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# WORKING PAPER SERIES

## TOWARDS A COGNITIVE EVOLUTIONARY ECONOMICS

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# Towards a Cognitive Evolutionary Economics

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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 variables[1]. 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 decision-making 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

[1] These subjects were further dealt with by Hayek (Rizzello 1999).

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.

Let us consider first of all evolutionary economics. After half century from its foundation (Alchian 1950), the evolutionary approach to economics presents today a very large spectrum of application. Gradually this paradigm – which was traditionally confined to explain the dynamics of competition from a Darwinian and Schumpeterian point of view - has been extended to many other ambits, the most relevant of which are endogenous change, path dependent dynamics, and organizational learning (Dosi 1991, Witt 1991, Dosi - Nelson 1994, Nelson 1995). It is not within the scope of this introduction to reconstruct the history of evolutionary economics. Yet it may be appropriate to shortly indicate the relevant passages of the development of evolutionary economics[2].

Nelson's and Winter's (1982) book represents both one the most relevant contribution to the comprehension of the dynamics of change, and a bridge that links different analytical traditions. In fact, on the one hand, following Alchian's (1950) seminal work, it clusters the Darwinian theory on natural selection and competition and the Schumpeterian ideas on technological change and economic dynamics. On the other hand, though it is mainly confined to the explanation of exogenous dynamics, this book contains analytical insights, which allows the integration of different tradition in the explanation of the dynamics of change.

[2] Hodgson (1995 and 1999) offers a wide reconstruction of the history of evolutionary economics.

In the last decade of '900, it is not difficult to find many contributions stressing the relevance of endogenous and path-dependent dynamics for economic change. Yet some problems had to be coped with in order to reach such integration. Next to Schumpeterian tradition, a new alternative approach arose. This can be synthesized as the Marshallian approach to economic change, stressing the relevance of endogenous change and self-organization analysis (Foster 1993 and 1997; Hodgson 1997a; Foss 1997; Witt 1997)[3]. The latter rejects also the use of biological analogies and gives prominence to the fact that the interpretation of Schumpeter's ideas on evolution is mainly a fruit of a misconception (Andersen 1997; Hodgson 1997b; Foster 2000).

Self-organizing approach is very relevant for evolutionary economics, because economic systems are mainly time-irreversible and dissipative structures[4].

Evolutionary analysis and cognitive economics should be integrated[5].

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-

[3] Some authors try to integrate these two traditions. In particular, Silveberg – Dosi – Orsenigo (1988) maintained that competitive selection and self-organizing approach could coexist in a neo-schumpeterian model. But, as Foster pointed out (2000, p. 325), "they do not employ an economic self-organizing approach, in the sense of Schumpeter, but, rather, a more complex form of competitive selection". Following Foster (1994 and 2000), Schumpeter offers good insights to integrate competitive selection in a wider self-organizing approach. Schumpeter, in fact, conceives development and evolution as jointed process in the economic domain.

[4] Foster (1993) considers economic systems as dissipative structures, which usually have the peculiarity to be non-equilibrium open systems (see Mori – Kuramoto 1998). In Prigogine's conception dissipative structures are thermodynamic systems, "whose behavior is determined by its boundary conditions, in contrast to what he defines as a dynamic system which is determined by its initial condition" (Foster 1993, p. 985). Economic systems are characterized also by time irreversibility, which differentiate them from mechanical models. Foster (1993, p. 982) proposes to revisit Marshall's thought. "Marshall was all too aware that not evolutionary economics could be possible until time irreversibility was properly understand". Furthermore, Foss (1997), Foster (1993, in particular p. 976) and Hodgson (1999) stress the relevance of Marshall' ideas on time irreversibility, which contrast with the economic mechanical paradigm, whose introduction in economics is erroneously addressed to Marshall. More generally, Witt (1991, p. 87) indicated in time irreversibility and in endogenous change two structural aspects of evolution.

[5] About the relevance of cognition for economics, the point of view here presented follows in particular the Austrian tradition on knowledge, creativity and novelty and it stresses their importance of these aspects for evolutionary economics, as Witt (1995 and 1999) pointed out.

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 behavior[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)[7]. Starting from Marshall's early writings, this tradition has continued with the contributions of the Austrian school – Menger and Hayek in particular - on the subjectivist theory of perception, knowledge and cultural evolution (Menger 1883, Hayek 1937, 1952, 1963, 1973, 1979). The '50s cognitive revolution integrated these theories with Simon's works on rationality and Knight's concept of structural uncertainty (Knight 1921, Simon 1957), and finally it allowed to integrate them in the behavioral economics of the firm (March-Simon 1958), the experimental economics approach to decision making (Kahneman – Tversky 1979), and the path-dependence literature on technological, organizational and institutional change (see respectively David 1985 and 1997, Antonelli 1999, Denzau-North 1993, Witt 1993).

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.

[6] Rizzello (1999) offers, among other things, an overview of this literature.

[7] As Raffaelli (1994) suggests, Marshall's account of the economic system (especially in Book IV of the *Principles*) was significantly influenced by his early encounters with problems of knowledge.

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.

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 'self-organization' (or autopoiesis) which enables them to export entropy and import free energy to maintain themselves" (Foster 1993, p. 185)[8]. The evolutionary aspects of these systems rely on the fact that if these structures cannot reverse easily, they can only change by evolving.

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.

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[9].

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"[10]. This means that the organism is able to make an action, in the

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[8] 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.

[9] 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).

[10] 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-

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)[11].

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[12], we can find a better answer by using the new analytical tools above mentioned.

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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.

[11] 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).

[12] 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*.

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[13]. 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). 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[14].

[13] 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).

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.

In the evolution of nervous systems a double mechanism works simultaneously: path-dependence 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[15]. 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.

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-

[15] 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).

neurobiological foundations. As will emerge, this is very close to the above-mentioned biological and anthropological literature[16].

## III. Hayek's psycho-neurobiological concept of evolution

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[17]. 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).

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

[17] 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

It may be appropriate to illustrate in this part a brief summary of the model of mind we can found in his book[18].

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.

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. 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.

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evolution, demonstrating the link between human mind and role of cultural evolution (on this issue see also Rizzello 2000, and Rizzello- Turvani 2000).

[18] A larger description of these contents can be found in Rizzello 1999.

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[19]. After this process, these latter result, in turn, modified and they are ready to co-opt new unfamiliar external data and so on.

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).

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 self-regulating mechanism - seems to be a useful tool to extend the analysis of the evolution of self-organization structures.

[19] Gould (1991) has stressed the relevance of exaptation for evolutionary psychology.

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)[20], it is possible to make an attempt to summarize in few sentences the main points introduced by this literature into economics.

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.

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

[20] See also Paul David's reaction to the criticism by Leibowitz and Margolis (David 1997).

surrounds a locally (or globally) stable equilibrium[21]. These kinds of equilibrium are stable but not (necessarily) optimal and they often result to be multiple ones.

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[22], 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. They depend at least on four aspects: the genetic neurobiological dimension of the individual; his/her previous experience; historical stochastic accidents; the feed-beck 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

[21] "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).

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. 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 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.

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: human genetic features are stochastic; previous experiences are idiosyncratic; historical accidents are not forecasting; 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

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

[22] 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

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.

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.

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

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physiological sensibility to the experience.

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.

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]. 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.

[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.

## VI. Concluding remarks

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 path-dependent terms.

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 - whit 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.

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