

1. ... and Neuroeconomics Appears and Spreads...

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For millions of years, man has considered himself different and superior to any other living species. This conviction is based on the certainty (never proved!) that only man has some special neural skills in the animal kingdom; skill as the capacity of awareness of himself, or the possibility to reflect on what he thinks, or to perceive emotion, to have intuition, to use a complex and evolving language exchanging knowledge with his counterparts, to learn by experiences lived or heard, to memorise them, to have the perception of the inexorability of his own death, etc. Man perceives variations in the environment and he can image and implement efficient solutions to adapt himself to them. He has a curiosity, *innate* and *voluntary*, to understand how natural phenomena manifest themselves and, in particular, how the human behaviour is influenced by genetic, physiological, biological, emotional, affective, cultural, economic, and social factors.

In western culture, *Hippocrates* (400 BC) was the first natural philosopher interested in the role of the *psyche* as the source of many factors that condition human behaviour. Over time, the *psyche* will be named as *pneuma*, *breath of life*, *soul*, *mind*, *intellect*, *thought*, *reason*, and recently as the *whole functions* performed by the *brain*. *Plato* (428 BC) indicates the human brain as the location of intelligence and rationality and, therefore, of the soul. *Aristotle* (384 BC), instead, locates them in the heart. *Galen* (120 BC) detects the relationship between specific lesions in the brain of some wounded

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gladiators and the motor or cognitive deficits in their behaviour. *Vesalius* (1514) investigates the nervous system. *Descartes* (1596) proposes an interdisciplinary vision of natural science, introducing the concept of *doubt* to stimulate investigations into the cognitive functions of the human mind. *John Loke* (1690) studies the logic process of the mind involved in the learning process through the experiences.

At the beginning, *moral philosophers' reflections* facilitate the propagation of beliefs about the active presence of a metaphysical and unknown entity to explain the universe, the appearance of life, and, above all, the human species' skills to perceive these phenomena and to investigate them. Consequently, various metaphysical and religious solutions spread. For centuries, they seem to satisfy completely those basic curiosities. For a long time, the political and cultural power of religion try to limit, even in a cruel way, the development in western culture of the thought of *natural philosophers*. Many scientists have been persecuted for a long time. They have, initially, few means to investigate and their knowledge is based, above all, on their direct meticulous observations. For centuries, the knowledge of the structure and functioning of the human body and human brain is based only on post-mortem examinations. In spite of this situation, the clergy fears that scientists disseminate the doubt about dogmas and criticise their authorised interpretations of sacred texts. Despite this, their reflections evolve, slowly, to propose the *dialogue*, the *measurement* of observed natural phenomena and the *empirical verification* of knowledge. The scenario began to change.

In the age of *Enlightenment* (17th and 18th centuries), the prevalent scientific culture reinforces trust in human reason and exasperates the use of the scientific method in every activity of human thought.

The *telescope* dethroned man from his anthropocentric role in the cosmos, criticising the religious visions². The *microscope* was invented and used largely by natural scientists. The *cell* is recognised as the basic element of every living organism and many infinitesimal life forms are discovered (virus and bacteria): for millennia, they have been considered divine punishments sent by God to redeem man from his sins³. Man is, more and more, proud of his ability to clarify the mysteries of nature using scientific

² After the astrophysical discoveries of Galileo Galilei, Johannes van Kepler, Mikolaj Kopernik and many others, man is reduced to a lone resident on a little planet rotating around a medium sized star that is his unique source of vital energy. This star is rotating inside a small and peripheral galaxy wandering in the sidereal space.

³ John Barrow, Frank Tipler: *The antropic, cosmological principle*. Ed. Oxford Univ. Press. 1988.

methods. This liberates him from beliefs, superstitions, dogmas, and acts of faith⁴. Scientific discoveries accelerate advances in language, writing, maths, geometry, chemistry, physics, biology, technology, natural sciences, etc.⁵.

New perspectives are opened continuously for scientists; they try also to satisfy many practical needs to improve the average living standards of people in Europe⁶. It is shared and usual to verify empirically any affirmation sustained. The widespread basic conceptual model adopted to explain the occurrence of natural phenomena is: “*stimulus - automatic reaction - reflex action*”. The “Theory of reflex” emerges in natural sciences and in animal and human behaviour analysis.

René Descartes (1596-1650) uses it to describe the role of the brain in individual behaviour⁷, distinguishing two aspects: the *simple* one and the *complex*. The first aspect considers the sensory stimuli collected; the *cause* of *automatic* processes that translate into a motor *reflex* action (*effect*). The second type is where the initial cause activates not only a motor reflex effect but also a *cognitive effect*. In this case, the cognitive effect should be attributed to the role played by the *soul* (or *mind*). The *Theory of reflex* spreads and it will be a science landmark for a long time⁸. It requires,

⁴ A large number of scientists consider *God as a simple source of energy* (mysterious) indispensable to every movement and change in the cosmos and in the atoms that constitute every kind of matter.

⁵ Isaac Newton (1643-1727), a naturalistic, mathematical, physical philosopher, discovers the role of the *Force of Gravity* that influences the evolution of matter, while not having the physical connotations of the latter; he refers to *magnetism*.

⁶ James Watt (in 1764), an engineer and mathematician, designs and experiments the first *steam engine*, which profoundly innovates manufacturing, leading to the British industrial revolution. George Stephenson, an engineer, invents the *steam train* (in 1825). Samuel Morse (1837) designs and executes the *telegraph* and Alessandro Volta (in 1800), physicist, invents the *electric battery*. Louis Pasteur (in 1856), chemist and biologist, discovers *vaccines* to prevent endemic pathologies. Alfred Nobel (in 1859), a chemist and engineer, invents *dynamite*; it develops the mining and transport industries (railroad, Transiberiana, Suez Canal). Thomas Alva Edison (in 1877), entrepreneur and inventor, manufactures the electric bulb. Karl Popper: *The logic of scientific discovery*. Ed. Martino Fine Books. 2014.

⁷ René Descartes: *Discourse on the method and meditations on first philosophy*. Ed. Oxford University Press. 2008.

⁸ There are many researches that support the dominant view of the reflex-theory on individual behavior. They start with the Marshall Hall (1790-1857) physiologist. They continue with the studies of Ivan Pavlov (1849-1936) and Charles Sherrington (1857-1952). Marshall Hall: *Memoires on the nervous system*. Ed. Andesite Press. (2017). Daniel Todes: *Ivan Pavlov. Exploring the animal machine*.

mainly, to quantify and to interpret some changes of individual behaviour. Some initial mathematical models are devised to estimate the probable and possible reflex action expected. These visions increase the number of scientists involved in *quantitative analysis* about the life process on the planet; few of them are curious, initially, of cognitive aspects. Someone is interested in understanding the unknown interactions between *Mind-Body* considering some certain factors that are difficult to measure⁹ and disapproving of the use of the *Theory of reflex* without any consideration of cognitive aspects in human behaviour.

Then, the *evolutionist theory* drawn up in 1859 by Charles Darwin dethrones the man, once again: his casual and late appearance is proved relatively to the thousands of years of life on the planet¹⁰. This vision reinforces the relevant role of the brain in the slow, long and complicated evolution of the human species in the animal kingdom. John Locke (1632-1704), philosopher and doctor, and Jean Jacques Rousseau (1712-1778) suggested considering mental factors influencing individual behaviour¹¹. Luigi Galvani (1737-1798) tests the role of electricity, discharged from the nervous system that excites the muscular and visceral system. He proved definitively the reflex action of muscles. In 1923, Ivan Pavlov, physiologist, reconsiders Descartes's conception of human behaviour and updates it investigating physiological and biological aspects in animal behaviour¹². Despite the similarity between the mammalian and human nervous system, some doubts arise when his scientific results are automatically transferred from animals to human behaviour.

In the main stream of scientific methods, economists are obliged to consider only *quantifiable* factors of phenomena observed to interpret – at the micro-economics level - individual behaviour. In economics, the need to have a mathematical model emerges to explain the different aspects of human behaviour. It should have been based on the reflex-type mechanism, on *quantifiable causes (sensory stimuli)* and *quantifiable effects*.

Ed: Oxford University Press. (2000). Charles Scott Sherrington: *Man on his nature*. Ed. Cambridge Univ. Press. (reprint 2009).

⁹ Karl Popper: *Knowledge and mind-body problem: In defence of interaction*. Ed. Routledge. (2000).

¹⁰ Charles Darwin: *On the origin of species by means of natural selection*. Ed. Independently published. 2017.

¹¹ Jean Jacques Rousseau: *Discourse on the origin of inequality*. Ed. Hackett Publishing Comp; John Locke: *An essay concerning human understanding*. Ed. Hackett Publishing Comp. 1996.

¹² Ivan Pavlov: *Conditioned reflexes. An investigation of physiological activity of the cerebral cortex*. In: *Annals of Neurosciences*. Vol. 3. (Jul. 2010). (136-141).

However, the problem must be solved to consider the cognitive aspects that are often part of the final effects induced by the exogenous *stimuli*. The new target is to have a shared theoretical vision, developed mathematically, that describes the motor and cognitive aspects of human behaviour. It would eliminate the *determinism* of reflex theory opening new reflections on the *stochastic* nature of human behaviour and *free will*.

Economists are affected diffusely by the cultural dominance of evolution in natural sciences that emerged in the *Enlightenment* century. The subsequent cultural movement, the *Romanticism*, feeds their vision introducing the distinctions between *macro* and *micro* levels in analysing economic phenomena and splitting *public interest* and *private interest*. Even in 1871, William Jevons asserted that investigation of the role of the psyche and the human brain in people's economic behaviour is useless since the human brain would be an unintelligible *black box*, where it would have not been possible to access its functioning¹³.

In reality, their analysis refers continually to the phenomena wholly influenced by cognitive factors that are not easy to be measured; many of them do not respect rigorously unchanging natural precepts and laws of nature. Personal preferences, choices, and decisions are modulated, rapidly and continuously, by emotions, mental states, affective, characterial, economic, social values, religious beliefs, cultural, elements, factors, etc. All these elements influence the cognitive aspects of observable human behaviour unpredictably and this complicates examining their role objectively.

This relevant lack of knowledge is less perceived by the spread of the metaphor of *Homo Oeconomicus*. It is a metaphor based on some naive conceptual hypotheses. The economic-financial agent is assumed, for example, *amoral*, *profit oriented*, *impermeable* to emotions, to mental states, to affections, to pleasing memories, or to regrets, etc. He is considered also *rational* in any decision assumed and *well-informed* about the *consequences* expected for any possible choice¹⁴. His *preferences* are hypothesised *invariables* in time and in space. The role played by emotional, affective, psychological, characterial, etc. factors in decision making are perceived as not relevant

¹³ William S. Jevons: *The theory of political economy*. Ed. Palgrave-MacMillan. (2013) (pag.25-35).

¹⁴ *Rationality* in economic and financial decisions (and forecasts) is called into question by the unexpected several crisis and speculative bubbles, in economic and financial markets, always imputed, *ex-post*, to the *ex-ante* individual or collective *irrationality*.

and excluded. People's behaviour is *described* and *interpreted* using a *rational-logical-consequential-quantitative* model¹⁵.

Despite these limits, economists and finance scholars still consider this metaphor a sort of dogma and they refer largely to it without sacrificing their vanity to adorn the outcomes of their studies with the term “*scientific*”¹⁶. In the meantime, somebody asks if economics and finance are to be considered as *sciences*¹⁷.

Since the 18th century, some (few) economists perceive, with intuitive foresight, the need, for a better understanding of human economic behaviour, to consider new factors whose role in the *Mind-Body* interaction is too difficult to be quantified.

Adam *Smith* (1723-1790), philosopher and economist, considers the role of some psychological factors to illustrate human behaviour and this vision is taken up by Alexander *Bain* (1818-1903), psychologist, and Friedrich *Von Hayek* (1889-1992), economist. In 1936, John *Watson* (1878-1958), psychologist, analyses the psychological aspects of an agent behaviour involved in *real* market negotiations (not in the lab). Physical knowledge pushes Burrhus Frederic *Skinner* (1904-1990), psychologist, to

¹⁵ Christian Schmidt: *What neuroeconomics does really mean?* In: Revue d'économie politique. Vol. 118. N. 1. (pp.7-34). Ed. Dalloz. 2008.

¹⁶ It is a habit that excites them, their students, and the journal editors who publish their works and it strengthens the academic approval of respective “*Scientific*” Societies. A scientist informs his reader about the level of completeness and homogeneity of data collected and processed, and about the reliability of the models used to interpret them and to forecast the possible evolution of phenomena observed. The economists rarely do it but they pretend that their traditional studies must be considered as “*scientific*” and publish their works with the editorial features of scientific papers. The result is a perfect *camouflage*. The dissemination of the “*scientific*” adjective satisfies the economist's vanity need to arouse in the reader the conviction that they offer results more reliably. For these reasons, it would be correct to continue considering Economics and Finance as *Humanities' disciplines*. Economics and Finance contexts are different from scientific disciplines, such as Physics, Chemistry, Biology, Physiology, etc., in which scientists have specific habits to face daily phenomena subject to the *immutable precepts* of Nature; a Nature divinely indifferent to the fate of the single living organism, including man. In the disciplines, named *Hard Sciences*, the researcher's discretion and subjectivity is not allowed or any consideration of the role of *emotion* and human *cognitive limits*. Usually scientists declare *all* known factors related with the evolution of phenomena observed and clarify the level of reliability of methods used to process data and information. Rarely do they interpret them with normative and predictive visions.

¹⁷ Robert Shiller: *Is economics a science?* In: The Guardian. 06.11. 2013. Alan Wang: *No, Economics is not a science*. In: Harvard Crimson. Dec. (2013).

study the role played by *exogenous* (environmental, emotional and cultural) stimuli in human behaviour¹⁸. By the end of the XIX century, some scholars underline how human behaviour is associated with the individual *impulsive* search of *pleasure* avoiding pain, loss, physical separation, in particular from his currency. Francis Ysidro *Edgeworth* (1845-1927), a mathematician and economist, tries to measure the intensity of *pleasure* induced by economic decisions. John Maynard *Keynes* (1883-1946), economist and politician, expresses the need to know the role of psychological factors, resuming some insights by *David j* (1711-1776), philosopher and economist, who was attentive to the spontaneous motivations that induce people to have confidence in the future and to push to act rapidly in economics. Keynes explains the high variability of economic and financial markets, with individual psychological factors stimulated by information asymmetries¹⁹. He proposes the innovative concept of individual *propensity* to *consumption*, or to *saving*; a psychological suggestion that includes the role of the widespread *irrationality* in individual decisions, fuelled by emotions²⁰.

Other economists continue to disapprove the metaphor of *Homo Oeconomicus*. They criticise its *poor scientific* hypothesis based on *partial* information. Furthermore, they disagree, particularly, with the analysis that does not consider the individual changing perception of risk level, implicit in any choice²¹. However, all the suggestions did not produce what they hoped-for.

¹⁸ Adam Smith: *The theory of moral sentiments*. Ed. CreateSpace independent publishing. 2016. Friedrich Von Hayek: *The Sensory Order: An Inquiry into the Foundation of Theoretical Psychology*. Ed. University of Chicago Press. 1952. Friedrich von Hayek: *Studies on the Abuse and Decline of Reason: Text and Documents: 13*. Ed. University of Chicago. 2010. Alexander Bain: *Mind and Body. The theories of their relation*. Ed. Kessinger Publishing 2010. John Watson: *Psychology as the behaviorist views*. Ed. www.all-about-psychology.com. 2011. John Watson: *Behaviorism*. Ed. West Press. 2013. Burrhus F. Skinner: *Science and human behaviour*. Ed. Free Press. 1975.

¹⁹ John Maynard Keynes: *The general theory of employment, interest and money. Modern macroeconomics and Keynesian revolution*. Ed. CreateSpace Independent Publishing Platform. 2015.

²⁰ These views are shared by John Elster (1944), sociologist and economist. John Elster: *Ulysses and sirens. Studies in rationality and irrationality*. Ed. Cambridge University Press. (1998).

²¹ Some authors fear that the above-mentioned metaphor of *Homo oeconomicus* could provoke illusions, intellectual addiction or dependence on it, and excessive self-referentiality. Vilfredo Pareto: *Manual of Political Economy* Ed. Augustus M. Kelley. Publisher (reprint 1971). Alfred Marshall: *Principles of economics*. Ed. Palgrave MacMillan (reprint 2013). John M. Keynes: *A treatise on probability*. Ed. Cosimo Classics. (reprint 2007). Amos Tversky: *Judgement under uncertainty. Heuristics and biases*. Ed. Cambridge Univ. Press. 1982.

For the first time, during the 1940s, some economists initiated considering the variations in the behaviour of both counterparties involved in a negotiation. These variations emerge as a relevant element also influencing macro-economic phenomena evolution²². In the same period, some authors tried to produce mathematical models considering the different aspects of individual and collective behaviour of economic operators.

Paul *Samuelson* (1915-1990), economist, formulates the *Expected Utility functions* in a mathematical key²³. Samuelson admits the limited significance of partial data used and he suggests considering, seriously, the role of psychological factors in human decision making²⁴. He describes, with his foresight, how the *expressed preferences' variations* are based on the individual desire to improve personal psycho-physical well-being continuously. It is no coincidence that someone formulates the *Theory of the Games*. It refers to Keynesian concepts of *propensity*, or *aversion*, or *indifference* to *speculative risk*. This theory recalls the impulse (difficult to control) to repeat pleasant experiences, avoiding the negative ones. Mathematical models based on it could suggest the best (optimal-rational) decisions for each one of the contractors during a negotiation in the lab. However, individual preferences and strategies in effective negotiation are continuously influenced by emotion, related with memories of experiences and expectancies of gain, or loss²⁵.

²² At the end of the 1930s, Kenneth *Arrow* (1921), economist, Gerard *Debreu* (1921-2007), economist, and Lionel Wilfred *McKenzie* (1919-2010), economist, formulated a new *Theory of general economic equilibrium*. Interactions between decisions of those who produce goods and services and the choices of those who buy them are considered relevant factors influencing prices and market evolution. Lionel McKenzie, Gerard Debreu: *Theory of value: an axiomatic analysis of economic equilibrium*. Ed: Yale University Press. 1977. Kenneth J. Arrow: *General equilibrium. Collected Papers of Kenneth Arrow*. Ed: Belknap Press of Harvard University Press. 1984. Lionel McKenzie: *Classical General Equilibrium Theory*. Ed: The MIT Press. 2002.

²³ Stanley Wong: *The Foundations of Paul Samuelson's revealed preference theory: a study by the method of rational reconstruction*. Ed. Routledge & K. Paul. 1975.

²⁴ Paul Samuelson, William Nordhaus: *Economics*. Ed. McGraw-Hill. 2009; Hal R. Varian: *Revealed Preference*. In: Samuelsonian Economics in the 21st century. Ed. Michael Szenberg. 2006.

²⁵ The first theory refers to the hypothesis of a market *risky*, or *uncertain*, or *ambiguous*, in which people assume decisions. The second theory describes, mathematically, the optimal behaviour for people representing opposed interests in a negotiation. Oscar *Morgenstern* (1902-1977), economist, John *von Neumann* (1903-1957), mathematician, and John Forbes *Nash*, (1928-2015), mathematician and economist, introduce *gambling* in the *Theory of Games* as a method to analyse the psychological factor's role in non-collaborative strategies between two competitors. John von Neumann, Oskar Morgenstern: *The Theory of Games and Economic Behavior*. Ed. Princeton

Some authors study the role of *uncertainty* as a source of *irrationality* diffused in individual decision making²⁶. They reflect how, on many occasions, an *irrational behaviour* is preferred; perhaps it reiterates, simply, high pleasant sensations and emotions (without any economic sense). Some psychologists start to confirm *unconscious* memories, emotions, regrets, mental status, etc. factors that support interaction between uncertainty and the (diffuse) *irrationality* in decision making²⁷. Herbert *Simon* (1916-2001), psychologist, economist and computer scientist, clarifies the relevant role of the emotional, psychological and mental factors as sources of the *irrationality* of individual behaviour. In addition, he theorises that *limited rationality* be attributed also to the incomplete, unreliable information, as well as to the cognitive limits that exist in perceiving exogenous stimuli and in processing and interpreting them²⁸.

Applied research to produce radar during the Second World War, innovates mathematical-statistical models and technology tools to process large amounts of data

University Press. 1944; John Nash: *Games Theory: the art of thinking strategically*. Ed. 50 minute.com. 2015. John Forbes Nash: *Equilibrium points in n-person games*. In: Proceedings of the National Academy of the USA. 1950. Vol. 36. N. 1; Duncan Luce and Howard Raiffa: *Games and Decisions*. Ed: Wiley. 1957.

²⁶ Milton *Friedman* (1912-2006), economist, proposes new methods to investigate the role of emotional factors as source of *irrationality* in decision making. Milton Friedman, Rose Friedman: *Free to choose. A personal statement*. Ed. Mariner Bok. (1990).

²⁷ In the same period, Maurice *Allais* (1911-2011), a physicist and economist, with a paradox (that will have its name) reinforces substantial doubts about the reliability of certain hypotheses of *Theory of expected Utility*. Daniel *Ellsberg* (1931), an economist, in 1961 with another paradox (Ellsberg's paradox), demonstrates how people estimate the probabilities of expected events, processing partial information and assuming decisions by visceral unconscious impulses to act. Maurice Allais "*Le Comportement de l'Homme Rationnel Devant Le Risque: Critique des Postulats et Axiomes de L'Ecole Americaine*". In: *Econometrica*. Vol. 21. N. 4 (pag. 503–546). (1953). Daniel Ellsberg: *Risk, ambiguity and the savage axioms*. In: *Quarterly Journal of Economics*. Vol. 75. N. 4. 1961. Some studies based on these theories have been furnished with an experimental collection of bio-physical responses (*Skin Conductance Response*). It is proved that bio-physical reactions derive from the (subjective) perception of exogenous (and endogenous) stimuli collected and processed in the brain before the neural responses reach the level of consciousness. Michael Dawson, Anne Shell: *The electrodermal System*. In: John Cacioppo, Louis Tassinary, Gary Bernston: *The handbook of psychophysiology*. Ed. Cambridge Press. 2009.

²⁸ Herbert Simon: *Models of bounded rationality*. Ed. Cambridge & London MIT University Press. 1982. (Chapt. 2). Herbert Simon, Massimo Egidi, Riccardo Viale, Robin Marris: *Economics, bounded, rationality and the cognitive revolution*. Ed. Edward Elgar Publishing. 2008.

more and more quickly. The *Operational Theory* reinforces the *Theory of rational Decision*, facilitating the selection of the best (optimal in the economic sense) decisions to assume in complex, risky, uncertain or ambiguous markets. It pursues the most rational (efficient) solution (*what is the best?*) or estimates the evolution of observed phenomenon in different scenarios, changing some variables (*what if?*). Different estimations of probabilities are proposed for each scenario (*stochastic vision*). Nevertheless, the data and information used are always partial; they arise, in fact, only from quantifiable revealed preferences.

The economists try to limit the gap, arising from not considering psychological, mental, emotive factors, introducing the concepts of *ordinal utility* and *revealed preference*. This permits to build the personal *Function of expected utility*; but, it requires collecting information about the individual preference and evaluating the probabilities to satisfy each one of them. It is too much of a complicated method. The preferred and shared final solution is to equate, at a conceptual level, the preferences influenced by mental and psychological elements to *revealed preferences (effectively assumed and declared)*. In this way, it will no longer be necessary to investigate factors arising from the brain (the so-called *black box*); however, that solution does not satisfy the scientific point of view.

During the XIXth century, modern *Psychology* strengthened and spread based on empirical analysis. In short, psychologists try to study the mind's role in a new way to solve negative effects in patients suffering from behavioural pathologies, such as compulsive craving, greed, squandering, etc.

Wilhelm Wundt (1858) initiates *experimental psychology* to investigate the role of emotions and studies how they are expressed in humans and animals. William James (1890) introduces the *functional psychology* that connects emotional stimuli to some behavioural pathologies. John Watson (1913) suggests a first systemic view of *behavioural psychology* to clarify also the causes of less serious pathological behaviour. Ulrich Neisser (1967) introduces *cognitive psychology*, in the 1960s, especially to have a general vision of mental disorders as a source of deficit in learning processes and in the short and long-term memory. Herbert Simon (1975) investigates the psychological aspects of individual behaviour in the economy. Maurice Allais (1986) takes a next step, showing how some behavioural aspects influence the *allocation efficiency of resources available* in the market. Richard Thaler (2004) consolidates the research of *cognitive psychology* correlated with *economic and financial phenomena*, both individual and collective.

They investigate and describe the *human mind* as a *continuous information process*, activated by (exogenous and endogenous) stimuli that induce instant behavioural

reactions at physical (motor) and cognitive levels. Psychologists are used to individuate the symptoms of some pathologies *externally* observing the behaviour of patient to interpret their verbal expressions with which they describe mood, emotion and mental states perceived in decision making process²⁹. The psychologists try to prove how *mind outcome* modulates a large part of individual behaviour to have a better knowledge of economic behaviour in *healthy* people.

In the early 1950s, (few) economists undertook a new venture deciding to collaborate with (few) psychologists to fill the knowledge gap cited in traditional quantitative economics. Gradually, a new area of interest and study emerges and spreads: *Behavioural Economics* (and after *Behavioural Finance*). New behavioural visions permit describing and interpreting human behaviour; they are based on a mix of quantitative (traditional) economic analysis and selected methods of psychological methods. In the meantime, biologists and physiologists prove how *each living organism only makes an effort if it maximises the probability of survival of itself and, consequently, of the species*³⁰. At the beginning of the XXIth century, some new mathematical models for the optimal economic choice were founded on the principle of *maximum output with minimum effort*. The *Theory of Choice* is proposed.

The updated *Theory of Choice*, in its *normative* version, considers the role of *probability* and *uncertainty* for selecting the best (*optimal*) decision. In its *descriptive* version, it examines the *irrationality* role in individual behaviour; the experimental protocols refer to the *Game Theory*. Economists try to analyse individual behaviour considering that every negotiation occurs between two (or more) people. The best representation of it is the *Game*. Each player, safeguarding their own interests, is committed to understanding the intentions of their counterpart, to prevent his choices and decisions. Various mathematical models are built to select the *rational* (best, optimal) decision (and strategy) in a *risky, uncertain, or ambiguous* and *competitive* game context: they are named *choice-models*. All of them are based,

²⁹ Psychologists recover the *method of introspection* suggested by the philosophers of Magna Greece to clarify the role of psyche, or soul in individual behaviour. Introspection of the soul is proposed also by St. Thomas *Aquinas* (1225-1274), dominican and philosopher, to investigate if the sinner's regret was sincere, profound, or not. Barry C. Smith: *Little changes make the biggest difference*. In: John Brockman: *This will change everything*. Ed. Edge Foundation. (2010).

³⁰ Some biologists suggest that the intrinsic value of nature includes that a gene of any species must survive and procreate, maintaining the equilibrium in the general ecosystem. Fred Van Dyke: *Conservation biology: foundation, concepts, applications*. Ed. Springer Verlag. (2008).