to both its epistemology and its ontology. To learn by observation, that is, to be instructed by invented regularities, brings the limitations of idealism and a world of theories that do not match a real non-uniform world. Anthropocentrism can be changed. On the other hand,
ontological assumptions that deny change and that assume fixed essences and causal efficacy in explaining the world are inconsistent in the realm of living beings. Evolutionary epistemology and critical rationalism establish a criticism whose reflective nature harmonizes with the stand proposed by process philosophy and evolutionary economics. These are more thoughtful approaches. We have delineated them through this chapter; the previous chapter concerned epistemology, while this chapter addresses ontology. Two related quotations from authors associated with both streams show how these stances coincide:

(i) Concluding his criticism of Kant and his transcendental (subjective) philosophy, and arguing in favor of an evolutionary epistemology, Vollmer (1987) states a defense of representationalism:

Perfect knowledge about nothing, or imperfect knowledge about the real world — what do we prefer? Of course, there is no choice. (Newton's theory is, in fact, false); but if there were a choice, would we not choose the second alternative? (p. 176)

The illusion here refers to a knowledge based on Kantian idealism, a knowledge that is merely a Berkeleyan idea; this is the "perfect knowledge" that Vollmer refers to. It is the same knowledge generated by the methods of management science (chapter 2).

(ii) Along the same lines, but motivated for different reasons, and concluding a critique of neoclassical economics, Dopfer (2005) underlines the following:

Evolutionary theory copes imperfectly with a complex reality, while neoclassical theory describes with precision and rigour a simple world that apparently does not exist. (p. 52)
The non-existent world refers here to the fictional assumptions made by the mainstream (e.g., *Homo oeconomicus*).

Indeed, such worlds, described as “illusions”, simply do not exist. Or more accurately, they exist only in fertile imaginations. In fact, *homo oeconomicus* is a fiction; it is not even a biological product; it is another subsidiary condition that one needs in order to work via induction. We return to the introduction to this dissertation. The neglect of ontology, the neglect of epistemology, the disinclination to pay attention to assumptions, the neglect of questions surrounding the method, the neglect of questions surrounding our most basic beliefs, the neglect of criticism, the neglect of history, and in one word, the neglect of reflection—these are indeed the best examples of non-rigorous thinking and the denial of *homo sapiens*.

In sum, this chapter faced the question of how to counteract the influence of pervasive idealism (i.e., presentationalism, instruction, Lamarckism, etc.) in our conceptions of knowledge and reality. The natural option, which is also implied by the selectionist theory of knowledge presented earlier, demands that one address real (as opposed to ideal) knowledge. For ontology to be subsumed under a narrow heading of epistemology was also commented upon (as the current philosophy of science). This led us to emphasize the importance of including ontological reflection in human knowledge processes, which implies a need to reflect on the character of evolving knowledge itself. The ontological requisite of including time was underlined by examining two programs that assume change as a principle and that therefore include time: the metaphysical program of process philosophy and evolutionary realism. Various distinctions were mentioned: among others were the foundational shift from thing to process, the distinction between generic and operant levels, the template provided by the latter proposal regarding the micro-meso-macro trajectories of (generic) rules, etc. A final consideration led to a suggestion that the process of reproduction be included in our theory of knowledge. The next chapter introduces a meta-design as a formal schema for handling the
evolution of knowledge according to the discussion presented in this dissertation up until now.
5. VARIATION

He who understands a baboon would do more toward metaphysics than
Locke.
Charles Darwin, 1838
M Notebook

Introduction

This dissertation is just part of the knowledge process known as "management science", an aspect of cultural cumulation. As such, it is also framed under the schema of variation and selection that drives the continuum of the growth of human knowledge. Up until now, the emphasis has been on selection, that is, on error elimination. The criticism that has been developed is just an attempt to discard and reject particular conceptions, theories, assumptions, methods, etc. that have been previously selected by several scientific communities and that have been identified here as mistaken, in spite of their popularity. This criticism has been made from the upper level of epistemology suggested by van Gigch in order to fight off competing paradigms. And this process ended with the inclusion of ontological reflection as necessary in elaborating an integrated and coherent assessment. We introduced the relevance of "meta-modeling" in the introduction to this dissertation, i.e., a meta-design with epistemological foundations. This meta-model has been suggested through the discussion by our accepting some postures, reformulating some of them, and rejecting others. And this particular articulation of several elements that has been developed forms the central thread of this meta-model, which turns out to be the variation that accompanies the exercise of criticism that has been carried out. This trial will be introduced in this chapter.
This chapter is organized as follows. The first section summarizes central aspects (taken from the previous chapters) that are required to define the grounding and the logic that the meta-model follows. The second section specifies the meta-model. The third section makes various remarks regarding related technical aspects and future applications; it introduces an illustration of how to connect the metamodel with a specific scientific subject: governance.

5.1. A Trial

We presented a meta-theory of knowledge. This meta-theory has arisen from factual biology and the advancement of human knowledge through the evolutionary continuum; recent findings in relevant areas like neuroscience and genetics have been shown to match why selectionism is a different kind of theory. That theory includes a logic for the growth of knowledge and a general theory of rationality (chapter 3). The significance of a logic of selection over a logic of instruction was presented and connected with epistemological discussions with a particular emphasis on the question of method. We also identified further ontological requirements. Process philosophy and evolutionary realism helped us to make additional distinctions, in particular about the nature of existences as processes, the notions of actualization and bimodality, and the significance of reproduction.

We will use the distinctions indicated up until now to build a preliminary proposal of a framework for advancing research in social systems, the domain of management science. The meta-model emphasizes, among several aspects to be included, the selectionist logic of the growth of knowledge, the assumption of man as a unique and creative organism and part of the biological continuum, the recognition of social organizations as also part of the same continuum, the process nature of living beings, the schemas of bimodality and association, the social character of knowledge in organizations, and the relevance of coordination at aggregated levels where different organizations interact. Fundamentally, this meta-model conceives of social systems as
knowledge-evolving processes. This means that organizations, composed of human beings and as part of the evolutionary layer described as "cultural cumulation", act as substitute functioning processes. The growth of knowledge, with the constant interplay between creative individuals, collectivities, and inter-collectivities, is formalized in this selectionist schema that acknowledges both the fact that human beings are biological products and the logic of selection for advancing human knowledge in those social systems. In particular, and following the proposal of Dopfer, delineated above, the entities to which we refer are conceived of here as carried ideas by human beings and are labeled as knowledge. These entities follow a selectionist growth of knowledge.

From the introduction, and following van Gigch (2003), metamodeling refers to the elaboration of an abstract metadesign at the epistemological level that feeds back to the level of "normal" science, which should serve as a platform for the generation of theories and methodologies (Figure 1). The metamodel introduced in this chapter is especially designed to guide the investigation of knowledge systems. It is a synthesis of the natural complementarity between the presented evolutionary theory of knowledge (chapter 3) and the evolutionary ontology indicated above (chapter 4). It uses specific and formal notation. The schema is arranged through a set of propositions, some of them represented with mathematical notions, which gives the advantage of abstraction and form. A glossary summarizes the main concepts and definitions.

Initially, various points should be clarified and noted. First, the schema follows a logical development starting with assumptions and basic categories. Propositions are numbered so as to clarify hierarchical and logic connections and in order to ease cross-referencing. Particular connections are made explicitly to other propositions, indicating their reference numbers. Some propositions are not strictly needed, but they mean to denote specific and unequivocal emphases. The schema is also left in an abstract form; its
application to a particular domain should require corresponding contextualizations and applicable definitions in such a domain. Second, and nevertheless, the notation and the schema follow an informal simplification. The complete formal schema can be further extended based on the premises and the derivative propositions; also the specification of domains and relations with universals, and several resultant properties, can be further derived. Some of the notation is relaxed and used only for convenience of illustration. Moreover, for future concrete applications, the schema starts to delineate formalization for computer modeling and simulation.

It must be underlined that the richness of evolutionary thought finds a natural place in the nomenclature of set theory; it is problematical to describe, to represent, or to visualize most of the important dynamics and multidimensional arrangements that are implied, i.e., there are neither simple networks, nor trees, nor simple hierarchies, nor simple cycles, nor static structures, nor static components, etc. As a last point, a portion of the introduced terms are mainly used in biology, but it must be noted that this schema is neither an analogy nor a metaphor, let alone an application or the like. The only directly terms shared with biology — and somehow concrete ones — are those of the "human being." The schema is an abstract arrangement of the development of knowledge processes in social systems; special terms, though familiar in other different domains, are defined and carry a general meaning. Nevertheless, the familiarity of some words is helpful in presenting the logic and the classification.

The meta-model integrates two main interrelated layers. On the one hand, there is the inter-action of organisms, which not only acknowledges individual differences but which also includes the processes of variation and of the selection of knowledge, that is, the evolutionary drive. On the other hand, the schema includes the structural representation of the systems, both (i) duple-entities [organism + actualized ideas], i.e., the phenotypic (operant) level, and (ii) the generic level of ideas. For this last part, the use of graphs is introduced.
The graphs are dynamic representations and their changes follow a selectionist evolution driven and propelled by the interaction of organisms and the creation and utilization of knowledge.

**Inter-acting Organisms and Evolutionary Entities**

Wide-ranging conditions help to specify the central requirements for modeling a selectionist schema for social systems. This should take into account not only the logic of selection — as distinct from a logic of instruction *(chapter 3)* — but also individuality (agency as acting, *

chapter 4*), since each organism utilizes its knowledge in a particular way. The basic conditions for building this selectionist metamodel, recapitulating the previous chapters, can be summarized as follows:

(i). There should be creative entities with a temporary existence; they come into being, subsist, and then cease to exist, i.e., they endure and they live in time.

(ii). Such entities are changing by nature. They exist in time and, on principle, they change. This is non-essentialism.

(iii). These entities must have the capacity to reproduce, the ability to produce offspring.

(iv). Entities are required to have a special dual existence: on the one hand, there should be a general blueprint that defines a class of entities; this blueprint—a sort of program with encoded information—characterizes different classes of entities with particular characteristics and functionalities that allow them to survive in an external changing environment. This program can change so that the survival of the entities may be enhanced. On the other hand, every actual entity must be conceived of as a physical and fuzzy manifestation (i.e., variety) of this blueprint and, yet, the existence of each
actual entity is should also be determined by the interaction between its blueprint and the environment.

(v). This duality introduces a further distinction: heredity. This is the transfer of the characteristics from a parent to its offspring; in particular, what is transmitted in the reproductive process is the blueprint—it constitutes the full hereditary information.

(vi). Variation: the blueprint should be able to vary; this variation must be conditioned neither by the environment nor by the past. It should be blind.

(vii). Given this variation, different classes of entities exist. Because the milieu and the resources are limited, the environment will provide some restrictions for the survival of the physical manifestations of all of the blueprints, but some of these programs will cope better with the restrictions or the changes in the environment so that this process will necessarily end in the selection of the more adequate blueprints.

In short, the meta-model should consider temporary existence, reproduction, dual existence, variety, heredity, blind variation, a changing and limited environment, co-existence, and selection.82

Dynamic Structures: Evolutionary Hypergraphs

The interactions of agents generate dynamic structures where duple-entities are interrelated; these arrangements are determined by the interactions of organisms. The choice of dynamic graphs emphasizes the relevance of both

82 All of these characteristics are not present in the inanimate world; the assumptions of an inadequate ontology (e.g., Newtonianism) and an inadequate epistemology (e.g., idealism) that were conceived for dealing with physical objects can deliver nothing but failure in social science. Moreover, such an epistemology is inadequate for physics as well if we expect to transcend our mental constructions of a real world.
structure and time. A graph here is defined in the usual way: $G := (V, E)$, with $V$: set of nodes and $E$: set of edges. The schema uses a special type of dynamic hyper-graph combined with multisets (as used for multigraphs). In a hyper-graph, the relations $E$ can connect any number of nodes $V$. That is, the set $E$ does not denote pairs of nodes but rather denotes hyper-relations or sets of nodes; this explicitly requires powersets (sets of subsets). In addition, a multiset entails a multiplicity of memberships in sets that will multiple replications of a given hyper-relation. The sources used for notation and terminology, and also concerning graph theory, can be found in (Diestel, 2005; Mesbahi, 2005); there are further references and related extensions for dynamic graphs (Cortes, Pregibon, & Volinsky, 2003; Demetrescu, Finocchi, & Italiano, 2005).

An example of this representation follows. A central aspect of the metamodel is the generic network, which is a dynamic graph whose nodes are the evolving ideas of a social system. That is, the structure is associated with the association of interacting organisms in a purposeful whole, e.g., a firm. The evolution of those ideas is driven by the interaction of duple entities defined as a pair $e := (i, o)$, where $i$ stands for the actualized idea and $o$ is the corresponding carrier agent (organism). These entities are arranged in a structure that describes their complementarity, arrangement, interplay, coordination, and use in the social system. Two or more ideas can be connected in several ways and under different criteria. This association is the graph $N_j$. Such a graph is defined as a dynamic labeled multi-hyper-graph. This means that (i) the nodes and edges are subject to discrete updates through time, (ii) each edge can connect not only two but any number of nodes (i.e., hyper-edges), and (iii) each hyperedge can have parallel hyper-edges, exact replicas with a different label. This structure allows several dynamic multi-dimensional arrangements describing the evolutionary structure and development of the interrelated ideas associated with the social system. The complete specification corresponds to section [3.3.4] of the meta-model.
A note on fonts and notation

The meta-model uses the following font utilization. Definitions are highlighted in italic font. Individual elements are indicated with lowercase letters; sets and collections are indicated with capital letters or with marks (e.g., caret: "^"). Subscripts denote indices. The specification of the scheme must be presented in Euclid font, which allows for better readability and display.

5.2. The Metamodel


A2. Categories (summary). The schema distinguishes four categories, each of them with three sub-categories:

1. Existences.
   1.1. Process.
   1.2. Bimodality.
   1.3. Association.
2. Kinds.
   2.1. Organisms.
   2.2. Ideas.
   2.3. Entities.
   3.1. Variation.
   3.2. Selection.
   3.3. Systems.
4. Explanation.
   4.1. Explanation of processes.
   4.2. Levels of description.
   4.3. Investigation of knowledge and idea systems.

1. Existences.

1.1. Process

1.1.1. It is a cell-complex.

1.1.2. It is a unity. It has temporal coherence.

1.1.3. It exists in passage through successive phases.

1.1.4. Phases are activities; something is being done.

1.2. Bimodality.

1.2.1. A bimodal existence is a composite inseparable ordered pair, a duple-form: $(a, b)$.

1.2.2. $a, b$ are kinds $[2]$.

1.3. Association

1.3.1. Grouped interrelated kinds form an association.

1.3.2. An association has a structure that exists in time.

1.3.3. Since kinds $[2]$ are processes, then the corresponding structure is dynamic; it changes through time.

1.3.4. Different associations of different kinds generate different types of structures.

2. Kinds.

2.1. Organism.

2.1.1. An organism $(o)$ is a process.

2.1.1.1 Hence, its existence is characterized by action and activities $[1.1]$.

2.1.2. It is a living being; in particular, it is a human being, an individual of the biological species *homo sapiens*.

2.1.3. It is a biological process and part of the neo-Darwinian continuum $[A1]$. Thus:

2.1.3.1. The organism is a multi-layered knowledge-process being corresponding to a selectionist theory of knowledge. Therefore:

2.1.3.1.1. The individual organism is constituted by interplaying substitute-functioning representational processes that include: non-mnemonic problem-solving, vicarious locomotor devices and the
sensorial system, habits, instincts, sensorial-supported thought, mnemonically supported thought, imitation, and language.

2.1.3.2. The processes of [2.1.3.1] follow blind-variation and selective-retention.

2.1.3.3. In particular, in every organism, knowledge generation [3.2.2] and knowledge reproduction [3.2.3] follow the process described by [2.1.3.1].

2.1.4. An organism is continuously engaged in problem-solving processes.

2.2. Idea.

2.2.1. An idea (i) is a process.

2.2.2. It is brought about by an organism following variation [3.1].

2.2.3. It has a finite existence ([3.2.4], [3.2.5]).

2.2.4. Its existence is motivated by a problem to be solved or a necessity to be fulfilled by an organism [2.1.4].

2.3. Entity.

2.3.1. An entity (e) is bimodal [1.2].

2.3.2. It is composed of a specific idea and a specific organism, e := (i, o).

2.3.3. Since both i and o are processes, therefore an entity e has a bimodal process character.

2.3.4. An entity is knowledge, i.e., an idea carried by an organism.

2.3.5. It is not eternal, since neither the idea i [2.2.3] nor the organism o [2.1.2] is eternal.

2.3.6. Every entity aims to respond with a solution to a specific problem or necessity of the corresponding organism o ([2.1.4], [2.2.4]).


3.1. Variation.

3.1.1. Idea production. It is a free trial produced by an organism through any of the processes of [2.1.3.1].

3.1.2. Hence, the trials are generated by blind variation, that is:

3.1.2.1. The emitted variations are independent of the environmental conditions of the occasion of their occurrence.
3.1.2.2. The occurrence of trials individually is uncorrelated with the solution—specific correct trials are no more likely to occur at any point in a series of trials than another, nor than specific incorrect trials.

3.1.2.3. The rejection of the notion of a "correcting" process between variations—i.e., a variation subsequent to an incorrect trial is not a "correction" of an earlier one.

3.1.3. Principle of variation: there are many different ideas \( i_1, i_2, i_3, \ldots \) that are generated by every organism at any time ([2.1.4], [2.2.4]).

3.1.4. There is no instruction [3.1.2.]. Thus, there is no "learning" conceived of as instruction by the environment, that is, there is no induction and there is no process of cumulative correction.

3.1.5. Already selected knowledge [3.2] (i.e., that which has been embodied in the organism) represents discovered "wisdom" regarding the interaction with the environment. This wisdom might guide further the generation of trials, though they keep on being blind-generated and, thus, selected knowledge is not fixed and can be further eliminated [3.2.4].

3.2. Selection

3.2.1. Symbol and notation: actualization is denoted with the symbol "\( \sim \)"

3.2.1.1. If an actualization gives birth to an entity \( e \), it is expressed: \( i \sim e \).

3.2.1.2. \( \left[ (i \sim e_1) \land (i \sim e_2) \right] \iff \left[ i \sim (e_1, e_2) \right] \). (Equivalence in notation and extended by transitivity).

3.2.1.3. \( \left[ i \sim e \right] \iff \left[ i \sim (e = (i, o)) \right] \).

3.2.2. Knowledge generation — first-time actualization of an idea.

3.2.2.1. Definition: a new trial-idea \( i \) [3.1] generated by an organism \( o_a \) is selected, that is, incorporated (embodied) in the same organism \( o_a \) when this is manifest in action.

3.2.2.2. The organism selects (actualizes) the idea according to [2.1.3].

3.2.2.2.1. Thus, there is no instruction.

3.2.2.3. A new entity \( e_1 \) is born in [3.2.2.1], that is, \( i \sim (e_1 = (i, o_a)) \).

3.2.2.4. Knowledge (an entity \( e \) is then conceived as a selected (actualized) idea in an organism.

3.2.3. Knowledge reproduction — new actualizations of an existing idea.
3.2.3.1. Definition: Let $e_1 = (i_i, o_a)$ be an existing entity. An organism $o_b, (a \neq b)$, selects (incorporates, embodies) the existing idea $i_i$ already selected in $o_a$. This is manifest in action. It is called knowledge acquisition by the organism.

3.2.3.1.1. The organism selects (actualizes) the existing idea according to [2.1.3].

3.2.3.2. A new and different entity $e_2$ is born in [3.2.3.1], that is:

$$i_i \sim (e_2 = (i_i, o_b)).$$

3.2.3.3. Conspecificity: $e_1$ [3.2.3.1] and $e_2$ [3.2.3.2] are conspecific, that is, these entities share a reproduced idea.

3.2.3.3.1. Conspecificity is a transitive relation—that is: if $e_1$ and $e_2$ are conspecific, and $e_2$ and $e_3$ are conspecific, then $e_1$ and $e_3$ are conspecific.

3.2.3.4. Every organism thinks, acts, and reacts differently [2.1].

3.2.3.4.1. Thus, every reproduction of the same idea $i$ produces a unique different entity: that is, $\forall \; i, \; e : (i \sim e_1, \; e_2) \rightarrow (e_1 \neq e_2)$ (implication notation). This is uniqueness.

3.2.3.4.2. Variability. The manifestation of an actualized idea in the action of a given organism [3.2.2.1] or [3.2.3.1] is not necessarily the same each time it is performed.

3.2.3.5. A genus (plural genera) $G_i$ is the set of all existing entities that share the same idea $i_i$:

$$G_i := \{ e_1, e_2, e_3, \ldots \} = \{ (i_i, o_{i_1}), (i_i, o_{i_2}), (i_i, o_{i_3}), \ldots \} = \{ e = (i, o) : i = i_i \}$$

3.2.3.5.1. If $|G_i| \geq 2$ then there is variety in $G_i$ [3.2.3.4.1].

3.2.3.6. A species $S_i$ is a reproductively isolated genus; that is:

Let $i_i$ be a specific existing idea,

Let $G_i$ be the corresponding genus $G_i := \{ e = (i, o) : i = i_i \}$,

Then, $\forall \; e_1, \; e_2 \in G_i$, if $e_1, \; e_2$ are conspecific [3.2.3.3.] then $e_1, \; e_2 \in S_i$.

3.2.3.6.1. Speciation. A species with its common ancestral idea $i_i$ may diverge with time, given its reproductive isolation and variability [3.2.3.4.2], until the point of becoming a new genus $G_j$, with $i \neq j$. 
3.2.3.7. **Diffusion.** Constant reproduction \([3.2.3.]\) drives the growth of a given genus \(G_i\), i.e., giving it more members (more entities \(e_i\)). This process of growth is called the diffusion of the corresponding idea \(i_i\).

3.2.4. **Elimination.** An entity \(e := (i_i, o)\) can be eliminated in two ways:

3.2.4.1. **Desactualization:** the idea \(i_i\) is disembodied from the organism \(o\)—the idea disappears from action; it is abandoned by the organism.
3.2.4.2. Or the organism \(o\) ceases to exist.
3.2.4.3. The corresponding genus \([3.2.3.5]\) and species \([3.2.3.6]\) lose their corresponding members.
3.2.4.4. Therefore, knowledge can be abandoned. There are no partial truths. Knowledge is conjectural.

3.2.5. **Extinction.** It denotes the elimination of an entire genus \(G_i\).

3.2.5.1. Any genus \(G_i\) is a dynamic set (i.e., reproduction \([3.2.3]\) and elimination \([3.2.4]\)).
3.2.5.2. **Extinction.** It is whenever \(|G_i| = 0\) (after a process of elimination). Therefore, the corresponding \(i_i\) is extinguished.

3.2.5.2.1. A species \(S_i\) can be eliminated in a particular habitat \(H_j\) \([3.3.2.4]\), that is, whenever \(|\bar{S}_j| = 0\). Yet, it is possible that its ancestral idea \(i_i\) may survive in other habitats; this may also generate new genera \([3.2.3.6.1]\). Thus, the elimination of a species \(S_i\) implies neither the extinction of the genus \(G_i\) nor the extinction of the idea \(i_i\).

3.3. **Systems.**

3.3.1. A **system** is a set of interrelated kinds.
3.3.2. A **social system** is an association of organisms \([2.1]\).

3.3.2.1. A social system \(O\) is a purposeful organization of organisms.
3.3.2.2. Every social system \(O\) can be described by a finite and dynamic set:
\[
O := \{ o_1, o_2, o_3, \ldots \}.
\]
3.3.2.3. A species \(S_i\) generated by the organisms of a given social system \(O_j\) is denoted as \(S_i(O_j)\) or \(\bar{s}_j\) (lowercase font), that is:
Let \(O_j\) be a specific social system \(O_j := \{ o_1, o_2, o_3, \ldots \}\),
Let \(\bar{s}_j\) be a specific idea,
Let $S_i$ be a species, $S_i := \{ e_1, e_2, e_3, \ldots \}$,

Then $\hat{s}_{ij} = S_i(O_j) := \{ e = (i, o) : e \in S_i \land o \in O_j \}$

**3.3.2.3.1. Knowledge communities.** Hence, a given system $O_j$ develops several species. This collection of species is denoted by $\hat{S}_j$ (uppercase font), and it is called the knowledge communities of $O_j$.

In other words, $\hat{S}_j$ is the set of genera $[3.2.3.5]$ in a given social system:

$\hat{S}_j := \{ S_1(O_j), S_2(O_j), S_3(O_j) \ldots \} = \{ \hat{s}_{ij}, \hat{s}_{ij}, \hat{s}_{ij}, \ldots \}$

$= e \in U\hat{S}_j \Leftrightarrow \exists \hat{s}_{ij} \in \hat{S}_j : e \in \hat{s}_{ij}$

**3.3.2.4. Habitat.** The problems to solve, necessities to fulfill, and goals to achieve for a specific social system $O_j$ constitute the habitat $H_j$ for its knowledge communities $[3.3.2.3.1]$—that is, $H_j$ is the habitat for the entities $e$ belonging to the collection of all the species $\hat{s}_{ij}, \hat{s}_{ij}, \hat{s}_{ij}, \ldots$ generated by the organisms of $O_j$.

**3.3.2.4.1.** A region is a specific group of interrelated problems, necessities or goals to achieve in $O_j$.

**3.3.2.4.2.** A specific species is related to one or more regions of $O_j$.

**3.3.3. A knowledge system is a set of entities $[2.3]$. There are two types: Repertoires and Semantic Networks.**

**3.3.3.1.** An organism is a generator and a selector (actualization) of ideas. In particular, the set of ideas selected by a given organism $o_i$ is the knowledge system of the organism. This is called its Repertoire, $R_i$.

**3.3.3.1.1.** Hence, $o_i \rightarrow R_i$; an organism implies the existence of its corresponding repertoire.

**3.3.3.1.2.** $R_i$ is a dynamic set:

$R_i := \{ e_1, e_2, e_3, \ldots \} \equiv \{ (i_1, o_i), (i_2, o_i), (i_3, o_i), \ldots \} = \{ e = (i, o) : o = o_i \}$

**3.3.3.1.2.1.** $R_i$ is dynamic since the organism is engaged in problem-solving and is actualizing and desactualizing ideas constantly $[2.1], [3.2.2], [3.2.3], [3.2.4.1.]$.

**3.3.3.1.2.2.** A particular idea that is preferred over other ones for a particular problem and that is recurrently used in action
Variation

(through one of its actualizations in one or more entities) by the organism \( o_i \) is called a prominent idea.

3.3.3.2. The Semantic Network \( N_i \) is the automatic association of the entities belonging to a same genus \( G_i \), that is, the semantic network of the corresponding idea \( i \).

3.3.3.2.1. Hence, \( G_i \to N_i \); a genus implies the existence of its corresponding semantic network.

3.3.3.2.2. Structure: \( N_i \) is a finite, undirected, complete, and dynamic graph:
\[ N_i := (G_i, T) \]

3.3.3.2.2.1. Nodes: \( G_i := \{ e = (i, o) : i = \hat{i} \} \)
(a). Notice that the organisms \( o_{i_1}, \ o_{i_2}, \ o_{i_3},… \) that generated the genus \( G_i \) do not necessarily belong to a same social system \( O \).

3.3.3.2.2.2. \( N_i \) is undirected. There is no preference in the edges regarding directions or orientations in the structure and distribution of entities. Each particular actualization of \( i \) in every organic component \( o_{ij} \) is understood as equal to the other ones. Therefore, \( T \) is the set of edges that is constituted by unordered pairs of distinct nodes:
\[ T := \{ \{e_1, e_2\}, \{e_1, e_3\},...,\{e_2, e_3\}... \} := \{t_1, t_2,...\} \]
(a). \( T \) is the Information Net of \( N_i \).
(b). \( T \) is a dynamic set driven by the changes in \( G_i \) (i.e., new members and elimination of members \([3.3.3.2.4])\).
(c). The edges \( t_1, t_2,... \) are not necessarily weighted. Yet, for particular applications, e.g., the measure of intensity or strength of various versions of the same idea between organisms, the use of related communication channels, etc., then the edges could be weighted.
3.3.3.2.3. $N_i$ is complete: there is a relation (edge) $t$ for every pair of nodes.

That is: $\forall e_i, e_j \in G_i, \exists t \in T : t = \{e_i, e_j\}, i \neq j$

3.3.3.2.4. Update. $N_i$ is a dynamic graph since $G_i$ is a dynamic set [3.2.5.1]. This implies that $N_i$ is a fully dynamic graph, since it can be updated via two processes:

(a). Every reproduction in $G_i$ brings multiple insertions:

(a1). The new node $e$ is inserted.

(a2). All the corresponding relations from the new node $e$ to all other nodes of $N_i$ are inserted.

(a3). Thus, both $G_i$ and $T$ are updated.

(b). Every elimination in $G_i$ brings multiple deletions:

(b1). The eliminated node $e$ is deleted.

(b2). All the corresponding relations from the eliminated node $e$ to all other nodes of $N_i$ are deleted.

(b3). Thus, both $G_i$ and $T$ are updated.

(c). Hence, the graph is subject to sequences of updates, i.e., discrete time change. Each step constitutes unrestricted insertions (a) or eliminations (b) of both nodes and edges. That is, an update of the graph $N_i$ has the form $N_i(t+1) = F(N_i(t))$. $N_i(t)$ is the graph at time $t$, and $F$ is a transformation that maps the graph to $N_i(t+1)$ according to the reproduction (a) or elimination (b) that take place.

3.3.3.2.5. Several other structures for $N_i$ are possible depending on particular characterizations of the domains or the structures ascribed to these
semantic networks; in general, several types of graphs are possible.

3.3.3.3. Elimination of a knowledge system.

3.3.3.3.1. A repertoire of an organism \( o_i \) is eliminated with the disappearance of the members of its corresponding repertoire \( R \).

3.3.3.3.2. The elimination of a semantic network \( N_i \) is implied by the extinction of its set of nodes \( G_i \) according to [3.2.5.2].

3.3.3.4. Notice that a given social system \( O_j = \{ o_1, o_2, o_3, \ldots \} \) involves many knowledge systems:

3.3.3.4.1. All the repertoires associated with each member \( o_i \).

3.3.3.4.2. The semantic networks of the knowledge communities of \( O_j \):  

3.3.3.4.2.1. A semantic network of a specific idea \( i \) actualized by the members of \( O_j \) is denoted as \( N_i(O_j) \) or \( \tilde{N}_{ij} \). In other words, \( \tilde{N}_{ij} \) is the semantic network whose set of nodes is the particular species \( \tilde{s}_{ij} \)—that is:

Let \( i \) be a specific idea,

Let \( O_j \) be a specific social system,

Then \( \tilde{N}_{ij} = N_i(O_j) := (\tilde{s}_{ij}, T) \)

(a). \( T \) is the respective information net of \( \tilde{s}_{ij} \).

3.3.3.4.2.2. All the semantic networks \( \tilde{N}_{ij}, \tilde{N}_{gj}, \tilde{N}_{sj}, \ldots \) associated with the members of \( O_j \) constitute the collection of dynamics graphs \( \tilde{N}_j \) and these are called the semantic communities of \( O_j \). That is:

Let \( O_j \) be a specific social system,

Let \( \tilde{S}_j \) be its knowledge communities,

Then \( \tilde{N}_j := \{ N_i(O_j), N_g(O_j), N_s(O_j), \ldots \} = \{ \tilde{N}_{ij}, \tilde{N}_{gj}, \tilde{N}_{sj}, \ldots \} = \{ \tilde{N} = (\tilde{s}, T) : \tilde{s} \in \tilde{S}_j \} \).
3.3.4. A system of ideas is a set of ideas \([2.2]\).

3.3.4.1. All the actualized (i.e., existing) ideas form the dynamic set diversity \(D\):
\[ D := \{i_1, i_2, i_3, \ldots\}. \]

3.3.4.2. The respective set of ideas of the knowledge communities \([3.3.2.3.1]\) of a given social system \(O_j\) constitutes the generic knowledge base \(G_j\):
\[ G_j := \{i_{1j}, i_{2j}, i_{3j}, \ldots\} = \{i: (e = (i, o)) \in \hat{S}_j\}. \]

3.3.4.3 The ideas of a given \(G_j\) are arranged in a structure that describes their complementarity, arrangement, interplay, coordination, and use, in \(O_j\). Two or more ideas can be connected in several ways and under different criteria. This association is the graph \(N_j\) and it is called the generic network of the corresponding social system \(O_j\).

3.3.4.3.1. Hence, \(G_j \rightarrow N_j\); every generic knowledge base has a corresponding generic network.

3.3.4.3.2. Structure: \(N_j\) will be defined as a dynamic, labeled, multi-hyper-graph. This means that: (i) the nodes and edges are subject to discrete updates through time; (ii) each edge can connect not just two but any number of nodes (i.e., hyper-edges); and (iii) each hyper-edge can have parallel hyper-edges, exact replicas with a different label. This structure allows there to be several dynamic multi-dimensional arrangements describing the evolutionary structure and development of the ideas in \(O_j\). Formally, \(N_j\) can be defined as a 6-tuple:
\[ N_j := (\Sigma_x, \Sigma_z, G_j, T, \phi_z, \phi_x), \]
in the following way:

3.3.4.3.2.1. Nodes. It is the generic knowledge base \(G_j\); that is:
\[ G_j := \{i: (e = (i, o)) \in \hat{S}_j\}. \]

3.3.4.3.2.2. \(T\) is a multiset of unordered hyper-edges; that is:

(a). Hyper-edges are sets of nodes.
Let $P(G_j)$ be the powerset of $G_j$ (i.e., the set of all subsets of $G_j$); that is: $P(G_j) := \{ T_1, T_2, T_3, \ldots \} = \{ T : T \subseteq G_j \}$.

Then: $T \subseteq P(G_j)$.

If $T = P(G_j)$ then $N_j$ is complete.

(b). Multigraph. Parallel hyper-edges are allowed, i.e., multiple hyper-edges with a same set of nodes. Thus, $T$ is a multi-set, which means that each of its members, i.e., each subset of $G_j$ describing a hyper-edge, has a multiplicity indicated by a natural number; this can be indicated by pairs $(T, n)$ where $n$ indicates how many memberships has $T$ in $T$. That is, the multiplicity is given by:

$$\forall T \in T, \exists n \in \mathbb{N} : (T, n).$$

(c). $T$ is a dynamic set driven by the evolution of $G_j$.

(d). The hyper-edges are not necessarily weighted. Yet, for questions introduced by concrete applications related to the prominence of some ideas in $O_j$ (and perhaps connected to particular regions and/or frequencies of occurrence), centrality, hubs, connectivity, paths, etc., then the hyper-edges could be weighted.

3.3.4.3.2.3. Labels. A label is a unique identifier. $\Sigma_\pi$ and $\Sigma_\tau$ are finite alphabets for the labels of both the nodes $G_i$ and the hyper-edges $T$, respectively.

3.3.4.3.2.4. Labeling. $\phi_\pi : G_i \rightarrow \Sigma_\pi$ and $\phi_\tau : T \rightarrow \Sigma_\tau$ are maps that assign labels to the nodes and to the hyper-edges.
3.3.4.3.2.5. Update. $N_j$ is a dynamic hyper-graph determined by the evolutionary dynamics of $G_j$. This implies that $N_j$ is a fully dynamic hyper-graph, since it can be updated via two processes:

(a). Every new species $\xi_j$ in $O_j$ brings multiple insertions:

(a1). The new node $i_{ij}$ is inserted.
(a2). All the corresponding relations from the new node $i_{ij}$ to its related nodes are inserted. That is, the hyper-edges are inserted.
(a3). Multiple parallel hyper-edges can be inserted.
(a4). Thus, both $G_j$ and $T$ are updated.

(b). Every elimination of a species $\xi_j$ brings multiple deletions:

(b1). The eliminated node $i_{ij}$ is deleted.
(b2). All the corresponding relations from the eliminated node $i_{ij}$ to its related nodes are deleted. That is, the related hyper-edges are deleted.
(b3). The multiple parallel hyper-edges are also deleted.
(b4). Thus, both $G_j$ and $T$ are updated.

(c). Hence, the graph is subject to sequences of updates, i.e., discrete time change. Each step constitutes unrestricted (a) insertions or (b) eliminations of both nodes and parallel hyper-edges. That is, an update of the graph $N_j$ has the form: $N_j(t+1) = F(N_j(t))$. $N_j(t)$ is the graph at time $t$, and $F$ is a transformation that maps the graph to $N_j(t+1)$ according to the generation or elimination that takes place.
### 3.3.5. **Knowledge evolution** in social systems is furnished by processes of competition.

#### 3.3.5.1. A *niche* is a particular region of a habitat $H_j$ (which is associated with a social system $O_j$ [3.3.2.4]), and it describes the relational position of a species as *effective* in responding to a particular problem or necessity that it aims to respond to in that particular region.

##### 3.3.5.1.1. **Effectiveness.** This is the capacity of a species to resolve the problem, fulfill the necessity or reach the goal in a particular niche. A species is effective as long as it is capable of producing desirable results.

#### 3.3.5.2. New species. Several new species can be introduced continuously in any niche of the habitat $H_j$ through knowledge generation and reproduction ([3.2.2], [3.2.3.1], [3.2.3.6]).

#### 3.3.5.3. **Competition.** Entities of the same species or of various different species may compete in the same niche of a given habitat $H_j$, that is, these entities are seen as struggling for survival. A superior adaptation and/or differential reproductive success may promote particular species over their rivals:

##### 3.3.5.3.1. **Adaptation.** Some entities $e_{i1}$, $e_{i2}$, $e_{i3}$, belonging to a species $s_{ij}$ (i.e., related to an idea $i_j$) may show more effectiveness in the given niche than competing entities $e_{j1}$, $e_{j2}$, $e_{j3}$,… of rival species $s_{jj}$, $s_{kj}$,… (related to other ideas $i_j$, $i_k$,…). It is said then that $s_{ij}$ is better adapted than its rivals with respect to the corresponding niche.

##### 3.3.5.3.2. **Differential reproductive success.** A species $s_{ij}$ may have an advantage in reproduction so that its entities might dominate the niche over rival species (which may end up eliminated [3.2.5.2.1]). This differential reproduction does not necessarily require superior adaptation, only more prolific reproduction.
3.3.5.3.3. The relative superiority of $\delta_{ij}$ ([3.3.5.3.1] or [3.3.5.3.2]) stimulates two processes:

3.3.5.3.3.1. The diffusion [3.2.3.7] of $i$ among the members of $O_j$:

(a). The idea $i$ may become prominent [3.3.3.1.2.2] among the repertoires of the organisms of $O_j$.

3.3.5.3.3.2. The desactualization [3.2.4.1] of the competing ideas $i_j, k_j, \ldots$ by the organisms of $O_j$.

3.3.5.3.3.3. Hence, [3.3.5.3.3.1] and [3.3.5.3.3.2] represent a renovation of the repertoires of the corresponding organisms.

3.3.5.3.4. The rival species $\delta_{ij}, \delta_{kj}, \ldots$ may find a different niche.

3.3.5.3.5. Those rivals $\delta_{ij}, \delta_{kj}, \ldots$ face the risk of elimination [3.2.5.2.1].

3.3.5.3.6. Competitive exclusion principle. Provided that one of the competing species $\delta_{ij}$ has advantage, i.e., [3.3.5.3.1] or [3.3.5.3.2], then two or more species cannot stably coexist competing in the exact same niche. In the long run, the competitors face elimination or a shift to a different niche.

3.3.5.3.6.1. If there are no rivals, then it is said that the species $\delta_{ij}$ is prevalent in the niche.

3.3.5.3.5. Niche differentiation is the process through which a niche is partitioned among rival species; the stable coexistence of two or more species brings about a segregation of the niche, which is then addressed by coexistent species.

3.3.5.4. Stability. A species $\delta_j$ that is prevalent [3.3.5.3.6.1] is said to be stably adapted to the habitat $H_j$. 
3.3.5.4.1. **Selective retention.** Stability means that the corresponding idea $i_i$ of the species $i_j$ has been selected in the corresponding social system $O_i$.

3.3.5.4.2. While the cardinality $|O_j|$ remains constant, then for a stable species $i_j$, its respective semantic community $\tilde{\mathcal{N}}_j$ [3.3.3.4.2.2] is said to be stable.

3.3.5.4.3. The collection $\tilde{\mathcal{S}}_j$ (the knowledge communities) is stable if its members have adapted stably to the corresponding habitat $H_j$.

3.3.5.4.3.1. Hence, the corresponding *generic knowledge base* $G_j$ is said to be stable as well.

3.3.5.4.4. **Stasis.** A species $i_j$ is in stasis if it is resistant to change in a varying habitat or in a highly competitive niche. This is a rigid form of stability.

3.3.5.4.4.1. Species with large populations may tend to be in stasis because of differential reproductive success [3.3.5.3.2], which does not imply better effectiveness ([3.3.5.1.1], [3.3.5.3.1]).

3.3.5.5. **Challenges to stability.** A stable generic knowledge base $G_j$ is constantly facing challenges to its stability in several ways:

3.3.5.5.1. Changes in regions and niches may provide opportunities for new species to compete.

3.3.5.5.2. Species displaced from other niches may also affect stability that has been achieved [3.3.5.3.4].

3.3.5.5.3. New regions [3.3.2.4.1] and niches [3.3.5.1] can be continuously identified in a particular habitat $H_j$.

3.3.5.5.4. Since the organisms are continuously engaged in problem-solving, then at any rate new species can be introduced in any niche. This is also furnished by the arrival of new organisms to the corresponding social system $O_j$. 
3.3.5.5.5. All of the processes of variation and selection, including competition and the challenges to stability, determine the structure and the dynamics of both the semantic communities $\tilde{N}_j$ and the generic knowledge base $G_j$.

3.3.5.5.5.1. Hence, the updating process of the generic network $N_j$ [3.3.4.3.] is also defined by the evolutionary dynamics of the entities in the social system $O_j$. Variation in and the selection of ideas take place. These processes define the transformation $F$ [3.3.4.3.2.5].

3.3.6. An ecosystem $\mathcal{E}$ is a collection of social systems: $\mathcal{E}_k := \{O_1, O_2, O_3, \ldots\}$. These systems are interrelated based on some criterion that they share, such as the domain of action, function, goals, location, activities, structure, some properties of their members, etc.

3.3.6.1. The interactions between systems are what define the ecosystem as a unit that allows the coexistence of the different social systems.

3.3.6.2. The ecosystem is a functional unit. The shared domains between the systems belonging to $\mathcal{E}_k$ constitute the eco-habitat $\mathcal{H}_k$.

3.3.6.2.1. *Eco-region.* The social systems of an ecosystem $\mathcal{E}_k$ may have to face particular problems and necessities together in their eco-habitat, or they may have joint goals to achieve. This space constitutes an eco-region.

3.3.6.2.2. The division in eco-regions is not a partition of the eco-habitat. There can be juxtaposition; the species can interact in different overlapping eco-regions.

3.3.6.3. The relevant group of species of the different systems (i.e., the pertinent knowledge communities [3.3.2.3.1]) interacting in the eco-habitat $\mathcal{H}_k$ constitute the ecological knowledge community, the collection $\mathcal{K}_k = \{\check{s}_1, \check{s}_2, \check{s}_3, \ldots\}$.
The relevance is determined by the domain they share \[3.3.6.2\]. That is:

Let \(i = 1..m\) be the sub-index that indicates an existing idea \(i\) \(\in D\ \[3.3.4.1\],

Let \(j = 1..n\) be the sub-index for the social systems of members of a given ecosystem \(\mathcal{E}_k\),

Let \(k = 1..p\) be a sub-index that indicates the relevant species interacting in the ecohabitat \(\mathcal{H}_k\).

Then \(\mathcal{K}_k := \{ \hat{s}_{ijk} : \hat{s}_{ijk} \in O_{i} \land O_{j} \in \mathcal{E}_k \} \).

3.3.6.4. The corresponding ideas of the species belonging to the ecological knowledge community \(\mathcal{K}_k\) constitute the generic knowledge of the ecosystem, the set \(W_k\). That is,

Let \(i, j, k\) be defined as in \[3.3.6.3\], then:

\(W_k := \{ i_1, i_2, i_3, \ldots \} = \{ i : \hat{s}_{ijk} \in \mathcal{K}_k \} \).

3.3.6.5. In the same way, at the system level, the ideas belonging to the generic knowledge \(W_k\) of the ecosystem \(\mathcal{E}_k\) are arranged in an eco-structure that describes the way in which coordination is achieved at the ecosystem level. This arrangement of generic knowledge in the ecosystem will be denoted as \(Q_k\).

3.3.6.5.1. Hence, \(W_k \rightarrow Q_k\); every piece of generic knowledge of a given ecosystem has a corresponding generic knowledge eco-structure.

3.3.6.5.2. The structure \(Q_k\) can be defined in the same way as the generic network \[3.3.4.3\] of a particular social system; that is:

\(Q_k := (\Sigma_W, \Sigma_T, W_k, T, \phi_W, \phi_T)\), with \(\Sigma_W, \Sigma_T, T, \phi_W, \phi_T\) defined as in \[3.3.4.3.2\] with the following annotations:

3.3.6.5.2.1. Keeping in mind that \(W_k = \{ i : \hat{s}_{ijk} \in \mathcal{K}_k \} \[3.3.6.4\] , then the species \(\hat{s}_{ijk}\) involved belong to diverse social systems, not only to a specific social system \(O_j\).
3.3.6.5.2.1. The process of updating the graph $Q_k$ is not directly determined by the subsistence or elimination of the corresponding species. It is determined by their membership in the ecological knowledge community $\mathcal{K}_k$, that is, according to the relevance of the domains involved ([3.3.6.2], [3.3.6.3]). The insertion of a node and its hyper-edges means that the corresponding idea $i$ has become relevant to a particular domain and hence that it has become a member of $\mathcal{K}_k$. Likewise, the deletion process means “no further relevance”.

3.3.6.5.2.2. Therefore, the corresponding definition of the transformation $F(Q_k(t))$ is not given directly by the evolutionary dynamics of the species but is instead provided by the defined criteria of coordination and the relevance of the particular domains involved.

(a). Nevertheless, evolutionary dynamics carried on in each social system bring about the generation and elimination of ideas in $\mathcal{K}_k$.

4. Explanation.

4.1. Explanation of processes.

4.1.1. A process [1.1] is what it becomes. Its being is its becoming.

4.1.2. Therefore, to understand the becoming of a process is to explain it as such.

4.1.3. A process is not separable; it is a whole.

4.1.4. Durations, activities, and phases identify an operating unit.

4.1.5. Hence, there are no essential causes; processes exist in change.

4.1.5.1. There is no morphological analysis of static classes or types.
4.2. Levels of description.

4.2.1. There are three interconnected levels of description: (i) organism, (ii) social system, and (iii) ecosystem.

4.2.2. An explanation should take into account the three levels of description; otherwise, it is incomplete given the interconnectivity across levels in time and space.

4.3. Investigation of knowledge and idea systems

4.3.1. Two different connotations of selection must be distinguished:

4.3.1.1. The selection (actualization) of an idea in an organism ([3.2.2.1] and [3.2.3.1]) refers to the biological process in which knowledge grows in organisms. These selections produce new entities ([3.2.2.3] and [3.2.3.2]). The use of the term "selection" is used here only to emphasize that organisms are not instructed in the process of actualization. The significance is the generation and reproduction of knowledge entities.

4.3.1.2. The selective retention [3.3.5.4.1] of an idea in a social system.

4.3.2. Two units of investigation are discriminated: (i) entities and (ii) ideas. Both units are significant, and since both are interdependent, both should be addressed.

4.3.3. Entities are manifest in the activities of organisms ([3.2.2.1] and [3.2.3.1]).

4.3.3.1. The becoming (existence) of an entity $e = (i, o)$ has three characters: the organism $o$ (character of the subject), the idea $i$ (character of the genus), and the actual action and its conditions in which is performed (character of circumstance, time and space).

4.3.3.2. Entities are social based on principle. They form societies, and they constitute species that interact in systems and ecosystems. Therefore any explanation should consider the way in which these interactions constitute stable species.
4.3.3. Entities have a historical nature. They are the product of variational evolution.

4.3.4. Ideas are abstractions.

4.3.4.1. Interrelation. The entities constitute the manifestations of ideas in action ([3.2.2.1] and [3.2.3.1]).

4.3.4.2. The interplay of entities and their relationships with the different habitats drive the dynamics of the ideas, i.e., the generic knowledge of the different systems. The activities of organisms, systems, and ecosystems are explained and characterized in terms of generic knowledge.

4.3.4.2.1. *Explanatory principle.* The evoluvionary dynamics of generic knowledge, i.e., systems of ideas [3.3.4], is the focus of explanation. But we do not search for explanations moving from facts (entities in action) to abstract ideas; we look to understand how and why the facts are manifestations of evolving abstractions (ideas).

4.3.4.2.1.1. In any case, given variation [3.1.3] and variety [3.2.3.5.1], induction is not possible.

4.3.4.2.1.2. The abstraction of a particular idea \(i_i\) requires the examination of the corresponding semantic network \(N_i\) [3.3.3.2] and, in the context of a given social system \(O_j\), then it requires the examination of the corresponding semantic community \(\tilde{N}_{ij}\) [3.3.3.4.2].

4.3.4.2.1.3. Concerning levels of description and the explanatory emphasis on generic knowledge, the explanatory principle denotes:

(a). With respect to organisms, explanation denotes the study of repertoires [3.3.3.1].

(b). With respect to social systems, particular interest is implied by the introduction of new ideas [3.3.5.2] or the reproduction ([3.3.5.3.2], [3.2.3.7]) of existing ones. These investigations
denote the design and development of policies. The study of adaptation [3.3.5.3.1], precedence (priorities of substitute-functioning processes, particularly in function of effectiveness [3.3.5.1.1]), and the dynamic relationships between ideas, constitute the study of systems' design and management. Therefore, this is the examination of the dynamics of generic networks [3.3.4.3].

4.3.5. Annotations on organisms.

4.3.5.1. Agency is constant transition (from [2.1.1]).

4.3.5.2. Agents are acting [2.1.1] and creative [3.1.1] individuals. They are not conditioned by the environment or by external instruction.

4.3.5.3. Rationality and agency always involve the knowledge processes which are inter-playing in any organism, e.g., habits, instincts, thought, imitation, language [2.1.3.1.1].

4.3.5.4. Hence, there is no "representative" or "average" organism.

4.3.6. Recursion. Scientific inquiry is an activity part of a relevant ecosystem and as such it follows the same processes of growth in knowledge characterized in this schema.

4.3.6.1. Particularly when the social system or the ecosystem under examination happens to be scientific practice itself then the selection of ideas via error-elimination, i.e., falsification, is purposefully and strongly pursued, i.e., critical rationalism.
GLOSSARY OF MAIN CONCEPTS, DEFINITIONS AND SYMBOLS

SYMBOLS

\( D \): Diversity.
\( e \): Entity.
\( E \): Ecosystem.
\( G \): Genus.
\( G \): Generic Knowledge Base.
\( H \): Habitat.
\( \hat{H} \): Ecohabitat.
\( i \): Idea.
\( \hat{K} \): Ecological Knowledge Community.
\( N \): Semantic Network.
\( N \): Semantic Communities.
\( N \): Generic Network.
\( o \): Organism.
\( O \): Social system.
\( Q \): Eco-structure.
\( R \): Repertoire.
\( S \): Species.
\( W \): Generic Knowledge of an Ecosystem.

CONCEPTS AND DEFINITIONS

Actualization: Selection (incorporation) of an idea that is manifest in action \[3.2.2\].

Adaptation: Quality of a species that it needs show more effectiveness in a given niche than do other rival species \[3.3.5.3.1\].

Association: Grouped interrelated kinds, i.e., organisms, ideas or entities, that are represented by a dynamic structure (which changes over time) \[1.3\].
**Variation**

**Competition**: Entities struggle for survival in the same niche. Advantage is given by superior adaptation or differential reproductive success \[3.3.5.3\].

**Competitive Exclusion Principle**: Two or more species cannot stably coexist competing in the same niche \[3.3.5.3.6\]; *see also* Competition.

**Conspecifity**: Entities that share the same idea through reproduction \[3.2.3.3\].

**Differential Reproductive Success**: More prolific reproduction of a species as related to other rival species in a given niche \[3.3.5.3.2\].

**Diversity** \((D)\): Set of all existing ideas \[3.3.4.1\].

**Ecohabitat** \((\mathcal{H})\): Shared domains between the systems belonging to a given ecosystem \[3.3.6.2\].

**Ecological Knowledge Community** \((\mathcal{K})\): Group of relevant species interacting in an eco-habitat \[3.3.6.3\].

**Eco-region**: Space with shared problems or necessities or with joint goals to achieve, as faced by the social systems of a given ecosystem \[3.3.6.2.1\].

**Eco-structure** \((\mathcal{Q})\): Association of ideas that describe the way in which coordination is achieved in a given eco-habitat \[3.3.6.5\].

**Ecosystem** \((\mathcal{E})\): A collection of social systems that are related by some criterion such as a domain of action, a function, goals, a location, activities, structure, a property of their members, etc. \[3.3.6\].

**Elimination**: Eradication of an entity through desactualization or because of the death of the related organism \[3.2.4\].

**Effectiveness**: The capacity of a species to resolve a problem, address a necessity or meet a goal in a particular niche. A species is effective as long as it is capable of producing desirable results \[3.3.5.1.1\].

**Entity** \((e)\): *Knowledge*, i.e., an idea carried by an organism \[2.3.4\].

**Explanatory Principle**: It is focused on the evolutionary dynamics of systems of ideas, i.e., generic knowledge \[4.3.4.2.1\].

**Extinction**: Elimination of a genus \[3.2.5\].

**Generic Knowledge Base** \((\mathcal{G})\): Set of ideas in a given social system \[3.3.4.2\].
**Generic Knowledge of an Ecosystem:** (\(W\)): Set of ideas of the species interacting in a given eco-habitat \([3.3.6.4]\).

**Generic Network** (\(N\)): Association of ideas in a given social system. It describes the complementarities, arrangement, interplay, coordination, and use of such ideas in the social system \([3.3.4.3]\).

**Genus** (\(G\)): Set of all entities that share the same idea \(i\) \([3.2.3.5]\).

**Habitat** (\(H\)): Problems to solve, necessities to fulfill, and goals to achieve in a specific social system \([3.3.2.4]\).

**Idea** (\(i\)): A method used by an organism to solve a problem or to fulfill a necessity \([2.2]\).

**Knowledge**: Selected idea in an organism \([3.2.2.4]\); see also Entity.

**Knowledge Communities**: Collection of species in a given social system \([3.3.2.3.1]\).

**Knowledge Generation**: first-time actualization of an idea \([3.2.2]\).

**Knowledge Reproduction**: New actualization of existing ideas in different organisms \([3.2.3]\).

**Knowledge System**: A set of entities, either a Repertoire or a Semantic network \([3.3.3]\).

**Niche**: A particular region in a social system that describes the relational position of a species as effective in responding to a particular problem or necessity \([3.3.5.1]\).

**Organism** (\(o\)): A human being \([2.1.2]\).

**Recursion**: The social system or the ecosystem can be instantiated in scientific practice as the domain of action, i.e., scientific inquiry.

**Region**: Specific group of interrelated problems, necessities or goals in a social system \([3.3.2.4.1]\).

**Repertoire** (\(R\)): Knowledge system of an organism, i.e., set of selected ideas held by the organism \([3.3.3.1]\).

**Selective Retention**: The stabilization (selection) of an idea in a social system \([3.3.5.4.1]\); see also Stability.

**Semantic Communities** (\(N\)): Collection of semantic networks of a given social system \([3.3.3.4.2.2]\).
**Semantic Network (N):** Association of entities that belong to the same genus [3.3.3.2].

**Species (S):** A reproductively isolated genus [3.2.3.6].

**Social system (O):** Purposeful association of organisms [3.3.2].

**Stability:** The quality of a species’ being prevalent (i.e., it has no rivals) in a given habitat [3.3.5.4].

**System:** Set of interrelated kinds, i.e., organisms, ideas or entities [3.3.1].

**Variability:** Manifestations through action of ideas (i.e., knowledge) are not necessarily the same for a given organism [3.2.3.4.2].

**Variation:** Idea production generated by blind variation [3.1].

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### 5.3. Remarks

This section concludes the presentation of the meta-model with various remarks regarding its future development and application.

**Technical Aspects**

Concerning technical aspects necessary in order to handle the hyper-graphs previously introduced, various technical details should be resolved first, since perhaps one of the first words that comes to mind is "intractability", especially if the meta-model is conceived of as a type of methodological isomorphism meant to develop full computational representations. Regarding dynamic graphs theory, graph rewriting mechanisms—where one or more sub-graphs are replaced by new graphs following evolutionary rules specified in a graph grammar—have been regaining recognition thanks to computational biology and artificial life studies (though graph rewriting as such is not new) given its potential to represent selectionist systems; see, e.g., an overview in the context of molecular biology in (Roselló & Valiente, 2005). The approach presented here presents various advantages; in the first place, the possibility of direct translation to computational graphs. Second, (spatial) relations and multi-level
designs are not restricted to limited lattices (e.g., 2D grids in cellular automata; for instance, concerning artificial life—compare with (Attoni, Stadler, & Flamm, 2005)). Moreover, connections and relations between agents or entities are significantly flexible; there is a wide range of possibilities with hypergraphs, multi-directed graphs, multi-labeled graphs, discrete dynamics, etc. Related antecedents can be mentioned. For instance, there are (a) graphs updating and rewriting mechanism analysis and Large Dynamic Graphs Theory — see, e.g., an overview of typical problems in (Demetrescu et al., 2005); a particular relevant application in cliques, i.e., complete sub-graphs, is found in (Stix, 2004). There is also (b) Evolutionary Graph Theory, as introduced by Lieberman, Hauert, and Nowak (2005) using a simple example of reproduction in a single population. In this dissertation, the former option is favored given the emphasis on discrete changes (e.g., insertion or deletion of nodes and/or edges), which should be more appropriate to the representation of variational evolution; the latter proposal points to functionability and continuity. In any case, given the emphasis on nested recursive dynamic hierarchies, bottom-up simulation and dynamic discrete graph updating are indicated here as more suitable than pursuing analytical or numerical solutions. A work that points to restricted multi-level evolutionary graph modeling is introduced in (Beck et al., 2004); regarding implementation and formal languages, a pertinent and powerful relational growth grammar for rewriting data structures is now available (Kniemeyer, Buck-Sorlin, & Kurth, 2003, 2004), which opens up the possibility of working with multi-hyper-graphs; direct connections with graph-based visualization can also be further developed—see, e.g., a related work in (Salzberg, A., & Sayama, 2006).

83 Another proposal in evolutionary economics for studying the diffusion of knowledge which uses dynamic graphs is presented in (Morone & Taylor, 2004), but with various restrictions (e.g., there are simple graph structures, the nodes are agents, and there is a simplified notion of knowledge and a non-selectionist logic of growth, among others). This type of work can be further extended using the formal framework presented here.
A Direct Application: Growth and Evolution of Complexity

It must be noticed that graph representations draw attention to a particular focus: structural complexity. In order to address questions regarding the growth of complexity, it is important to recognize the importance of network-like structural aspects and the relational nature of such representations. As Standish (2005) underlines, it is conceivable that complexity growth takes place in the network of ecological interactions between individuals — which nevertheless can be connected with organism complexity (Maron & Fernando, 2006). The representation and analysis of graphs provides an indication for handling and formalizing the study of relational complexity. The task implies a long-term span, but the range of possibilities is also broad. Relevant examples will be highlighted next.

A measure of complexity for networks based on information content and computational feasibility is presented in the aforementioned work by Standish; a discussion of this approach with the closely related problem of open-ended evolution is found in (Standish, 2003). A framework for multilevel agent environments that uses dynamic graphs is introduced in (Yamins, 2002) with the aim of dealing with the persistent problem of modeling dynamical hierarchies (Lenaerts, Groß, & Watson, 2002); see also (Yamins, 2005). In (Demetrescu et al., 2005), there is an examination of different tools for dynamic graphs, e.g., clustering, sparsification, randomization, etc., so as to address typical problems such as connectivity, minimum spanning tree, transitive closure and shortest paths; for the shortest hyper-paths, see, e.g., (Ramalingam & Reps, 1996). A related issue is the transversal hyper-graph generation problem, i.e., that of generating the set of minimal transversals (the hyper-graph whose hyper-edges are the minimal hitting sets of the primary one), which is addressed in (Kavvadias & Stavropoulos, 2005; Wahlström, 2004); see an example applied to phylogenetics in (Downey, Fellows, & Stege, 1999) to measure evolutionary relatedness. Consider also the more specific vertex cover problem, i.e., given a parameter k, the problem of deciding if a
Variation

graph has a vertex cover of k vertices; e.g., (Chen & Kanj, 2001) provide algorithms for this problem. The modular decomposition of hyper-graphs is addressed in (Bonizzoni & Della Vedova, 1999), which explains how to obtain a tree representation of the graph by means of modules, subsets of vertices that share the common property of being adjacent to the same vertices outside the module, which, for example, tackles problems of graph comparability. Computational complexity in clique hyper-graphs is indicated in (Kratochvíl & Tuza, 2002), in this case with the problem of bi-colorability. Traditional problems of centrality might be relevant as well, e.g., the notion of closeness centrality, which measures the independence and efficiency of an agent; a randomized approximation algorithm for centrality is found in (Eppstein & Wang, 2004). A related analysis has to do with the interdependence of species and the problem of finding dominators in ecosystems, which has been addressed using network topological structures (Allesina & Bodini, 2004) and analyzed through graph algorithms in (Georgiadis, Tarjan, & Werneck, 2006). Tools and methods for the analysis, specification and detection of graph patterns and motifs (collections of related patterns) are also available, see, e.g., (Klukas, Koschützki, & Schreiber, 2005). Some of the mentioned traditional measures of complexity for graphs, e.g., connectivity, have been recognized as unsatisfactory; an alternative is to directly relate structure with process (Anastasiadis et al., 2005; Terhesiu & da Costa, 2006), e.g., to measure complex structures of graphs based on the dynamics used to generate them.

Extensions of these analyses, applied to the type of dynamic multi-hyper-graphs introduced in this dissertation (and connections with measures of dynamic relational complexity), represent nontrivial tasks but also suggestions for promising lines of research.

_A Selectionist Management Science_

Nevertheless, the main interest is in introducing the meta-model as a formal representation in order to address the investigation of systems characterized by
evolving knowledge. These systems include the domain of management science: organizations, firms, and social systems in general. The category of explanation of the meta-model provides these guidelines embedded in the selectionist logic of the growth of knowledge. An overview follows.

The presented schema poses the dual entities \((e)\), i.e., carried ideas, as knowledge. Such entities follow evolutionary regimes driving the development of (generic) ideas \((i)\) in social systems. It is assumed that such knowledge is generated by human beings and selected in the way depicted by evolutionary epistemology, i.e., selection, as opposed to instruction. Furthermore, the selectionist model develops the setting for the interaction of the entities \((e)\) and the evolution of knowledge. All the distinctions previously discussed (chapter 3) that are related to the growth of knowledge via selection are included. The focus of our attention can be an ecosystem, a particular social system, or aspects of individual human knowledge; nevertheless, the schema emphasizes the inter-connectivity of the three levels of description, e.g., the study of a social system cannot ignore the particular ecosystems to which it belongs. Examples of typical ecosystems include industrial sectors, (public) governance settings, and in general any grouping of diverse social organizations belonging to the same arrangement. Yet, ecosystems can also be larger, e.g., a scientific field or, for instance, the particular economic issues of the European Union; they can be also smaller, e.g., an organization or a firm (at this lower level, the social systems become the usual organizational subsystems distinguished based on a given criterion, e.g., function, location, etc.). The application of the schema requires the contextualization of terms within the particular domain.

As an example, consider for instance the central questions related to control and strategic planning. These processes should aim for flexibility, and, overall, the organization must not undermine the possibility of blind variation across the whole system; every sub-group, every individual, every knowledge process counts as a generator of trials. The grounding of the meta-model is the assumption that organizations are always changing in principle. This ever-
changing nature defies entrenched notions of organizations like "identity", "mission", "vision", and “innovation”—indeed, all of these notions might be re-formulated and some of them even rejected.\textsuperscript{84} The main point to deliver here is a deep shift—the coherent complementary views: ontology (existences are processes) and epistemology (evolution of knowledge). Organizations are part of the same continuum of the growth of knowledge. The meta-model indicates a way to integrate these perspectives. A brief example follows.

\textbf{An example: Governance as an Ecosystem}

In order to illustrate the connection between the meta-model and a specific scientific question (level 2 of the schema of van Gigch), this section briefly takes up the issue of \textit{governance} in public management research.

The term “governance” comes originally from the notion of "steering"\textsuperscript{85}, that is, the act of governing. However, it should be noticed that a still-more-conventional notion seems to prevail: "Governance — whether public or

\textsuperscript{84} Consider for instance what has been called "value innovation". The famous paper by Kim and Mauborgne (1997) addressed the question of sustained high growth for some companies; for five years, they examined 30 companies and, in short, the "successful" companies did not pay attention to their rivals (not benchmarking); the industry's conditions were not taken as given, and instead of fixing decisions as dependant on resources, assets, or capabilities (a standard view), these firms ask: "What if we start anew?". There are several examples, and this view gained popularity. Yet, there are three aspects to notice. (i) This was an inductive study intended to generate a conjecture; an evolutionary view would have saved the researchers some trouble, since, roughly speaking, "speculation" is a principle. (ii) The evolutionary theory provides a broader and coherent explanation of why these companies were successful. (iii) Moreover, since the change is foundational then this does not just affect innovation theories. It changes the way we conceive of firms, the role of individuals, how we "study" these firms, how they grow, etc., among several other shifts.

\textsuperscript{85} This happens to be a very old term. "Govern" comes at least from 1297, from the Old French \textit{governer} "govern", which in turns comes from the Latin \textit{gubernare}, "to direct, rule, guide," originally "to steer," from the Greek \textit{kybernan} "to steer or pilot a ship, direct". This is the same root of Cybernetics (Simpson & Weiner, 1989). The notion of "steering" denotes a process of \textit{coordination}. 
private — has been defined simply as the general exercise of authority, where authority refers to systems of accountability and control" (Hill & Lynn, 2004). Pierre and Peters (2000) identify four major ways to conceive of governance: as hierarchies, markets, communities, and networks. In particular, the notion of a “network” is directly connected with the meta-model, and it is also the central notion that characterizes the so-called shift "from government to governance". A network underlines the change from the traditional assumption of the exercise of hierarchical and direct control to the notion of "influence" in networked arrangements (Peters & Pierre, 1998). Hill and Lynn (2004) define governance as the "regime of laws, rules, judicial decisions, and administrative practices that constrain, prescribe, and enable the provision of publicly supported goods and services through associations with agents in the public and private sectors" (p. 4). Particularly relevant here is the structural focus, so that the term stresses the set of relationships that constitute the systems for policy choice and action (Meier, O'Toole, & Nicholson-Crotty, 2004). This view emphasizes networks over agencies and programs, with a special concern for associational hybridized entities; it is opposed to the customary focus on hierarchies and exchange, and it underlines coordination and integration over command and control (Lynn, 2003). Some authors assume a relative structural stability but with multiple forms and types, and with an extension beyond formal linkages (O'Toole, 1997). Peters and Pierre (1998) also underline such a diverse collection of actors that control policy, underscoring that these actors are not formal policy-making governmental institutions.

This network conception is perhaps best condensed by Rhodes:

Governance refers to self-organizing, interorganizational networks and has the following characteristics.
(1) Interdependence between organizations. Governance is broader than government, covering non-state actors. Pushing back the boundaries of the State dissolves the boundaries between public, private and voluntary sectors.
Variation

(2) Continuing interactions between network members caused by the need to exchange resources and negotiate shared purposes.

(3) The interactions are game-like, rooted in trust and regulated by the agreed-upon rules of the game.

(4) There is no sovereign authority, so networks have a significant degree of autonomy from the state and are not accountable to it. They are self-organizing.

(5) Networks are a governing structure, an alternative to markets and hierarchies.

Whereas government is about imposing order and ruling relatively simple systems, governance is about managing disorder and steering complex systems. (Cope, Leishman, and Starie, 1997)

Within these lines, Feldman and Khademian (2002) indicate that governance structures should be addressed focusing on the dynamic interaction of people in different and reciprocal roles. As contrasted with the traditional hierarchies, here governance is the result of network transactions instead of the imposition of top-down control. It is also underlined that a governance regime is the result of several dynamic processes linking numerous issues: citizen preferences and interests (expressed politically), public choice (expressed in legislation and executive policies), formal structures and processes associated with public agencies, discretionary management, core technologies, primary work and service transactions overseen by public agencies, consequences (outcomes, outputs, or results), and stakeholder assessments of performance (Hill & Lynn, 2004).

A greater effort should be made to conduct research within the field of public management that explores performance at the macro or system-wide level. In such a networked pattern, new questions for public managers and researchers arise; i.e., what particular organizational structures are better for attaining specific goals? If so, why, for whom, when, and where? (Hill & Lynn, 2004).
How is the concept of a network understood? What is a structure? What would be the components or the nature of these structures? How do these structures change through time? Guidelines for addressing these broad questions can be provided by defining “governance” as the ecosystem as defined in the meta-model [3.3.6.], that is, as a collection of social systems. The criterion of interrelationships can be defined, for example, as referring to the organizations that deliver public services in a particular country. Thus, governance becomes a system of ideas [3.3.4], which, in turn, is the focus of scientific explanation. In other words, the study of the evolutionary dynamics of the generic knowledge of the ecosystem [3.3.6.4.] turns out to be the unit of investigation, i.e., the study of variation, adaptation, effectiveness, reproduction, differential reproductive success, speciation, diffusion, elimination, competition, habitats, niches, and all the evolutionary dynamics that take place in this ecosystem. The meta-model specifically underlines that a scientific explanation for governance deals with the study of the coordination of the eco-structure, that is, the dynamic arrangement of generic knowledge. All of these tasks outline a broad research agenda at the level of normal science in public management research.

**Final remarks**

To conclude, notice also that the schema itself is both rational and empirical. The necessity of equilibrium between these two extremes of the spectrum was underlined in the previous chapter. But both facets must be underlined; with the term "rational", we mean that the schema is coherent and logical, and with the expression "empirical", we underline, apart from its consistency with biological facts, that it is applicable and adequate. The presented schema

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86 The emphasis on “coordination” is frequently invoked in studies of public management addressed to the macrolevel (the state). This emphasis concerns the role of the government as a builder and driver of interorganizational coalitions, which is usually identified with tasks such as political entrepreneurship, priority-setting, and goal definitions (Peters & Pierre, 1998).

87 These distinctions between “rational” and “empirical” are borrowed from Whitehead (1978).
delineates a logic for the growth of knowledge in (human) social systems provided that essential conditions are met; in our case, the entities (i.e., knowledge — carried ideas) and their environment follow an evolutionary growth of knowledge, not only because of biological results (i.e., human knowledge has been assumed as part of the biological continuum; human beings are the carriers of ideas) but also because relevant structural and functioning conditions follow the same pattern (e.g., entities with a temporary existence, reproduction, dual existence, variety, heredity, variation, changing and limited environment, co-existence, selection, etc.).

A further, third variation for sustaining the argument could be also introduced using the transformation formalized by Beer (1965; 1984). Framed in Group Theory, a scientific model can be defined as a homomorphism, i.e., a structure-preserving map between two groups. This schema follows. Let $M$ be the set of elements $a$, the totality of world events to examine. Let $A \subseteq M$ be the subset of events that we know about. Let $N$ be the set of elements $b$, the totality of systemic science. Let $B \subseteq N$ be the configuration of the system that we understand. And finally, let $f$ be a mapping so that as $\forall a \in A$ exists then a corresponding $b \in B : b = f(a)$. Then a model is the image of $A$: $f(A) \subseteq N$. An isomorphism is a bijective homomorphism, that is, $f^{-1}$ is a function, so that $f(A) \subseteq N = f^{-1}(B) \subseteq M$. This isomorphic mapping can be used to theorize and develop scientific models; in such mapping, the invariances between the two systems that apply to all systems of a particular class become a scientific model. The presented metamodel provides the transformation $f$. The formal scheme of a selectionist growth of knowledge is isomorphic to selectionist systems; such a transformation $f$ includes what is relevant in structure and functionality, forming a one-to-one map.
6. OUTLOOK

An incorrigible anthropocentrism characterizes our traditional and pervasive epistemologies, which, paradoxically and inconsistently, recognize the obvious imperfections of our sensorial apparatus but nevertheless rely for knowledge on perception (observation, etc.). This is, positivism, which is nothing more than our anxiety to confirm and validate our "imperfect" knowledge, and yet, which is supposedly achievable, regardless of whether such knowledge is represented with words or numbers (this happens to be a misleading criterion). This narrow epistemology took the command in the 20th century, and it became the *metaphysics* for any attempt to increase our understanding of the world; in particular, it became the metaphysics of management research, disguised under a misleading debate (quantitative methods “vs.” qualitative methods). The problems with such epistemology, labeled in this dissertation as “presentationalism”, are greatly overlooked. This dissertation develops a corresponding criticism. The situation is ironic, since *realism* was the doctrine defended by the most influential *scientists* of modern times: Newton, Darwin, and Einstein. The biggest paradox, no doubt, is that this anthropocentrism has led us to neglect humanity, i.e., to neglect the creative and unique character of human beings and the dynamic nature of the universe.

Following the presented meta-model, the criticism and characterization of the current grounding of management science can be re-stated in the following way.

- There is not selection but instruction by the environment; there is conditioned adaptation to what is perceived.
- Since there is not blind variation but instruction, the process of actualization $i \sim (e = (i, o))$ would be restricted, since the idea $i$ is understood in the sense of Berkeley as the solely product of sense perception in the mind of the organism $o$. 

Regardless of the inaccuracy of our sensorial system, the process of the growth of knowledge is driven by the instructional logic of correction based on supposedly achieved partial truths.

Therefore, all of the ideas and species are mind-products sourced exclusively in perception (research methods).

There is no variety. This means:

\[ \forall \ i, \ e : (i \sim e_a, e_b) \Rightarrow (e_a = e_b). \]  
All knowledge entities are identical.

\[ \forall \ G, \ i, \ |G_i| = 1. \]

There is no variation. For any problem, a law-like statement encompasses a description and a prescription.

The organism performs actualized ideas in the same way each time; variability is inexistent.

Hence, there is no distinction between idea and action. To observe behavior is sufficient.

Thus, induction is possible: to observe organisms allows us to generalize in space and time (prediction).

In contrast, the meta-model organizes prominent features for conceiving social systems as knowledge processes. Important wide-ranging elements to recall are:

- Recognition of the biological condition of man.
- Knowledge is evolving constantly, propelled by the creativity and the action of individuals.
- Knowledge is not transmitted. It is selected.
- The recognition of uniqueness of organisms in space and time.
- The selectionist process provides the diversity and growth of knowledge, i.e., its increasing adequacy and effectiveness in a changing environment.
- Instead of being conditioned by the environment, i.e., by imperfect sensorial perception, individuals have an active role in the generation of
knowledge. That is, impelled by blind variation, their generated knowledge is not conditioned by perception. In particular, the generation of scientific knowledge should be centered on more speculation, on more trials, and on the systematic elimination of unsuccessful responses.

This dissertation introduces a novel and formal way to approach the description and explanation of knowledge systems in order to create a framework for generating theories. It is conceived for addressing the Science of Management—recall from the introduction that this metascience deals with the epistemological issues of the management discipline.

**Summary of Contributions**

To raise the level of abstraction provides a wider perspective that helps one to understand and to address a general situation, in this case the condition of management research. The problems of management science are not problems of method *per se*. They are a consequence of the current neglect of epistemology in its research practices. The methodological framework for conducting management research proposed here is an answer along those lines. Three major contributions of this study are:

- A novel assessment of management science epistemology that may help to explain why current research is trapped in one single perspective. This assessment widens the current view. The fundamental statement is: management is doing mere normal science and fails to learn as a discipline because it is working within an unsuitable and unnoticed paradigm. Such a diagnosis is not present in research discussions in spite of several researchers’ claiming the contrary. In particular, in line with Level 3 of the management discipline as suggested by van Gigch (2003), this dissertation developed the following tasks:
The sources of knowledge were identified. The categorization of management science as normal science was anchored in one single paradigm: presentationalism—i.e., empirical basis, the prominence of the observer, justificationism, the method (induction), the goals of generalization and prediction, explanation as causal laws, the status of confirmation and verification.

This type of knowledge was characterized and criticized as inadequate because of its inconsistency (the problem of induction) and its commitment to a uniform world where change is excluded.

- An updated characterization of a distinctive type of knowledge to pursue in management research:
  Knowledge as an evolving process and as part of a continuum consistent with biology. This process advances via blind variation and natural selection.
  Human and scientific knowledge as part of a single continuum ranging from the most primitive non-mnemonic problem-solving layer through higher levels like habit, instinct, visually and mnemonically supported thought, and imitation, to the highest levels, such as language, cultural cumulation, and science. Evolving selection criteria are nested in this hierarchy, which is also consistent with current biology.
  A commitment to basic ontological premises anchored in process philosophy and, mainly, in evolutionary realism.

- A formal meta-model for the science of management. This level of abstraction delivers a broad scope and opens up possibilities for diverse domains. Among the various characteristics of this framework, we can mention:
The formal integration of an evolutionary theory of knowledge with corresponding ontological premises. The introduction of dynamic hyper-graphs as a way to represent changing structures at multiple inter-related levels that match the presented evolutionary theory of knowledge.

The relation with the study of the evolution of complexity, especially if “complexity” is understood as relational, that is, ecological. In the meta-model, the definitions of habitat, region, niche, eco-region, and eco-habitat formalize these interdependences, where success is attached to the definition of stability, which in turn depends on the effectiveness of the problem-solving knowledge — which, for instance, underlines that selection is relative to tasks and performance by organisms.

**Final Words**

This dissertation is an invitation to management scholars to consider alternatives. Evolutionary thought, an attitude that allows one to properly recognize change, resembles the use of a very different lens to see the world. Overall, the manner in which management science approaches knowledge has been criticized here, and an alternative has been suggested. This knowledge, individual knowledge, social knowledge, scientific knowledge, etc., has been characterized as conjectural, as evolving following a selectionist logic, as part of a biological continuum, as variational, and as real. Ultimately, the discussion can be summarized by saying that our customary processes of knowledge tend to work under the same pervasive premises of invariance and regularities. But evolutionary thought works under a very different premise: change is assumed as the principle of nature and living beings. This is surely the origin of the deep divide. Shall we impose invariance? Or shall we recognize change?


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