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HAYEK ON EXPECTATIONS: THE INTERPLAY BETWEEN TWO COMPLEX SYSTEMS

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Hayek on Expectations: The Interplay between Two Complex Systems*

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Abstract: In this paper, we argue that Hayek's approach to expectations can be better understood if one takes into account the interplay between two related complex evolving systems: the cognitive system and the system of behavioural rules of action. The interplay between these two systems involves both positive and negative feedback mechanisms so that an individual system of rules can produce higher order regularities that preserve their existence over time. Our contribution complements existing work on Hayek's cognitive theory by providing insights on how Hayek's approach to expectations can inform modern behavioural economics.

Keywords: Hayek; emergence; knowledge; expectations

Subject classification codes: B25; B4; B53; D84

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Introduction

In *The Counter-Revolution of Science*, Hayek points out some new problems which the advance of subjectivism in economic theory makes salient, notably: “the problem of the compatibility of intentions and expectations of different people, of the division of knowledge between them, and the process by which the relevant knowledge is acquired and expectations formed” (Hayek 1952b: 31).

Hayek’s perspective on expectations has changed through time, switching from the norm of stationary equilibrium in his 1928 article to “a state of mutual consistency of plans with correct foresight” in his 1937 article. However, his writings on expectations are marked by a continuous search for a general theory of expectations beyond the tautological explanation attached to economic general equilibrium theory. Hayek realised in the 1930s that an equilibrium of expectations does not simply require an assumption about the foresight capabilities of agents, but also that the required assumption is an equilibrium notion in itself (Zappia 1999). This insight seems to be inspired by Morgenstern (1936)’s critique of Hayek (1928).

In order to grasp Hayek’s approach to expectations we need to understand the interplay between two related evolving complex systems: the cognitive system and the system of behavioural rules of action. Based on the properties of the cognitive system, the system of rules can provide higher order regularities that preserve their existence over time. As we will explain, the interplay between these two complex systems involves both positive and negative feedback mechanisms. This interpretation permits us to go beyond existing accounts of Hayek’s theory of expectations which mainly address its link with his cognitive theory of mind (Butos and Koppl 1993) or are

focused on its divergence from the rational expectation hypothesis that has pervaded contemporary macroeconomics since the 1970s (Butos 1997). Moreover, it complements existing work on Hayek's cognitive theory and its relation with his theory of cultural evolution (cf. Gick and Gick 2001) by providing insights about what a behavioural economics approach to expectations that is informed by Hayek's thinking could look like.

The rest of the article is structured as follows: Section 1 gives detailed descriptions of the two complex systems and emphasises the differences. Section 2 deals with the interplay between the two systems and discusses the consequences regarding the forming of expectations. Section 3 sums up the main arguments.

1. Hayek's approach to expectation is based on two complex systems

In this section, we describe successively the two complex systems Hayek is concerned with, i.e., the cognitive system and the system of rules of conduct. Then we indicate some of the main differences between them.

1.1. The cognitive complex system

Hayek's view of individual cognition is developed in *The Sensory Order* (1952a – *TSO* hereafter), a contribution to theoretical cognitive psychology he wrote in the 20s but first published in the 50s.² Hayek at the time described *TSO* as “the most important thing

² The circumstances under which Hayek developed his ideas is worth mentioning. In the winter of 1919-1920 a fuel shortage closed the University of Vienna. This presented Hayek with

I have ever done” (letter to John Nef, dated 6 November 1948, cited from Caldwell, 1997: 1856). Unfortunately, as noted by Butos and Koppl (2007), despite the recognition Hayek’s cognitive theory has received from outside economics by scholars such as Gerald Edelman³, Joaquin Fuster and Edward Boring, its influence on researchers in economics and social sciences must be described as at best tangential (Butos and Koppl 2007: 35).

According to us, what is not highlighted enough in the secondary literature is *the method* Hayek uses in *TSO* because this has consequences that are far from negligible. *TSO* is based on both General System Theory that Hayek takes from von Bertalanffy

an opportunity to spend a few weeks in Zurich working in the laboratory of the brain anatomist Constantin von Monakow, tracing fibre bundles of the brain (cf. Hayek 1994, 55). A few months later, Hayek wrote the initial working material for *The Sensory Order*, a student paper manuscript entitled “Beiträge zur Theorie der Entwicklung des Bewusstseins”. *TSO* has been recently re-edited by Viktor Vanberg (2017) with an extensive introduction.

3 Gerald Edelman who was awarded the Nobel Prize in Physiology in 1972 was inspired by some of Hayek’s ideas on neuronal selection: “I have been deeply gratified by reading a book [Hayek’s *The Sensory Order*] of which I had not been aware when I wrote my little essay on group selection theory (...). I was deeply impressed (...). I recommend this book to your attention [i.e. The American Academy of Arts and Sciences], as an exercise in profound thinking by a man who simply considers knowledge for its own sake. What impressed me most is his understanding that the key to the problem of perception is to comprehend the nature of classification. Taxonomists have struggled with this problem many times, but I think Hayek considered this problem in a broader sense.” (Gerald Edelman, “Through a Computer Darkly: Group Selection and Higher Brain Function”, *Bulletin — The American Academy of Arts and Sciences*, Vol. XXXVI, No. 1, Oct. 1982, p. 24). Other scientists outside economics have praised Hayek’s contribution. According to Steele (2002), Hayek’s *The Sensory Order* also anticipates Henry Plotkin’s evolutionary epistemology.

(1932) and cybernetics that Hayek borrows from Ashby, Craik, McCulloch and Wiener.⁴ Both anecdotal evidence and theoretical arguments supports this claim. First, in the preface to *TSO* Hayek gave tribute to his “friends Karl R. Popper and L. von Bertalanffy and to Professor J.C. Eccles” [he is] “much indebted for reading and commenting upon earlier drafts of this book” (Hayek 1952a: ix).⁵ Second, Hayek’s article entitled “The Primacy of the abstract” (Hayek 1969) was first published in a book edited by Arthur Koestler and John Raymond Smythies. This book collects the contributions for the Alpbach Symposium organised in 1968 by Arthur Koestler on “New perspectives in the Science of Man”.⁶ Among the participants and authors were Jean Piaget and Ludwig von Bertalanffy, known as defenders of structuralism and system theory respectively.⁷

From a theoretical point of view, Hayek’s *TSO* is organised on principles that are in line with Bertalanffy’s General System Theory applied to biology. As Hayek himself wrote:

⁴ For a more complete analysis of the relationships between Hayek and von Bertalanffy, see Lewis and Lewin, (2015) and Lewis (2016a). On the influence of cybernetics on Hayek’s thought, see Dupuy (1992) and Lewis (2016b).

⁵ J.C. Eccles won the 1963 Nobel Prize in Physiology or Medicine for his work on the synapse.

⁶ “The European Forum Alpbach took place for the first time in August 1945 as one of the earliest international political and intellectual events in post-WWII Europe. Its founders were Otto Molden, who had been active in the resistance movement during the Second World War, and philosophy lecturer Simon Moser from Innsbruck, as well as a number of other influential personalities.” (<http://www.alpbach.org/en/about-us/unsere-geschichte/>).

⁷ During this symposium, Koestler brought together many important thinkers, such as Ludwig von Bertalanffy, Viktor Emil Frankl, Friedrich August Hayek, Jean Piaget, William Homan Thorpe, Conrad Hal Waddington and Paul Alfred Weiss.

any attempt to explain the highly complex kind of purposive action made possible by a developed central nervous system may be premature so long as we do not possess a fully adequate biological theory of the *comparatively simpler kind of purposive functioning* (...) [L. von Bertalanffy's] theory of 'open systems' in a steady state (*Fliessgleichgewicht*) in which 'equifinality' prevails because the equilibrium that will be reached will be in some measure be (*sic*) independent of the initial conditions, seems to provide the most helpful contribution to this problem. (Hayek 1952a: 82-83; our emphasis)

The main features of the cognitive complex system as described by Hayek in *TSO* can be summarised as follows: First, Hayek distinguished between the physical order, the neural order and the sensory order. Second, he emphasised that the logic of the cognitive system is based on hierarchical successive classifications. Third, Hayek describes two important cognitive mechanisms, namely, the "map" and the "model" that combined generate individuals' perceptions of their environment.

1.1.1. The distinction between the different orders

Early in his book, Hayek distinguishes the *physical order* (i.e., the domain of external stimuli) from the *sensory order* or the mind. For him, there is a fundamental discontinuity between these two orders.^s

On the one hand, the sensory order forms a "*self-contained system*" so that we can describe any one of these qualities only in terms of its relations to other such

^s As we will detail below, these two orders must however be somehow related in order to avoid circular reasoning.

qualities, and that many of these relations themselves also belong to the qualitative order” (Hayek 1952a: 37, our emphasis).

On the other hand, there exists no one-to-one correspondence between the physical order (i.e. external stimuli) and the sensory order (i.e., the experience of a sensation). As emphasised by Caldwell (2004), Hayek’s endeavour in *TSO* was to challenge the dominant doctrine in psychology known as the ‘doctrine of psychophysiological parallelism’ endorsed by Ernst Mach and a few others in Vienna.

More precisely, as shown in Figure 1, the sensory order combines two orders: the neural order and the mental order.⁹ Hayek specifies the relations among these three orders by having recourse to the notion of isomorphism, a notion he borrowed from the Gestalt School but qualified in order to restrict it to a topological – and not a spatial – mathematical meaning.¹⁰

⁹ “The neural order of the fibres, and of the impulses proceeding in these fibres, which, though undoubtedly part of the complete physical order, is yet a part of it which is not directly known but can only be reconstructed” (Hayek 1952a: 39). By contrast, “The mental or phenomenal order of sensations (and other mental qualities) directly known although our knowledge of it is largely only a ‘knowing how’ and not a ‘knowing that’, and although we may never be able to bring out by analysis all the relations which determine that order” (Hayek 1952a: 39). As for the distinction between ‘know how’ and ‘know that’ Hayek refers in a note to Ryle (1945) who introduced this distinction.

¹⁰ According to Hayek, the notion of isomorphism is “used in its strict mathematical meaning of a structural correspondence between systems of related elements in which the relations connecting these elements possess the same formal properties” (Hayek 1952, 38). In mathematics an isomorphism is a specific morphism. A morphism satisfies the two following axioms:

Identity: for every object X , there exists a morphism $\text{id}_X: X \rightarrow X$ called the identity morphism on X , such that for every morphism $f: A \rightarrow B$ we have $\text{id}_B \circ f = f = f \circ \text{id}_A$.

Associativity: $h \circ (g \circ f) = (h \circ g) \circ f$ whenever the operations are defined.

According to this definition, the neural order (the second one) and the mental order (the third one) are isomorphic. Therefore, the physical order (the first one) cannot be isomorphic to the neural order (the second one) due to the fundamental disconnect between the physical order and the sensory order. This does not mean that they are unrelated. Hayek refers to the more vague notion of similarity (that one could interpret as an approximation to the mathematical notion of mapping or correspondence¹¹) in order to account for the fact that the mind gives an interpretation, but not an exact description of the physical world.¹² Hayek's specification gets rid of circular reasoning since the neural order, which is a sub-set of the physical order, is isomorphic with the mental order.

In less abstract terms, the sensory order is the combination of the neural and mental orders which are defined as equivalent. The relations between the physical order and the neural one are mediated through *stimuli*, whereas the relations inside the neural order are linked by means of *impulses*.¹³

$f: X \rightarrow Y$ is called an isomorphism if there exists a morphism $g: Y \rightarrow X$ such that $f \circ g = \text{id}$, and $g \circ f = \text{id}$. If a morphism has both left-inverse and right-inverse, then the two inverses are equal, so f is an isomorphism, and g is called simply the inverse of f .

¹¹ A correspondence is an ordered triple (X, Y, f) , where f is a relation from X to Y , i.e. any subset of the Cartesian product $X \times Y$.

¹² This idea is perfectly summarised by Edelman (1989): "A closed universal description of objects is not available to an adaptive creature, even to one with concepts; there is no 'voice in the burning bush' telling animals what the world description should be" (Edelman 1989: 32).

¹³ "The term *stimulus* will be used throughout this discussion to describe an event external to the nervous system which causes (through or without the mediation of special receptor organs) processes in some nerve fibres which by these fibres are conducted from the point at which the stimulus acts to some other point of the nervous system. It appears that at least some receptor organs are sensitive not to the continuous action of any one given stimulus

1.1.2. The logic of the cognitive system is based on the principle of increasing classification

According to Hayek, the logic of classification reflects the relations that take place in the cognitive system between events and effects:

By ‘classification’ we shall mean a process in which on each occasion on which a certain recurring event happens it produces the same specific effect, and where the effects produced by any one kind of such events may be either the same or different from those which any other kind of event produces in a similar manner. All the different events which whenever they occur produce the same effect will be said to be events of the same class, and the fact that every one of them produces the same effect will be the *sole* criterion which makes them members of the same class. (Hayek 1952a: 48)

Accordingly, classification is defined as a binary relation on the set of events. This binary relation is defined as “to have the same effect”. What is important to note is that the *events belong to the set of impulses*, i.e., they are parts of the neural order.¹⁴ As far as the effects are concerned, they are not reducible to behaviour (as behaviourism does assume), but defined in terms of sensory qualities in the mental order:

but only to changes in that stimulus. Whatever it is that is produced in the nerve fibre and propagated though it we shall call the *impulse*” (Hayek 1952a: 8).

¹⁴ “Any individual neural event may have physical properties which are similar or different from other such events if investigated in isolation. But, irrespective of the properties which those events will possess by themselves, they will possess others solely as the result of their position in the order of inter-connected neural events. As an isolated event, tested for its effects on all sorts of other such events, it will show one set of properties and therefore have to be assigned a particular place in the order of classification of such single events; as an element of the complete neural structure it may show quite different properties” (Hayek 1952a: 46).

Once we include among the ‘effects’ of a stimulus all the intermediate links which may intervene between the stimulus causing a sensation and the overt response to it, the difficulty of defining sensory qualities in terms of their effects largely disappears. (Hayek 1952a: 45)

In compliance with the logic of multi-level systems in cybernetics, classification is a hierarchical process.¹⁵ As Hayek explains, “the classification may thus be ‘multiple’ in more than one respect” (Hayek 1952a: 50). First, “not only may each individual event belong to more than one class, but it may also contribute to produce different responses of the machine if and only if it occurs in combination with certain other events” (*ibid.*). Second, “different groups consisting of different individual events may (...) evoke the same response and the machine would then classify not only individual events but also groups consisting of a number of (simultaneous or successive) events” (*ibid.*). Third, the logic of classification is ‘multiple’ in a third sense due to its reflexivity: “it can take place on many successive levels or stages, and any one of the various classes in which an impulse may be included may in turn become the object of further classification” (*ibid.*: 70).

In sum, the logics of classification and reclassification give a high degree of plasticity to the cognitive complex system, while negative feedback processes provide the property of homeostasis.¹⁶ As we will explain, these negative feedback processes

¹⁵ “This classification is determined by the position of the individual impulse or group of impulses in a complex structure of connexions, extending through a hierarchy of levels, follow certain important conclusions concerning the effects which physiological or anatomical changes must be expected to have on mental functions” (Hayek 1952a: 147).

¹⁶ “A negative feedback system reverses a change in input and responds to a perturbation in the opposite direction.” (Anufriev et al., 2013, p. 666).

consist of the corrections of errors due to possible differences between expected and experienced effects (see section 2.1). Classification is therefore an emergent property of the mind.¹⁷ As Lewis puts it,

Hayek's analysis suggests that the capacity to classify stimuli arises only when the individual nerve fibres are arranged so as to form a structured, hierarchical whole. That capacity is, therefore, an emergent property. Its bearer is the higher-level or emergent entity, namely the human mind, that is formed when a set of nerve fibres is arranged into the type of structure that is required to facilitate the classification of external stimuli (Lewis 2012: 372).

Similarly, Rosser points out that for Hayek, cognition clearly relates to "pattern formation out of perceptions [that] can be seen as another example of the spontaneous emergence of order in the complex system of the mind" (Rosser 2010: 170).

The logic of classification and reclassification is at the root of Hayek's often emphasised proposition that abstraction precedes perception. In other words, the sensory order is organised along a pyramidal system of categorisation of increasing degrees of abstraction so that our conscious experience is the product of "specification by superimposition" (Hayek 1969 in Hayek 1978, 48).

¹⁷ Emergence is a property of complex systems. See for example Rosser (1999) and Koppl (2009).

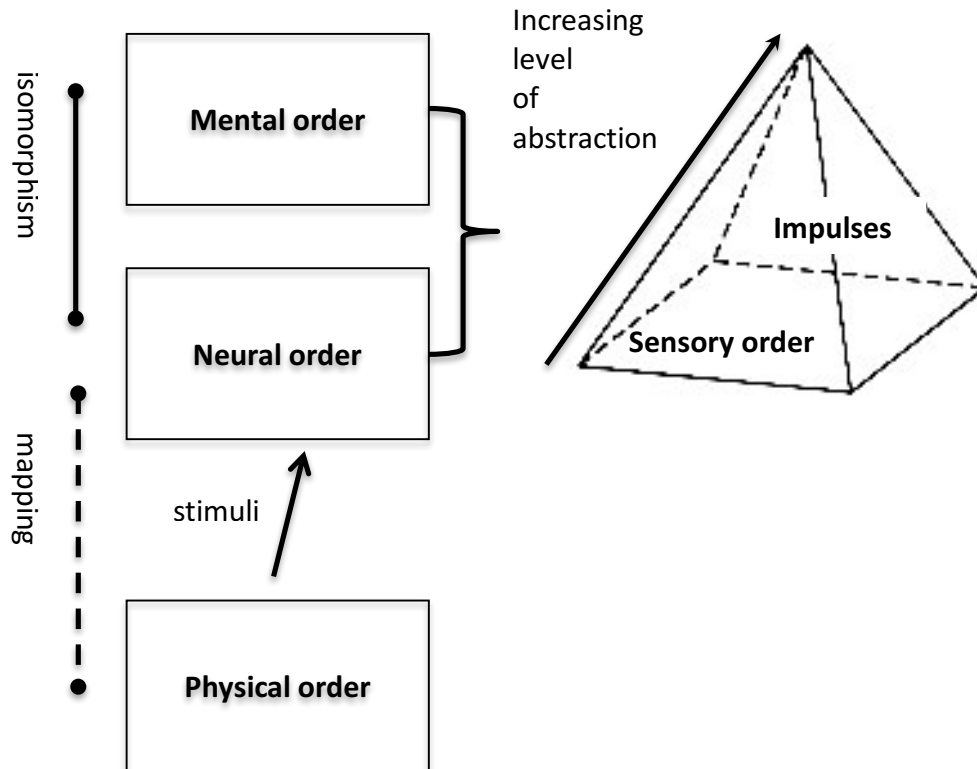


Figure 1. The cognitive complex system

Let us now investigate how classification and reclassification operate in the structure of the brain by means of two related cognitive mechanisms: the map and the model.

1.1.3. The map(s) and the model

Hayek (1952a: 104) describes the organisation of the nervous system as a network of “linkages”, which are the mechanisms by which “the formation of new connexions by the simultaneous occurrence of several afferent impulses” proceeds. The linkages are themselves organised into a map, which can be conceived as the set of hierarchical

systems of impulses that constitute the structural memory. The map is nevertheless subject to “continuous although very gradual change” because “the relationships between various kinds of events in the external world, which the linkages will gradually produce in the higher nervous centres” change over time (*ibid.*: 110).

Hayek’s description of the hierarchical organisation of the brain is very close to Bertalanffy’s second principle of General System Theory, to wit, the ‘principle of hierarchisation’ or the ‘principle of progressive organisation’. This principle states that “the properties and modes of action of the higher levels are not explainable by the summation of the properties and modes of action of *their components as studied only in isolation.*” (Bertalanffy 1932: 99, italics in the original).¹⁸ Hayek seems to have something very similar in mind when he writes:

As any afferent impulse is passed on to higher levels, it will send out more and more branches which will potentially be capable of reinforcing or inhibiting an ever-increasing range of other impulses. This increasing ramification of every chain of impulses, as it ascends through successive relays to higher levels, will mean that at any moment the general excitatory state of the whole nervous system

¹⁸ This has to be linked to the notion of emergence Hayek introduces in *The Theory of Complex Phenomena* (1964): The “emergence” of “new” patterns as a result of the increase in the number of elements between which simple relations exist, means that this larger structure will possess certain general or abstract features which will recur independently of the particular values of the individual data, so long as the general structure (as described, e.g., by an algebraic equation) is preserved. Such “wholes”, defined in terms of certain general properties of their structure, will constitute distinctive objects of explanation for a theory, even though such a theory may be merely a particular way of fitting together statements about the relations between individual elements.” (Hayek 1967 [1964]: 26). For an account of the way in which the notion of ‘emergence’ entered Hayek’s thinking see Lewis, P.A. (2016c).

will depend less and less on the new stimuli currently received, and more and more on the continued course of chains of impulses set up by stimuli which were received during some period of the past. (Hayek 1952a: 112)

This organisation as a pyramid of maps largely determines how individuals perceive (in a very simplified way) their environment. In particular, it guides them in discriminating between what can be considered as a stable or an unstable environment. Hayek (*ibid.*: 114) suggests that this is rendered possible by the fact that “certain constellations of impulses mutually support each other, or that by a sort of circular process they will tend to re-evoke themselves rather than a different constellation corresponding to a different environment” (*ibid.*). In other terms, the maps provide a kind of reinforcement or positive feedback process between the sets of impulses that permits individuals to expect a stable environment (see Figure 3). Note that this property is similar to the concept of re-entrance in neural Darwinism (see Edelman 1987).

According to Hayek, the map has to be distinguished from what he calls the model. While the map is a mental matrix made of the “semi-permanent connexions representing not the environment of the moment but the kind of events which the organism has met during its whole past”, the model “is formed at any moment by the active impulses” (*ibid.*: 115). In a nutshell, it could be said that the maps are a multi-level system of potential impulses inherited from the past generations whereas the model is their current realisation, that is the path or trajectory that the impulses effectively take in the structural network formed by the maps in the course of one’s personal life (see Figure 2).

In compliance with the logic of classification and reclassification, the model is appraised and modified in terms of its expected consequences, by means of a negative feedback mechanism¹⁹:

The current sensory reports about what is happening will be checked against expectations, and the difference between the two will act as a further stimulus indicating the required corrections. The result of every step in the course of actions will, as it were, be evaluated against the expected results, and any difference will serve as an indicator of the corrections required. (Hayek 1952a: 95)

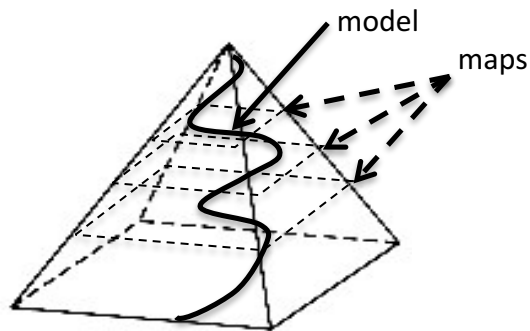


Figure 2. The maps and the model

¹⁹ Hayek quotes N. Wiener (1948a and 1948b), W. S. McCulloch (1948) and W. R. Ashby (1947, 1948, and 1949) in a footnote in Hayek (1952a: 95). In passing, there is a typographical error since Ashley is referred to, including in the index p. 205, instead of Ashby, correctly spelled in the bibliography p. 195. Here again, Hayek uses the results from cybernetics. It might also be worth mentioning here the work of Kenneth Craik. He was one of the founding fathers of cybernetics, along with Wiener and McCulloch, and it is from his work that Hayek took the notion of the “model”. See Lewis, P.A. (2016b).

To sum up, Hayek's conception of individual rules of action is based on a General System Theory approach *à la* Bertalanffy. As a system, the mind is a complex one and as such it is non-deterministic.²⁰ Accordingly, it is impossible to forecast its reaction to the external changing world. First, because the mind only gives an abstract partly unconscious interpretation of it, and second, because the internal connections inside the mind are not univocally determined (different stimuli can imply the same reaction²¹ and the same stimuli can end in different reactions). Third, it is an adaptive system characterised by a tension between positive feedback that helps to discriminate between different (and new) environments and negative feedback that permits to learn from prediction errors.

Let us now describe the second complex system, which regards individual and social rules of conduct.

1.2. The system of rules of conduct

The system of rules of conduct described by Hayek is best illustrated by the famous formula “the result of human action but not of human design”²² which inevitably evokes Menger's organic approach to social phenomena such as institutions²³:

²⁰ See for example Rosser (1999), Koppl (2009) and Kirman (2011).

²¹ This property is similar to the notion of degeneracy in biology, i.e., the ability of elements that are structurally different to perform the same function or yield the same output.

²² This formula is the title of Hayek's article first published in French in *Les fondements philosophiques des sociétés économiques : Textes de J. Rueff et essais rédigés en son honneur le 23 août 1966*, Emil Claassen (ed.), 1967, Payot : Paris. Published in English in F.A. Hayek (1967), pp. 96–105.

Hayek's analysis of the complex system of rules of conduct is found in his "Notes on the Evolution of Systems of Rules of Conduct" (1967), which is a central piece of his often debated theory of cultural evolution (see Vanberg 1994 and Festré and Garrouste 2009). In this article, Hayek explains how individual rules of conducts followed by groups of individuals give rise to orders of actions that take place at the level of the group as a whole at a given time in the course of evolution.

As we will explain, this process of selection of rules involves two distinct systems or levels of analysis: "the elements of any order" and the "resulting order" in general terms, or, in the particular instance of Hayek's social theory, "the individuals" and "the group of individuals" (Hayek 1967: 67 and footnote 1). As emphasised by Hayek:

The systems of rules of individual conduct and the order of actions which results from the individuals acting in accordance with them *are not the same thing*. (Hayek 1967: 67; our emphasis)

The essence of the argument is that in a human society, as in an animal society, individuals observe common rules of conduct, which, depending on the circumstances under which they live, will produce certain action rules. But there is no one-to-one correspondence between the rules at work at the individual level and those that apply at the group or social level:

²³ "How can it be that institutions which serve the common welfare and are extremely significant for its development come into being without a common will directed toward establishing them?" (Menger 1963 [1883]: 146).

It is the resulting overall order of actions but not the regularity of the actions of the separate individuals as such which is important for the preservation of the group; and a certain kind of overall order may in the same manner contribute to the survival of the members of the group whatever the particular rules of conduct of individuals are which bring it about. (Hayek 1967: 68)²⁴

Hayek comments at length on the reasons why these two systems differ from one another. In particular, he notes that “the same order of actions can be produced by different sets of rules of individual conduct” and that “the same set of rules of individual conduct may in some circumstances bring about a certain order of actions, but not do so in different external circumstances (Hayek 1967: 68).²⁵

Upon closer investigation, these reasons boil down to the enumeration of the properties of the notion of emergence. In philosophy, the notion of emergence is defined by three key properties: Supervenience, irreducibility and downward causation (Kim 2006). The first property states that there exists a dependence relation between the (macroscopic) emerging properties and the micro-properties of the system, so that systems with similar micro-properties have the same emergent properties. It is also referred to as upward causality. The principle of irreducibility means that a complete account of the macro-properties of a system is not possible at the level of the micro-properties of the same system. It also implies that the higher level possesses novel properties beyond prediction and explanation. Finally, downward causality means that there exist proper causal effects from the macro-properties on the micro-conditions of the system. This means that in the same way as the macro-properties cannot be

²⁴ The ‘overall order of actions’ – which is the trait upon which selection acts – is an *emergent property*. See Gaus (2006) and Lewis (2012).

²⁵ As an example, charity-giving as an order of actions can be produced by two different individual rules of conduct: impure as well as pure altruism (cf. Andreoni 1990).

reducible to the micro-conditions of the system, its micro-properties cannot be understood independently from the effect that the emergent level exerts on them.

The idea of downward and upward causation are expressed in Hayek's terms as follows²⁶:

(...) the individual with a particular structure and behaviour owes its existence in this form to a society of a particular structure, because only within such a society has it been advantageous to develop some of its peculiar characteristics, while the order of society in turn is a result of these regularities of conduct which the individuals have developed in society. (Hayek 1967: 76)²⁷

The idea of non-intentionality plays an important role in explaining why the level of the order of actions cannot be reducible to the level of individual rules of conduct. Hayek makes clear that when using the term 'rule', he does not intend that "such a rule is 'known' to the individuals in any other sense than they normally act in accordance with it" (Hayek 1967: 67).

²⁶ Note that this is reminiscent of Menger's idea of mutual causation at the core of what he labels in his *Untersuchung* the "compositive method": "This holds true first of the analogy which is supposed to exist between the two groups of phenomena under discussion here with regard to the normal nature and the normal function of the whole being conditioned by the parts and of the parts by the whole. There is a view that the parts of a whole and the whole itself are mutually *cause* and *effect* simultaneously (that a *mutual causation* takes place), a view which has frequently taken root in the organic orientation of social research" (Menger 1995 [1883]: 132–33).

²⁷ Lewis (2012) discusses the notion of "downward causation" in Hayek.

Moreover, the order of rules does not derive from individual motives in a direct and trivial way since the “consequence of observing (...) rules is wholly beyond their knowledge” (*ibid.*: 77)²⁸

Hayek also emphasises that the twofold rule selection processes also involve two different ontological principles of selection, namely a natural one at the individual level, and a cultural one at the group level:

The genetic (and in a great measure the cultural) transmission of rules of conduct takes place from individual to individual, while what may be called the natural selection of rules will operate on the basis of the greater or lesser efficiency of the resulting order of the group. (Hayek 1967: 67, italics in the original)

28 In the same vein, Hayek wrote in “Individualism: True and False”: “All the possible differences in men’s moral attitudes amount to little, so far as their significance for social organization is concerned, compared with the fact that all man’s mind can effectively comprehend are the facts of the narrow circle of which he is the center; that, whether he is completely selfish or the most perfect altruist, the human needs for which he can effectively care are an almost negligible fraction of the needs, of all members of society” (Hayek 1948: 14).

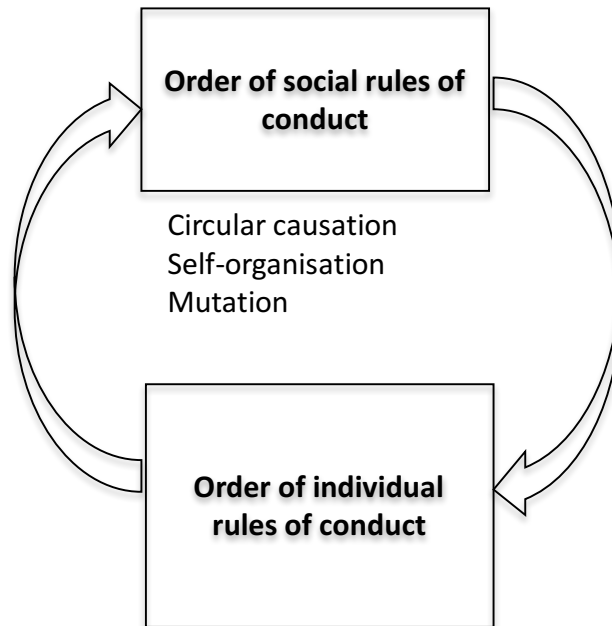


Figure 3. The complex system of rules of conduct

The two complex systems we have described so far share some of the properties of spontaneous orders such as indeterminacy. But they also differ in that the structure of the mind is hierarchic, whereas it is not the case for the complex system of rules of conduct. This feature is undermined in the literature in favour of the tempting and often used mind-society analogy.²⁹ But contrary to what most commentators suggest, Hayek is reluctant to use this metaphor, as the following quote from Hayek’s “Notes on the Evolution of Systems of Rules of Conduct” (1967) makes clear:

Although the brain may be organized on principles similar to those on which a society is organized, society is not a brain and must not be represented as a sort of super-brain, because in it the acting parts and those between which the relations determining the structure are established are the same, and the ordering task is not deputized to any part in which a model is performed. (Hayek 1967: 74)

²⁹ For instance, Colin Blakemore, a British neurologist, writes: “the brain struggling to understand the brain is society trying to explain itself” (Blakemore 1977: 185).

In the cognitive system, as Hayek explains, the relations between the physical order, i.e., “the physical order of the external world or the physical stimuli” (Hayek 1952a: 39) and the neural order involves elements of different nature.³⁰ Moreover, the connection between the neural order and the sensory order involves a multi-level mental processes hierarchy.

By contrast, in the society, the acting parts, i.e., individual rules of conduct and those between which the relations determining the structure are established, namely, the order of actions, are the same; in other words, they are of the same nature. To be clear, the order of actions is not an interpretation of individual rules through pre-defined categories. Moreover, the interplay between rules of individual conduct and the social order of action involves no hierarchy. Hayek refers to the social order of actions interchangeably as a “single-stage”, “polycentric”³¹ or “non-hierarchic” order endowed with “self-organizing forces” and which “dispenses with the necessity of first communicating all the information on which its several elements act to common centre and conceivably may make the use of more information possible than could be transmitted to, and digested by, a centre” (Hayek 1967: 74). In a nutshell, what Hayek rejects in the mind-society metaphor is, above all, the mistakenly assumed necessity of the existence of a relation between a directing unit and the rest which would be ‘executive’ (see Birner 1999: 1959). As he explains, the crucial difference between the

³⁰ This does not imply that they are disconnected since stimuli from the physical order are reflected into ontologically different objects called impulses in the neural order.

³¹ Note that when Hayek uses the term “polycentric” he explicitly refers to Michael Polanyi’s distinction between monocentric and polycentric orders³¹ in his book *The Logic of Liberty* (1951).

mind and self-organised structures, such as single-stage orders involving direct interaction between the parts and the whole, is that it is a prerequisite for survival that the brain deals with “representations of an effect to be expected” based on “patterns of actions” that have been selected *ex ante*. Single-stage orders such as the interplay between individual rules of actions and the order of actions which results from them can deal directly with “actual effects”, the selection process of action rules having the ‘desirable effects’ taking place *ex post* (Hayek 1967: 73).

As we will emphasise in Section 2, these differences are crucial in order to understand how individuals can form expectations with respect to their own knowledge as well as with respect to the consequences of their actions on others.

2. What kind of theory of expectations and prediction follows from Hayek’s conception of human cognition and behaviour?

2.1. The limits to prediction when dealing with complex systems

As we have emphasised, the cognitive system and the system of rules of conduct are two complex systems, which share some properties of emergence in multi-level analysis. This leads inevitably to some degree of indeterminacy, whether it concerns the exact relations between causes and effects in the cognitive system or the result of the selection processes occurring at both the individual and the social levels.

Concerning indeterminacy in complex systems, Hayek refers to Gödel’s 1931 incompleteness theorems and use statements that could be interpreted in terms of the

later known Ashby's Law of Requisite Variety (1956).³² According to this law, regulation and control of a system are possible if and only if the system that undertakes to control and regulate this system is at least of the same variety³³. Hayek expresses a very similar idea when he writes in his essay on "Scientism and the study of society" that

any apparatus of classification would always have to possess a degree of complexity greater than any one of the different things which it classifies; and if this is correct it would follow that it is impossible that our brain should ever be able to produce a complete explanation (as distinguished from a mere explanation of the principle) of the particular ways in which it itself classifies external stimuli. (Hayek 1952b: 49)

As emphasised by Caldwell (2004: 248), Hayek's increased interest for complex systems can be traced back to the 1950s when he moved to the Committee on Social Thought at the University of Chicago. This committee organised a seminar, which attracted many natural scientists from around the University³⁴. The manuscripts of Hayek's two ongoing works, *TSO* (1952a) and his essay on "Scientism and the study of society" (Hayek 1952b) were the major readings under discussion that prompted

³² See Hayek (1967), p. 62. The exact meaning of the supposed relationship between Gödel's theorems and the essential propositions of Hayek's theory of mind is subject to interpretation. For a thorough discussion, see van den Hauwe (2011).

³³ "If V_d [the variety V of a set D is the number of distinguishable elements it contains] is given and fixed, $V_d - V_r$ can be lessened only by a corresponding increase in V_r . Thus *the variety in the outcomes, if minimal, can be decreased further only by a corresponding increase in that of R.*"..."This is the Law of Requisite Variety." (Ashby 1956: 207) This law permits to define the possibility of regulation and control of a system.

³⁴ We know from the archives that Hayek later considered this seminar as "one of the greatest experiences in [his] life" (Hayek 1983: 184).

Hayek's interest in complex systems such as cybernetics, the system theory of Ludwig von Bertalanffy, and von Neumann's theory of automata.

It is also in this period that Hayek began to move away from his former dichotomy between natural and social sciences in favour of the classification by the philosopher of science Warren Weaver (1948), distinguishing between "simple systems", "disorganized" and "organized complexity".³⁵ Finally, it was also in the fifties, more precisely in 1952, that Hayek worked on a manuscript entitled "Within Systems and about Systems" that he later decided to split into two parts: one became his 1955 essay "Degree of explanation" (Hayek 1955 in Hayek 1967) and the other "The Theory of complex phenomena" (Hayek 1964 in Hayek 1967).³⁶ Hayek's main arguments concerning the limits to prediction in complex systems are found in these two articles.

First, he explains that theories of complex systems do not constitute closed self-contained systems but define "only a kind (or a class) of patterns" while "the particular

³⁵ The former dichotomy is the one Hayek refers to in particular in his essay on "Scientism and the study of society" (Hayek 1952b). Weaver (1948: 538–40) defines 'simple problems' as two-variable problems that characterised physical sciences before 1900. Complex problems are divided into two categories: "disorganized" vs. "organized complexity". "Disorganized complexity" defines "problems in which the number of variables is very large, and (...) in which each of the many variables has a behaviour which is individually erratic, or perhaps totally unknown (...) and "to which statistical methods hold the key". Hayek left aside the intermediate category of "disorganized complexity" in order to concentrate on "organized complexity", which characterizes problems that "involve dealing with a *sizeable number of factors which are interrelated into an organic whole.*" (Weaver 1948: 537, italics in the original).

³⁶ For more details, see Caldwell (2000: 11 and footnote 6 p. 20). This essay is reproduced in Vanberg (2017).

manifestation of the pattern to be expected will depend on (...) particular circumstances” such as “initial and marginal conditions (...) we shall refer as ‘data’”. Consequently, the extent of prediction will depend on “how many of those data we can ascertain” (Hayek 1964 in Hayek 1967: 24). In a nutshell, the more complex is a system the less we are able to predict particular phenomena. As compared to the natural sciences, the phenomena of life, mind, and society are more complex. Following Hayek, the degree of complexity of phenomena is defined as “the minimum number of elements of which an instance of the pattern must consist in order to exhibit all the characteristics attributes of the class of patterns in question” (*ibid.*: 25). It follows that we must contend ourselves with explanations “of the principle of the thing” and resist the temptation of control: “Such activities in which we are guided by a knowledge merely of the principle of the thing should be better described by the term *cultivation* than by the familiar term ‘control’” (Hayek 1955 in Hayek 1967: 19).

Hayek also points out the consequences in terms of the refutation criterion of Popper:

It seems to be a decreasing degree of falsifiability, as the advances of the sciences penetrates further and further into more complex phenomena: “(...) the more we move into the realm of the very complex, the more our knowledge is likely to be of the principle only, of the significant outline rather than of the detail. (...) only the theoretical system as a whole but no longer in part can be really falsified. (Hayek 1964 in Hayek 1967: 18-20)

Finally, concerning the indeterminacy of social structures related to the two levels of selection of rules of conduct, Hayek refers to “conjectural history” as an adequate term for describing (social) structures or events, such as “the existence of life on earth” that “are concerned with those factors in a sequence of events which are in

principle repeatable, though in fact they may have occurred once.” (Hayek 1967: 75).

The indeterminacy of the result of the selection processes is due in particular to the manifold influences occurring both at the cognitive level and at the social level:

The concrete individual actions will always be the joint effect of internal impulses, such as hunger, the particular external events acting upon the individual (including the actions of members of the group), and the rules applicable to the situation thus determined. (Hayek 1967, 69)

As we will explain in section 2.2, the cognitive level consists of impulses and individual rules of conduct, while the social level includes social learning and imitation as well as traditions that characterise social interactions.

Having this in mind, let us return to our starting hypothesis that the interactions between the two systems are important in order to grasp Hayek’s view on expectations and prediction in a satisfactory way. Let us examine this perspective more closely.

2.2. The interactions between the two complex systems and the factors facilitating the convergence between economic expectations

In this section, we argue that Hayek’s approach to expectations can be better understood if we consider the interaction between the two complex systems that we have described. We will show that this interaction involves two different kinds of emergent systems, one more focused on the creation of subjective representations through the logic of classification at the individual level, the other aimed at the selection of rules of conduct at the social level. We will also discuss the factors that operate as positive and negative feedback mechanisms within and between the two systems.

2.2.1. *The interactions between the two complex systems*

Figure 4 gives a schematic representation of the interactions between the two complex systems. It shows in particular that both systems are related to the external environment, although in different ways. On the one hand, as already explained, the cognitive system is only connected to the physical world through a mapping relation and *via* external stimuli. On the other hand, the system of rules of conduct articulates two levels of analysis that permit to take into account more explicitly the role of social interactions. Obviously, the two systems are related. According to Leslie Marsh (2013: 198), Hayek stands apart from classical Cartesian internalism by developing a conception of extended cognition, whereby the operation of the cogniser's mental states must be supplemented by an appeal to external considerations, in particular to social interactions in order to evolve over time. As Hayek wrote in the *Constitution of Liberty*:

The whole conception of man already endowed with a mind capable of conceiving civilization setting out to create it is fundamentally false. Man did not simply impose upon the world a pattern created by his mind. His mind is itself a system that constantly changes as a result of his endeavor to adapt himself to his surroundings. (Hayek 1960, 23)

Figure 4 shows that the two complex systems interact through feedback mechanisms from the environment towards the brain/mind. One can distinguish positive feedback loops³⁷ that reflect the stability of the environment through the reinforcement of impulses (i.e., a reinforcement of the 'map' as already emphasised in section 1.1.) from negative feedback loops that result from the updating of expectations when current

³⁷ "A positive feedback system reinforces a change in input by responding to a perturbation in the same direction" (Anufriev et al., 2013: 666).

realisations differ from expected results of actions.³⁸

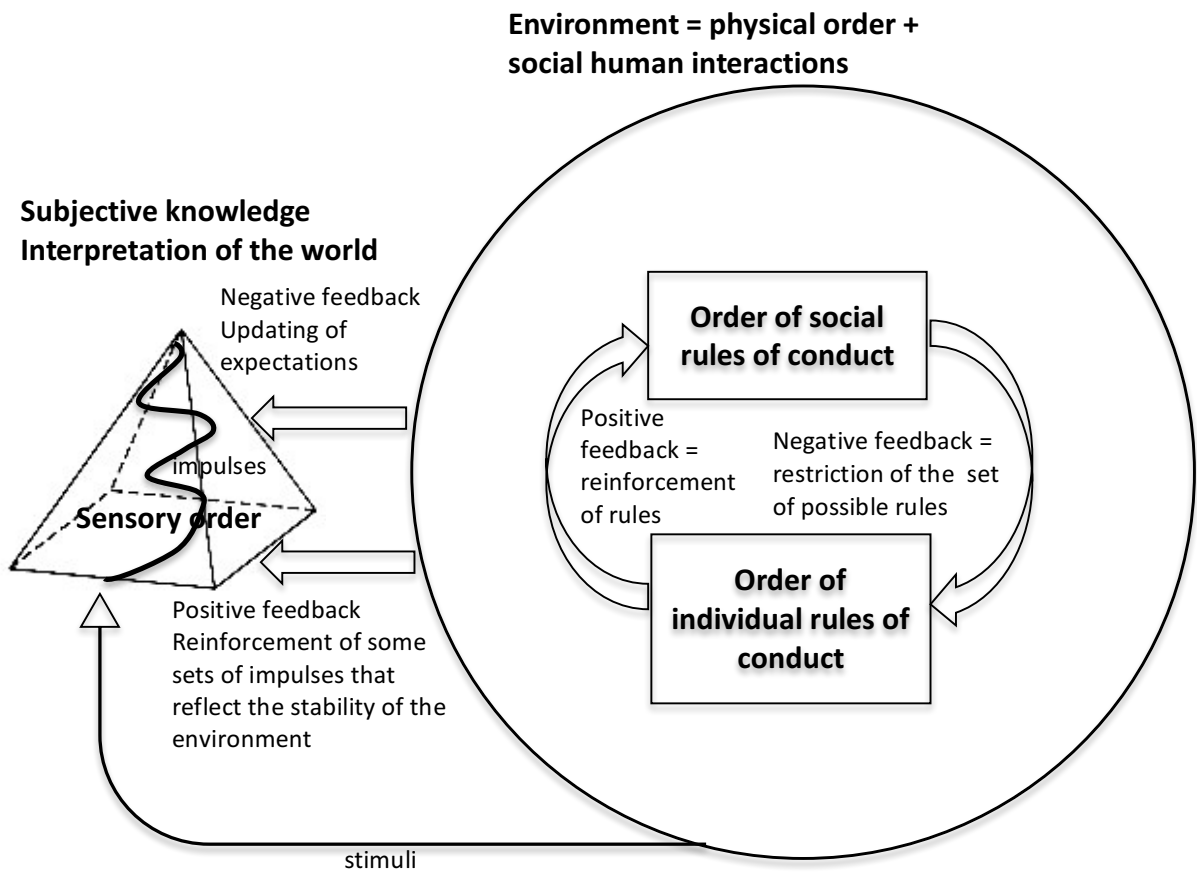


Figure 4. The interactions between the cognitive system and the system of rules of conduct

³⁸ This has to be linked with the idea that “in economic markets in general both types of feedback will play a role. On the whole however, negative feedback is usually associated with supply driven commodity markets and positive feedback with demand driven speculative asset markets” (Anufriev et al., 2013: 667)

This conception of cognition can hardly be reconciled with the common view associated with the assumption of rational expectations: homogenous individual agents who benefit from equally distributed, unambiguous, codified and complete information, do not, on average, make systematically biased expectation errors since they are able to use all relevant information in order to make economic choices. In other terms, according to this assumption, agents do have model-consistent expectations, assuming a unique and stable model.

For Hayek, the cognitive system is the result of a historical process, which is partly innate and partly acquired through social learning. This implies that each individual has his own ‘model’ or representation of the environment in which he lives. Already in his 1937 article on “Economics and knowledge” Hayek expressed his dissatisfaction with the notion of perfect foresight conveyed by general equilibrium theory, which according to him, is tautological:

Correct foresight is not (...) a precondition which must exist in order that equilibrium may be arrived at. It is rather the defining characteristic of a state of equilibrium. (Hayek 1937 in Hayek 1948: 45)

He also made transparently clear that this notion was inappropriate to deal with social interactions since it implicitly assumes a single representative agent:

The concept of equilibrium itself and the methods which we employ in pure analysis have a clear meaning only when confined to the analysis of the action of a single person and that we are really passing into a different sphere and silently introducing a new element of altogether different character when we apply it to the explanation of the interactions of a number of different individuals. (ibid.: 35)

Moreover, he also pointed out its inability to deal with the problem of time:

Since equilibrium is a relationship between actions, and since the actions of one person must necessarily take place successively in time, it is obvious that the

passage of time is essential to give the concept of equilibrium any meaning. This deserves mention, since many economists appear to have been unable to find a place for time in equilibrium analysis and consequently have suggested that equilibrium must be conceived as timeless. This seems to me to be a meaningless statement. (ibid., 36-37)

In his 1945 article on the “Use of knowledge in society”, Hayek also refers to “the knowledge of the particular circumstances of time and space” (Hayek 1945 in Hayek 1948: 80) as a kind of local or tacit knowledge, which does not have the property of scientific knowledge to be general, unambiguous, codifiable, articulable, and therefore easily available and transferable to the whole society.

Moreover, Hayek’s writings on expectations do share one characteristic, which may, at first sight, seem at odds with the way he conceives of human cognition and behaviour.³⁹ In all the versions of his business cycle theory as well as in his articles on knowledge, Hayek refers to the existence of a tendency towards equilibrium.

In his 1937 article, he re-affirms the existence of such a tendency and assigns to expectations a key role in the process:

a tendency toward equilibrium (...) can hardly mean anything but that, under certain conditions, the knowledge and intentions of the different members of society are supposed to come more and more into agreement or, to put the same thing in less general and less exact but more concrete terms, that the expectations of the people and particularly of the entrepreneurs will become more and more correct. (Hayek 1937 in Hayek 1948: 45)

³⁹ This implies that we consider that Hayek’s technical economics is not separable from his writings on cognitive theory. This viewpoint can be criticised, or at least is subject to different interpretations (see Butos 1997: 225).

In the above quotation, Hayek has recourse to several arguments that can hardly be understood without invoking his cognitive theory. As we will explain, these arguments can be interpreted in terms of positive and negative feedback mechanisms that facilitate inter-individual coordination and learning, and therefore, the convergence of expectations despite the evolutionary and non-deterministic character of both the cognitive and the two level-rule complex systems.

2.2.2. The factors facilitating the convergence of expectations

The first argument used by Hayek in order to explain why a process of convergence of expectations may occur lies in the fact that human beings share common structures of perceptions and in particular, the property of the brain as being structured along a principle of classification through increasing degrees of abstraction.

As he wrote in *TSO*:

It would, of course, not be possible to discuss the phenomenal world with other people if they did not perceive this world in terms of the same, or at least of a very similar, order of qualities as we do. This means that the conscious mind of other people classifies stimuli in a manner similar to that in which our own mind does so, and that the different sensory qualities are for them related to each other in a manner which is similar to that which we know. In other words, although the system of sensory qualities is 'subjective' in the sense of belonging to the perceiving subject as distinguished from 'objective' (belonging to the perceived objects) - a distinction which is the same as that between the phenomenal and the physical order - it is yet inter-personal and not (or at least not entirely) peculiar to the individual. (Hayek 1952a: 23)

In other words, inter-subjectivity is rendered possible through the understanding that

others have minds like oneself. The second argument relates to human attentional capabilities.⁴⁰ It is interesting to mention this point since Hayek repeatedly argued that “it is impossible that our brain should ever be able to produce a complete explanation (as distinguished from a mere explanation of the principle) of the particular ways in which it itself classifies external stimuli”, or that “to ‘explain’ our own knowledge would require that we should know more than we actually do” (Hayek 1952b: 47). However, he considers that attention can give access to consciousness. More precisely, for Hayek consciousness is nothing else *in natura* than a classification system with the distinctive feature that it is associated with the highest degree of generality of classification or evaluation or its “highest degree of comprehensiveness” (Hayek 1952a: 137). Moreover, one of the criteria of consciousness is its unity, i.e., a “close connexion between *all* conscious events” (*ibid.*: 136) in contrast to unconsciousness, which occurs at different backward strata of decreasing abstraction, characterised by its diversity. Attention is regarded by Hayek as only slightly different from consciousness, being concerned mainly with “events that are in some sense expected or anticipated” (Hayek 1952a: 139). Another characteristic of attention is that it makes it possible to highlight some of the patterns involved in the ‘model’ directing behaviour and therefore to become more aware of the mental events resulting from them (*ibid.*: 140). Finally, and more importantly, with respect to the problems of diffusion of tacit knowledge and inter-subjective coordination, human attentional aptitudes to focus on special events and trace back the process of abstraction that gave rise to them provide the condition “for the individual to participate in a social or conventional representation of the world which he shares with his fellows” (Hayek 1952a: 142).

⁴⁰ See Festré and Garrouste (2015) for more details.

The third argument regards the role of social norms or traditions for the cultural transmission of rules of conduct, and the related idea that individuals are reluctant to norm violation. For Hayek, the cultural transmission of rules of conduct involves learning through social imitation. In compliance with his view of the functioning of the brain, learning is conceived as prior to reason, insight and understanding. It is therefore the only way to become wise, rational and good in some sense (Hayek 1988: 21). Let us now investigate what are the social forces and motives underlying such social imitation.

Imitation of some members of the groups by others is explained by “the order of dominance of the individuals within the group”, namely the relative distribution between young individuals who are attached to particular adult members of the group from which they learn, and “dominant old individuals who are firmly set in their ways and not likely to change their habits”, but whose position is such that if they do acquire new practices they are “more likely to be imitated than to be expelled from the group” (Hayek 1967: 79). Furthermore, social imitation is facilitated by deep-rooted emotions such as the “fear of retribution” (*ibid.*) in case of transgression of the norms of behaviour. The motive for social approval or rules following behaviour is deeply rooted in human behaviour and has little to do with the idea that people would be inherently subject to conformism or fascinated by power. Hayek interestingly emphasises that the fear of retribution is rather to be interpreted as a “fear of the unknown” (*ibid.*) that permits to increase the predictability of the world⁴¹:

⁴¹ In passing, this interpretation precludes the argument according to which norm obedience upon sanction is subject to the ‘second-order free-rider problem’ (who should punish the punisher who do not sanction deviant behaviour?), since the fear of punishment is sufficient to ensure the observance of rules (see Festré and Garrouste 2009: 271).

The knowledge of some regularities of the environment (...) create a preference for those kinds of conduct which produce a confident expectations of certain consequences (...) This establishes a sort of connection between the knowledge that rules exist in the objective world (...) and therefore also the belief that events follow rules and the feeling that one 'ought' to observe rules in one's conduct. (ibid.: 79)

Finally, rule following behaviour is strongly related to the structure of the brain and to how people learn. Since the only way to have access to knowledge is to follow rules as the brain creates relations between stimuli and patterns of action, rule following behaviour is predominant.

The fourth argument relates to what Hayek calls the "Knowledge of society" in the *Constitution of Liberty* (Hayek 1960: 25). This kind of knowledge is derived from Michaël Polanyi's concept of tacit knowledge (Polanyi 1951). In a similar way as common perceptions abilities, the knowledge of society allows to overcome the limit of strict subjectivism by creating a space for a relatively autonomous objective reference. Another way to interpret it is to regard the knowledge of society as a positive externality of all the individual particular knowledge stemming from social interactions (Arena and Festré 2006).

Fleetwood qualifies this interpretation, noting that by drawing upon this kind of collective knowledge, "agents avail themselves of the collective wisdom of an evolving society, and are thereby enabled to initiate socioeconomic activity, although they can never know or articulate this collective wisdom" (Fleetwood 1997: 170).

3. Concluding remarks: Open minds in an open society

In this investigation, we have confirmed the already discussed view in the secondary literature that Hayek's conception of mind and society can hardly be reconciled with the dominant rational expectation assumption in economic theory. This assumption supposes model-consistency, i.e., a stable environment in which people are able to read directly the environment in which they live, except for an error term, which does not however alter the structure of the model (cf. Butos 1997 in particular).

On the contrary, for Hayek, there are no pre-existing data, but knowledge is the result of a creative process and is necessary fragmented as well as only partially conscious. As a result, the main issue for Hayek is to understand how knowledge is created and how it changes rather than to take it as a given data. As Boettke et al. (2013) encapsulate Hayek's knowledge problem, "error is obvious, coordination is the puzzle".

According to our reading of Hayek, the difficulty for individuals in forming correct expectations is due to the interplay between two evolutionary complex systems. On the one hand, the complexity of the cognitive system, whose structure is marked by hierarchically, abstract orders of classifications of impulses inside the brain, implies that the real world is perceived through a distorting and continuously changing and subjective mirror, which result from the combination of the map and the model. Perceptions are therefore adaptive rather than strictly veridical and specific to an individual even if, as we have emphasised, there are factors, such as common perception and attention abilities of people that allow inter-individual coordination.

On the other hand, the complexity of the system of rules arises as the result of the blind selection process that takes place at the social level is non-deterministic and not necessarily, nor directly, related to individual motives or intentions.

In a short paper “Two types of minds”, Hayek (1978) distinguished between “the master of his subject” and the “puzzlers” or “muddlers”. He described himself as a puzzler who makes use of “wordless thought”. To paraphrase Leijonhufvud (1993: 2), we think that the main justification for Hayek to conceive both the mind and the society in terms of orders of complexity, has certainly been to provide an answer to the puzzling question of how believably simple people can cope with incredibly complex situations, whereas the tendency of economists after the 50s has been to describe the behaviour of incredibly smart people within unbelievably simple structures.

We have also shown that a coherent reconstruction of Hayek’s approach to expectations requires that Hayek’s theory of mind and his theory of cultural evolution need to be seen, neither as mere analogies, nor as disconnected parts of Hayek’s overall work, but should be considered from an integrated perspective (Gick and Gick 2001).

This integrated perspective permits us to understand that both the mind and the society interferes in order to build individual representations that can be shared within a given population. It also provides cognitive and behavioural foundations for a theory of expectations able to deal with radical uncertainty and heterogeneity among individuals not assumed to be perfectly rational. This approach consists of simple and realistic rules that are reinforced and checked *via* positive and negative feedback mechanisms and that operate both at the individual and the social level.

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