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The Economics of Attention/
L'économie de l'attention

The 'Economics of Attention': A History of Economic Thought Perspective

Agnès Festré and Pierre Garrouste*

This article takes stock of the increasing interest that the economic profession has shown for the role of attention in our economies this last decade. It also highlights that the concept of attention is an old issue in social sciences and that it has been central for those economists of the past most interested in the relation between the functioning of the brain beyond mere economic rationality and economic decisions. This exercise provides then the opportunity to investigate today's literature on the economics of attention in comparative as well as critical terms. Finally, the article attempts to look ahead in the context of the rising influence of behavioural economics and address issues at stake in order to capture all the dimensions of human attention and their implications for the understanding and analysis of economic phenomena.

Keywords: economics of attention, rationality, economic psychology, cognitive economics

« L'économie de l'attention » :
une perspective d'histoire de la pensée économique

Cet article s'intéresse à la littérature économique portant sur la notion d'attention qui s'est développée ces dernières années. Il retient une perspective d'histoire de la pensée en retraçant l'origine de cette notion depuis la philosophie en passant par la psychologie cognitive et la théorie économique d'auteurs qui ont poussé la réflexion à propos de la rationalité et de la prise de décision au-delà des frontières usuelles de la discipline économique. Cet exercice présente l'intérêt d'appréhender la littérature émergente sous un angle à la fois comparatif et critique. Finalement, l'article tente de proposer des pistes de réflexion et d'approfondissement de la littérature existante sur la notion d'attention à la lumière des développements dans le domaine de l'économie comportementale.

Mots-clés : économie de l'attention, rationalité, psychologie économique, économie cognitive

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1. State of the Art

The "economics of attention" increasingly gained importance in academic research since the first appearance of the term in 1997 in a seminal on-line article by Michael Goldhaber where he defined it as a sub-field of the "Internet economics", focusing on the time-consuming dimension of overflowing information. The rising activity of bloggers or the intense use of social networks (*Facebook*, *Twitter*, etc.) in the last decade is a clear indication of the fact that attention (rather than information or knowledge) has become a critical economic resource for decision-making. Quite some economists have addressed the problem of limited attention and its economic consequences. As anticipated by Camerer (2003), it has become one of the most important topics of behavioural economics[1]. Applied to macroeconomic policy, this problem is coined as rational inattention[2] and has been put forward by central bankers as one of the lessons to be drawn from the 2008 financial crisis (Trichet, 2010[3]) and by some economists (Akerlof, Dickens and Perry, 2000; Sims, 2003; Shiller, 1997) as an alternative to the assumption of rational expectations for inflation forecasts notably. In the field of financial theory, Hirschleifer and Teoh (2003) analyze the implications of investors' limited attention for firms' information policy and financial market equilibrium.

The notion of attention is however an old concept in social sciences. Originally a philosophical, then a psychological notion, it became popularized in economics thanks to Herbert Simon, whose work on information and cybernetics in the 50s focused on the interference between information and cognitive capacities.

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1 "Another interesting psychological concept, neglected in behavioral economics until recently, is limited attention. Attention is the ultimate scarce cognitive resource. It is possible to learn to attend to many stimuli at the same time—as busy financial-market floor traders and cell-phone-using drivers do—but long-term memory suffers. Scarce attention might be useful for explaining economic phenomena like organizational structure (division of labor expands organizational attention but is constrained by the need to coordinate) and advertising (which 'grabs' attention)." (Camerer, 2003, 16)

2 Rational inattention deals with the issue of which parts of macroeconomic data should rational agents evaluate if limited-processing capacity forces them to discard part of the data.

3The following statement by Trichet in his opening address dedicated to "Lessons from the crisis for macroeconomics and finance theory" at the ECB Central Banking Conference held in Frankfurt in November 2010 is exemplary: "When the crisis came, the serious limitations of existing economic and financial models immediately became apparent…we may need to consider a richer characterization of expectation formation. Rational expectations theory has brought macroeconomic analysis a long way over the past four decades. But there is a clear need to reexamine this assumption. Very encouraging work is under way on new concepts, such as learning and rational inattention." (Trichet, 2010)

The endeavor of this article is to look at the concept of attention from a history of economic thought perspective in order to evaluate the so-called 'attention economics' current literature.

The paper will be organized as follows. Section 2 briefly reminds the reader of the philosophical and psychological roots of the notion of attention.

Section 3 endeavors to trace back the process of diffusion of the concept of attention in economics from a history of economic thought perspective.

Section 4 attempts to provide a critical account of the current literature in 'attention economics' and suggests the range of questions still to be addressed by scholars in the area.

2. The Notion of Attention in Old and New Psychology

The notion of attention was originally discussed by philosophers and closely linked to theories of knowledge. Among the issues considered was the role of attention on conscious awareness and thought, referred to as *apperception*, defined as the process of understanding something or new ideas perceived in terms of previous experience or pre-existing ideas4. For instance, Leibniz (1704) suggested, using the metaphor of one's loss of awareness of the constant sound of a waterfall that events could cease to be apperceived (i.e. represented in consciousness) without specific attention. He therefore claimed that attention determines both what is and what is not apperceived (that is, represented in consciousness). Incidentally, we may also refer to Adam Smith, who in his *History of Astronomy* (1775), referred to a notion, which he labels 'wonder' (or the effect of novelty as he states himself) and which is very much related to the concept of attention as later defined by psychologists[5]. According to him, 'wonder' plays a major role in the process of discovery by scientists to the extent that it per-

4 For a history of the notion of attention in philosophy, see Théodule Ribot (1889) and the introduction of Ribot (2007) by Serge Nicolas. Among the mentioned forerunners in philosophy that have been interested in the notion of apperception are Aristotle (300 B.C. [1984]), Malebranche (1675), Leibniz (1704), Condillac (1754) and Bonnet (1760).

5 Smith also referred to the notion of 'surprise', which he distinguished from 'wonder': "We wonder at all extraordinary and uncommon objects, at all the rarer phenomena of nature, at meteors, comets, eclipses, at singular plants and animals, and at everything, in short, with which we have before been either little or not at all acquainted; and we still wonder, though forewarned of what we are to see." By contrast, "we are surprised at those things which we have seen often, but which we least of all expected to meet with in the place where we find them; we are surprised at the sudden appearance of a friend, whom we have seen a thousand times, but whom we did not imagine we were to see then." (Smith, [1795] 1975, 44)

mits to bring together distinct current and forgone events so as to make sense and form a consistent whole[6].

The term of apperception was still employed when psychology became a young autonomous science in the 18th century[7] and even after. For instance, Wilhelm Wundt (1832-1920), one of the founders of experimental psychology (through the development of psychophysical methods), uses the term in order to describe different concentric fields of awareness from general (*Blickfeld*) to focal (*Blickpunkt*) features of human awareness (Wundt, 1893, vol. 2., 267). More precisely, he distinguished between perception, which was the entry into the field of attention, and apperception, which was responsible for entry in the inner focus (*Blickpunkt*) and assumed that the focus of attention could narrow or widen. At the end of the 19th century, Hermann von Helmholz (1821-1894) also contributed to the development of the experimental perspective on attention, with emphasis on the role of 'covert attention' for visual perception (Helmholz, 1910). In particular, using himself as a subject and pages of briefly visible printed letters, he anticipated some later work in the 50s showing that attention could be directed in advance of the stimulus presentation to a particular region of the page, even though the eyes were kept fixed at a central point. Moreover, he found that attention was limited: some letters in the visual field, even in the vicinity of the fixation point, were not automatically perceived.

Undoubtedly one of the most well-known works on attention in psychology is William James's *Principles of Psychology* (1890), where attention is defined as "…the taking possession by the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought. Focalization, concentration, of consciousness are of its essence. It implies withdrawal from some things in order to deal effectively with others, and is a condition which has a real opposite in the confused, dazed, scatterbrained state." (James, 1890, 403-404)

In James' time, the method more commonly used to study attention was introspection, except for isolate attempts to measure atten-

6 As Smith wrote: "Their [the scientists'] imagination, which accompanies with ease and delight the regular process of nature, is stopped and embarrassed by those seeming incoherencies; they excite their wonder, and seem to require some chain of intermediate events, which, by connecting them with something that has gone before, may thus render the whole course of the universe consistent and of a piece. Wonder, therefore, and not any expectation of advantage from its discoveries, is the first principle which prompts mankind to the study of Philosophy." (Smith, [1775] 1975, 26)

7 For a history of attention in psychology, see Hatfield (1995, 1998), Titchener (1908) and Neumann (1971). Hatfield (1995) claims that the notion of attention has been introduced in psychology in 1730s by Wolff (1738).

tion[8], and one of the major debates of this period was whether it was possible to split attention (i.e., to attend to two things at a time) or to attend to something in a state of distraction.

At the beginning of the XXth century, while methods to measure attention, which could have helped to resolve the debate, were developing, the study of attention as a mental process became marginalized by the rise of behaviourism and positivism[9]. Behaviourism's principal advocate, John Watson (1878-1958), was interested primarily in stimulus-response relations, and therefore, confined attention to an operational concept defined in terms of discriminative response to external stimuli[10].

Interest in attention revived during the cognitive revolution of the 1940s, when engineers and applied psychologists became involved in problems of man-machine interaction in various applied contexts. The research originated from concern about the performance of radar operators during the World War 2 and cognitive psychology was mainly concerned with human information processing. It also draws on Shannon's mathematical theory of communication[11] (Shannon, 1940).

8 The empirical works in order to measure attention are due to Wolff (1738), Bonnet (1760) and Donders (1864), a Dutch ophthalmologist who was a precursor in using mental chronometry. Mental chronometry is studied using the measurements of reaction time (RT). Reaction time is the elapsed time between the presentation of a sensory stimulus and the subsequent behavioral response. In psychometric psychology it is considered to be an index of speed of processing.

9 This point is controversial. Lovie (1983), who compiled tables showing the numbers of papers on attention listed in Psychological Abstracts and its predecessors, Psychological Index, in five-year intervals from 1910 to 1960, showed that numerous studies on attention were conducted during this time periods: for instance, Jersild (1927) on the ability to shift attention or Telford (1931) on the psychological refractory period (PRP) effect. Moreover, Stroop published in 1935 what is certainly one of the most widely cited studies in the field of psychology, in which he demonstrated that stimulus information that is irrelevant to the task can have a major impact on performance (Stroop, 1935). This research has given rise to the famous Stroop Color-Word Task, widely used in psychology. In this cognitive task, participants are asked to name the color of the ink in which an incompatible color word is printed. This test evidences that, e.g., it takes longer to say "red" aloud in response to the stimulus GREEN printed in red ink than to say "red" to the stimulus XXXXX printed in red ink.

10 Note that previous experiments by the Russian physiologists Pavlov and Bekhterev on dogs and animals showed that the conditioned responses to stimuli included measureable signs of attention such as pricked-up ears, head turned towards the stimulus, increased muscular tension, etc.

11 A central notion of this theory is 'Shannon capacity', which is a measure of information flow rate that is inherently probabilistic. It uses the reduction in the entropy (which is a global measure of uncertainty) of a probability distribution as the measure of information flow.

During this period, Cherry (1953) conducted one of the seminal works on the problem of *selective attention*[12] also known as "the cocktail party phenomenon,[13]" as he himself called it. He used a procedure called dichotic listening in which he presented different messages to ear through headphones. This experiment showed that when subjects are told to listen to two streams of words in different ears, they selectively attend to one stream. Broadbent (1952) built on Cherry's experiments and developed the first complete model of selective attention called Filter Theory (Broadbent, 1958). This model assumes that information selection occurs at a very early stage with no guarantee that the selected information is relevant to the task[14]. Anne Treisman (1960), who is one of the most influential cognitive psychologist[15] reformulated it into a more flexible version called the Filter-

12 *Selective attention* is often loosely defined. A few definitions from the literature are: "The differential processing of simultaneous sources of information" (Johnson and Dark, 1986, 44); "A system of cognitive processes that manages the burden of having too much to do at once by prioritizing among stimuli to be processed" (Carr, 2004, 56); and "the generic term for those mechanisms which lead our experience to be dominated by one thing rather than another" (Driver, 2001, 53). Nowadays, one point of agreement is that selective attention is a broad concept covering many distinct mechanisms operating in a variety of brain systems, if not the entire system rather than one specific function or mechanism as some scientists maintained. For instance, Posner (2004) localized this function in the "attentional organ system", LaBerge (1997) in the "triangular circuit" and McKnight (2007) in the synchronization of activity between prefrontal, parietal and mediotemporal cortex.

13 The Cocktail Party Effect illustrates the ability to focus our listening on a single talker among a mixture of conversations and background noises, and to pay attention to a stimulus that grabs our attention suddenly, such as our names.

14 Broadbent (1952) conducted an experiment of dichotic listening in which participants were instructed to answer a series of Yes-No questions about a visual display over a radio-telephone. For example, the participants would be asked "S-1 from G.D.O. Is there a heart on Position 1? Over", to which the participants should answer "G.D.O. from S-1. Yes, over." The participants were assigned to five different groups and their ability to answer one of two messages delivered at the same time (but one of which was irrelevant) was tested under varying contexts that manipulate information given by the instructor (through visual or auditory cues) concerning which of the two voices is to be answered. In the first four groups, participants heard two successive series of messages, in which two voices (G.D.O. and Turret) spoke simultaneously during some of the messages. In the fifth group, they heard two new recordings that permit to make simultaneous messages more distinct than for the other groups in addition to the recordings of group I, II, III and IV. Results indicate that visual cue to the correct voice is useless, thus suggesting that process of discarding part of the information contained in the mixed voices has already taken place.

15 Anne Treisman did her PhD in Oxford, when she met and marry three years later Michel Treisman, another Oxford graduate student. She remarried in 1978 to Daniel Kahneman. Shortly after, they accepted positions at the University of British Columbia, Canada.

Attenuation Theory. The working hypothesis of this theory is that processing of unattended information is attenuated or reduced, rather than completely filtered out, accounting for the fact that unattended information sometimes reaches consciousness.

In brief, the development of information-processing cognitive psychology during this period was first punctuated by debates as to whether the selection filter operated before or after cognitive processing (early vs. late selection models of attention[16]).

But modern psychology also evolved along two main paths that gave rise to the differentiation between filter and executive attention theories[17].

Executive attention[18] theories can be best defined by referring to Kahneman's (1973) famous model of attention. They emerged in the early 70s when a shift in the study of attention occurred: from experiments mainly based on auditory tasks towards experiments involv-

16 Broadbent (1958) and Treisman (1969) concluded in favor of early selection models, showing that attention shuts down or attenuates processing in the unattended ear before the mind can analyze its semantic content. At the opposite, Deutsch and Deutsch (1963) supported the late selection view by showing that the content in both ears is analyzed semantically, even if the words in the unattended ear cannot access consciousness. Results like that of MacKay (1973) posed problems for filters theories, by showing that even unconscious stimuli could be processed to a high degree. For a survey on the early literature on attention in psychology, see Kahneman and Treisman (1984).

17 Pashler (1998) summarizes the empirical evidence obtained in attention psychology and asserts that capacity limits and perceptual gating both characterize human perceptual processing (Pashler, 1998, 224). According to this author, many controversies in psychology research result from the fact that some researchers identify the concept of attention with the allocation of a limited processing capacity to a given set of items, while others relate attention to the selection of this set by a gating mechanism. The gating mechanism implies that mental resources are allocated only to those items that have passed the perceptual filter, while the rest is ignored.

Wickens (1980) refers to Kahneman's model as an approach focusing on the 'energetic' side of attention as compared to filter theories that focus on its 'selective' side. As summarized by Ruz, "whereas selection theories aimed at localizing the point in the processing chain (from perception to motor responses) at which irrelevant stimuli were filtered out (i.e., the location of the 'bottleneck'), energetic views investigated how resources were divided among tasks or the unitary or multiple nature of this 'attentional energy'." (Ruz, 2006, 499)

18 The notion of executive attention is even more loosely defined that the one of selective attention. It was defined by Posner and Rothbart (1998) as "the regulation of thought, emotion and behavior" (Posner and Rothbart, 1998, 1915). Norman and Shallice included planning, conflict resolution, decision-making, error correction, and overcoming habitual responses to perform novel or difficult tasks as executive processes (Norman and Shallice, 1986, 2-3). Nowadays, the consensus seems to be that executive attention involves *centralized supervisory control*, which requires two important functions 1) information about and 2) causal influence over the things supervised and controlled.

ing visual tasks. Contrary to filter theories that focused on selective attention, Kahneman's model was based on the idea that there is one central resource capacity for attention (based in the frontal cortex) for which all activities requiring attention compete[19]. Research on attention blossomed during the last quarter of the 20th century and many studies emanating from multiple source models corroborated the assumption that it is easier to perform two tasks together when the tasks use different stimulus or response modalities than when they use the same modalities. Treisman and Gelade (1980) published a seminal paper in which the very influential Feature Integration Theory was propounded. This theory extended the Spotlight theory of visual attention[20], which assumed that it was possible to change the focus .

Attention is now viewed by some psychologists as functioning as networks connecting distributed areas of the brain, although these "networks support not only the general functions of attention common to all people, but also the individual differences that relate to aspects of temperament and intelligences." (Posner and Rothbart, 2007, 18)

In a nutshell, in recent years, there has been extensive research aimed at supporting the production of mental taxonomy, with converging evidence coming from different domains (psychology, psychophysiology, cognitive sciences, psychophysics, and so on). Moreover, the idea of selective attention is now studied from different perspectives in the social sciences[21].

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19 In passing, it is to be noted that this model derives from Kahneman's dual-task system based on the differentiation between endogenous (voluntary) and exogenous (involuntary/automatic) control. In Kahneman's (1973) words, voluntary attention means that the subject's attention is driven towards because they are relevant to a task that he has chosen to perform (Kahneman, 1973, 4), whereas "involuntary attention is related to level of arousal, which is largely controlled by the properties of the stimuli to which an organism is exposed" (ibid., 3). Kahneman's model of executive attention has been criticized on the ground that it involves a "homunculus problem": to wit, "a little man inside the brain" (Allport, 1980, 113) who directs attention. For Stinson (2009), this homunculus problem is attached to all theories of attention where executive attention is thought of as a cause rather than an effect. Moreover, Stinson argues that neither empirical evidences in neurosciences nor computational models purporting to support causal executive theories of attention can set down the issue in a satisfactory way.

20 Spotlight theory of visual attention (Posner et al., 1980) assumed that subjects are able *to shift* their spotlight of attention from location to location, independently and prior to eye position, and adjust the size of the attended region like a zoom length. However, the theory assumed that the *attentional spotlight* cannot divide across multiple locations.

21 A an example, eye tracking is used to analyze the way individuals read and then learn to read (see for example, Just and Carpenter, 1980; Baccino and Manunta, 2005) but also the effects of advertising (Pieters, Rosenberg and Wedel, 1999; Pieters, Wedel and Zhang, 2009) and more generally the relations between

Let us know investigate how the notion of attention penetrated the field of economics. Robert Lanham[22] (2006), who attempts to trace the intellectual roots of what he calls the "economics of attention," refers to Simon but also to Gregory Bateson and Friedrich Hayek as forerunners. For the sake of conciseness and homogeneity, we shall put aside the contribution of Gregory Bateson, which, albeit very interesting[23], cannot be directly linked to the development of today's economics. Besides, we will pay special attention to the contribution of Michael Polanyi, whose epistemological stance at the nature of knowledge is valuable for current economic analysis.

3. The Diffusion of the Notion of Attention in Economics: A History of Economic Thought Perspective

The notion of attention penetrated the realm of economics and organizational sciences through various authors who can be characterized by a strong interest in multidisciplinary approaches and in particular, psychology, organization science as well as epistemology and philosophy of science.

3.1. Herbert Simon

Regarding the topic of attention, Herbert Simon[24] first observed the simple but fundamental connection between information and attention:

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eye movements and individuals' behavior: see, e.g. Arieli et al. (2011) who use eye tracking techniques in order to investigate how people choose between two lotteries.

22 Robert Lanham is Professor emeritus of English literature at UCLA. His book *The Economics of Attention* is about the move from an economic system based on things and objects to an economics of attention where the central commodity is not stuff but style, i.e., what he labels *fluff*, for style is what competes for our attention amid the din and deluge of new media in order for us to make sense of overflowing information.

23 In particular, in *Steps to an Ecology of Mind* (1972), Gregory Bateson insisted on the scarcity of conscious attention, an economy he labelled 'systemic awareness', and focused on the cognitive and emotional aspects of ecological knowledge. The notion of ecological knowledge is related to the idea that socio-cultural and ecological relationships link any learning object with its context matter. Because relationships transform both the knower and the known, individual minds may be disconnected from each other and from nature.

24 Herbert A. Simon, who was awarded the Nobel Prize in Economics in 1978 for his pioneering research into the decision-making process within economic organizations, was an American economist and psychologist (with a Ph.D. in political science from the University of Chicago in 1942) whose research ranged across the fields of cognitive psychology, computer science, public administration, economics, management, philosophy of science and sociology. He was the Richard King Mellon Professor of Computer Science and Psychology at Carnegie Mellon Uni-

> What information consumes is rather obvious: it consumes the attention of its consumers. Hence a wealth of information creates a poverty of attention and a need to allocate that attention efficiently among the overabundance of information sources that might consume it. (Simon, 1971, 40)

Retrospectively, Simon's contribution regarding attention may be characterized by a dual emphasis on cognition (limited attention capacity) and structure (how organization shapes individual's attention).

In his early work on administrative behaviour (1947), he emphasized that the well-known 'bounded rationality' assumption hinges on the limited attentional capability of humans and serves as a justification for the existence of organizations and institutions as means of orienting attention. As Simon wrote, "organizations and institutions provide the general stimuli and attention-directors that channelize the behaviors of the members of the group, and that provide the members with the intermediate objectives that stimulate action" (Simon, 1947, 100-101).

Later in *The Science of the Artificial* (1969) he emphasized the role played by visual memory, pointing out both its limits and its organization. Borrowing from the work of the Dutch A. de Groot on chess, he explained that visual memory is related to the attention that chess players put on some emerging features of the arrangement of the pieces on the chess board that have been printed in their brain as a result of abstraction from previous play and experience. It is what Simon names intuition conceived as a process of subconscious pattern recognition[25]:

> Evidence about the nature of the storage of 'visual' images, pointing in the same direction as the example I have just given, is provided by the well-known experiments of A. de Groot [in the 40s] and others on chess perception [see De Groot 1966]. De Groot put chess positions – taken from actual games – before subjects for, say five seconds; then he removed the positions and asked the subjects to reconstruct them. Chess grandmasters and masters could reconstruct the positions (with perhaps 20 to 24 pieces on the board) almost without error, while duffers were able to locate hardly

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versity in Pittsburgh, Pennsylvania, where he taught for 52 years. Simon was among the founding fathers of artificial Intelligence, information processing, decision-making, problem-solving, attention economics, organization theory, complex systems, and computer simulation of scientific discovery. He was the first to analyze the architecture of complexity (Simon, 1962). As well as receiving the highest honor possible in economics, he was the recipient of the American Psychological Association's Award for Outstanding Lifetime Contributions to Psychology in 1993, and the prestigious A. M. Turing Award for his work in computer science (1975).

25 "The process is subconscious pattern recognition based on experiences stored in memory and retrieved when necessary. While short term memory can store only small amount of information, long term memory is, metaphorically speaking, a large encyclopedia with an elaborated index in which information is cross-referenced." (Frantz, 2003, 270)

> any of the pieces correctly and the performance of players of intermediate skill fell somewhat between masters and duffers. But the remarkable fact was that, when masters and grandmasters where shown other chess boards with the same numbers of pieces *arranged at random*, their abilities to reconstruct the boards were only marginally better than the duffers' with the boards from actual games, while the duffers performed as well or poorly as they had before. (Simon, [1969] 1996, 71-72)

In other terms, previous experiments serve as a selection device that facilitates problem solving by focusing attention on a few characteristics only. Newell and Simon's symbolic framework (1973) is based on the idea that information processing is about the manipulation of representations. For Simon, information processing psychology permits to explain what people really do when they have to take difficult decisions and solve complex problems:

> Information processing theories envisage problem solving as involving very selective search through problem spaces that are often immense. Selectivity, based on rules of thumb or 'heuristics', tends to guide the search into promising regions, so that solutions will generally be found after search of only a tiny part of the total space. Satisficing criteria terminate search when satisfactory problem solutions have been found. (Simon, 1978, 362)

Therefore, problem solving is all about design and abstraction and requires mechanisms that permit to hierarchize and select from a vast array of information. The role of the near-decomposability of a problem into sub-problems is a mean that facilitates problem-solving, that is, the search of solutions[26]. This has to be linked with Simon's idea that social sciences have to borrow methods and tools that natural sciences have developed. It is the reason why he conceived the human problem-solving process as similar to computer/software programming[27].

Those mechanisms are assimilated to pre-stored schemata or prior knowledge based on previous experience that attract our attention and permit to economize on trial-and-error search. As Simon wrote:

> We see this particularly clearly when the problem to be solved is similar to one that has been solved before. Then, by simply trying again the paths

26 "Recently the near-decomposability hypothesis has been renamed 'modularity hypothesis' and is pervading diverse disciplines, ranging from software design (where the object-oriented programming paradigm is nothing but a prescription of highly modular system) to management science (where largely the same principle are applied to the organization of firms and manufacturing systems)." (Egidi and Marengo, 2004, 342-343). Fodor (1983) is an attempt to apply the modularity hypothesis to cognitive sciences.

27 "I have argued that an epistemology for computers is possible because computers do think." (Simon, 1989, 19)

> that led to the earlier solution, or their analogues, trial-and-error search is greatly reduced or altogether eliminated. (Simon [1969], 1996, 196-197)[28]

As we know, Simon's influence first penetrated the field of organization theory, where the concept of attention has a long history and tradition. Different authors have stressed different aspects of attention allocation and structuring, but not in a unified perspective. In particular, they have emphasized either attention as shaped by routines and bounded rationality (March and Simon, 1958; Cyert and March, 1963), or alternatively, as loosely coupled through enactment processes[29] (Weick, 1979) and organized anarchy[30] (Cohen, March and Olsen, 1972).

More recently, there have been some developments in managerial sciences that borrow from Simon's look at attentional problems in organizations. For instance Ocasio (1997) laments the lack of interest of scholars to study "the effects of the social structure on the channelling and distribution of decision-makers" (Ocasio, 1997, 188). He instead tries to develop an explanation for firm behaviour based on the structuring of organizational attention. Organization attention processing and regulation is shown to be the result of three principles: (1) At the level of individual cognition, the principle of focus of attention links attentional processing to individual cognition and behaviour; (2) at the level of social cognition, the principle of situated attention highlights the importance of the situational context in explaining what decision-makers attend to; (3) at the organizational level, the principle of structural distribution of attention explains how the firm's economic and social structures regulate and channel issues, answers, and decision-makers into the activities, communications, and procedures that constitute the situational context of decision-making.

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28 Interestingly the ideas of memory and similarity are at the basis of the Cased-Based Decision Theory (CBDT) developed by Gilboa and Schmeidler (1995). "CBDT has some common features with the notion of 'satisficing' decisions of Simon (1957) and March and Simon (1958), and may be viewed as formalizing this idea." (612).

29 Weick describes the term enactment as representing the notion that when people act they bring structures and events into existence and set them in action. Weick uses this term in the context of 'sensemaking' by managers or employees. He also describes how they can enact 'limitations' upon the system to avoid issues or experiences. It is also seen as a form of social construction. To date enactment is related to organizations and their environment and strategic management.

30 Organized anarchies are associated with the so-called "garbage can model" of decision making. They correspond to organizations, such as universities, which fail to adhere to the conditions of more classical models of decision making in some or all of three important ways: preferences are problematic, technology is unclear, or participation is "fluid", i.e., it involves formal and informal groups at all levels, all interacting at various levels of the organization, all increasing various levels of complexity.

Rerup (2010) extends Ocasio's framework by focusing not only on top-down senior management processes in directing attention but also on their synchronization with bottom-up processes, which are ignored by Ocasio's approach. According to Rerup, "an attention delay denotes the time it takes to make a non-salient issue salient to top management." His approach consists in combining "theories of organizational attention and coordination to propose that attention delays can be mitigated when organizations develop designs that generate 'synchronized prospective attention', through which an organization's different hierarchical levels proactively and iteratively consider the future impact that non-salient issues might have." (Rerup, 2010, 4) This "synchronized prospective attention" is of prime importance when non-salient but potentially very damaging threats are involved in organizations. These situations are characteristic of the health care sector (Madsen et al. 2006), of military or intelligence activities (Baker and Hulse, 2009), or of air traffic control, were organizations need to swiftly allocate attention to emerging issues.

To sum up, one of the major contributions of Simon is to have stressed the dual – cognitive (individual) and structural (organizational) –aspect of human decision-making. This led him to consider attention, conceived as a device highly related to abstraction and simplification in the context of overabundance of information, as a key device in problem solving. He also explored the overwhelming theoretical and empirical implications of the interplay between cognition and structure in a vast array of fields such as information processing, organizational design or scientific research in general. As will be developed next, Friedrich Hayek was also deeply interested in the attentional aspects of human cognition, though from a different perspective.

3.2. Friedrich Hayek

Friedrich Hayek can also be considered as a major forerunner of the economics of attention. His interest for the role of attention is highly related to his conception of knowledge, as developed in *The Sensory Order* (1952), a contribution to theoretical cognitive psychology he wrote in the 20s but only published in the 50s[31]. Hayek contempora-

31 The curious context in which Hayek developed his ideas is worth to be reminded. In the winter of 1919-1920 a fuel shortage and forced closure of the University of Vienna presented Hayek with an opportunity to spend a few weeks in Zurich working in the laboratory of the brain anatomist Constantin von Monakow, tracing fiber bundles of the brain (cf. Hayek, 1994, 63-64). 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". As emphasized by Caldwell (2004), Hayek's endeavor was to challenge the dominant doctrine in psychology known as the "doctrine of psychophysiological parallelism" endorsed by Ernst Mach and few others in Vienna.

neously described *The Sensory Order* as "the most important thing 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 Edelman[32], Joaquin Fuster and Edward Boring, its influence for researchers in economics and the social sciences must be described at best tangential (Butos and Koppl, 2007, 35).

Hayek's innovative idea at the core of *The Sensory Order* is that mind functions as a classification system which permits to connect, though not in a one-to-one mapping, the order of physical stimuli or objects with the order of mental states or categories. This process of classification involves what Hayek will later refer in his 1978 paper "The Primacy of the Abstract" as "specification by superimposition" (Hayek, 1978, 48). In *The Sensory Order*, he used the analogy of a topological 'map' and explains how different vertically sub-systems of neural connexions form a pyramid of partial maps operating at different levels of abstraction or generality[33]:

> Every sub-system of this kind will constitute a partial map of the environment, and the maps formed at the lower levels will serve for the guidance of merely a limited range of responses, and at the same time act as filters or preselectors for the impulses sent on the higher centers, for which in turn, the maps of the lower levels constitute a part of the environment. (Hayek, 1952, 111)

Hayek is indeed very skeptical of the existence of one-to-one correspondence between an external stimulus and the experience of a sensation (Caldwell, 2004, 140). Hayek's interest in the role of knowledge in economics is also illustrated by two famous articles: "Economics and Knowledge" (1937) and "The use of information in society" (1945).

32 Gerald Edelman who won the Nobel Prize in Physiology in 1972 confesses that he has been inspired by some of Hayek's ideas on neuronal selection: "I must say that 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, 24). Other scientists outside economics have praised Hayek's contribution. According to Steele (2002), Hayek's *Sensory Order* also foreshadows Henry Potkin's evolutionary epistemology.

33 "As the classification becomes…more 'general' and less 'specific', the classifying event also becomes more and more definitely a central process while the relations to any particular peripheral response become at the same time more remote and round-about." (Hayek, 1952, 113).

This semi-permanent structure provides an apparatus for classification and orientation of the impulses from neuron to neuron, which derives from past experience and exists "independently of the particular impulses proceeding in it at a given moment" (Hayek, 1952, 115). The map is partly innate, partly related to previous experience, which implies that it has a certain degree of autonomy vis-à-vis the neural impulses. Moreover, it is specific to each individual. What Hayek refers to as "the model" by contrast is made by "the flow of impulses which at any moment trace a further pattern which will have significance only by its position in that structural framework [the map, *added by us*] within which it moves" (Hayek, 1952, 116) and with regard to the "attitudes", "sets" or "dispositions" that follow from certain "emotions", "needs" or "drives" (Hayek, 1952, 96-97). The combination of the map and the model determines behaviour and action: "It is only through the superimposition of many classifications and dispositions that a particular action is specified." (Hayek, 1978, 40)

A logical consequence of this conception of the mind is that it entails some fundamental limitations of knowledge: "We shall never be able to achieve more than an explanation of the principle, on which mind operates, and shall never succeed in fully explaining any particular mental act." (Hayek, 1952, 35) This is so because sensory perception must be viewed as an act of classification that abstracts from the physical world and "always precede[s] the more abstract mental contents." (Hayek, 1952, 137) As Hayek stated it: "What we perceive are never unique properties which the objects have in common with other objects. Perception is thus always an interpretation, the placing of something into one or several classes of objects." (Hayek, 1952, xviii)[34]

From this it results that consciousness is nothing else *in natura* that a classification system which distinctive feature is that it is "associated with the highest degree of generality of classification or evaluation." (Hayek, 1952, 137) Moreover, it is impossible to define it properly or to have a precise recognition of the mental facts it entails, due to the limits of knowledge the classification systems inherently entails. This is why Hayek thinks that, in order to discriminate between consciousness and unconsciousness, it is more useful to concentrate on what consciousness *does* rather than on what consciousness *is* (ibid., 133). Hayek explains that one of the criteria of consciousness is its unity, i.e., a close connexion between all conscious events (ibid., 136), while unconsciousness which occurs at different strata of decreasing abstraction is characterized by its diversity. The

34 This quotation can be paralleled with Edelman's one: "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 that animals what the world description should be." (Edelman, 1989, 32)

unity of consciousness means that consciousness deals with a common space-time framework, which is only the emerged part of the iceberg, apparently separate from the foundations, i.e., the different levels of neural connexions that gave rise to it: "Conscious experiences have in this respect justly been compared to mountain tops rising above the clouds which, while alone visible, yet presuppose an invisible substructure determining their position relative to each other." (ibid., 33)[35]

Now, it is interesting to emphasize how Hayek distinguishes attention from consciousness. At first sight, and judging by his reference to Boring's view that "consciousness is attentive, attention is selective, consciousness is selective" (Boring, 1933, 231-232; quoted by Hayek, 1952, 139), Hayek seems to conceive attention as almost synonymous to consciousness. But on the other hand, he made clear that attention slightly differs from consciousness for being concerned mainly with events that are in some sense expected or anticipated: It is a "characteristic of attention that it has these effects" of greater discrimination "only with regards to events which are in some sense expected or anticipated": Attention "is thus always directed, or confined to a particular class of events for which we are on the look-out and which, in consequence, we perceive with greater distinctness when one of them occurs." (Hayek, 1952, 139)

From this perspective, attention is most correctly described by its anticipatory character or by being a "state of excitatory preparedness", which is not confined to the conscious level (ibid., 140). For instance, hypnotic practices can illustrate this feature of attention (in this case, involuntary attention) occurring at remote level of unconsciousness.

Another characteristic of attention is provided by its complementarity with abstractness: perception based on abstraction, namely on general or generic attributes, of the perceived objects may be supplemented by "directing our attention to more specific or particular features" (ibid., 145). Therefore it is as if attention permitted to highlight some of the patterns involved in the model directing behavior and therefore made us more aware of the mental events resulting from them. Attention is therefore a special instance of the more general category that Hayek labels "the model", which is linked to the "dispositions" or the "sets" of individuals (Hayek, 1952, 140).

35 In passing, this is one of the reasons why Hayek has some difficulty to deal with intentionality and has recourse to the idea of spontaneous order, being the result of human action and not of human design. But this argument should be qualified by taking into account the plasticity and mutability of the classification structure of the brain. The cognitive process, according to Hayek, despite being constrained by tacit rules and its own physiology, has "the capacity for self-conscious and reflective activity" since it is an "active, input-transforming knowledge generating adaptive system." (Butos and Koppl, 2006, 39)

Moreover, and interestingly enough for the diffusion of knowledge and inter-individual coordination, this individual aptitude to focus on special events and trace back the process of abstraction that gave rise to them "also provides the condition for the individual to participate in a social or conventional representation of the world which he shares with his fellows." (Hayek, 1952, 142)

This leads us to endorse the view that *The Sensory Order* is of great interest not only as a piece of theoretical psychology *per se* but also because it captures Hayek's conception of knowledge. The latter, in turn, is essential in order to reach a synthetic view of his overall contribution, and in particular to understand how he characterized market mechanisms[36]. As emphasized by Butos and Koppl (2006) and contrary to other commentators of Hayek who endorse the discontinuity thesis[37], the *Sensory Order* perspective can be applied, not only to the problem of (discovery and use) of knowledge – as it often reduced to – but also to the understanding and "analysis of different social arrangements and structures" which produce orders that are "not simply aggregations of agents and their capacities" but involve "a transformation of knowledge into a unique kind of social knowledge that could not have been otherwise produced." (Butos and Koppl, 2006, 40)

Contrary to many interpretations, neither the idea of division of knowledge among individuals (i.e., the knowledge of the particular circumstances of time and space), nor the distinction between theoretical knowledge and the knowledge of the particular circumstances of time and space (Hayek, 1945, 521) are sufficient to explain why Hayek

36 In this perspective, it is interesting to note that Simon praised Hayek for his way to characterize market mechanisms: "No one has characterized market mechanisms better than Friedrich Hayek." (Simon, *The Sciences of the Artificial*, 2nd Edition, Cambridge: The MIT Press, 1981, 41). The idea of an analogy between the brain and the organization of markets has been a source of inspiration for many researchers in social sciences, and has valuable implications for economic analysis even if, in economics, the interest for cognition and psychology has experiences several setbacks.

37 Early interpretations (see Machlup, 1974 or Runde, 1988) view *The Sensory Order* as ancillary to the rest Hayek's work on philosophy, politics, and economics. More recent interpretations (see Birner, 1999 or Vanberg, 2004) consider Hayek's writings on cognitive psychology mostly as a methodological contribution disconnected from his economics. This is surprising, judging from the central role played by perceptions and expectations in Hayek's business cycle theory. As Birner puts it: "Contrary to what might expect, however, none of the mental mechanisms of his earlier theory on perception and cognition play a part in his economics." (Birner, 1999, 43). At the opposite, Caldwell (2004) or Butos and Koppl (2006) seem to consider that *The Sensory Order* is foundation work in Hayek's economics. D'Amico and Boettke (2010) endorse a more qualified view, by inversing the causality: "It is Hayek's vision of the working economy that is the key to understand his theoretical psychology" and not the other way around (D'Amico and Boettke, 2010, 360).

considers that socialist planning is not an efficient coordination mechanism. As rightly pointed out by Butos and McQuade (2002), "it is strictly incorrect to say that the market gathers up 'divided' individual knowledge and makes the information available to many others…Instead, the market takes, as input knowledge in the initial sense…and classifies this, producing a totally different kind of knowledge." (Butos and McQuade, 2002, 128) As Hayek claims: "Knowledge which any individual mind consciously manipulates is only a small part of the knowledge which at any one time contributes to the success of his action." (Hayek, 1960, 24)

In retrospect, Hayek's concern for the economics of attention is conceptually-related to his conception of the nature of knowledge. This lead him to consider attention as a way to circumvent the limits of knowledge due to its fragmented nature (1) by permitting a higher degree of awareness on the causality between peculiar circumstances and the specific outcome they give rise to in a context of excitatory preparedness and (2) by providing the conditions for individuals to communicate between each other since they are conscious to share the same cognitive structures in particular abstracting abilities.

As will be developed in the next sub-section, Michael Polanyi also focused on the limits of knowledge in many of his writings. It is therefore quite natural to consider him as another forerunner of the economics of attention.

3.3. Michael Polanyi

Michael Polanyi was an eclectic scientist (from medicine to research in physical chemistry, economics, social and political analysis) but also a philosopher with strong interests in theology and aesthetics. He was the brother of the well-known economist Karl Polanyi and the father of John Polanyi who won the Nobel Prize in chemistry in 1986.

As Hayek, Michael Polanyi focused on the tacit dimension of knowledge and related it to the concept of integration. For Polanyi, tacit knowledge is a key component of all kind of knowledge, scientific, artistic or religious. He emphasizes that "all knowledge is *either tacit* or *rooted in tacit knowledge*. A *wholly* explicit knowledge is unthinkable" (Polanyi, 1966a, 7). This is the main reason why he constantly insisted on the fundamental indeterminacy of science: "Scientific discovery cannot be achieved by explicit inference, nor can its true claims be explicitly stated. Discovery must be arrived at by the tacit powers of the mind and its content, so far as it is indeterminate, can be only tacitly known." (Polanyi, 1966, 1) The intellectual roots of Michael Polanyi's thought can be traced back to both Gestalt psychology[38] and Piaget's theory of intellectual development. Accordingly,

38 *Gestalt psychology* is a theory of mind and brain, which considers that the brain is holistic, parallel and analog, with self-organizing tendencies. This suggests that

tacit knowledge is conceived as the result of a process of integration or "tacit inference" (Polanyi, 1966a) that involves two kinds of cognitive systems: one which he describes as the "*proximal term* of tacit knowing" and the other, described as the "*distal term* of tacit knowing":

> [The] act of integration, which we can identify both in the visual perception of objects and in the discovery of scientific theory, is the tacit power we have been looking for. I shall call it tacit knowing. It will facilitate my discussion of tacit knowing if I speak of the clues or parts that are subsidiarily known as the *proximal term* of tacit knowing and of that which is focally known as the *distal term* of tacit knowing." (Polanyi, 1966a, 73)[39]

What is original in Polanyi is that he uses seeing as a paradigm for knowing. A basic element in Polanyi's account of tacit knowledge is indeed the distinction between two kinds of awareness (subsidiary vs. focal awareness), inspired from stereoscopic pictures[40], which exemplify this dual process of cognition. *Focal awareness* is the ordinary kind of full awareness we have in focusing attention on a specifiable object. *Subsidiary awareness*, in contrast, refers to the more remote peripheral noticing of the features of an object that are not attended to in themselves but seen as pointers or clues to the object of focal attention. Polanyi also refers to subsidiary awareness as *from-awareness* since he says that we attend *from* subsidiary particulars *to* an entity under scrutiny, and calls the relation between the particulars and the whole entity the "from to relation" (Polanyi, 1966a, 146).

In a nutshell, the two kinds of awareness are linked by a logical relation (the relation between clues and the image to which the clues are pointing), which is similar to the relation between body and mind[41] and explain both the roots and the dynamic features of our personal knowledge: "The tracing of personal knowledge to its roots in the subsidiary awareness of our body as merged in our focal

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the human beings see objects in their entirety before perceiving their component parts.

39 In *The Body-Mind Relation*, Polanyi writes: "When I point my finger at a wall and call out: 'Look at this!' all eyes turn to wall, away from my finger. You are clearly attending to my pointing finger, but only in order to look at something; namely the point to which my finger is directing your attention." (Polanyi, 1968, 85) The finger is the proximal term although the wall is the distal one.

40 Stereoscopy refers to the techniques used by 3D imaging for creating or enhancing the illusion of depth in an image by means of stereopsis for binocular vision. Most stereoscopic methods present two offset images separately to the left and right eye of the viewer (a metaphor for subsidiary awareness). These two-dimensional are then combined in the brain to give the perception of 3D depth (a metaphor for focal awareness).

41 "*The purpose of this paper is to show that the relation between body and mind has the same logical structure as the relation between clues and the image to which the clues are pointing*. I suggest that the body is a subsidiary thing which bears on the mind which is its meaning." (Polanyi, 1968, 90; italics in the original)

awareness of external objects, reveal not only the logical structure of our personal knowledge but also its dynamic sources." (Polanyi, 1962, 60)

Moreover, focal and subsidiary awareness are mutually exclusive relative to sense making. As Polanyi states it in *Personal Knowledge*, "…in our from-awareness of a thing we see it as having a meaning, a meaning which is wiped out when we focus our attention [focal awareness] on the thing of which we have only had a from-awareness." (Polanyi, 1975, 39) In other terms, the specificity of from-awareness is that it is sense making, whereas the functional characteristic of focal awareness lies in it being sense depriving. But for Polanyi, attention is sense depriving not due to cognitive limitations. We may be able to specify all the items or subsidiary clues that are entering into an integrated meaning. But when focal attention is directed on a subsidiary clue, "it turns into a different thing *deprived of the meaning* it had while serving as a subsidiary" (Polanyi, 1975, 39).

For this reason subsidiary clues are "*essentially* unspecifiable": "We must distinguish…between two types of unspecifiability of subsidiaries. One type is due to the difficulty of tracing the subsidiaries – a condition that is widespread but not universal; the other type is due to a sense deprivation which is *logically* necessary and in principle absolute." (ibid., 39)

In other words, Polanyi distinguishes between two kinds of irreversibility and shows why the process of tacit inference is not symmetrical. The first one, i.e., contingent irreversibility, is due to our likely impossibility to identify all the clues we have integrated. The second one, i.e., logical irreversibility, on the other hand, always holds, and refers to the fact that when we go back to the subsidiaries we loose their joint meaning. This means that "a process of *logical disintegration has reduced a comprehensive entity to its entirely meaningless* fragments." (Polanyi, 1965, 800) This is the reason why, for Polanyi, "the process of formalizing all knowledge to the exclusion of tacit knowledge is self-defeating." (Polanyi, [1966b], 2009, 20) and may have subversive implications since it may destroy the subject matter itself.

Finally, the distinction between focal awareness and subsidiary awareness is not reducible to the distinction between consciousness and unconsciousness. For Polanyi, focal awareness is always fully conscious, while subsidiary awareness "can exist at any level of consciousness, ranging from the subliminal to the fully conscious". Polanyi adds: "What makes awareness subsidiary is its functional character…" (Polanyi, 1975, 39)

To sum up, Polanyi's account of attention is also related to the problem of knowledge but more focused on the process of tacit inference, which logically goes from subsidiary to focal awareness, and its properties (sense depriving, not symmetrical, involving different lev-

els of consciousness). Polanyi also warns us against the opportunity cost of attention, i.e., its non-reversible sense depriving character.

4. The Economics of Attention Today: Taking Stock and Looking Ahead

In this last section, we put the nowadays literature on the so-called 'economics of attention' in perspective with the insights of the previous section. The main objective of this exercise is to suggest new directions of research that still need to be developed. Two of the forerunners of economics of attention, Hayek and Polanyi do not inspire recent literature dealing with attention. As for Hayek (see below) his conception of information and knowledge seems to be the main explanation of this lack of descent. Polanyi's case is due, first to his eclecticism and, second to the fact that his conception of 'awareness' has been underrated as compared with his notion of 'tacit knowledge' that has been highly popularized by the economics of innovation and economics of knowledge as well.

Very briefly there are two different approaches in economics that deal with attention economies.

According to the first approach, attention economics is considered as a ramification of information economics, which derives from Shannon's mathematical theory of communication (Shannon, 1948). From this perspective, attention is conceived, in compliance with the principles of the mathematical theory of communication (Shannon, 1948), as a function of the unlikelihood of an event to happen and of the frequency of similar past events (which provides a measure of the surprise value or the degree of novelty). Consequently, an event that has never been experienced before is supposed to have a high surprise value and therefore to attract attention, even if it lacks any specific associations or consequences. This seems however at odds with the diffused idea in cognitive psychology that attention depends on both the unexpectedness of events and of their familiar association. This drawback, together with the recognition of the incalculable effect of past experience on the information carried by any binary digit ultimately led them to abandon information theory[42].

If cognitive psychology abandoned this direction, the information-economics approach instead adopted it. As well-known, this approach assumes full rationality and considers sub-optimalities caused by asymmetric information and information overload. Key empirical issues relate to information pollution and its solutions (technological tools, market-based mechanisms, or institutional arrangements and regulatory devices).

42 See for example Garrouste (2001).

Note that there is an alternative strand of formal approach to information, which builds on Aumann's seminal "Agreeing to disagree" theorem. This algebraic approach has become prominent in the economic literature and has given rise to recent developments dedicated to awareness[43].

But there is a second approach of economics of attention, which focuses on expectations and predictions and considers that cognitive limits of attention constitute behavioral foundations of bounded rationality.

Not surprisingly, the first approach of the literature on the economics of attention, as exemplified by Shapiro and Varian 1999's Handbook *Economics of Information and Networks* considers attention as a scarce economic resource and discusses its empirical consequences for information users. More precisely, the literature analyses the various business strategies (price or product discrimination in the presence of network externalities, switching costs, product sharing, etc.) to particularize information in order to catch users' attention and increase their utility by providing them with more relevant information. But usually attention scarcity has an asymmetric impact on information users and providers. This explains that an important part of the literature is concerned with the problem of spamming. This problem is a typical case of externality or information pollution in a context of asymmetric information between the e-mail sender, who knows the contents of the message, and the receiver, who does not. It is a case of externality or information pollution the sender of the message imposes to the receiver. Three main solutions have been proposed, the technological, the institutional and the market-based one[44]. From our history of economic thought perspective, it is very interesting to note that Hotelling as soon as 1938 warned against the harmful effect of excess demand for attention on behalf of media and advertising businesses, as the following quotation strikingly exemplifies:

> Another thing of limited quantity for which the demand exceeds the supply is the attention of people. Attention is desired for a variety of commercial, political, and other purposes, and is obtained with the help of billboards, newspaper, radio, and other advertising. Expropriation of the attention of the general public and its commercial sale and exploitation constitute a lucrative business. From some aspects this business appears to be of a similar character to that of the medieval robber barons, and therefore to be an appropriate subject for prohibition by a state democratically controlled by those from whom their attention is stolen. But attention attracting of some kinds and in some degree is bound to persist; and where it

43 For the sake of brevity, we shall not review this literature. Cf. the website at http://www.econ.ucdavis.edu/faculty/schipper/unaw.htm for a bibliography.
44 See Kraut et al. (2002 2005), Van Alstyne, Loder, and Wash (2004), Zandt (2001) and Loder, Van Alstyne and Wash (2004) for a comparison of these alternative solutions.

> does, it may appropriately be taxed as a utilization of a limited resource. Taxation of advertising on this basis would be in addition to any taxation imposed for the purpose of diminishing its quantity with a view to restoring the property of attention to its rightful owners. (Hotelling, 1938, 257)

To sum up, the economics of attention seen as a ramification of information theory conveys two conflicting rationales for economic agents, depending on whether it focuses on the user or the provider of information: on one side we find economic and management models that analyze how it is possible for firms to capture the attention of customers or audiences in order to make money from it; on the other side there are analyses that focus on the overload of information from the viewpoint of consumers and provide solutions in order to protect the attention of users from information overload and pollution. Kessous, Mellet and Zouinar (2010) adopt an economic sociology perspective and interpret current innovations in the digital economy as attempts to reconcile customer relationship (CRM[45]) and vendor relationship (VRM[46]) management practices.

The literature on attention economics belonging to the second approach borrows more explicitly from Simon, although, as we will develop, it can be split into two strands, which corroborates the traditional dividing line between two distinct interpretations of Simon's conception of bounded rationality: on one hand, the *pars destruens*, criticizing neoclassical view; on the other hand, the *pars construens*, consisting of an attempt to model behavior in a more realistic way (cf. Rizzello, 1999). According to the first interpretation, bounded rationality is seen as a limitation to human rationality. By contrast, the second interpretation conceives bounded rationality as an adaptive capacity. This conception is endorsed by the stream of 'ecological rationality' (Smith, Nobel Lecture, 2002; Gigerenzer and Todd, 1999)

45 CRM is a widely implemented model for managing a company's interactions with customers, clients, and sales prospects. It involves using technology to organize, automate, and synchronize business processes—principally sales activities, but also those for marketing, customer service, and technical support. The overall goals are to find, attract, and win new clients; nurture and retain those the company already has; entice former clients back into the fold; and reduce the costs of marketing and client service.

46 *Attentiontrust* is an example of VRM practices. It consists of a set of principles to govern the attention economy on the self-ownership of the data we create, and specialized software to regulate their use. Specifically, AttentionTrust believes that we all have the right 1) to own at least a copy of our data, 2) to store that data where we want and move it when we want, 3) to exchange it for something of value to us, and 4) to know what others intend to do with our data, so that we can make informed decisions about who should have access to it. (http://www.attentiontrust.org/blog). More generally, VRM is a category of business activity made possible by software tools that provide customers with both independence from vendors and better means for engaging with vendors and is conceived as the necessary complement of CRM.

according to which fast, information-economizing and frugal heuristics based on salient rules can be efficient means of reasoning. In particular, the assumption that individuals neither look up nor integrate all information conveys a context-dependent conception of rationality. In a nutshell, rationality is contingent to the institutional environment and can only be measured in an evolutionary perspective.

To be sure, the emerging macroeconomic literature on rational inattention we have hinted at in the introduction is clearly to be related to the first interpretation, which acknowledges that attention is limited, but restricts this limitation to a noise, which does not impair economic rationality. As emphasized by Sims (2003), the assumption of limited attention (or rational inattention) provides a microfoundation for economic behavior that looks enough like the familiar rational expectation assumption to ensure usefulness and tractability, even though the implications for policy are different enough to be interesting (Sims 2003, 1). Similarly, Akerlof, Dickens and Perry (2000) show that assuming near-rational wage and price setting in macroeconomic modeling on the ground that experimental observations show that agents have some cognitive biases in macroeconomic does not impair the robustness of the results, and is consistent with some empirical findings. In the same vein, Falkinger (2008) develops a general equilibrium model where agents are conceived as passive signal receivers characterized by limited attention and information providers are seeking to catch their attention by sending messages. The ability of agents to process an additional signal depends on the spared capacity left after the load imposed by exposure to other signals. Moreover, there exists a minimum (marginal) strength of a message in order for it to be perceived by the consumers. When total signal exposure lies below a certain level (this is the case of information-poor economies), there is no interference between different signals. Beyond this point (this is the case of information-rich economies) capacity limits lead to such interference. Falkinger concludes that information-rich economies reach an inefficient equilibrium –and therefore faces some welfare losses– due to attention-seekers engaging in wasteful signalling in the competition for attention. But, to repeat it, in these kinds of models, the traditional assumption of economic rationality is preserved.

The other strand of the literature consisting of a second series of theoretical developments focusing on selective attention and problem solving (see, e.g., Gabaix et al., 2003; Gabaix et al., 2006; Schwartzstein, 2010), by contrast, is more in line with the second interpretation of bounded rationality. These contributions provide models whose theoretical predictions are corroborated by some experiments. In particular, they show how selective attention may lead individuals to persistently fail to recognize important empirical regularities, make biased forecasts, and hold incorrect beliefs about the statistical rela-

tionships between variables. This literature is linked to the notions of accessibility and salience put forward by Kahneman in his dual cognitive system based on the distinction between intuition (system 1) and reasoning (system 2), where he defines accessibility as "the ease with which particular mental contents come to mind" (Higgins, 1996, quoted by Kahneman in his 2002 Nobel Lecture; Kahneman, 2003, 1452) as well as to heuristics used as efficient means of solving problems that we can find in Gigerenzer and Todd (1999). Interesting work based on both theoretical modeling and experiments[47] by Gabaix et al. (2005, 2006) supports the theoretical benchmark of partially myopic cognition due to limited but 'efficient' attention (what Gabaix and Laibson, 2005 call the 'Directed Cognition model') and the empirical existence of some heuristics[48].

Whether this second strand of the literature can be considered as a kind of middle ground between standard and ecological rationality is a question of interpretation. But given the trade-off between tractability and realism involved in theoretical modeling, this literature looks however very promising and reveals a more profound rupture with the classical conception of rationality in economics.

But the problem does not limit itself to the question of rationality. Another classical drawback of information economics is that it is based on the mathematical theory of information introduced by Shannon (1948). One major drawback relates to the problem of the meaning of information, which, if it is not a concern in the mathematical theory of information, becomes of utmost importance when dealing with attention. Whether we pay attention to somebody or something can reasonably be expected to depend on how the same information is interpreted or perceived by different individuals or even by the same individual depending on the context[49]. Arrow (1974) already stressed that the same information can have very different value for different individuals. Boulding (1955) also emphasized that

47 The experimental design derives from previous work by Camerer et al. (1993), Camerer and Johnson (2004) and Costa-Gomes (2001). It uses the "Mouselab" programming language to measure subjects' information acquisition. Information is hidden behind boxes on a computer screen and subjects have to use the computer mouse to open (or close) the boxes in order to get (costly) information that helps solving a problem (of income maximization) in a given limited period of time. On the one hand, Mouselab records permit to know the order and duration of information acquisition. On the other hand, since one screen box can be open at any time, it is possible to know what information is acquired on a second-by-second basis throughout the experiment.

48 In particular, they show that subjects tend to become more and more likely to end an analysis of a problem the more boxes they open holding fixed the economic benefit of additional analysis (what they call the 'box heuristics').

49 See Garrouste and Langlois (1997) for an appraisal of the problem of interpretation of information, and therefore, of its derived economic value, that economists have to take into account seriously.

> we cannot regard knowledge as simply the accumulation of information in a stockpile, even though all messages that are received by the brain may leave some sort of deposit there. Knowledge must itself be regarded as a structure, a very complex and frequently quite loose pattern...with its parts connected in various ways by ties of varying degrees of strength. Messages are continually shot into this structure; some of them pass right through its interstices...without effecting any perceptible change in it. Sometimes messages 'stick' to the structure and become part of it....Occasionally, however, a message which is inconsistent with the basic pattern of the mental structure, but which is of a nature that it cannot be disbelieved hits the structure, which is then forced to undergo a complete reorganization" (Boulding, 1955, 103-104).

This explains the fact that some scholars, mostly belonging to the Austrian tradition, stress the idea that information and knowledge are different concepts and that their differences are not reducible to the distinction between a flow and a stock, as it is the case in information economics[50]. This conceptual assimilation of knowledge to information seems the reason why Hayek's conception of attention is not developed by economics of attention. A related problem lies in the nature of information, which can be manifold in reality and therefore, cannot be always easily reducible to bits limited by a Shannon capacity constraint. As noticed by Sims (2006, 4), information can take the form of internal human information processing, of wiring media (telephone lines, internet connection, periodical subscription etc.) but also of costly investigation through interviews, surveys etc. If the two former kinds of information can be dealt with using a unitary and plastic concept of information, it is no more the case with the last form of information which involves discontinuities.

5. Conclusion

As far as our investigation suggests, it is not easy to circumvent the economic literature dealing with attention and to encompass the various aspects of the notion of attention that may be useful for economists.

In view of critics addressed to the information-based "economics of attention" and insights from the authors from the past whom we have considered, some interesting lines of research to be developed are worth pointing out.

First, the comparison between Hayek and Polanyi's respective conceptions of attention suggests that the relation between attention and intentionality is all but obvious and should be taken more seriously by social scientists today.

In addition, the fact that attention is a historical process and context-dependent is an invitation to think more deeply about how to

50 See Boettke (2002).

handle and regulate the scarcity of attention in our societies. Such a global research question calls for an interdisciplinary approach involving economists but also historians, philosophers, psychologists, sociologists, as well as management scientists. The ways to look at the economic issues raised by the scarcity of attention are manifold. One could be to revisit Foucault's thought on political discourse and 'governmentality'. Another one could consist in wearing the eyeglasses of Thaler and Sunstein (2008)'s approach of 'nudging', a recent concept in economics which is linked with the idea that it is possible to countervail behavioral biases in a non-invasive way in order to enhance both individual and social welfare.

We have emphasized some of the drawbacks and limits of the economic approach of attention, pointing out in particular the risk of confining the economics of attention to a mere ramification of information economics.

No doubt that one of the greatest unmet scientific challenges of our societies is to provide an institutional framework that permits to sustain an appropriate balance between the interest of information providers and users. Obviously there is a lot of work to be done but some innovative research lines are currently being explored that enhance our understanding of the role that attention plays in various contexts of economic decision-making.

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