

Chapter 2

Neuroeconomics

2.1 Neuroeconomics and Causality

The rational choice theory (TRC), in its standard interpretation, is not presented as a causal theory, but as a formal-normative theory. Experimental economics, replacing the standard assumptions regarding the interpretation of the TRC's more realistic assumptions—for example, a utility function that includes social preferences—has allowed us to improve the prediction. However, experimental economics has failed to overcome another theoretical difficulty that affects the TRC, the absence of a formal causal link to the entities hypothesized. In the end we are before the same problem Chomskyan linguistics faced. Chomsky, in fact, proposed a formal model of explanation of linguistic competency assuming a division into elements (e.g., verbal or nominal groups) and operations (the rules of formation and transformation of sentences). However, in this theoretical model neither the elements nor operations corresponded to neural, anatomical or molecular structures, but only to a set of computational processes. Therefore, the Chomsky model explains human linguistic competence, but it cannot explain (and moreover Chomsky did not intend for it to do so) how, for example, auditory and motor areas interact to produce or understand sentences. Conversely, there are phenomena that can be explained by leveraging counterparts' materials, namely a model in which each element of the explanation can be identified with a real material structure, capable of causal interaction. The diagram of a combustion engine, for example, represents parts (piston, valve, etc.) which can be identified in a real engine. In Chomsky's model of explanation, by contrast, the elements and operations are described without being coupled to material structures; in practice we consider the adequacy of the functional relationships (input/output) of the model and those of the system under consideration.

Neuroeconomics, the science through which the study of brain processes, enables us to find new foundations for economic theories, and in recent years has received particular attention from researchers and scholars. This “new” science, placing itself at the intersection of neuroscience and economics, makes it possible

to understand the neural basis of decision-making. It would also be able to offer privileged access to what, going beyond the formal models of economists, actually produces human behavior.

The Neuroeconomy, therefore, combines the knowledge of different approaches such as cognitive science, neuroscience and economics with the aim of studying the neural correlates of tasks in economic decision using brain imaging techniques, in particular the Resonance Functional Magnetic Imaging (fMRI). The latter uses the nuclear properties of certain atoms in the presence of magnetic fields. The technique came into use in the seventies in order to obtain detailed images of the anatomy brain. Through ultra-fast data detection techniques, it became possible to take pictures of very small increments of time (one hundredth of a second), which allowed them to follow in carrying out certain aspects of metabolism. Applied physiology of the brain, fMRI has allowed to display on a time scale very fine changes in oxygenation of cortical regions, changes that are considered to be closely related to the degree of activity in those regions. The magnetic properties of the hemoglobin molecules, which differ slightly depending on whether or not this is related to oxygen, are exploited for this purpose. Therefore, it is assumed that the fMRI images faithfully represent regional changes in neural activity which are apparent when a contrast is highlighted between regions that are rich in oxyhemoglobin, that is when blood flow is increased, and regions that exhibit normal blood flow.

There are strong reasons to be attracted to neuroscience. We owe our lives and all that we are to our brain and it is therefore legitimate to try to see how it works. But at the same time, we should wonder about the multiplication of the branches of scientific knowledge that use the prefix “neuro”: Neuropolitics, Neuromarketing, Neuroethics, Neuroaesthetics, to name a few. To what extent are we dealing with really new areas of knowledge? To what extent are we instead faced with attempts by some researchers who work outside neuroscience to take advantage of the prestige and interest that neuroimaging techniques arouse? As specified by Paolo Legrenzi and Carlo Umiltà: “As all fields of human knowledge depend on the functioning of the brain, there is nothing to prevent the application of neuropsychology to disciplines such as economics, aesthetics, pedagogy, theology, etc. In fact, neuropsychology could have been (and was, to a certain degree) extended to these disciplines without the need to invent new terms by the pleonastic use of the ‘neuro’ prefix.” (Legrenzi and Umiltà 2011, p. 9). And in particular for what concerns neuroeconomics: “It must be said, out of intellectual honesty, that neuroeconomy is very fashionable. Frequently the enthusiasm of the supporters of this new field of research leads them to reformulate what is already acquired knowledge thanks to the experiments conducted by psychologists, simply by substituting ‘mind’ by ‘brain’, and believing that in doing so they have enriched the reputation of this field of study.” (Legrenzi and Umiltà 2011, p. 77).

Moreover, as with other methods that aim to explain the complex relationship between the brain and behavior, it must be said that brain imaging includes, within this theoretical framework, a number of ways to make observational data as transparent as possible and to limit the proliferation of possible explanations

of the phenomena examined. Actually, in the case of business decisions, these are crucial features for the simple fact that models are applied behavioral interpretations of neurophysiologic data in nature. The methodology that is well accepted in neuroscience is known as “cognitive subtraction”. To understand the role of subtractive methods one must take a step backward in the history of cognitive science up to Frans Cornelis Donders’ studies (1869) in experimental psychology and reaction times of mental processes. In these studies Donders developed a rudimentary subtractive technique that would allow him to isolate the different operations performed by a subject during a particular cognitive activity. The basic logic of Donders’ method consisted of the idea that the duration of a processing step can be measured by comparing the time required to resolve a version of a particular task (for example, press a button after the recognition of a particular visual stimulus), with a second version of the task that differed from the first only by omitting the step of processing (the pure reaction to the visual stimulus). The difference in time required to resolve the two versions represented the time that was spent in the stage of development taken into account. Donders’ subtractive method was resumed and completed a century later by Saul Sternberg by the method of “additive factors”. Stenberg (1969), in fact, demonstrated that the reaction times of mental processes were subject to variations as a result of the manipulation of certain variables: for example, in the case of the time necessary for a subject to determine whether a number belongs to a list first choice, influential variables may be the clarity with which the number is visually presented (therefore the clarity of the signal), the search in the active memory of the length of the stored list, the activation of the response of its compatibility, and so on. So assuming that a task that requires a sequence of operations, said Stenberg, it can be assessed to what extent manipulating variables are affecting the duration of individual operations. The importance of Donders’ subtractive method and Sternberg’s additive factors in brain imaging studies is due to the collaboration between the neurologist Marcus E. Raichle and psychologist Michael Posner (Posner and Raichle 1994). In the two authors’ studies, the subtraction is used in the reconstruction of the factors that generate the neural activity detected. In fact, the principle adopted by Posner follows Donders and Sternberg and is subtracted, the activation maps, the values for the state control than those relating to the activated state. For example, according to the two authors, it can be assumed that you can isolate the brain activity related to a subject’s passive fixation on a single set of visual stimulus by subtracting the control values recorded from the same subject while keeping his eyes closed. From the above, therefore, it must be inferred that the study of physiology and functional anatomy provides information independent of the psychological models, which departs from the architecture of cognition. Thus, when we use cognitive subtraction, if we make mistakes in the choice of the control task, we run the risk that research results will be worthless if not misleading (Legrenzi and Umiltà 2011).

These objections are legitimate. The researchers of the standard disciplines (economics, marketing, aesthetics, etc.) must not surrender to the charm that the brain images obtained through the use of functional magnetic resonance imaging

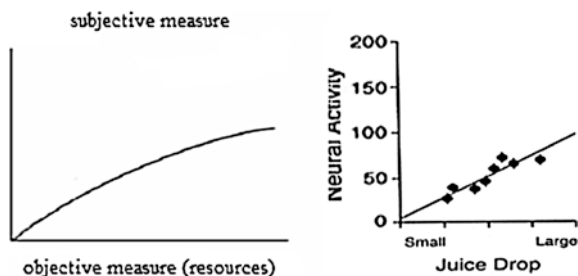
can arouse. However, there is a simple reason for thinking that the neurosciences are necessary for the understanding of the processes of decision-making. The observation of human behavior “to the naked eye” is likely to reveal regularity, but does not tell us how these are derived from unobservable processes and structures and, in particular, from how they derive from the nervous system. The claim of neuroeconomics is thus first to open the “black box” showing how decision-making is carried out by the brain. To use a more properly philosophical jargon, neuroeconomics investigates decision-making in a “causal” outlook. It tries to show that as a high-level phenomenon, decision-making can be produced by underlying components and assets. Explaining decision-making, thus becomes first of all describing the mechanism that produces it. Neuroeconomics therefore wants to reintroduce to the study of decision-making, causal considerations which have been neglected or simply set aside, from standard economics. Unlike the neo-classical paradigm, which only provided the tools which allowed to predict the behavior, the claim of neuroeconomics is to explain it.

From the neoclassical point of view, the utility function is a formal term used to designate a preferable relationship between baskets of goods. To say that basket A is more useful than basket B, according to the neoclassical theorists, is simply affirming that there was a relationship between the two, that a rational agent—i.e. whose utility function that meets certain formal constraints—will select basket A rather than the basket B. On the contrary, neuroeconomics aims to understand the choice of basket A as a result of a neural mechanism that consists of components, activities or structures of the brain. The utility of a choice is not determined by formal preference relationships, but rather it is the result of a complex mechanism, which implicates, for example, specialized components in the production of pleasure, motivation, learning, attention or of cognitive control. Recent discoveries on the brain’s function allow us to reformulate, in a more realistic and accurate way, the fundamental insights surrounding the concept of utility function according to the standard assumptions which rest on the idea that the marginal utility is positive and decreasing, i.e. that $U' > 0$ and $U'' < 0$.

For example, an experiment Platt and Glimcher (1999) conducted on rhesus monkeys illustrates that the brain can actually encode this kind of function. The experiment was to teach the monkeys to choose between two bright spots (which appeared on screens placed to the right or left of the observation point the monkeys were). When, with a head movement, the monkeys made the right choice they got a reward (food). To maximize its usefulness, a monkey had to remember the probabilities associated with his earlier choice and of course the value of the reward. The experimental task was performed on blocks of 100 tasks. In some of these blocks, the probability of movement towards the right side, was steady at 80 % and at 20 % towards the left. In other blocks of the experiment, these probabilities were reversed. In this way, the anterior and posterior probabilities in each of these blocks had to be continually assessed by the monkey brain.

The goal was to change the probability of reward by maintaining constant visual stimuli and motor movements in such a way as to verify whether the activation of neurons in the lateral intraparietal region was related in one way or another with

Fig. 2.1 Source Glimcher (2003)



the front or rear probabilities. Maintaining constant stimuli and the movements of the monkeys, the authors concluded that the probability of reward and their changes was related to neuronal activation. Platt and Glimcher interpreted this signal as evidence that first of all the apes were seeking to maximize their chances of gain.

After showing that the monkey brain can encode the probabilities associated with a reward, a second part of the experiment was devoted to ascertaining whether the monkey is able to do the same with the value of the reward. The authors, therefore, kept movements, the stimuli and the probability of reward constant (set at 50 %) and varied, from one block of tasks to another, only the amount of rewards (in some blocks, the amount of food obtained was 0.2 ml by looking left and 0.1 ml by looking right, in other blocks, the quantities were reversed). The results underlined how the value of earnings, when the elements were kept constant, were encoded by neurons practically speaking: the neurons were more active when the hope of gain was high. The fact that the brains of monkeys were able to simultaneously encode both the magnitude of the rewards and their probability, shows two things. Firstly, the concept of hope of utility seems to have found a neurological corollary. Secondly, that some concepts whose basis can be found in economic theory can be accommodated within the framework of neuroscientific analysis. Economics and neuroscience can therefore benefit from each other. Figure 2.1 shows a certain similarity between how economic science understands this basic concept and the data which were recorded from the brains of the monkeys.

What is surprising compared to the research of Platt and Glimcher is that subsequent studies using fMRI in humans come to quite similar conclusions. For example, activation of the posterior parietal cortex is correlated to the magnitude of monetary gain (Paulus et al. 2001) so that its anticipation would be positively correlated with the activation of the ventral striatum region (Knutson and Peterson 2005). Two important observations are indicated by Brian Knutson and Richard Peterson. Firstly, the ventral striatum is active only in anticipation of monetary gain; gain, loss, or anticipation of monetary loss apparently has no effect on this region. The second observation concerns the medial prefrontal cortex region. According to the two authors, this region keeps track of monetary gains and is deactivated when the monetary gain is zero. It should be noted, that it is neither

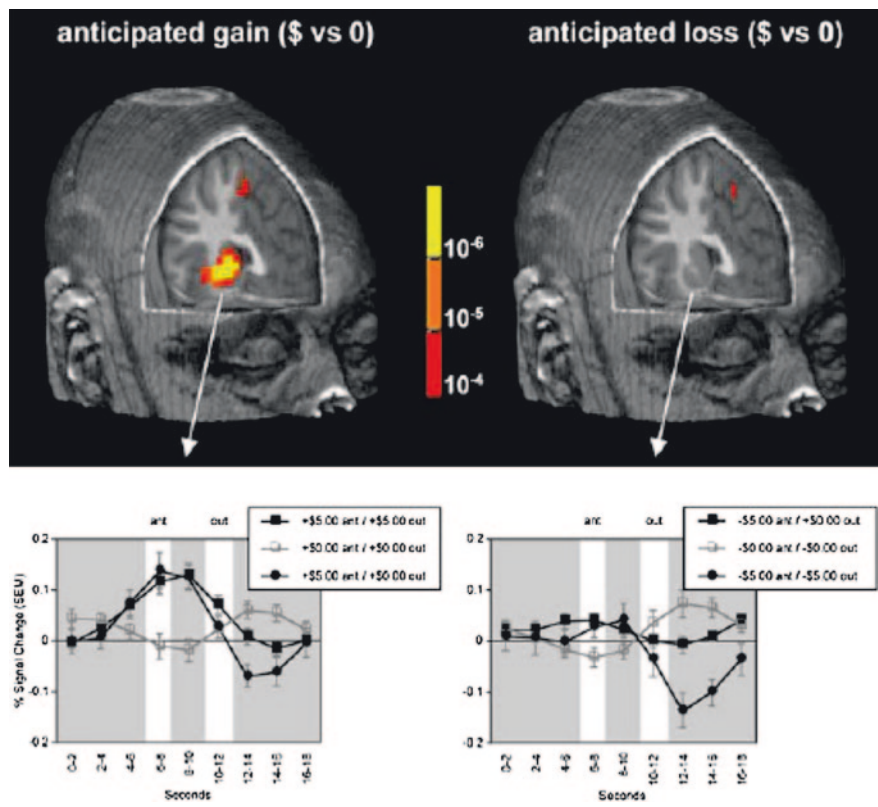


Fig. 2.2 Source Knutson and Peterson (2005)

active for anticipations (gains or losses), nor for losses: the prefrontal cortex is therefore not implicated in the anticipation of a reward previously known of.

Figure 2.2 shows the region of the striatum when activated by the anticipation of a monetary gain (left side of the figure) but not activated by the anticipation of a loss (right side of the figure). Therefore, the Knutson and Peterson framework for interpretation partially diverges from that of Platt and Glimcher. In fact, Knutson and Peterson interpret their results in light of Kahneman Tversky's prospective theory, namely that the prospects of gain and loss are not supposed be treated by the same neural mechanisms. In short, some interpretations and research allow insight to confirm some of the intuitions or precepts of the neoclassical approach (utility function, hope of utility as in Platt and Glimcher) but also some competing or complementary approaches underlined by Knutson and Peterson (prospective theory).

However, from both searches, what is revealed is that the concept of reward is a key construct in understanding human behaviour. Indeed, the ability to search and get rewards for their actions as a goal is, from a developmental point of

view, essential to the successful breeding of complex organisms. As specified by Wolfram Schultz (2004), in an evolutionary sense, we can describe at least three functions of reward:

- (a) Produce learning as it promotes the recurrence of the same conduct;
- (b) Production and consumption behaviour approach;
- (c) Generate positive experiences.

One of the most important discoveries made by Neuroeconomy relating to the important role of the concept of reward, is the one that has highlighted how this important process takes place in the neural structures situated in the most ancient part of the brain, namely “dopaminergic systems”, which are involved in motivation and evaluation (Montague 2006). The first evidence that systems related to dopamine receptors are of primary importance were made by Olds and Milner (1954). Their research showed an increase of dopamine in certain brain regions in mice when they were involved in rewarding activities. This allowed a glimpse of a link between dopamine and hedonistic pleasure. In fact, these initial assumptions established a direct causal link between the feeling of pleasure and dopamine. This interpretation has now been called into question. Recent neuroscientific discoveries, rather, have demonstrated the link between dopamine and learning through experience, in which the dopaminergic response is transferred from an unconditioned stimulus (the reward itself) to a conditioned stimulus (the reward announcer). The dopaminergic neurons, which initially are triggered by the arrival of the reward, therefore, are activated later particularly in light of the conditioned stimuli (Schultz et al. 1997; Schultz 1998). The decision and the choices would then be oriented towards satisfying the dopaminergic neurons. As Roy A. Wise explains: “It is the return to a reward previously experienced that is the essence of habit and addiction. [...] the return to a previously experienced reward involves the return to reward-associated landmarks as much as it involves return to the reward itself. [...] The sounds, sights, and smells associated with the food are clearly predictors of reward, and the efficiency of the animal increases with the identification of more and more distal predictors of reward, predictors that guide the foraging and that are important for the “error signals” that guide corrections to the foraging path.” (Wise 2002, p. 233). To ensure its survival, all species must be able to satisfy the vital functions, which vary from simply feeding to responding to aggression and reproducing. The brain’s reward circuit allows the attainment of these objectives. The ventral segmental area, a group of neurons located in the centre of the brain, is particularly important in the operation of this circuit. It receives input from many other regions that inform the level of satisfaction of basic needs (or more specifically human needs). At the arrival of a signal announcing a reward, then after treatment of the sensory cortex, the activities of ATV are increased. This region then transmits this information by means of a chemical messenger, dopamine, that is “released” from the “accumbens nucleus” but also by the amygdale and the prefrontal cortex. The circuit formed by these structures selectively responds to primary rewards (food, herbs, sexual stimuli) and secondary rewards (money, music, cars, or social stimuli like faces attractive, pleasant

tactile stimuli or emotionally connoted words). In particular, based on the experimental task, the accumbens nucleus has been demonstrated as having specific activation in relation to pleasant stimuli whose occurrence is predictable (on the contrary, it is not activated by stimuli that are always pleasant in nature but are not predictable). This feature seems to demonstrate the presence of a neuro functional structure capable of mediating the cognitive processing of stimuli in relation to their predictability. In fact, as it has been shown in research by Samuel McClure and colleagues (McClure et al. 2004), the complex-striatum accumbens seems to reflect the so-called prediction error (the difference between the probability value expected with respect to a certain reward and the actual value found) at the Neuro—functional level.

The daily experience of the subjects with expectations and their subsequent evaluation of errors with respect to certain contingencies that are repeated over time, allows individuals to learn more and become more refined, making them able to train the body to conduct a more appropriate and optimal response to its environment. This learning mechanism, functional optimization (maximization) of their behaviour in situations of uncertainty, seems to be mediated by the accumbens nucleus that plays a key role in determining the subjective behaviour in situations where the individual needs to evaluate alternatives with probability values and uncertain utility.

The amygdale, however, is the sub cortical region of the brain best studied for its role in emotional processing, with particular relevance to the formation of conditioned responses to dangerous stimuli. This thesis has been tested, among others, by Michael A. Paradise and colleagues (Paradiso et al. 1999), through an experiment that would establish the role of the amygdale in the evaluation of negative stimuli (presented in visual form through photographs). The author, noting a greater activation of the amygdale in negative evaluation of pictures (not experiencing the same activation in the evaluation of positive and neutral pictures), concluded with the assertion that the amygdale was involved only in the evaluation of a wide range of negative stimuli, but not in the assessment of positive stimuli. However, this interpretation is inconsistent with a growing number of recent results from research conducted both in animals (Davis and Whalen 2001; Everitt et al. 2000) and human beings, suggesting the involvement of the amygdale in the treatment of positive stimuli. For example, faces expressing joy (Gorno-Tempini et al. 2001), positive words (Hamann and Mao 2002) positive pictures (Hamann et al. 2002), excerpts of erotic videos (Beauregard et al. 2001; Karama et al. 2002). The role of the amygdale in emotional processing is therefore very wide, being involved in the development of both positive and negative emotions. The amygdale also seems related to the formation of estimates with respect to financial rewards, showing how this anatomical structure appears to correspond to the intensity of the stimulus, showing that peaks of activation are implicated as positive reinforcement (Hommer et al. 2003).

However, the brain area that undoubtedly represents an area of particular interest for the study of decisions in general and for studying higher cognitive processes is the prefrontal cortex, which is located in the frontal lobe and in front of

the drive and premotor region. It is characterized by a late development from both phylogenetic trees; in primates, much of the ontogenetic myelination continues, in fact, even during the early years of childhood, and the dendritic and synaptic maturation reaches a stable level only in adolescence. In particular, this region provides important reciprocal connections with the sub-cortical regions (diencephalon, midbrain and limbic system) as well as with several cortical areas, mainly somatic, auditory and visual (Fuster 1989). Several routes also link the prefrontal cortex to the basal ganglia and the thalamus that are, themselves, the main regions involved in the motor activity of man. However, several studies have highlighted the different tasks performed by different areas that make up the prefrontal cortex, classically distinguishing three major prefrontal regions, which are linked to specific behavioural and cognitive functions. The first of these areas, the anterior cingulate cortex (Brodman area of 24, 25 and 32) seems to be implicated in the control of autonomic functions, the initiation of the response, intention, the treatment of the conflict or error, and the allocation of cognitive resources (Bush et al. 2000; Holroyd and Coles 2002; Botvinick et al. 2004). The orbit frontal cortex (Brodman area 12 and 13) seems to play an important role in the functions instead of needing a front control of the limbic system, such as inhibition, the encoding of the motivational value of an object or of a stimulus, decision-making and control action based on reward, impulse control and interference, mood and social behaviour (Bechara et al. 2000; Rolls 2000). Finally, the lateral prefrontal cortex, particularly the dorsum—lateral (Brodman areas of nine forty-six) is usually associated with functions involved in executive control, such as changes or representations of all the current rules (set-shifting), the resolution of complex problems, the recovery of memories in long-term memory, organization and strategies of working memory (Goldman-Rakic 1987; Fuster 2001; Watanabe et al. 2005). The prefrontal cortex, along with other structures such as the anterior cingulate cortex and the insula, seems to be involved in the regulation of social interactions and behavioural conduct so that they are handled in a timely manner.

In conclusion, the approach aims to analyze neuroeconomy in the more substantial economic structures of the mind through the study of the brain during its operation. Many neuroeconomists are convinced that a better understanding of the mechanisms by which the brain assesses and compares alternatives and various forms of rewards can assist us in learning what determines our choices and our behaviours. As we shall see later, neuroeconomics does not attempt to analyze the brains of individual decision makers, but it tries to extend its domain to the interactions between different agents using game theory.

2.2 Game Theory and Neuroscience

In recent years, game theory models have been used by neuroscientists convinced that by so doing new findings could emerge that might prove useful both to economists and scientists that study the brain. From this perspective it is interesting

to consider the works of James K. Rilling, who along with his colleagues used a version of the Prisoner's Dilemma in order to observe the cerebral activity of 19 participants (11 girls and 8 boys) when they played both against human counterparts and against a computer. Rilling found that participants cooperate more (in the 81 % of cases) when their adversaries are human beings. The researchers subsequently identified the cerebral regions that were activated in the cooperative acts and in the defection acts in order to analyze their dopaminergic impact, recording a BOLD activation (Blood Oxygen Level Dependent Signal) of part of the striatum and of the prefrontal ventromedial cortex. This activation, it was also noted, was not meaningful when player A had to deal with a computer: the nature of the interaction therefore plays a relevant role in the BOLD activation (Rilling et al. 2002). Other research has confirmed the assumption that a positive social interaction with others is particularly gratifying. For example, Tania Singer and her colleagues (Singer et al. 2004) use the Prisoner's Dilemma themselves in order to demonstrate that simply seeing the face of a person who had previously cooperated activates reward circuit areas of the brain.

Hence, these neurological observations complete empirical observations previously reported: adopting cooperative behavior and obtaining mutually beneficial behavior will produce an activation of the reward circuit implying a sort of gratification. Moving in the same direction, but also useful for testing the role of emotions in economical decisions, is the research carried out by Alan Sanfey and his colleagues (Sanfey et al. 2003) who used the "Ultimatum Game—UG" to evaluate the neurological foundations of economic decisions. The protagonists are two players who are given the chance to share a certain amount of money. One of them, player A, makes the offer, the other, B, can accept it or not. If B accepts the offer, the money will be shared as proposed, but, if he refuses it, both remain without anything and the game ends there. It would seem natural that player A would make the most favorable proposal for himself, and that B would accept it, rather than remain with nothing (on the rational basis that the money he was offered is in any case preferable to zero). This, however, is not the case. Regardless of the amount at stake, the proposed sharing is most of the times fair, and not only. Low offers have approximately 50 % chance of being rejected, a detail which demonstrates how under certain circumstances people are motivated to refuse an economic benefit.

But, why does this happen? Excluding the possibility that the players did not understand the rules of the game or that they have difficulties in conceptualizing the match played in just one move, it is meaningful that when confronted with an unfair offer, the rejection is often associated to an angry reaction to an offer perceived as unfair. In fact, studies carried out in several countries, have demonstrated that the vast majority of people offer, within the third day, half the amount (Camerer and Loewenstein 2002). Moreover, it has been remarked that the rejection of an offer, by the second player, is usually combined with a feeling of anger (Pillutla and Murnighan 1996). The expression of feelings, during the game phases, has its relevance indeed: an offer can be rejected, for example, in order to keep a good reputation in the game (the acceptance of low offers damages the

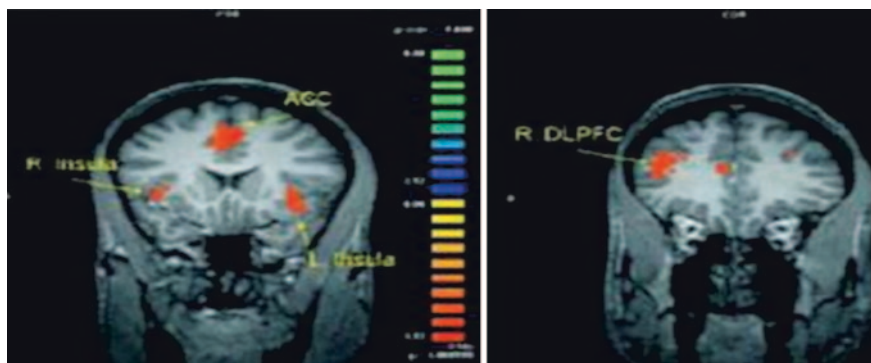


Fig. 2.3 Activated cerebral regions during the Ultimatum Game (Sanfey et al. 2003)

player's reputation, increasing as a consequence the chance of being proposed further low offers (Nowak et al. 2000). The only exceptions, where people made and accepted low offers, were found in some autistic adults: hence, paradoxically, a rational behavior is observed, mostly in subjects having cerebral deficits (Camerer 2003). It is Sanfey and his colleagues who are credited with using the "Ultimatum Game" in economic studies (Sanfey et al. 2003). In fact, thanks to the use of the fMRI technique (functional Magnetic Resonance Imaging), Sanfey studied the cerebral activation of 19 subjects taking part in the "Ultimatum Game", paying more attention to the cerebral activations of the participants who were proposed low offers (20 % of the sum at stake).

Assuming that such an offer would cause a conflict between the emotional desire of not accepting on the one hand, and the will to accumulate as much money as possible on the other, Sanfey and his colleagues identified the areas of the brain potentially involved in these mental processes. The authors noticed, in particular, a higher activation of three cerebral areas: the anterior cingulate cortex (ACC), the anterior bilateral region (right insula and left insula) and the dorsolateral prefrontal cortex (DLPFC) (Fig. 2.3).

During their experiment, Sanfey and his colleagues, asked their participants to complete 30 rounds, each of 36 s, of the Ultimatum Game (10 with people, 10 with a computer and 10 as a control). Before the partner's offer was disclosed, a picture of the sparring partner (whether a person or a computer) was shown on a display. Researchers found very similar results to those mentioned above: the acceptance rate was negatively correlated with the unfairness degree of the offer. Interesting to remark was also that the players' behavior was different depending on whether the offer was made by another player or by a computer. The rejection in fact was meaningfully higher when the offer was made by a human being. This demonstrated how the players were sensitive, not only to the amount offered, but also to the context (i.e. whether the low offer was made by a human adversary or by a computer). In particular, the regions of the insula were those showing the greatest activation. From this, Sanfey deduced that, being the region of the insula

associated to negative emotional states, its activation, following an unfair offer, had to be interpreted as an effect of a negative emotion.

Hence, according to the authors, the activation (or not) of this region, allows the prediction of the rejection of an economic offer; on the contrary, the other cerebral region of interest, the DLPFC, which is supposed to be linked to the will of maximizing the monetary benefit (hence the rational part), on its own (not being correlated with the acceptance rate of low offers), does not allow the prediction of the behavior. Nonetheless, the authors suggest that it can enter into competition with other cerebral regions (the insula for example) for control over decision-making. So, to sum up, the findings show that if the activity of the insula is higher than the activity of the DLPFC, the offer is rejected; on the contrary, if the activity of the DLPFC is relatively higher, the offers are accepted. For the purpose of our study, we are simply interested in highlighting the role played by emotions in decision-making in an economic situation, and emphasizing how these are now (rightly so) being taken into consideration in the studies of this field.

Moreover, it is worth mentioning how corroborations to Sanfey's study have come from the evolutionist perspective as well. We refer to an experiment carried out by Sarah F. Brosman and Frans De Waal (Brosman and De Waal 2003), where the authors demonstrated that when a monkey, after working hard in order to be rewarded, gets less than another monkey (or when the other monkey did nothing to deserve a better reward), has an emotional reaction inducing it to reject a deal that, he would have almost surely accepted if he had been alone. In other words, the monkeys seem to measure, as men do, their rewards in relative terms: comparing their level of offer and of benefit with that of others. The studies we have just described have had the merit of including emotions as a factor in the study of economic decision-making behavior, and have highlighted how man cannot be represented as a calculator with no limits, recalling the inevitable complexity requested by the interaction among different levels of study.

A clear understanding and investigation cannot operate without research competences and methodologies that concern different disciplinary sectors, in which neuroscience clearly plays a major role. The integration of these disciplines does not just generate an exchange of knowledge and expertise, but entails the change and specification of the object of study as well. It is in this sense that the *Homo Economicus* is replaced by the *Homo neurobiologicus* (the neurobiological man), whose behavior derives from a neurobiological development able to generate sentiments, belief, actions and the capacity to make decision. Moving beyond Colin Camerer and other strong ideas put forth by other neuroeconomists that claim that just the measurements of cerebral activity during decision-making allows us to verify economic notions (primarily utility), there can be other fundamental reasons according to which the proposal of crossing economic models with psychological and neurobiological data might prove to be beneficial.

An example comes from Ernst Fehr, and it consists in exploring systematically the neuronal basis of altruistic behaviors in order to discover whether they are conditioned by strategic attitudes and considerations rather than by purely pro-social

inclinations and emotions (Singer and Fehr 2005). Another interesting question could be that of understanding whether the perception of others' intentions is really an indispensable resource for the execution of a rational strategy in a game, or if on the contrary, the development in infancy of this cognitional capacity would instead have the tendency of making us deviate from the Nash equilibria. Thanks to the emergence of such research programs, in fact, it is being demonstrated more and more, in a convincing and rigorous manner, how the classic universal material self-interest model presents rather frequent violations when put under the test of experimental analysis.

In particular, with specific regard to game theory, the idea that individual preferences could be, besides being driven by the pursuit of a personal interest, also not directly self-interested, is being consolidated. There are, in fact, some social preferences (preferences of a social type) that are positively or negatively influenced by the behaviors, preferences, or intentions of other subjects. For example, thanks to the Ultimatum Game it has convincingly been demonstrated that decision-makers are in general not self-interested, being disposed to punish adversaries who make offers perceived as being unfair, despite this being costly for them. In fact, the profile of the subjects that take part in the UG is, as emphasized by Sacco and Zarri (2003), self-interested from a motivational point of view, but in fearing that a low offer might be rejected by the adversary, the player takes precautions and makes offers which could be perceived as fair and that could reasonably be accepted by the other player.

It appears therefore, worthy of note, how the tendency to reason strategically at the level of the motivational states of adversaries, emerges from the experimental evidence. In the UG, the proponent, in fact, does not offer large amounts to the decision-maker because of an innate sense of equity, but rather on the basis of a belief leading him to predict that the other player, from a motivational point of view, is not acting out of self-interest either and that the offer made is satisfactory. Hence, the beliefs of subject A, with regard to the motivations of player B, influence the choices of A himself, through a judgment that A formulates with regard to B's intentions. If, in fact, A is an individual who decides to cooperate in a conditioned way, or in other words in virtue of an expectation that the other player will cooperate (positive reciprocity), but that will instead refuse to cooperate in the case the other does not (negative reciprocity), in the case in which his beliefs suggest to him that B intends to defect, A will trigger his choice to defect rather than cooperate.

Therefore, if in a certain interaction, both A and B are driven by reciprocity based on their intentions, then their preferences will be directly interdependent. From what has been said an interesting parallel can be established between the psychological mechanisms involved in decision-making within game theory and the psychological mechanisms involved in the resolution of the ToM (Theory of Mind) tasks. To this purpose let us consider respectively, the classic version of the unexpected transfer of the false belief task (Wimmer and Perner 1983) along with the two games we have discussed so far: the Ultimatum Game and the Prisoner's Dilemma.

The concept of theory of mind (ToM) was introduced in 1978 by David Premack and Guy Woodruff, in an article provocatively entitled “Does the chimpanzee have a theory of mind?” (Premack and Woodruff 1978). Their study intended to demonstrate the capability of primates to understand mental states and hence to predict human behavior in situations finalized to a purpose. The two primatologists concluded in their essay that monkeys are endowed with “Machiavellian intelligence” allowing them to plan behaviors of alliance or of deception in order to achieve their goals. The theory of mind was hence defined as that capability of understanding, of inferring and attributing mental states (desires, beliefs) to oneself and to others, in order to understand and predict their behaviors.

The issue concerning the presence or not of a mentalizing capacity in species other than human, has aroused and continues to arouse debate. It seems that some species of great apes attain a certain level of comprehension of the thoughts of others without having a theoretical capacity of the mind as complex and developed as that of the human mind. But beyond this very specific problem, researchers in the psychology of development rapidly became interested in the mechanisms and the development of this cognitive function in human beings.

The very first studies in this direction were those conducted by Heinz Wimmer and Josef Perner. Their purpose was to test the ability of children to attribute a false belief (Wimmer and Perner 1983). The classic version of their experiment is as follows. A first child, named Max, puts some chocolate in a green box and goes out of the room. His mother appears on the scene and moves the chocolate to a blue box. At this point Max re-enters the room and looks for the chocolate. Now imagine asking a second child who witnessed the whole scene where in his opinion Max will look for the chocolate or where he’ll think it is. What will the second child answer? Any normal adult understands that Max’s knowledge will not allow him to look for the chocolate in the right place and, thus, in order to respond correctly must adopt Max’s point of view of the false belief and not the one of reality.

The two researchers hypothesized that until the age of 4, children tend to answer adopting the point of view of reality, hence stating that Max should look for the chocolate in the blue box. In the several replications of the test that have followed the original, the notion of false belief has become a central criterion to establish when children completely develop a theory of mind structurally similar to that of adults. Nevertheless, success in a task of false belief can depend upon several factors rather than just theory of mind (for example, the comprehension of counterfactuals and the ability to carefully follow complex situations); moreover, false belief is not the only existing mental state, and studies of the mental states of others suggest a gradual development of this ability, characterized differently at different ages.

Mentalizing is therefore a complex ability which is made up of several components such as shared attention (which develops in the first year of life) and other more complex abilities (such as counterfactual reasoning for example). Nevertheless, despite all these limitations the scientific knowledge obtained through the test of false belief still remains strong (Leslie 2005); although, what the mechanisms are that drive children to identify themselves with others and to

reflect on their mental states continues to be a matter of dispute among researchers of the ontogenetic development of theory of mind.

The ToM requires a structured set of innate abilities that gradually allow humans to construct representations of internal states of other individuals of their species (but also others), in order to be able to predict the behaviour of others. But regarding the specific issue of how information processing occurs which then leads to the understanding and prediction of behaviour, two different theories have tried to give an answer: the theory of theory and the theory of simulation. According to the theory of theory, every human being is built through the experience of a folk theory (folk psychology) about mental representations, motivations, goals and emotions that lead to different behaviours. The theory of theory presupposes that every individual has available a rather sophisticated inferential system, under which one foresees what will happen starting from one's data of experience, which are the axioms of the folk theory. The peculiarity of the theory, then, is precisely to consider the capabilities expressed by the psychology of common sense as part of a theory. Obviously, this is a theory that for most individuals would remain in an implicit state. The theory of fact does not suggest that everyone is able to reflect on individual aspects of the theory or check back to make the right inferences. But the systematic aspect of the predictor would remain, even if latent, in each of us. The limits of the theory of theory seem very obvious. It presupposes the existence of a folk theory of behaviour which, in turn, seems to presuppose the accessibility of complex inferential processes by one's consciousness and one's ability to abstract representation of rules. The theory of simulation, which opened in the mid-eighties by Robert Gordon, however, rejects the use of such a chain of logical inferences to explain inter subjectivity, which it considers too rich, wasteful, uneconomic, preferring a more modest model based on imitation and imagination, and on the belief that beyond individual differences all humans are endowed with a mind that works similarly in similar circumstances.

Therefore, in order to pass a task of false belief, one has to temporarily suspend the knowledge of factual reality (known to the participants of the test and to the experimenter) in order to represent the mental state of the protagonist or, in the terms of the simulationist approach, one has to mentally "put oneself in the other's shoes". In other words, the task of false belief requires making a prediction with regard to a behavioral outcome, in response to the question: "where will the child look for the chocolate?" In order to correctly answer this question and predict the child's decision, one has to set aside one's knowledge for a moment, that is knowing perfectly well where the chocolate was moved to, in order to represent the state of knowledge of the other, who instead does not know that the chocolate was moved and who thus has a false belief that will drive his behavior.

If the theory of theory shows its major limitation as being entirely directed towards the other person, whose mind is trying to understand the operational concept in terms of chains of arguments and logical inference, the simulation shows the theory to be, on the contrary, too ego centred, since it plays all its cards on the ability of the ego to imagine itself in place of the other. On closer inspection,

however, that selfishness is at the same time a de-centring of the ego, since one has put aside one's beliefs in merely assuming the beliefs of others. In doing so, the theory of simulation, which is able to understand and predict behaviour based on the closeness of the affinity between the observer and the observed agent, fails to explain how it is possible to predict the behaviour of agents outside of oneself. Moreover, it seems quite plausible that the obvious purpose of a simulation is not understanding how you would act in the place of someone else, but just imagining how one would behave just the other would. In other words, when one puts himself in the shoes of another he does not bring along his own mind, but he tries to see the world through the eyes of the one whom he is imagining (Perconti 2003).

The current state of the art in the debate of theory of mind is most certainly polarized by the positions of some of the supporters of the theory of pure theory and other extreme proponents of the theory of simulation. However, there have been different attempts at hybridization between the two poles and reciprocal concessions on certain specific points in the theoretical modelling. For example, the simulationist is willing to admit that, in one's understanding of others, one ends up with recursive logical-inferential arguments that refer to a system of conceptual knowledge about the way the other's mind works (which even does not depart from the fundamental point that this happens only after one takes on the other's first-person perspective and one just puts himself in the other's shoes with an imaginative non-inferential logic-simulation).

At this point we want to hypothesize that, in a subject who has to predict the decision in a game, a mechanism triggers a meta-representation of the mental state of the other, similar to the one we have just discussed for the tasks of false belief. Let us use the example of the Ultimatum Game: the player has to think of the sum he should offer to the other player, that is whether to propose a high, low or fair offer, because if the other player should reject it, he will lose everything himself and will not gain the remainder. So, in thinking of how much he should offer, the player has to evaluate the other person's attributes. If he knows him, we can imagine he will evaluate some character traits, such as, whether he is a "take it all" subject, or in other words, a type of person that no matter what the offer will be most probably will accept; or if he is a subject that carefully evaluates received offers and therefore will not likely accept an offer under a given threshold, in such a circumstance the proposal of a low offer would mean to risk leaving with empty pockets.

We can similarly imagine what is in going on in the mind of the player receiving the offer. If he receives a low offer he could for example think: "he made me a low offer because he thinks I'll accept it anyway?" In the most extreme case he could think: "rather than letting him gain so much, I will reject the offer. I'll gain nothing, but neither will he". The same mechanism seems to take place in the Prisoner's Dilemma, the other game we have discussed. When we are questioned, we have the chance to decide whether to cooperate or not; nonetheless, this choice cannot be made without taking into consideration the move made by the partner: in fact, if you choose to cooperate you risk a lot because you appear to trust the

other from which you expect a reciprocity of the behavior. If the partner decides not to cooperate (and to act like a spy) everything will be at the expense of the one who cooperated (Marchetti and Castelli 2006).

Nevertheless, from what has been discussed, it is clear that it is not enough to put yourself in someone else's shoes and to wonder what you would do under the same circumstances in order to adopt a "winning" strategy. To this first simulation level, we have to add a second higher level, made up of the set of mental assumptions that enable us to imagine the "internal life" of the other, for example, the counterfactual imagination (i.e. the ability to assume that things can take a course that is different from the actual one). In other words, we need an "integrated" approach of simulation and common sense psychology. Therefore, it is necessary to integrate the theory of mind and simulationism in a further theory where simulation processes are the basis for behavioral prediction. At the same time, a major role could also be played by the processes regarding our psychological intuitive knowledge and those regarding the particular mind of the person we are trying to simulate (Perconti 2003).

The theory we are alluding to is the one known by the name of "social cognition", whose main components are: mind reading, imitation, shared attention, empathy, language, self-awareness, one's own ability to lie and to detect the lies of the others, and imagining the point of view of others. The set of these components make the typical forms of human society possible, rendering possible the complex cultural practices which earn man a central place in the animal kingdom (Ferretti 2006).

2.3 The Role of Social Cognition

In general, social cognition is the process that allows people to think about and give meaning to themselves, others and social situations (Fiske and Taylor 1991). In particular, it concerns the ways in which we form an impression (positive or negative) of the personality, role and identity of others. The notion of social cognition must therefore take into account a number of features of human cognition: (1) the recognition by the subject of an actor who works in an environment intentionally; (2) the consideration that the beliefs and representations of others are related to their actions; and (3) changes in the constitution of beliefs and representations about the goals of a subject. Therefore, the way we define other people affects our social interaction, but at the same time, the other is also influenced by social interaction, that is, we form the view that is both an effect and a cause of social interaction.

Usually, people think that social cognition primarily serves a practical purpose (Fiske 1992). According to studies of social cognition, people must balance their impressions of others with the requirements of appropriate social interaction as a result of the limitations of the cognitive system. As a result, people engaged in social interaction are usually "motivated tacticians", who mostly use "quick and

dirty” judgments to conserve cognitive capacity but can be trained to use strategies yielding thoughtful and detailed impressions (Fiske and Taylor 1991). An example of this comes from the issue of trust (distrust) versus social reputation. In social interactions, trust (distrust) of others plays a crucial role. People expect others to be competent, friendly, honest and trustworthy. When we need to make quick decisions, we use heuristics, stereotypes, habit patterns, and other gimmicks to evaluate others. Many experimental data show that one of the key assumptions in our social interactions is the so-called “positivity bias” (positive bias); that is, most people expect from others, *ceteris paribus*, a kind of benevolence. People emphasize the pleasant and avoid the unpleasant; they communicate good news more often than bad and are more likely to judge unpleasant events as pleasant (Rothbarth and Park 1986). Similarly, in a phenomenon known as “positive bias of the person” (person positivity bias), people are evaluated more favorably than corresponding abstract entities; that is, students evaluate individual teachers more favorably than the courses they taught, or individual politicians more favorably than their political party in general (Sears 1983). All of this, of course, is reflected in language; in fact, in most languages, positive terms outnumber negative terms (Zajonc 1998).

The assumption of positivity is clearly present in our expectations about other individuals and events. In social situations, positivity encourages interaction with our fellow humans and the environment.

Compared to trust, reputation seems to need more time to build. In fact, a person’s reputation (positive or negative) must have time to stabilize before it can become a form of capital for related actors. This stabilization reduces uncertainty in the expectations of those who attribute to the other qualities of a certain type (for example, absence of opportunistic behavior or skills and ability to carry out commitments made previously). Social reputation can be represented as the stable expectations of a plurality of agents (another fundamental difference compared to simple trust, which is generally based on dyadic relationships) relating to certain qualities. Moreover, unlike trust, due to risk aversion (Savadori and Rumiati 2005), a bad reputation spreads faster than a good reputation, and we tend to accept information about a person’s bad reputation without independently verifying it; the limiting case is represented by prejudice. On the contrary, a good reputation tends to be accepted only after the positive qualities of the subject have been carefully checked.

From the foregoing it becomes clear that indefinite cooperation in a repeated game (such as a Prisoner’s Dilemma) is not in any way “irrational”. On the contrary, over time, a reliably cooperative player builds a good reputation that may prove useful in later negotiations.

An alternative explanation has been proposed by neoclassical economic theory that is based on the interpretation that agents do not want to behave in a selfish way because they are driven by altruistic behavior to maximize the profits of others. This interpretation, however, conflicts with a large body of experimental evidence showing that the percentage of cooperation in a finite Prisoner’s Dilemma game decreases progressively (Guala 2006). The apparent paradox of

the experiments conducted using models of game theory in which there is a high level of cooperation in the early rounds that decreases gradually with the progress of the game can be easily explained by the fact that people tend to initially build a good reputation, but as they begin to play the game, they come to understand what is the best move, altering their choices by the end of play. This explanation has led to the creation of games built on models with “error and learning” in which subjects are initially involved in the experiment above the Nash equilibrium, but gradually align themselves to it (Kreps et al. 1982). Rules of conduct are similar in the case of the Ultimatum Game. The answers provided by participants in the game seem to contradict the predictions of neoclassical theory, with bids higher than the percentage of waste and significantly high offers. However, in this case, it was noted that if we introduce to the game an element of competition among the players, the kind of behavior predicted by neoclassical models is restored (Guala 2006). Therefore, although the hypothesis that individuals are always rational maximizers of their utility is discredited by some experimental data, it is true that the neoclassical predictions are supported when you are able to interpret the true reasons that motivate individuals to behave in certain ways. These behaviors may seem irrational at first glance, but they possess some degree of meaningfulness when the goal is to achieve certain economic or social objectives, without aspiring to optimality. Thomas Ulen writes in *Rational Choice Theory in Law and Economics* that the agents are probably influenced by social context such that, even if you expect them to behave in a selfish way to maximize their own interests, they instead cooperate unexpectedly: “These experimental results present a puzzle for rational choice theory: why do people cooperate when there appears to be a rational basis for not cooperating? One possibility is that people start any given interaction from the presumption that it is better to cooperate than not; they continue to cooperate until the evidence shows this to be ill-advised; and then they quit cooperating.” (Ulen 1999, p. 803). In the literature, imitation re-establishes a sort of balance between individual rationality and social rationality. Imitation, which has been a topic of interest to great researchers across the social sciences, from Piaget in psychology to Keynes and Hayek in economics, is still central to the interests of many social psychologists, ethologists and philosophers of the mind. Despite the many differences between the various approaches, we can break down imitation into two main categories: automatic or unconscious processes present in human beings from birth and imitative and reflective processes that qualify as rational imitation. Contrary to Piaget’s theories, recent studies have shown that humans have a rudimentary representational capacity at birth, measured in terms of deferred imitation, which develops later during interactions with their environment.

Imitation is primarily concerned with a few superficial behaviors and is then extended to phenomena that are not directly visible (for example, the intention behind an action), even before the appearance of language. This has been highlighted through a series of experiments that show this ability in children at 14 months of age. In one such study by Meltzoff (1988), an adult sat at a table, on which a lamp was placed. As the child watched, the adult bent over

the light and turned it on by pressing it with his forehead. Two-thirds of the children imitated this behavior a week later. In fact, they did not use their hands to light the lamp, although that would have been much easier. This experiment can be interpreted in two ways: the first interpretation is that children have not considered the adult as an intentional agent and have simply imitated his behavior without really understanding his goals, and the second interpretation is that children have understood the intentions of the adult and therefore used the same means to fulfill the same purpose (in this case, the goal may have been to turn the light on with one's forehead). This second conclusion was subsequently confirmed by other experiments (Zelazo and Lourenco 2003), suggesting that children's imitation is more sophisticated than mere reproduction of an observed behavior; on the contrary, imitation in prelinguistic children is already a selective and interpretive process (in this sense, we speak of "rational imitation"). These studies in developmental psychology have been corroborated by some neuroscientific studies of strategies and intentions and their products in the form of actions in the environment (Chaminade et al. 2002). Imitation is therefore a feature that enables human beings to interact with the world beginning at birth. Over the years, to the extent that the child learns to distinguish the content of knowledge, imitation becomes less and less automatic and more the result of deliberation. Therefore, imitation pervasively characterizes the social dimension of human existence by intervening at multiple levels. In fact, mutual mimicking increases in more intimate relationships and occurs when a dyad must interact successfully for the sake of the group; if the dyad fails to meet this goal, imitation increases in future attempts (Ferguson and Bargh 2004). Mimicry appears to be a key tool by which human beings attain social satisfaction. Far from being a simple, passive registration process (as evidenced by developmental psychology research), imitation plays an important role in understanding other individuals.

We have seen so far that imitation plays an important role in the characterization of the processes of social transmission in human beings. We just have to show that imitation may prove to be an interesting approach of some emerging phenomena within the decision-making. We begin with a very intuitive definition of imitation that will serve us later for a more precise definition. Consider two agents, O (observing subject) and M (model), involved in a single activity, such as playing football. Suppose that O recurrently observed that M is better at drawing penalties. Then O will seek to know the reason: If he comes to think that M's success depends on a trait T O can imitate, such as following a specific diet or wearing a certain type of shoes, chances are that O mimics M when trying to acquire this property. In this case, the interest of O in T is not direct, but is aroused by the fact that M has this feature, after the success that O binds to M in his personal reading of world events. Thus, we find the typical triangular structure of imitation, Model-Based Object, most of which is located in the literature of modelling and imitation with a slightly different approach in René Girard (in the terminology of the latter the triangle is composed of Subject-Intermediary—Object; Girard 1961).

Imitation thus proceeds in three stages:

- (1) choice of a model, according to a certain criterion that belongs to the subject, in the course of an act of observation,
- (2) selection of a feature that belongs to the model which the subject contributes to the fulfilment of this criterion,
- (3) an attempt by the party to copy the feature.

These three stages suggest several characteristics of imitation. The first is that the choice of model depends on the particular feature that will be imitated, since the latter is not necessarily known at this stage, but is a general criterion that allows the assessment of individuals, which reflects the purpose or intent of the subject. Moreover, the subject engages in an act of imitation only if it believes that the model is better than him on one of the dimensions covered by this policy. This therefore requires a comparison between the model reflective of the subject and himself, on this criterion. The second characteristic is that the subject has to identify some characteristics of its potential model and infer the one or ones that are involved in its positive assessment of the model. This step will therefore be favoured by the subject's ability to categorize and reflect on these various categories. This requires in particular meta-cognitive and reflective skills. Finally, the third stage brings into play the capabilities of the individual learning of the subject from a model.

From the foregoing, imitation (like reading the mind of others outlined in the previous paragraph), denotes different levels and modes of interaction by which the individuals establish sensory ties with the other. Also speaking to the mimetic phenomena, another capacity, especially in recent years that has been the subject of much research (including neuroscience) is undoubtedly Empathy, namely that special ability to understand how others feel, their feelings, their emotions, and in a sense to share them. At a superficial level it seems normal to think that mind-reading, imitation and empathy differ significantly. In each of these three types of interpersonal relationships, it seems we are confronted with apparently different objects: in the case of imitation of the actions of someone else, translating the observed into executed movements; in the case of mind reading, recognizing the reasons which have produced a behaviour; while in the case of empathy, experiencing the emotions and feelings of others. Based on these superficial differences, it may appear legitimate to assume that imitation, mind reading and empathy depend on different mechanisms. In what follows we will support the contrary view, namely that imitation, mind reading and empathy share many more of those things that separate them, primarily the same specific functional mechanism: the embodied simulation (Rizzolatti et al. 1996).

2.4 Empathy Basic and Empathy Re-Enactive

The word "Empathy" appeared in Anglo-Saxon languages in the early twentieth century and translates the German word "Einfühlung" (which appeared in proto-romantic Germany from the turn of the late eighteenth century until the 1860s),

which was originally used to characterize a form of aesthetic experience in which the subject is projected in the act of imagining a work of art. This aesthetic theory was developed by Lipps (1903), who later extended the use of the term “Einfühlung” to the domain of interpersonal relationships, designating Empathy as the ability one has to put oneself in the other’s shoes. If one succeeds, then he/she has an empathetic personality. However, when we move away from the use of the term in ordinary language, we can easily see that the term Empathy is used as an “umbrella name” for a whole class of terms only seemingly overlapped such as, for example, identification, imitation, emotional contagion, sympathizing. It should, therefore, be distinguished, even if at times it becomes somewhat arbitrary insofar as this term appears to be floating, but so that it still designates real differences between the actual phenomena observed. For example, it is undoubtedly an excellent thing to distinguish between Empathy and emotional contagion. The latter term, for the most part, is the phenomenon of propagation of an emotion from one individual to another. This phenomenon is well known from the psychology of crowds and is also found in children who hear to the cries of another baby and respond by starting to cry themselves. It is generally agreed, that emotional contagion is characterized by a form of non-differentiation between oneself and others, both in the case of children, where the basis for this differentiation is not yet sufficiently well placed, and in the case of phenomena of crowds, where we witness a form of temporary abolition of the distinction of the individual self that merges into a collective I. Empathy differs from sympathy, however, in another dimension. In both cases, the distinction of self/others is preserved. The essential difference between the two phenomena, according to Wispé (1986), lay in the purposes intended in each. With sympathy, as indicated by its etymology, we assume that the emotions are felt by another, sharing one’s pain or, more generally, his emotional experience. Sympathy brings into play altruistic purposes and presupposes the establishment of an emotional connection within what it covers. Empathy on the other hand is a process of imagination that seeks to understand the other and not to the establishment of emotional bonds. Empathy can certainly entertain sympathy, but this is not a necessary consequence of the first. Empathy can also help for altruistic reasons. Understanding the regret another feels does not mean that one agrees with it or is trying to reduce it. As Wispé said: “The object of Empathy is understanding. The object of sympathy is the welfare of others”. (Wispé 1986, p. 318). Therefore, Empathy is used for the most part today when we have the ability to know the other perspective, and assume the other’s role: the ability to put oneself in another’s place, to see the world as seen by another while retaining, however, always a clear separation between who has experienced and who empathizes.

Having outlined these differences, the crucial point becomes how to characterize this particular form of understanding between individuals. The fact that we are all more or less able to interact with others in itself does not excuse us from trying to understand how we do it. The answer to this question came from two Italian neuroscientists at the University of Parma, Giacomo Rizzolatti and Vittorio Gallese, who in the early nineties found a particular population of deputy

vasomotor neurons in the cerebral cortex that process information concerning the behaviour of others, the so-called “mirror neurons”, forcing everyone involved in inter subjectivity to confront a new paradigm centred on the hypothesis of a neuronal correlate of empathy and the idea of a biological basis of sociality. In particular, through a series of recordings of individual neurons, the two researchers discovered that in a sector of the premotor cortex of the monkey (area F5) there are neurons which are activated during both the active execution, by the monkey’s actions such as grasping or manipulating objects, and during the observation of similar actions performed by another agent (another monkey or a human). These neurons were then called mirror neurons to emphasize their dual nature of action and action observation. Therefore, from a neuronal point of view there is some difference between when a subject completes an act and when he/she simply observes another individual accomplishing the act. Over the past 10 years, numerous neuroimaging research studies have allowed us to locate the operation of the human mirror system in different situations and to verify the existence of an anatomical correspondence between the cortical circuit involved in visual-motor transformation as studied in macaques and that also exists in humans (Rizzolatti and Sinigaglia 2006). When a human being observes an action, there is an activation of complex brain areas that include the occipital, temporal, parietal lobe of the visual areas, and two areas with a mainly motor function: the rostral portion of the parietal lobe and the lower part of the pre-central gyrus together with the rear part of the inferior frontal gyrus (IFG). Comparative studies have suggested that at the end of the human homologue of area F5 of the monkey can be identified in the pars opercularis (Brodmann area 44), an area that has always been assumed to be related to speech production. However, more recent studies have actually shown that it is also implicated in the processes of organizational actions, foreshadowing of motor acts and understanding of actions, demonstrating how the area 44 is not exclusively used for the language (Iacoboni et al. 1999; Buccino et al. 2001).

The discovery of mirror neurons has corroborated the theory of social psychology and the automaticity and pervasiveness of imitation and empathy. It is not only the vision of the motor patterns of others that trigger the activity of mirror neurons, the observation of emotional response also generates a mirror response: when seeing other people’s emotions, the observer can determine the activation of the cortical region that is normally active when the observer tests that emotion (Rizzolatti and Vozza 2008). In people, the two emotional experiences, direct and observed, cause an activation of the same areas of the cortex. The properties of these neurons reflect not only movement but also dissolve the problem of the emotions of other minds: humans are social animals because our neural activity is coordinated with, and depends on the neural activity of people who are around. This feature leads to intentional consonance; by virtue of the mechanisms of mirroring, the other is experienced as another self (Gallese 2007). To understand the importance of reflection at the cognitive level of brain activity it is interesting to report an experiment that explored the role of mimicry in the expression of the cognitive skills of general knowledge (Ferguson and

Bargh 2004). It was asked of healthy adult human volunteers to answer general knowledge questions from the board game “Trivial Pursuit”. Those who before being subjected to questions had been engaged for thirty minutes reading articles on Hooligans showed significantly lower performance than subjects who had read for thirty minutes narratives of scientists or writers. Specifically, according to Vittorio Gallese: “If—through simulation—we go even for half an hour in the cognitive framing of a Hooligan, our pre-existing cultural knowledge produces a poorer performance than when we enter a period equivalent to the cognitive framing of an intellectual” (Gallese 2007, p. 203). Mirror neurons allow an implicit form of understanding the actions of others, establishing a sort of bridge between the observer and an actor of an action and enabling very important imitative behaviour. This neuronal identity allows us to explain the particular affinity that was observed experimentally between the behaviour of a player and behaviours that he observed in another player, but there was a limit because of the strictly motor function of these mirror neurons. What interests us, beyond the actions performed by players, are the intentions that guide them and make them intelligible to others. If the character of such knowledge among the players can be explained by the mirror system, its intentional content, however, is elusive. Some experiments that link the intentionality of an action to its contextualization suggest that this system could also be extended to the recognition of intentions (Iacoboni et al. 2005).

However, the answer to our question is not simply limited to players and to identifying the intentions of others, but that their intentions are also identified by other players. The mirror system allows us to recognize, for example, that another person is angry or wants to grasp an object. However, we must also be able to explain the subsequent conduct of an individual in a complex social situation (such as those alleged by game theory). It is not enough to recognize that the other is angry but one must try to realize why he’s angry, tracing and updating it in oneself the reasons for his state of mind, reconstructing the context that caused the error. Along these lines, a very interesting position is advanced by the philosopher Stueber (2010) who proposes to distinguish between empathy (basic) and re-enactive empathy. The first defines the unmediated mechanisms that underlie our theoretical capabilities to perceive and recognize other creatures directly as essentially thinking beings like us. Re-enactive empathy, in contrast, contains our cognitive capacities and resolutions that allow us to actualize and imitate the thought processes of others in our mind and then to design the complex social behaviour of other people’s behaviour as rational agents that act on the basis of reason. While basic empathy can be explained by considerations related to neurological mechanisms (mirror neurons) and the results derived from experimental psychology, empirical, re-enactive empathy requires a philosophical reflection from the vantage point of the investigations on the nature of rational action (folk psychology). Specifies the author: “.... use the term “empathy re-enactive” to refer to the required Simulative Capacities Because, in contrast to Goldman, for example, I see the Notion of rational agency to be at the centre of our folk psychological practices. Rational agents are not creatures who act merely, because something is

happening inside them. Rather, they are able to take a reflective stance towards their own agency and to take ownership of their action in terms of their reasons for acting. Being able to do this, I maintain requires that One's agency is potentially intelligible to oneself in terms of one's understanding of the world, one's long-term plans, and the standards and rules of conduct that one is committed to..." (Stueber 2012, p. 59).

While it is true that we cannot explain all the complex inter-subjective experiences only with the help of mirror neurons, actually something has been accepted by the discoverer himself when he says: "Mirror neurons do not empathize anything, simply for the fact that they are not people. They know nothing about actions, intentions, beliefs, emotions, know only the exchange of sodium and potassium, and electrical impulses. Give the subject a direct mechanism, automatic, non-predicative and non-inferential simulation". It seems to Stueber, that we are asking a bit too much of re-enactive Empathy, so that, with good reason, Shaun Gallagher writes about Stueber, "Third, a problem that is both terminological and conceptual. Stueber (2012) uses 'empathy' as just another term for social cognition, even the most basic, default, and automatic resonance-based mode of social cognition. To associate it with mirror neuron activation, as Stueber and many others do, is to make empathy the automatic default mode of social cognition. On this view, if it is true that my mirror neurons activate whenever I see you engage in intentional action, and this generates some basic form of empathy, then, in effect, I cannot help but empathize with you—even in the case of seeing you engage in what I take to be an obnoxious action. Stueber (2012) also considers high-level re-enactive processes as a further variety of empathy. In either respect, however, there is no difference between empathy and ordinary, everyday understandings of others, or what some theorists call 'mindreading.' Other theorists, including myself, however, and in some agreement with ordinary language, suggest that empathic behavior involves an other-directed feeling of concern or interest, distinct from both sympathy and mindreading. Is this not another variety of empathy to be considered?" (Gallagher 2012, p. 65).

Gallagher rightly makes mention of the term social cognition because this expression of empathy is more comprehensive since it refers, as we have seen, to all the cognitive processes that mediate interpersonal relationships (not only empathy, but also mind-reading and imitation, along with language and consciousness). Trying to capture the essence of social behaviour and avoid the temptations reductionism implies necessarily taking into account the different levels of description of the matter: from neural dynamics to social dynamics, the adaptive logic of its path of development in the phylogenetic and its appearance during the ontogenetic development of different species. With regard to our specific field of investigation, therefore, it seems once again that when we want to understand and anticipate the behaviour of others, calibrating their actions accordingly, we need all the components of social cognition with the result that we need to integrate different investigation techniques in a multidisciplinary perspective.

2.5 Doubts, Feasibility and Future of Neuroeconomics

Neuroeconomics seems to have secured an important place in research, and numerous laboratories and centers have been created to develop research and studies in this new field. Now that its concepts and methods have been clarified, it has become possible to examine and question the relationship that it might establish with traditional economic research. Many economists, in fact, have expressed doubts about the relevance of neuroeconomics and in general of neuroscience in traditional economic studies. The more radical criticism is to deny the relevance of the neurological and psychological causes of behavior to economics. This criticism has been made forcefully by Gul and Pesendorfer (2008). In fact, they argue that economics is not normally interested in such matters as neuroscience and psychology: economics pursues different objectives and must use abstractions suitable to its own purposes. Gul and Pesendorfer are particularly important in this debate because they put forward a distinction between “true utility” and “choice utility”. In the opinion of the two authors, economics should be interested only in the second (as is the standard economic theory), by defining the utility function of an agent only in relation to the notion of choice. To say one option is more useful than another, in this sense, simply means to say that a rational agent would choose it. Gul and Pesendorfer oppose, by contrast, the tendency of many neuroeconomists wanting to return to the idea that there is “true utility” linked to pleasure or to some other motivating factor, which is similar in many respects to the cardinal concept present in the early utilitarian philosophers. The neurological or psychological variables that cause choices are not simply relevant from an economic point of view. The economist does not need to know, for example, that to prefer x to y is motivated by the pursuit of happiness, a sense of duty, a religious obligation or an impulse (Gul and Pesendorfer 2008). The only thing that should matter to economists is the relationship of preference revealed by the choices.

This defense of the standard approach does not imply that the economy is entirely isolated from psychological research. However, it must incorporate only relevant data, i.e. data on choices and behaviors. The data produced by psychology or by experimental economics can thus be used as a model to measure and predict future choices or balances. In contrast, data or variables unrelated to choice, such as neuronal activity data, must not find space in the theoretical model. To paraphrase Hilary Putnam, it is irrelevant to the theory proposed by Gul and Pesendorfer whether the brain is made of gray matter or Swiss cheese.

There are many ways to respond to criticisms made by Gul and Pesendorfer. The first of these, advanced by Ross (2005, 2008), is to argue that neuroeconomics is not limited to the approach that they criticize. According to Don Ross, in fact there are at least two ways to study neuroeconomics. The first one which he called “behavioral economics through the scanner”, which is also the best known, seeks to identify the neural mechanisms which produce decision-making. But

there is also a second way, less known but no less important, namely “neurocellular economics”. This approach aims to apply methods and economic techniques to unconventional systems: networks of neurons. The originality of this position consists in stating that the neoclassical approach to economics is better suited to the construction of behavioral models of neural networks than to those of traditional economic agents (individuals). Neural networks, in fact, are less likely to violate the axioms of the theory of revealed preference, which makes neoclassical theory particularly useful to building models of their behavior. This paradigm assumes, for example, that a given cortical area or a dopamine circuit acts as a market whose behavior can be modeled thanks to the theory of general equilibrium. Neurons, instead, are regarded as agents whose activation reveals preferences. The application of neoclassical theory to neuronal circuits is promising: it allows us to question an idea according to different abstractions used by neuroscience and economics, related to the various objectives they pursue (Bourgeois-Gironde and Schoonover 2008).

However, this approach shows a greater enrichment of neuroscience through economic theory and, therefore, the criticism raised by Gul and Pesendorfer remains intact with regard to the relevance of neuroscience for economics itself. A decisive answer from this point of view comes from Colin Camerer, according to whom economic theory is not obliged to disavow its neoclassical matrix, it has only to gain and draw from the conceptual and empirical wealth of psychology and neuroscience to build models of adequate explanation. In his reply to the text of Gul and Pesendorfer, Colin Camerer, recognizes that “since behavioral economics is meant to be a generalization of rational choice theory which incorporates limits on rationality, willpower and self-interest in a formal way. These generalizations allow the possibility that conventional rationality is an adequate approximation, and often permit a parametric way to measure the “degree” of limitedly rational behavior and its economic impact.” (Camerer 2008a, p. 44). In particular, according to Camerer, neuroeconomics adds a neuro-causal component to the theory of rational choice, but his approach is not fundamentally different from that of neoclassical theory. Let’s give an example. The theory of revealed preference claims that it is necessary to draw a utility function from the observation of the behavior of the agents, which allows one to predict their future behavior. If you choose, for example, to eat, in different contexts, an orange rather than an apple and if your choice resists various forms of interference and is firm, we can conclude that you prefer oranges to apples. Neuroeconomics only expands the data and the variables considered in the previous example to include the behavior of neuronal components. Consequently, the central question, one to which Gul and Pesendorfer do not respond, is whether the data and neuronal activations allow as is always stated by Camerer to improve the ability to understand and predict the choices, while maintaining the discipline of mathematics and the use of behavioral data (Camerer 2008a).

Certainly, a good part of economics remains heavily influenced by the instrumentalist interpretation which sees in the forecast (rather than in the explanation) the highest goal of the models it develops. But even if one accepts this

interpretation, one must bear in mind that the safest way to predict the behavior of any system is to have a good understanding of its functioning. Gul and Pesendorfer emphasize strongly that the economist should rely on “the data on the choices” to measure the reliability of its models. The problem is obviously that it is impossible to interpret the behavior of an individual such as, for example, his choices without a variety of underlying assumptions, which are based in particular on how this individual will represent the options and their probability (the beliefs) and on the way in which he attributes them a value (his wishes). Without these options on the way in which states of mind change, a set of behaviors cannot simply reveal the relationship between preferences: we would be faced with the practical problem of indeterminacy of Quine-Duhem (Guala 2005). This affirms that the economist does not need to know if the agent “is motivated by the pursuit of happiness, a sense of duty, an obligation or a religious impulse” (Gul and Pesendorfer 2008, p. 24), which introduces considerable confusion. In fact, even at the level of ordinary language, the concepts “the pursuit of happiness” “sense of duty”, “religious obligation” or “on impulse” define determining characteristics of the utility functions of agents. To say that someone acts on “impulse”, for example, means attributing to the agent a utility function which is sensitive to the passage of time. So there is behavioral data relevant to determining whether or not someone acts on impulse: just measure the impact of the passage of time on his behavior. At the same time, it is interesting for an economist to know if a person acts out of a “sense of duty” or “interest”, because “the sense of duty” refers to the idea that his preference would remain the same even if his interest changed. One can reply by saying that the economist does not just want to know whether or not a given behavior is or is not sensitive to the passage of time, but he wants to be able to quantify the impact of the time variable in a formal model. Or again, he wants to know exactly to what extent the sense of duty makes the behavior resistant to the interference of personal interests. Once the question is presented in this way, however, it becomes much less interesting to try to determine if the economist has the right to use a concept such as “impulse” to describe a utility function or whether he should limit himself to formal representations of preference relationships. You could support the second option, as do Gul and Pesendorfer, but this implies a narrow vision of the conceptual means available to the economist. Moreover, this also leads the economic theorist to move away from the concrete practice. Contrary to what happens in theory, the naive and scientific psychology terminology is ubiquitous for describing utility functions.

However, if we admit that neuroeconomics may be relevant, we must understand if it is already or if it can potentially become so. On this subject, opinions differ. Some, like Harrison (2008), appear largely pessimistic due to the considerable gap between the claims and achievements of neuroeconomists. Others, like the aforementioned Colin Camerer, are quite optimistic and believe that the contribution of neuroeconomics is already real. Harrison’s skepticism derives from a characteristic of neuroeconomic research referred to above. We saw, in fact, that neuroeconomics is often limited to a search for neural correlates of known and studied phenomena in psychology and behavioral economics: for example, the

aversion that comes from receiving unfair offers, the pleasure of punishing incorrect behavior, the suffering related to social exclusion. But, if a phenomenon has already been studied on a psychological and behavioral level, what need is there to know the neural correlates? Harrison raises precisely this point. Let us consider variables such as risk aversion or aversion to ambiguity. Not only are the phenomena well-known on a psychological level, but there are numerous experimental methods which allow determining the value of the agents. What then can neuroeconomics add? Ideally, it can help to identify the components of the mechanisms involved in the production of these two phenomena. For example, Brian Knutson and colleagues (Knutson et al. 2005) showed that the medial prefrontal cortex (CPFm) is activated in proportion to the objective probability of gain. For their part, Ming Hsu and colleagues (Hsu et al. 2005) have established that there is a positive correlation between the ambiguity of a choice and activation of a circuit connecting the amygdale and the orbital frontal cortex (COF). These studies show, therefore, that two phenomena are identified as distinct from behavioral economists—risk aversion and aversion to ambiguity—are produced by distinct mechanisms. What can the economist derive from this discovery? Does it allow him to better assess the utility functions of the methods traditionally used by behavioral economics? Once again Camerer (2008b) seeks to give an answer to this question by trying to clarify what the economist can derive from the analysis of neurons. Camerer's idea is to use data on the brain to decide empirically between theories that are difficult to distinguish by means of tests of market forecasting (using the usual data). Camerer's claims therefore remain relatively modest.

Neuroeconomics allows us to see if the models are on the right track, by verifying for example, if separate variables correspond to components or separate processes. Neuroeconomics, according to Camerer, however, may be destined to play a greater role, leading economists to consider the importance of variables hitherto neglected. In this case, it would cease to trail psychology and behavioral economics, and would drag the economy directly to a beneficial progress.

If the idea of producing decision-making neuroscience is seductive, it is however, necessary to recognize the limitations of the research conducted so far. Neuroeconomics meets the same methodological difficulties as cognitive neuroscience. As shown in detail by Craver (2007), all neuroscience methodology has limitations. The visualization of brain imaging and recording unitary neuronal activity, for example, are used to locate areas in which brain activation coincides with decision-making, but are not enough to prove the causal implications of these surfaces. Further arguments must be added to the techniques of localization. Some authors have criticized the tendency of neuroeconomics to draw hasty conclusions based on very limited experimental data (Rubinstein 2006; Harrison 2008). If the criticism is justified, it is more about the rhetoric that often accompanies these studies, and the neuroeconomists are certainly not to blame for wanting to promote their research programs. The limits of the various approaches do not justify the abandonment of the search for causal mechanisms, but encourage us to be prudent and to remember the importance of the integration of the different methods.

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