University of Rome "Tor Vergata"
Academic Year 2013/14
Second Semester

Master of Science in Business Administration

Course:
Innovation and Cognitive Economics

Prof. Riccardo Cappellin

LECTURE 8

COGNITIVE ECONOMICS AND EVOLUTIONARY APPROACHES IN SOCIAL AND NATURAL SCIENCES AND THE CONCEPT OF SPACE

Towards a Cognitive Evolutionary Economics

Salvatore Rizzello

Centre for Cognitive Economics
Università del Piemonte Orientale
Dipartimento di Economia "S. Cognetti de Martiis"
Centro di Studi sulla Storia e i Metodi dell'Economia Politica
"Claudio Napoleoni"
(CESMEP)
Working paper No. 03/2003
Università di Torino

Selezione dal testo originale a cura di R. Cappellin ai fini didattici

After the dissolution of the Neoclassical theory as the exclusive reference paradigm in economics, various approaches have come to the forefront in the research in the economic field. **Cognitive economics** stands out from them, being one of the most fertile. **It is an interdisciplinary approach concerned with the following subjects**: **problem solving, choice and change in the explanation of economic transactions, the nature and evolution of organizations and institutions in a context characterized by structural uncertainty, scarcity and incentives**. The economic agents' behaviour has psycho-neurobiological foundations and is analyzed in the light of bounded information, bounded and procedural rationality and satisfacing behaviour. **Cognitive economics is contributing to a large spectrum of economic fields, such as consumer theory, economics of the firm, economics of innovation, evolutionary economics, institutional economics and experimental economics.** This book illustrates the most recent developments in this field.

The aim of this introduction is twofold: supplying the reader with a general survey of the transversal subjects dealt with in the various chapters; sorting out the future perspectives which can be already perceived in this field of research.

For the first point, we will refer to the **key words** of this book - **cognition, evolution, learning, uncertainty and path-dependence** – and we will analyze them in detail. As concerns the second purpose, this introduction will try to illustrate the **"cognitive evolutionary approach",** which satisfactorily summarizes the future perspectives of cognitive economics, especially in the field of the analysis of endogenous change processes in dynamic economic systems.

From the point of view of its historical evolution, cognitive economics is certainly linked to the **Cognitivist revolution of the 50'** (Rizzello 1999 ch.8); still, the development of this discipline has its own history. **Alfred Marshall can be considered one of the founders of this approach**, **thanks to his views on the profound connection between the structure of organizations and the workings of the mind and the role and structure of the brain** (Raffaelli 1994). In the XIX century an important role in the emergence of this approach was also played by Carl Menger and his views on the spontaneous nature and the role of social cement of norms, and on institutions seen as dependent on the limits of human mind in handling all the complex environmental variables1. Also Thorstein Veblen is to be mentioned among those who were aware of the connection between mental mechanisms, evolution and role of norms, as recently pointed out in a series of papers published on the *Cambridge Journal of Economics* (July 1998, Vol. 22, No. 4). The history of the XX century follows with its major representatives in this field: **Hayek with his development of a model of mind aimed at explaining the role of bounded information and the nature of institutions in economic processes**; **Simon, who highlighted the connection between mental processes and the nature of human rationality and economic institutions**; **Boulding (1956), who shed light on the role of the image in the production of knowledge on the part of individuals, and on its relevance in decisionmaking and more generally in economic processes**; Allais, Khaneman and Tversky and that relevant part of researchers in the field of experimental economics, who study individual and organizational learning processes and the processes of coordination of agents in a condition of uncertainty and bounded information, and who have stressed the limits of the expected utility theory and developed alternative theories.

Moreover, in this field of research, we will mention the recent contributions of the agent-based simulation approach in economics (Luna and Perrone 2001), which are being developed along with the development of computer technology and of systems using artificial agents. Such contributions are more and more often proposing very interesting exchanges of ideas with **experimental economics**. All these subjects will be dealt with in the following chapters. Coherent with its aims, this introduction is organized

as follows: **the first section deals with the connection between cognition and evolution**. By integrating the cognitive and the evolutionary approach to economics, the main purpose of this section is to demonstrate that **the new self-organizing approach to explain the dynamics of change in economics** is very relevant and compatible with cognitive economics. **Section II** concerns this relevance and **presents economic systems as cybernetic ones**. **It introduces in economics the relatively new concepts of exaptation and neurognosis,** used in biology and anthropology, which give us new tools to explain the nature and role of learning in evolution. **Section III** outlines the **compatibility of this approach with the nature and workings of the mind**. In particular, it describes the affinity of these concepts with **Hayek's psychological foundations of the concept of evolution**. As will emerge, all these processes are path-dependent. To this purpose, **section IV describes path-dependence as resistance to change**. This relatively new concept is compatible with Paul David's and Brian Arthur's **idea of path-dependence**, and it seems to be most appropriate in explaining evolutionary dynamics of self-organizing systems. Section V takes into consideration the relevance of this approach for organizational and institutional change. Section VI offers some concluding remarks.

I. Cognition and Evolution

Cognition and evolution are two relevant features of economics. To support this point of view it is enough to consider that **individual behavior** is the analytical unit to understand **economic systems, such as markets, organizations and institutions**. Moreover, the latter are **dynamic systems, characterized by feedback, change, time irreversibility and development**. When considering **individual behavior**, it is very important to take into account what **psychology and neurobiology** teach us. It is also relevant to model choice by taking into consideration **how human mind works** and **which role is played by learning in decision making**. Furthermore, to describe **the dynamics of change, innovation and development of economic systems** it is advisable to assume **an *evolutionary* approach** to economics.

Whereas the evolutionary approach is emerging as an almost consolidate new strand, **the cognitive perspective is relatively new in economics**. In the first place it is necessary to point out that both – cognition and evolution – are two wide theoretical concepts, which tend to resist satisfactory definition. In fact, although a growing number of economists uses them, it is still possible to register different theoretical positions.

……..

Cognitive economics considers the relevance for economics of **human cognitive aspects.** In particular, it stresses that **"economics implies choices. A choice is the result of psycho- neurobiological acts.** The assumptions that are at the basis of economic theory, therefore, must be consistent with **the mechanisms that guide the workings of the human mind**" (Rizzello 1999, p. xv). A relevant part of heterodox literature presents a very interesting approach that stresses **the relevance of mind's workings in explaining economic behaviour (6)**. Although one may think that the cognitive approach to economics is very recent, **we can find some relevant contributions in the past, starting from the 1867 Marshall's writings** on the relevance of the mind to analyze organizations (Marshall 1867-8; 1961 [1871] Ch. IX).

…. …… …..
A common element in this literature is that the microfoundations of economic behavior are directly linked to the nature and role of the human mental mechanisms in charge of the production of knowledge and the emergence and use of rules, routines and their evolution.

This point of view affects and tries to integrate both the neurobiological and the psychological human dimension, and **learning is its analytical cornerstone. But learning represents also the main bridge between cognitive and evolutionary economics.**

Learning is crucial, in fact, in understanding how people choose, but also in explaining how routines and rules emerge in an organizational and institutional context, and the way how the individual – environment feed-back occurs.

II. SELF-ORGANIZATION, NEUROGNOSIS AND EXAPTATION.

SELF-ORGANIZATION: AUTOPOIESIS

The self-organization approach is emerging as a new promising branch of evolutionary economics, which differs in some respects from the most traditional models of evolution, applied to economic change. By proposing a new point of view on evolution, such an approach seems able to answer some open relevant questions in evolutionary economics that invest the nature, role and dynamics of economic change. **Such an approach is typical of time-irreversibility and dissipative structures in**

which change is not linear, and uncertainty, creativity and novelty matter. The analytical foundations of time- irreversibility are based on **the second law of thermodynamics (the principle of increasing entropy)** that consider the capacity of the systems to acquire free energy and to promote structural evolution (Foster 1993, Hodgson 1995, Lesourne 1997, Witt 1997). Therefore, **time irreversible systems are non-equilibrium open thermodynamics ones and they can be defined as dissipative structures which, in Prigoginean tradition, "are able to achieve a degree of 'selforganization' (or autopoiesis) which enables them to export entropy and import free energy to maintain themselves"** (Foster 1993, p. 185) (1). The evolutionary aspects of these systems rely on the fact that if these structures cannot reverse easily, they can only change by evolving.

1 **Humberto Maturana coined the term "autopoiesis" about in 1960. Maturana and Varela use the term to refer to the fundamental process of living systems. Autopoiesis is essentially the mechanism by which living systems continually produce themselves as autonomous unities.**

The self-organization approach presents a wide range of applicability that includes also socioeconomic systems, characterized by their informational rather than energetic nature. The most important units of analysis in economic systems are active agents and their intelligent nature, which produce knowledge (creativity) and informational flows.

From a very general point of view, the main question to be answered concerns how change happens.

EVOLUTION BY MEANS OF NATURAL SELECTION

Usually, standard evolutionary economics presents two separated levels of analysis to explain change, i.e. **an endogenous and an exogenous level**. Most recently, evolutionary economists tried to integrate these levels (the first contributions in this direction are Silverberg-Dosi-Orsenigo 1988, Lane 1993a and 1993b, Dosi – Kaniovsky 1994). The major tools used are directly borrowed from biology and **consist mainly in evolution by means of natural selection** (in a Darwinian or Lamarckian tradition). They use biological analogies to explain the relationship between agents (or firms) and environment, or to model the evolution of routines like genes (2).

(2) The use of biological analogies in economics and the criticism of their use is a controversial issue. In the '50s, Alchian's (1950) paper primed a debate between Armen Alchian and Edith Penrose, who criticized the use of biological analogies (see Hodgson 1999 and Rizzello 2000). Rizzello (2000) reproposes to Nelson and Winter's 1982 book some remarks of Penrose's criticism to Alchian. For other criticism about the use of biological analogies in evolutionary economics see Mirowski (1983), Witt (1996 and 1999) and Foster (2000).

ORGANISM IS ABLE TO MAKE AN ACTION: COGNITIVE DISSONANCE AND NEGATIVE FEEDBACKS

The point of view here presented considers **the relevance of the internal dynamics of evolution of systems**, **as human beings, organizations and institutions**. Because of their entropic and cybernetic nature, **it is advisable to study the dynamics of these systems by means of new analytical tools like *neurognosis* and *exaptation*, which emerged in biology and anthropology.**

Because of their informational nature, economic systems are entropic. They produce, use and waste information. Yet they are also cybernetic systems. The latter are characterized by their **capacity to self-regulate and evolve in a mutable environment**. This implies the presence of **channels of communication**, **allowing the systems to react to changeability. Usually this happens by means of "negative feedback" (3).**

(3) As Boulding (1992) pointed out, **next to classical cybernetics, characterized by negative feedbacks**, creodic processes and **positive feedbacks play an important role in evolutionary processes**. A **creodic process is typical of a system that evolves following a blueprint or a design**. As a good example of creodic processes, one can consider **the construction of a building or the evolution of an egg**. Positive feedbacks work in the opposite way of the negative ones. **Far from re- equilibrate systems, they increase the forces of disruption**. Usually they concern the **drastic and catastrophic changes** and in referring to economic systems they can be utilized to describe, for example, **technological crisis in schumpeterian terms**.

This means that the organism is able to make an action, in the opposite sense as respect to the external input. Many examples of this kind are easily found in living organisms, as well as in organizations and institutions. The reference here is not only to the **capacity to regulate the temperature of the body**, for example, but also to **some interesting psychological cybernetics mechanisms,** which sometimes allow us to "**deny the validity of information which is too upsetting to our identity** or **to our existing images of the world**", as suggests Boulding (1992, p. 289; see also Boulding 1956) (4).

4 In literature this interesting aspect of human behavior is referred to as **cognitive dissonance**, which describes **how people are emotionally averse to cognitive inconsistencies and seek to reduce them**. Economics also offers some application of cognitive dissonance (for a shortly description see Rizzello 1999, pp. 80 - 81).

INDIVIDUALS DO NOT SIMPLY "ADAPT" THEMSELVES TO THE CHANGING ENVIRONMENT

This aspect is particularly relevant. **Human mind is in fact able to build images of the world allowing organisms to adapt them to changes**. In the cognitive literature there is wide evidence that mind is the product of brain activity. And **human brain can be easily described as a cybernetic structure. To describe how it works, it may be appropriate to explore how the mechanisms of perception, learning and adaptation work**.

The traditional answer that biology gives us (evolution by means of selection) is not completely satisfying. Certainly it is a good tool to explain how organisms adapt themselves to the changing environment, but **it is not able to explain the functioning of the polarity between environmental adaptation and the protection of their internal integrity**. **Individuals do not simply "adapt" themselves to the changing environment, they resist, as long as possible, to these changes by interpreting and selecting external data in a way that results to be the most appropriate for their cognitive maps.**

If we take into consideration that evolution does not occur only by means of an adaptation mechanism, but that in **the process of change and development the cognitive innate structures prevail** (5), we can find a better answer by using the new analytical tools above mentioned.
(5) Reber (1993, p. 148-9) emphasizes that the existence and the relevance of some forms of nativism in the development of mind/brain is almost uniformly recognized, and that **no one today defends a pure empiricism in the sense of Locke's *tabula rasa*.**

NEUROGNOSIS - INITIAL ORGANIZATION OF NEUROGNOSTIC STRUCTURES

Let us consider neurognosis. When an organism faces new information, its capacity to give significance to this information depends on its previously stored experience and on its innate neurognostic structures (6). Experience, in fact, is the result of active interaction between associative structures (neurobiological) and sensorial data. "The neural networks comprising the cognized environment have their developmental origin in **initial neurognostic structures that are generally present before, at, or just after birth. The initial organization of neurognostic structures is primarily determined by the genotype".** Since our birth we are therefore structured to explore and model the world. **The brain, at every moment, "imposes its relatively conservative order upon the experience it constructs"** (Laughlin 1996, p. 365).

(6) **ABSORPTIVE CAPACITY The notion of neurognosis is linked to the idea that knowledge is constructed in cognitive frameworks**. This aspect is not new at all in **the literature on organization and management of "absorptive capacity"** (see Cohen and Levinthal 1990). **From this perspective, firms have been theorized as "sensemaking systems", "focusing device", "systems of shared meanings"** (Smircich 1983, Weick and Roberts 1993, Weick 1995, Choo 1998, Nooteboom 1999).

A PATH-DEPENDENT PROCESS OF EVOLUTION OF HUMAN BRAIN

The main characteristic of our brain is its capacity to evolve in a self-regulated way, including a degree of elasticity that allows it to explore, and interpret its world actively. **Mental structures play a central role in the process of perception, and in that of giving significance and of constructing knowledge,** and neurognosis seems to be able to offer a good tool to explore this dimension. **Human brain and mind evolve by following a path, that strongly depends on innate preexisting structures.** Because of this dependence on its previous experiences and its innate structures, **this can be clearly described as a path-dependent process**. But **it is important to stress that path-dependence emerges here more as a mechanism of resistance to change, rather than as a simple influence of the previous path on the development of organisms**. Human mind tends to preserve itself, as much as possible, from change (7).

(7) In this context it is interesting to point out that **this idea of mental mechanisms seen in path-dependent terms as a resistance to change is quite similar to the theory of personality of George Kelly**, which was based on the idea that **interpretative systems are resistant to change** and might be overwhelmed by major departures from familiar circumstances.

PATHDEPENDENCE AND FEED BACK: EXAPTATION

In the evolution of nervous systems **a double mechanism** works simultaneously: **pathdependence and feed back**. The brain collects external stimuli and the mind gives them significance. The brain associates the new stimuli by following its structures and **it continuously tries to verify – by means of a feed back mechanism – the reliability of its classification. The mind gives significance to the stimuli it receives by using feed back and path dependence**. The arising question at this point is: **which is the mechanism that can explain how brain and organisms evolve?** We can find the answer in considering **exaptation.**

The term exaptation was coined by biologists to design the situations in which evolutionary systems discover new uses for old inventory (Varela 1979, Gould – Vbra 1982, Gould 1991). **This happens when organisms become able to use, for a novel function, something which arose for some other reasons** (8). Following Gould, major innovations in evolution are all fruit of an exaptation process. "**The human brain is, par excellence, the chief exemplar of exaptation**" (Gould 1991, 55). **It continuously builds models of world and of itself and, in doing so, new neuronal structures emerge, in order to give significance to the sensorial data from old ones**. Exaptation is not predictable because it is **an act of co-optation for the new function of something which evolved for different reasons**.

(8) **A famous example in this literature concerns penguins' wings**. Usually wings arose in birds in the context of flight, but it was an exaptation process that conferrd advantages to penguins in swimming (Gould – Vrba 1982).

HOW TO RECONCILE NEUROGNOSIS AND EXAPTATION: HAYEK'S CONCEPT OF EVOLUTION

Apparently exaptation is irreconcilable with neurognosis. The latter, in fact, stresses the relevance of innate structures in explaining evolution. The former does not consider innatisme explicitly and **it does not clearly underline the role of path dependence**. But the point of view here proposed supports these two analytical categories as complementary, by presenting **Hayek's idea of evolution, selection and change. Hayek's surprising concept of evolution has psycho- neurobiological foundations.** As will emerge, this is very close to the above-mentioned biological and anthropological literature (9).

(9) This problem is linked to another well-known problem in organizational literature, that of **combining "exploitation and exploration**" (March 1991).

III. Hayek's psycho-neurobiological concept of evolution

EVOLUTION OF RULES AND INSTITUTIONS: LIMITED COGNITIVE CAPACITY

Although **the interpretation of Hayek's ideas on cultural evolution and group selection** is still a controversial issue among his scholars (Caldwell 2000, Witt 2000), there is wide evidence that by means of this concept **he refers to how learnt rules, group norms of conduct, habits, routines and institutions emerge and evolve**. Furthermore, **the role played by human mind's nature and limits appears evident in Hayek's conception of evolution of rules and institutions**. Very shortly, **we can state that rules of conduct, habits and routines emerge from the human limits in interpreting the very complex external world**. **Following rules and codifying them in institutions is an "economic way" to act successfully. Rules and organic institutions, in fact, standardize the world and in so doing they simplify the ambit in which humans use their limited cognitive capacity.**

In the last decade a growing number of scientific contributions stressed the relevance of Hayek's book on psycho-neurobiology, which for many years was neglected by scholars. *The Sensory Order* was conceived by Hayek in the 20's but published only thirty years later. The late acknowledgement of the relevance of this book permits today to revisit some central concepts of Hayek's thought (10). As he stressed many times, *The Sensory Order* is a cornerstone to understand Hayek's thought on knowledge, competition and cultural evolution (Hayek 1979, pp. 199 – 200, and Hayek 1994).

(10) In two recent papers Caldwell (2000) and Horwitz (2000) underlined once more the relevance of *The Sensory Order* for the understanding of Hayekian conception of evolution and for the spontaneous construction of a liberal order, respectively. Caldwell, in particular, describes the centrality of this book in the emergence of Hayek's ideas on evolution, demonstrating the link between human mind and role of cultural evolution (on this issue see also Rizzello 2000, and Rizzello- Turvani 2000).

It may be appropriate to illustrate in this part a brief summary of the model of mind we can found in his book (11).
(11) A larger description of these contents can be found in Rizzello 1999.

HAYEK'S CONCEPTION OF THE MIND - THE MIND IS A FRAMEWORK THAT ORDERS PERCEPTIONS

In Hayek's conception, mind is a framework that orders perception through acts of interpretation. The human neuronal structure **classifies external sensorial data by means of a process of association of classes of stimuli into classes of responses**. The significance that we give to each perception **depends upon the genetic characteristics of the individual and upon his/her previous activity of classifications of external stimuli (experience). The mind does not receive sensations in a passive way. On the contrary, it is an active tool that interacts with external environment.** Not only. The mind continuously builds an image of itself and of the world and **rebuilds them in a tacit and unconscious way**.

ORIGINAL IDIOSYNCRATIC INTERPRETATION OF THE EXTERNAL (OBJECTIVE) INFORMATION - IMAGE OF OURSELVES AND IMAGE OF THE EXTERNAL WORLD

This image of itself and of the world is the framework that allows us to give significance, by means of personal and idiosyncratic interpretation, to external information. More important, **this allows us to construct knowledge, that is a fruit of an internal and subjectivist process**, which we use to act. Being based on the person's genetic traits and on his/her personal experiences, **every person acts after performing a process of "interpretation" of the external (objective) information, which he transforms into subjective knowledge, which is unique and original.**

THE POLARITY BETWEEN ENVIRONMENTAL ADAPTATION AND THE PROTECTION OF INTERNAL INTEGRITY

Through a learning process that takes place over the years, in turn, **genetic traits and personal experiences continuously redesign the neuronal circuitries that represent our imagine of ourselves and of the external world**, depending on both personal activities and the action of innate bioregulatory circuitries. **This mechanism explains how brains assure the polarity between environmental adaptation and the protection of its internal integrity.**

As is emerging, neurognosis and exaptation are evident in Hayek's conception of the human brain.

EXAPTATION: CAPACITY OF PREVIOUS NEURONAL STRUCTURES TO CO-OPT NEW CONFIGURATIONS AND FUNCTIONS

The evolution of the mind – i.e. the evolution of our capacity to build and process images and symbols to generate knowledge – happens, in fact, by means of a balance between ontogenesis and phylogenesis. Starting from its native structures, brain evolves by building new nervous circuitries. **They result from the feedback with the relatively inelastic (but not completely rigid) nature of our a-priori mental schemes which interpret external information in a path-dependent way**. This interpretation is carried out by means of **exaptation**.

In other words, **previous neuronal structures built and developed to solve problems of interpretations of external world effectively, reveal their capacity to co-opt new configurations and functions when individual faces new problems (12).** After this process, these latter result, in turn, modified and they are ready to co-opt new unfamiliar external data and so on.
(12) 19 Gould (1991) has stressed the relevance of exaptation for evolutionary psychology.

BALANCE BETWEEN STABLE AND UNSTABLE CIRCUITRIES - VARIETY OF CLASSIFICATION, INDIVIDUAL INTERPRETATIVE OUTCOMES AND ACTIONS

Some cerebral circuitries remain stable, and the brain builds up its balance between stable and unstable circuitries. When faced with a problematic new situation, individuals generally refer to previous successfully experimented schemas of action that permit to read the new phenomena accordingly (Butos – Koppl 1997). **Classification through individual association of stimuli leads to interpretative outcomes and action, which can vary greatly from an individual to another**. **At any given point in an individual's life, a great part of his cerebral circuits is personal and unique, since it reflects his genetic characteristics, and the history and events of that particular organism** (Witt 1992, Vanberg 1994, Ch. 6), which is also the result of the interactive process which takes place – by means of exaptation and feedback - with his/her cultural and social context (Hayek 1963).

THE EVOLUTION OF THE MIND AND THE EVOLUTION OF INSTITUTIONS: SELFORGANIZATION STRUCTURES

Therefore, **Hayek emphasizes the importance of the connection between the evolution of the mind and the evolution of institutions**. Even if it is not in the purposes of this introduction to consider the controversial debate on Hayek's concept of evolution, it is certainly worth pointing out that **this particular conception - so strongly linked to the role and function of mind seen as a selfregulating mechanism - seems to be a useful tool to extend the analysis of the evolution of selforganization structures.**

All these aspects of Hayek's thought are, in fact, surprisingly coherent with the biological and anthropological **micro-foundations of the analysis of self-regulating systems**. This represents a good reason to make an attempt to integrate this "evolutionary" literature with the cognitive tradition and in particular with Hayek's ideas. To this purpose, we need to make two more steps. Since path-dependence seems to play a crucial role for understanding these processes, **the first step concerns the explanation of how path-dependent analysis is coherent both with Hayek's ideas and with the neurognostic biological tradition. The second one consists in illustrating the new perspectives of economics of the firm and institutional economics introduced by this approach**.

IV. Path-dependence in human cognition

Path-dependence is a relevant analytical tool for economic theory. In the last couples of decades, a growing literature has dealt with this topic. It is not in the bounds of this introduction to propose a review of this interesting literature. But, in spite of the unconvincing criticisms by Lebowitz and Margolis (1995) (13), it is possible to make an attempt to summarize in few sentences the main points introduced by this literature into economics.
(13) See also Paul David's reaction to the criticism by Leibowitz and Margolis (David 1997).

Two basic ideas are central in path-dependence: (i) history matters in determining the dynamics of social and economic processes; (ii) the passage from a state to another of an economic system depends on the previous paths.

HISTORY MATTERS – EXISTENCE OF RIGIDITIES AND EXISTENCE OF VARIOUS PATHS – LOCK IN

The first idea conveys the principle that **historical events (even small ones) condition the system's evolution with some rigidities that the economic action can modify only in part**.

The second one stresses the aspect that **the outcome of a path-dependent process is not foreseeable at all**. The final equilibrium reached by the system can be a sub-optimal one. As David and Arthur demonstrated, **the path of dynamic systems depends on a stochastic and self-reinforcing mechanism that usually conducts to "lock in" the system into a trapping region**, i.e. the basin of attraction that surrounds a locally (or globally) stable equilibrium (14). **These kinds of equilibrium are stable but not (necessarily) optimal and they often result to be multiple ones.**

(14) "**When a dynamical economic system enters such a region, it cannot escape except through the intervention of some external force, or shock,** that alters its configuration or transforms the underlying structural relationships among the agents" (David 1997, p. 34).

PATH-DEPENDENCE IS FOUNDED IN THE HUMAN BRAIN

A relevant aspect that is usually neglected in this literature is that **the early mechanism of path-dependence is founded in the human brain** (Rizzello 1997). The dynamics of economic systems depend, in fact, on the interaction among individuals and on their **choices. The latter depend on the way how agents acquire information and produce and use knowledge.** This is a crucial process for economic theory, as Hayek clearly supported. Moreover, it is coherent with **the idea that economic systems (from individual to institutional dimensions) are cybernetic and neurognostic.** Not only. **If we assume the central role of human mind and brain to explain economic processes, exaptation become a better tool to explain how these systems evolve**. Let us explain this point in depth.

Following Hayek's insights and the more recent neurobiological and cognitive teachings (15), we can note that human brain presents a particular pre-natal structure allowing it to interpret and give significance to the external world. This neuronal structure evolves by means of exaptation in classifying new external stimuli in its preexisting nets. **The actions which can solve problematic situations successfully are interpreted as satisficing (in Simon's sense) choices**.

(15) For a complete overview, see Wilson and Keil 1999. Liepert *et al.* (2000) offer, among other things, an empirical confirmation of the neuronal plasticity, of the continuous transformation and reorganization of the brain, and of its physiological sensibility to the experience.

EXAPTATION: ACTIONS WHICH CAN SOLVE PROBLEMATIC SITUATIONS IN SATISFYCING TERMS – IT ALSO LEADS TO NEUROGNOSIS: RESISTANCE TO CHANGE

They depend at least on **four aspects**: a) **the genetic neurobiological dimension of the individual**; b) **his/her previous experience; c) historical stochastic accidents; d) the feed-back with the environment.** It is easy to picture the brain as a neurognostic mechanism which tries to perceive external data by balancing its pre-existing neuronal structure, so as to interpret and use the new stimuli effectively.

The interpretation of external stimuli generates an action. If this is successful - in satisficing terms -, it reinforces the perception mechanism that reduces the neurobiological elasticity to interpret (to exapt) in a different way the same situation when it recurs.

Or, in other words, it **increases the resistance to change of our (neurognostic) brain**. **This mechanism of perception and feedback is coherent with the "lock-in" idea.**

PATH DEPENDENCE IS RELATED TO THE EXISTENCE OF INNATE NEUROBIOLOGICAL PERCEIVING STRUCTURES AND THEIR EVOLUTION - EXAPTATION FOLLOWING PREVIOUS EXPERIENCE

But, whereas usually path-dependence literature refers in general this mechanism to economic systems, the point of view supported here is **to extend the idea of the "trapping states" to individual decision-making, starting from the brain's processes of perception and mind's mechanisms of representation.** The image of the external and internal world, which each individual constructs, depends both on **his/her innate neurobiological perceiving structures and on the evolution of these structures that exapt themselves following previous experiences.**

THE EVOLUTION OF THE BRAIN IS PATH-DEPENDENT: IT DEPENDS ON ITS HISTORY AND ALSO ON ITS NEUROGNOSTIC STRUCTURE

The fact that the evolution of the brain is path-dependent means that it certainly depends on its history, but also on its neurognostic structure, which in turn resists to continuous changes. The **image of the self and the external world tends to preserve the previous one, as long as possible.** In a sense, neuronal structures have a conservative nature, but they are not completely rigid.

FOUR KINDS OF UNCERTAINTY WHEN BRAIN PRODUCES KNOWLEDGE

As is emerging, when brain processes information and produces knowledge, it acts in a dimension characterized by structural uncertainty. **It clusters four kinds of uncertainty** that we can summarize as follow: a) **human genetic features** are stochastic; b) **previous experiences** are idiosyncratic; c) **historical accidents** are not forecasting; d) **successful feed-back processes** depend on the combination of the other three levels and **interindividual communication takes place thanks to a common institutional framework, education, language and rules of conduct that individuals shared.**

V. EVOLUTION AND ORGANIZATIONAL AND INSTITUTIONAL CHANGE

INDIVIDUAL DECISION MAKING AND INDUSTRIAL AND INSTITUTIONAL CHANGE

Up to now, we are referring this model to **decision-making processes, which combine Hayek's view on perception and knowledge**, **the tradition on path-dependence** and **the new biological conception of evolution**.

Still it might be possible **to extend its applicability to organizational and institutional levels**. The latter are the object of a wide literature on path dependence and evolution. It might be fruitful to consider, **in industrial and institutional economics**, the **dynamics of change as characterized by exaptation**, **taking into account, for example, that innovation depends both on a firm's history and on its resistance to change**. Or, similarly, **the evolution of institutions as linked to history paths and also to cultural rigidities**.

THE CREATION AND THE CONTROL OF DEMAND BY THE FIRMS

On the industrial economic side, this idea could improve **the models of the creation and control of demand by the firm**, proposing a different and integrating point of view as compared to the literature that stresses in particular exogenous change. As Momigliano (1975) stressed 25 years ago, **firms not only meet existing needs, they also create new ones**.

Research, innovations and inventions become more and more important within production processes. This view implies a concept of the competition process in which **firms, instead of meeting the needs arising on the demand side, try to "frame" the market ad to create their own demand artificially**. Such strategies are **strongly dependent on the firm's specific characteristics** and on its role on the market, **its organizational structure, its history, previously adopted strategies**, on how quickly it can get access to credit, on the process of learning in the use of scientific research and also on positive externalities due to economic policy. In other words, Momigliano proposes a (self-organizing) model of innovation and development of dynamic structuralism (Antonelli 1995), stressing the relationship between firm's structure, characteristics of the economic system it works within, and its performance.

A MODEL OF EVOLUTION WHICH LINKS THE INDIVIDUAL MIND AND THE INSTITUTIONS

As regards the institutional side, the above proposal could further reinforce **the models that consider the link between mind and institutions, in explaining institutional change** (Hayek 1942, Denzau-North 1994, Rizzello-Turvani 2000 and 2002). Or more generally it could represent **a step to explain further the relevance of endogenous dynamics in the evolution of economic systems**, by offering the **new concept of evolution proposed by Hayek** and **different from that of Nelson and Winter** (Rizzello 2000).

Stressing the role of evolution in human mind and brain and the link between mental mechanism and the emergence and nature of rules and institutions, Hayek gives us a model of evolution in which both ontogenesis and phylogenesis played a balanced role. In this light, **the evolutionary cognitive approach could fill in the gap between the cognitive individual dimension and the holistic one**. Let us consider this aspect very briefly.

THE INDIVIDUAL COGNITIVE MAP AND THE COMMON CULTURAL CONTEXT SHARED BY A GROUP

As suggested above, **individual cognitive maps evolve by exaptation**. But it is relevant to consider also **that it mainly happens in a "cultural" context**. From a cognitive point of view, **culture is an ensemble of representations shared by all the members of a group**. This kind of representations is not "perfectly" shared, because what individuals share are not mental facts but an "epidemiological" distribution of casually linked mental and public facts in a human population (Sperber – Hirschfeld 1999, p. cxxii). **Human cognitive dispositions** allow **individuals to adopt spontaneously cultural representations** that are **reinforced by previously acquired institutional constraints** (23).

(23) **The social cognitive learning theory** (Bandura 1986) **seems to offer good analytical tools in understanding the behavioral foundation of cultural evolution**, as suggested by Witt (2000) and Rizzello-Turvani 2002.

Because of the neurognostic structure of their brain and their ability to exapt, humans continuously evolve by both resisting to change and by adopting changes.

Moreover, cognitive processes, involved in most relevant activity, do not take place just in one single mind but they are distributed throughout many members. Since there is still a very big open problem in neoinstitutional literature, this could be a simple suggestion to address further developments.

V. Concluding remarks

INTEGRATION OF A COGNITIVE APPROACH AND SELF-ORGANIZING MODELS

With reference to the key words of this book, one the main purposes of this introduction was to stress the **relevance of the integration of the cognitive approach to change and decision-making in evolutionary economics with particular reference to self-organizing models**. By introducing the concepts of neurognosis and exaptation it has tried to show that **a unifying mechanism of evolution exists** at every level of analysis, and it reinforces the idea that **economic systems evolve in pathdependent terms**.

A MICROFOUNDATION OF EVOLUTIONARY DYNAMICS: THE SELF-ORGANIZATION APPROACH COMBINES NEUROGNOSIS, EXAPTATION AND PATH-DEPENDENCE

The introduction did not supply a wide discussion on all the aspects concerning evolutionary economics (as the reader will gain a good knowledge of them in the following chapters). On the contrary, **it focused on the microfoundations of evolutionary dynamics**. By doing so, it has tried to show the affinity of this approach - which **tries to combine neurognosis, exaptation and path-dependence** - with the neuropsychological foundations of Hayek's conception of evolution.

Summing up**, the self-organization approach to evolutionary economics seems to be particularly relevant in explaining endogenous change**. The point of view here proposed analyzed the cognitive aspects of this approach and some evolutionary implications. Following Hayek's insights, it is time to go beyond the endogenous/exogenous dichotomy, taking into account the views which biology, anthropology and psychology propose on the same issues. In such an interdisciplinary perspective, ***cognitive evolutionary economics*** **seems to offer good tools in order to improve the research into the dynamics of economic systems.**

Cognitive economics considers the relevance for economics of human cognitive aspects
economics implies choices.
a choice is the result of psycho-neurobiological acts.

Neurognosis
preexisting neuronal structures
protection of the internal integrity
resistance to changes

Exaptation
adopting changes
negative feedback
environmental adaptation
individual cognitive maps evolve
classifying new external stimuli in preexisting nets
pathdependence
selfregulation (autopoiesis)

Principle of increasing entropy
timeirreversible systems are non-equilibrium open thermodynamics ch Prigogin's dissipative structures
"are able to achieve a degree of 'selforganization' (or autopoiesis)
time-irreversibility, change is not linear and novelty matter

Idiosyncratic interpretation of external information
human genetic features
historical accidents
previous experiences
successful feed-back processes

Feedback and path-dependence
interpretation or classifications of external stimuli
success, reliability of classifications
experience
evolution of innate neurobiological perceiving structures,
creation of new neuronal structures
increases the resistance to change

Hayek's conception of the mind
Rules, routines, institutions
Saving the limited cognitive capacity
The evolution of the mind
psycho-neurobiological concept of evolution

The evolution of the mind
redesign the neuronal circuitries
balance between stable and unstable circuitries

Institutional economics
the evolution of the mind and the evolution of institutions
neurognosis, exaptation and path-dependence,
common culture, history paths

Cognitive economics, path dependency and institutions

International Knowledge and Innovation Networks

Knowledge Creation and Innovation in Medium-technology Clusters

Riccardo Cappellin

University of Rome Tor Vergata, Italy

Rüdiger Wink

Leipzig University of Applied Sciences, Germany

NEW HORIZONS IN REGIONAL SCIENCE

Edward Elgar
Cheltenham, UK • Northampton, MA, USA

6. The localized character of cognitive processes

The literature on cognitive economics highlights a third approach in explaining the spatial agglomeration of innovative activities, different from those indicated by the industrial economics and the regional economics literature. In fact, the spatial concentration or diffusion of innovative activities has a more fundamental reason than the existence of "localization factors" working on the attraction of innovative firms. **This reason is routed in the intrinsic spatial nature of the process of knowledge creation**. In particular, our study aims to come to a better understanding of the processes of knowledge generation, transfer and absorption within and between firms and other organisations within a region, by **focusing the attention on innovation as the result of an interactive process involving the sharing and exchanging of different forms of knowledge between regional actors**. This perspective is clearly important when analyzing the relationships between small and medium size firms in the process of innovation adoption.

In synthesis, **knowledge creation is the result of pattern making or of the classification and reclassification of exogenous stimulus**. Thus, **the process of knowledge creation has an interactive and a combinative character** and a closer geographical proximity and/or a greater cognitive proximity facilitate the interaction between various complementary actors and the combination of complementary pieces of knowledge. **Knowledge can only develop in a localized or specific framework** and calls for a geographical and cognitive proximity of the various actors, which participate to an interactive learning process. **Knowledge creation only apparently has an a-spatial character** and cognitive sciences clarify on the base of theoretical considerations that the process of knowledge creation works in a localized framework. Thus, **the agglomeration of innovative productions can be explained on the base of the spatial or localized nature of the processes of knowledge creation.**

The analysis of the relationship between the process of cognition and space can be based on the psychological theories of those economists, who first investigated the problem of knowledge creation and who provided contributions which have later been confirmed by recent advances in neurosciences, such as neurobiology and psychology. According to cognitive theories, a brain operates, as in Smith's (1980 [1795]), Marshall's (1994) and Hayek's (1952) theories, by forming selective connections. **According to Adam Smith, it is characteristic of human nature to be uncomfortable when unable to make sense of a particular phenomenon**, especially when that phenomenon is repeated; people therefore try to invent **'connecting principles'** that will collect unexplained phenomena into categories and provide an acceptable explanation of these categories. In fact, Adam Smith pointed to the role of those "specialised philosophers and men of speculation, who are often capable of combining together the powers of the most distant and dissimilar objects" (Smith, 1776). Satisfactorily explanations are a source of positive pleasure, especially if the solution is aesthetically pleasing, and are likely to be widely adopted by those encountering such phenomena (Loasby, 2003).

According to Marshall and Smith the brain works by linking the idea of **an initial impression received by the body with the idea of an action which the body performs in response**, and then linking the latter with the idea of an impression that is interpreted as a consequence of that action (Marshall 1994, Raffaelli 2003, Smith 1795, Loasby, 2003). In fact the brain is a selective system and it works not according to logics and mathematical thinking, but rather according to the recognition of configurations. This pattern making activity performs the vital function to allow to the brain to orient itself in the surrounding space: a function which is crucial for survival and has been developed through human evolution. In fact, cognitive activity seems necessarily represent the result of a reaction to the stimulus coming from the local environment. Connections clearly imply a spatial framework and proximity enhance connections. The spatial dimension of the process of cognition is also clarified by the fact that the local environment and the aim to respond to new needs and to solve the problems of local users are the most important stimulus to innovate for the firms. Cognition and innovation are related to the stimulus of a problem emerging in a specific field or to the opportunity to satisfy an emerging demand in a specific market (Gallouj and

Weinstein, 1997). The local environment is the source of challenges and risks for the individual actor and it is related to the national and international economy. Firms should respond to the new needs and demand (as indicated in the TKM approach to be illustrated below) in local markets and aim to solve problems of local users. The strength of the stimulus and the possibility to perceive it depends on the spatial accessibility (as in the TKM approach). Moreover, cognitive proximity and a low geographical and cognitive distance facilitate the identification of weak signals and enhance collaborations.

A second key concept in the process of cognition is that of routines and path dependence (Loasby, 2001, 2002). According to Marshall, over time the brain may develop a range of closely connected impressions and actions, which we might call routines. In fact, the application of solutions or the repetition of new actions develops new connections between different parts of the brain (Marshall 1920, p. 252), which gradually take over the maintenance of these activities, leaving the conscious brain activity free for new initiatives, including those which utilise these now-automatic connections. According to Rizzello (2003), "neurognosis" indicates that when an organism faces new information, its capacity to give significance to this information depends on its previously stored experience and on its neurognostic structures. Thus, human brain and mind evolve by following a path, that strongly depends on pre-existing structures, as it adapts to external challenges while searching to maintain consistency and integrity. That implies time irreversibility and that experience matters.This concept implies that spatial and cognitive proximity are a key condition in order to promote frequent and strong connections between different actors. Activities are mostly strongly linked or embedded in their local environment. Firms and actors respond by aiming to survive and to preserve the integrity of the local environment. That process explains the "receptivity" to external stimulus by local actors (as in the TKM approach). In particular, **external stimulus should be compatible with the internal integrity of the local production system and should lead to a gradual process of adaptation**. In fact, firms and actors respond and adapt in order to survive and to preserve the identity and integrity of the local environment facing the threats of external competition. The process of

knowledge creation in a given location is characterized by switching costs and rigidities, inertia or stickiness and it evolves according specific paths.

The concepts of local endogenous development and of complex adaptive systems imply some form of immobility of resources and of internal integration and coherence, as it is implied by the neurognosis concept. The territory represents a resource in economic development and it is characterized also by a specific identity (as in the TKM approach), which increases internal cohesion and synergy, but it may also determine a form of spatial dependence, as the specific characteristics of the local selection environment may create obstacles and lead to lock-in effects. For example, in local industrial clusters (Steiner, 1998) specialized in medium technology sectors, knowledge creation is tightly related to the sectoral specialization, the industrial culture and know-how existing in the innovation systems to be considered. These factors may facilitate the early identification or the design of new patterns, combining previously existing ideas and pieces of information and knowledge. At the same time, however, they also constrain the discovery of new pattern in the attempt to insure the consistency and compatibility with existing solutions causing path-dependency and in some cases "lock-in" effects.

A third concept elaborated by cognitive theories is that of "exaptation" (Rizzello, 2003). While new knowledge, which is corroborated by apparently successful application, is consolidated into new routines, if directed action fails to achieve its objective, the recognition of failure leads either to a modification of existing routines or to experimentation resulting in new routines. Thus, knowledge that is already organized into routines facilitates the creation of new knowledge especially that which builds on the old. That introduces imagination and the possibility of trial and error within the mind, as in modern practices of research and development. Problems in the economy require combinations of routines and novelty, and these combinations are themselves modified by evolutionary processes of trial and error. This sequence of creativity against a background of routines, leading to new routines which provide a more advanced basis for further creativity, is a dialectical process. Each resource, instead of constituting a well-defined input into one or more production functions, is a multi-specific asset, the

potential uses of which have to be discovered, invented, or imagined. It is indeed a most important characteristic of knowledge that it can be reused, but in a way that is not simply deducible from current uses. As indicated by Rizzello (2003), "exaptation" is the phenomenon through which previous neuronal structures built and developed to solve problems of interpretation of external world effectively reveal their capacity to co-opt new configurations and functions when individual faces new problems. In fact, new neuronal structures emerge from old one, in order to give significance to the sensorial data. Coase (1992) explained the firm as a set of incompletely-specified contracts, which provided resources to be deployed at some date yet to be chose and within domain that could be broadly envisaged, thus avoiding the cost and time of making the necessary arrangements at that date. It is an investment in creating capabilities that provide options. A Coasean firm is a combination of purpose and capabilities which retain sufficient degrees of freedom to allow people to take decisions that may make a difference.

The concept of exaptation is tightly related to that of creativity and to variations. In fact, the growth of knowledge is always at the margin (Loasby, 2003). The generation of variety across organisations is a natural consequence, as imperfect specification is a condition of those experiments at the margin on which Marshall relied for the variations, that were a chief cause of progress (Marshall 1920, p. 355). In particular, a movement is easiest to adjacent states, but typically there are many states that are adjacent to each current position, so that even individuals or organisations with identical current positions may develop in different ways. In practice, individuals and firms will not have identical positions, even those with similar experiences and engaged in similar businesses, and this increases the potential for variation, as Marshall noted. Marshall believed that this process tended to result in ever greater differentiation of function, matched by closer co-ordination (Marshall 1920, p. 241). The concept of specialization is related to the division of labour and Adam Smith suggested that the most fundamental aspect of the division of labour is the division of knowledge (Metcalfe and Ramlogan, 2005) as: 'each individual becomes more expert in his own peculiar branch, more work is done upon the whole, and the quantity of science is considerably increased by it' (Smith, 1776). According to Marshall and Hayek, the

same stimulus may generate a variety of responses due to the differences in initial perceptions and the selective connections which are due to the reinforcement of what appears to work (Loasby, 2003). According to Hayek, any impulse is a 'representation', which is itself interpreted in terms of the relationships which have already been established within the brain (Hayek,1952). Similarly spatial dependence is related to the fact that **the same external stimulus may lead to different "creative" responses according to the casual combination of the actors** involved in the process of interactive learning or the connections established with them, as it characteristic of a complex, adaptive system (Metcalfe and Ramlogan, 2005).

Clearly space matters in the process of knowledge creation. Innovation requires the search and the integration of complementary resources and capabilities and that is enhanced by the existence of network relations with other local actors. In fact, Hayek argues that instead of direct connections between particular stimuli and particular sensory qualities, the effect that is produced by any stimulus depends, on the location of this impulse in relation to other impulses within the network of connections (Hayek, 1952). In a spatial perspective, tacit knowledge explains why clusters are faster in adoption innovation. It is perhaps because of this double threat to initiative and variety that Marshall was so impressed with the virtues of an industrial district, which seemed to ensure the automatic organization (Marshall 1919, p. 600) of highly specialised activities while facilitating both the generation and the active discussion of novel ideas, including ideas for constructing new patterns of relationships between firms. The spatial dimension of these concepts elaborated by the cognitive economics literature is indicated by the fact that reconversion of existing capabilities to new uses is possible only within a limited domain and it implies geographical or cognitive proximity, as firms initially look for the support of local suppliers and for the demand of local customers.

However, inventions and innovations increasingly are the result not of individual creative activity but of a collective process of searching and learning. Innovation requires the sharing of tacit knowledge, which is more ambiguous, redundant and fungible than codified knowledge, but it requires direct personal contacts. Complex

adaptive systems (Holland 2002) are highly innovative and are also necessarily localized in geographical space. In particular, regional innovation systems (RIS) can be interpreted as evolutionary networks made by interacting brains, which thorough explicit collaboration or through spontaneous market selection generate systemic innovation. Network externalities emerge in a territorial framework and local networks facilitate interaction and flows of information and knowledge. Interactive learning is the key process in knowledge creation and the links and the frequency of the contacts are constrained by spatial distance. The process of interactive learning within a regional innovation system leads not only to imitation, but also to an increasing specialization and differentiation of the individual pre-existing firms into new productions and to the spin-offs of new firms. Thus, creativity is enhanced and limited by local capabilities (as in the TKM approach).

For example, the development of the thought of individual scientists has been affected by their respective local cultural environment. The various schools of thought are often related to specific cities or countries and not only to an historical period. Moreover, learning together is often a characteristics of the professional communities and know-how is often collective and localized. In fact, the urbanization economies and the Jacobs externalities (Jacobs, 1969), related to the diversity of metropolitan areas, or the localization economies, related to the specialization of industrial clusters, allow to easily identify local complementary capabilities in the process of innovation. The concentration of firms in large metropolitan areas facilitates innovation, both because this concentration decreases transaction costs between the actors (Cappellin, 1988) and because this diversity enhances business opportunities and entrepreneurship capabilities, due to the high diversity of origins, sectors, competencies existing in these areas and the easy access to a wide scope of new emerging needs and complementary resources.

Table 5: The spatial/localized dimension of cognitive processes

Components of the cognitive processes	Territorial factors and processes
1. According to cognitive theories, knowledge creation is the result of pattern making or of the classification and reclassification of exogenous stimulus	1. Cognition and innovation are related to the stimulus of a problem emerging in a specific field or to the opportunity to satisfy an emerging demand in a specific market. Spatial and cognitive proximity are a key condition in order to promote frequent and strong connections between different actors.
2. The capacity of an organism facing new information to give significance to this information depends on its previously stored experience and on its neurognostic structures. Firms and actors respond and adapt in order to survive and to preserve the identity and integrity of the local environment facing the threats of external competition. The human brain and mind evolve by following a path, that strongly depends on these neurognostic structures.	2. The image of the external world is shared by the members of a group and leads to a common identity or culture. Complex adaptive systems (CAS) are highly innovative and are also localized in geographical space. The territory is characterized by a specific identity, which increases internal cohesion and synergy, but it may also determine obstacles and lead to lock-in effects.
4. The same stimulus may generate a variety of responses due to the differences in initial perceptions and the selective connections which are due to the	3. Local networks facilitate interaction and flows of information and knowledge. The process of interactive learning within a regional innovation system leads to an

reinforcement of what appears to work.	increasing specialization and differentiation of the firms into new productions. Thus, creativity is enhanced and limited by local capabilities.
3. "Exaptation" is the phenomenon through which previous neuronal structures built and developed to solve problems of interpretation of external world effectively reveal their capacity to co-opt new configurations and functions when individual faces new problems.	4. The reconversion of existing capabilities to new uses is possible only within a limited domain and it implies geographical or cognitive proximity.
5. Over time the brain may develop a range of closely connected impressions and actions, which we might call routines. Following rules and codifying them in institutions is an "economic way" to act successfully.	5. Institutions are linked to territorial sovereignty and political participation and to local history, common culture, place identity, values, norms, visions, trust.

A further key concept in cognitive theories, when applied to the analysis of the economy, is the concept of institutions. Smith's, Marshall's and Hayek's psychological systems rely on routines and institutions which economise on cognition. Institutions play a key role in the process of knowledge creation. Rules and organic institutions standardize the world and in so doing they simplify the ambit in which humans use their limited cognitive capabilities. In fact, routines facilitate the connections and create free time to be devoted to the explicit thinking on innovation (Hayek,1952). Thus, following rules and codifying them in institutions is an "economic way" to act successfully. The routines and institutions within Smiths, Marshalls and Hayeks psychological systems allow to focus attention on the issues for which they are inadequate at any particular time. According to Loasby (200, 2002, 2003), the maintenance of stable baselines within particular domains is a prime function of formal organisations, and the appropriateness of the baseline is a major determinant of organisational success or failure. Order makes room for creativity, which is stabilised in a new order which combines newly-established

expectations and beliefs into a patterned performance. Thus, in the brain conscious attention is reserved for problem-solving or the introduction of novelty. Cognitive processes indicate an evolutionary sequence made by variety generation, selection, and the preservation of selected variants in the form of modified or novel routines and institutions (Loasby 2003).

The spatial dimension of the concept of institutions is clarified by the fact that coordination by institutions is a necessary process when knowledge is spatially dispersed between different actors and for solving the problems of information asymmetries. Moreover, it is impossible to refer to institutions without considering the territory, on which they exercise their power, the geographical or sectoral borders with respect to other institutions and to the political participation by the people living or working in a given area. In fact, institutions are linked to the concept of territorial sovereignty and to the concept of legitimacy, which implies a local constituency. The spatial dimension of institutions is clearly indicated by their relations to local history, to the memory of centuries of interdependence between local actors, to the existence of a common culture, to the distinctive characteristics of the individual places and the existence of a place identity, to common visions of the future, common values, specific norms and routines and reciprocal trust. The process of economic development in specific regions depends on the existence of "intermediate institutions" and on the local "social capital" (Coleman, 1988; Scott, 2000; Maskell, 1999; Ferlie, 2003; Sorensen, 2003) and they facilitate the connections and decrease the cognitive distance between the local actors. In particular, strategic dedicated organizations and institutions seems to be required for the management of knowledge and innovation networks of SMEs in intermediate technology sectors within a given territory (as in the TKM approach)**.**

The focus on the specific phases of the cognitive process, highlighted by the cognitive economics literature, allows to identify their tight correspondence with specific territorial factors and process and the role of space and geographical distance on the creation of ideas and new knowledge (table 5). Moreover, the theoretical concepts indicated above correspond to a large extent to **the various phases of the "territorial**

knowledge management" approach, to be illustrated later in this chapter (Cappellin 2003b, 2007). In particular, the concept of connections corresponds to that of **external stimulus**. The concept of neurognosis corresponds to those of **receptivity and of common identity**. The concepts of exaptation and variation correspond to the concepts of **creativity** and of **interactive learning within a local network**. The concept of institutions is clearly related to the concept of **governance** of knowledge and innovation networks.

Thus, the previous analysis highlights that **space is relevant not only in order to examine the process of territorial diffusion of innovation** or to **examine the impact of innovation on the structure of the territory and on regional disparities**. On the contrary, the focus on the localized dimension of cognitive processes allows to highlight that **space and the territory affect the process of knowledge creation**. In fact, that is **the fundamental reason of the spatial agglomeration of innovative activities, which are based on the knowledge creation processes occurring in specific geographical areas**. The specific characteristics of these areas, both the central and most developed areas and also the peripheral and less developed area, **lead to different characteristics of the processes of knowledge creation in these individual areas and that affects the innovation and the competitiveness of local firms**. Therefore, the relationships between the space economy and knowledge are clarified not only by the uneven spatial diffusion of different types of knowledge, such as codified and tacit knowledge, or analytic, synthetic and symbolic knowledge, or by the existence of urbanization or localization economies explaining the agglomeration of innovative activities in specific geographical areas. On the contrary, what seems more relevant is the role that space is directly playing on the process of cognition or on the generation of knowledge and innovation.

In conclusion, it is possible to **underline the difference between a temporal or evolutionary perspective and a spatial or territorial perspective in the analysis of the knowledge creation process**. **In a temporal perspective**, individuals classify new stimulus and associate pattern of stimulus to patterns of response on **the base of the success in previous experience**. The exchange of ideas, information and knowledge activate a

creative process of re-elaboration of the own knowledge and of increasing specialization by **connecting existing elements in new ways within the mind of the considered person**. **A spatial perspective** to the analysis of the innovation process **introduces also the interaction between various local and external actors**, as a new element with respect the combination of different pieces of knowledge within an individual mind or firm, as indicated by a functional or temporal perspective. Knowledge creation is the result not only of the combination of a new stimulus with the individual previous experience, but also of the **combination of different competencies between the various actors, who are interacting in a learning process occurring within a given network or local area.**

That explains the different spatial pattern of creativity and the effect of lock-in. In fact, **in a spatial perspective, the same stimulus may determine a different pattern of response in each regional innovation system according to the different form of the network of local actors**, as the way an innovation system is responding to an external stimulus depends **not only on the existing individual capabilities of the actors**, who interact in the learning process, **but also on the level of integration and the forms of the links, which have been built between them**. Not only the plurality of the individuals allows a plurality of responses, as an individual combines the stimulus with its own experiences, but also **the stimulus to an individual actor may be combined with the different complementary competencies of the various actors, who are directly or indirectly linked to him. That leads to differences in the pattern of innovation within diversified communities or systems of SMEs.**

The increasing integration within a regional innovation system is leading to an increasing specialization of the various local actors. In particular, the knowledge which is shared between the various actors usually has a different meaning for the donor and the receiver, as is significance depends on its combination with their respective specific internal capabilities. **This increased knowledge is leading them to specialize in order to perform a specific or rather unique function within an innovation network.** Thus, the processes of the

interaction between regional actors and of the combination of different pieces of knowledge, specific of different scientific or production fields are related to **the process of adaptation, greater specialization, selection and greater integration of the actors within a knowledge and innovation network.** These processes in a local production system of SMEs occur in a rather informal or automatic way, rather than being planned by a superior coordinating authority, such as within an individual large firm.

Moreover, **cognitive theories explain that the building of mental frameworks, connections or routines in our mind is leading to link in a automatic way pattern of stimulus with pattern of responses.** This combination of the external stimulus with the previous individual knowledge **is leading to the phenomenon of "path dependence".** Similarly, **in a spatial perspective, the success in solving previous problems is leading to strengthen the particular links between some specific actors and to create soft infrastructures, such as routines, norms, intermediate institutions, trust, common identity and sense of place belonging, facilitating the future interactions between these same actors.** In other words, the external stimulus may lead to combine the individual competencies of an actor with the competencies of other selected actors in the same local community and **that may lead to "embeddedness" or to "spatial dependence". In a functional perspective, a lock-in effect may be the result of the lack of capability by an actor** to perceive and to adapt to a new stimulus, which is too different from his individual capabilities. However, **in a spatial perspective, a lock-in effect may also be the result of the exclusion of some external actors,** who appear too different, and a too strong internal homogeneity within a local innovation system may hinder the receptivity to diversity and the interaction with external actors. Thus, **we may conclude that the time and the space dimensions are both relevant in the process of innovation. While the "evolutive approach" clarifies the "path dependent" character of the innovation process, a "network approach" clarifies the "spatially embedded" character of the innovation process, as this latter depends on the interaction between various local actors within a collective learning process.**