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Review

Embodied economics: how bodily information shapes the social coordination dynamics of decision-making

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To date, experiments in economics are restricted to situations in which individuals are not influenced by the physical presence of other people. In such contexts, interactions remain at an abstract level, agents guessing what another person is thinking or is about to decide based on money exchange. Physical presence and bodily signals are therefore left out of the picture. However, in real life, social interactions (involving economic decisions or not) are not solely determined by a person's inference about someone else's state-of-mind. In this essay, we argue for *embodied economics*: an approach to neuroeconomics that takes into account how information provided by the entire body and its coordination dynamics influences the way we make economic decisions. Considering the role of embodiment in economics—movements, posture, sensitivity to mimicry and every kind of information the body conveys—makes sense. This is what we claim in this essay which, to some extent, constitutes a plea to consider bodily interactions between agents in social (neuro)economics.

Keywords: neuroeconomics; motor cognition; sensory theory of value; interpersonal interactions; sensorimotor coordination; mimicry

> 'To the soul's desires, the body listens
> What the flesh requires, keeps the heart imprisoned
> What the spirit seeks, the mind will follow
> When the body speaks, all else is hollow'
> Martin L. Gore (2001)

In real social life, the signals sent by the body and the physical presence of others influence the way we act and decide. In economic theory they do not. But why would there be salesmen or bank employees working so hard to gain our trust and influence our economic decisions with their smiles, gestures and manners if their actions were useless? In other words: 'Behavior affords behaviour. [...] what the buyer affords the seller cannot be separated from what the seller affords the buyer, and so on' (Gibson 1979, p. 135). Hence, in economics, considering the role of the human body—its movements, postures and every kind of information it conveys including emotions—makes sense.

A better understanding of how agents physically interact would certainly enrich our knowledge of the coordination dynamics of economic decision-making in individual and social contexts. To a certain extent, many scientist consider that this need to study the effects of bodily factors on economic decision has been filled using neuroscientific tools and the advent of *neuroeconomics* (Glimcher *et al.* 2008). But a brain is not a body, it just happens to be a(n important) part of it. Moreover, on its own, a brain happens to be rather useless. As Erwin Schrödinger wrote: *'Consciousness finds itself intimately connected with, and dependent on, the physical state of a limited region of matter, the body'*. (Schrödinger 1958 [1992, p. 88]).

So one might ask: *what do we have a brain for?* A simple (or simplistic) answer could be that our brains allow us to produce adaptive behaviour and therefore to live. In order to achieve this goal, the brain needs to do what it does best: interacting. The brain 'lives' in the human body to which it 'talks' and 'listens' constantly thanks to the nervous and endocrine systems. The body lives and moves in a physical environment, picking up information, perceiving and also acting upon it. Other bodies evolve in this environment creating social interactions and giving rise to a society. And, as if things were not complicated and complex enough, experiences and goals, i.e. past and future, come into the game, or the equation, depending on how one envisions

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One contribution of 12 to a Theme Issue 'Rationality and emotions'.

interactions. But, '*biological brains are first and foremost the control systems for biological bodies. Biological bodies move and act in rich real-world surroundings*' (Clark 1998, p. 506; cited in Wilson 2002).

This is why we argue for *embodied economics*: an approach to (neuro)economics that takes into account how information provided by bodily signals, the physical presence and displacements of others (or its imagination) influence the way we make economic decisions. At least this is what we claim in this essay which, to some extent, constitutes a plea to considering bodily interactions between agents in social (neuro)economics.

1. THE PHYSICALIST INSPIRATION: A DISEMBODIED CONSTRUCTION OF ECONOMICS

For political economics, physics has not only constituted a means of reaching mathematical formalization (Mirowski 1989) but also a way to avoid the caveat of subjective analysis and distinguish itself from sociology and psychology. However, one should keep in mind that physics still bears a substantial level of subjectivity. To provide information, a dataset requires the inspection of an observer and when the time comes to read and interpret these data his senses and subjectivity are at stake (Schrödinger 1958 [1992]). Along a similar line, Lakoff & Johnson (1999, p. 522) insisted on the importance of metaphorical interpretation in (mathematical game theory used in) rational choice theory: 'The point of the analysis is to show that the mathematics alone, with no metaphorical interpretation, says nothing whatever about rational choice'.

One way or another, the human scientist, with his knowledge and emotional states-of-mind comes to interpret the data and problems (Polanyi 1966 [2009]), injecting bits of subjectivity and aesthetics here and there (Changeux 2002). Even results obtained thanks to the most rigorous measurement tools and protocols need at one point to be discussed. This is why, like many other fields, physics cannot be abstracted from the arbitrary of our senses and emotions: 'our body is the ultimate instrument of all our external knowledge, whether intellectual or practical' (Polanyi 1966 [2009], p. 15). The world surrounding us might be an assembly of physical properties, but the world as we perceive it is the (by-)product of our interacting brain and therefore of our subjectivity: 'The take home lesson is that our body, our brain, and our consciousness did not evolve to yield a scientific picture of the world' (Edelman 2004, p. 136).

Hence, the human body pertains to our world. We are not just talking about the body of the observer here, but also the bodies of other people. Contrary to the 'principle of objectivation' that runs in mainstream scientific beliefs, we have to take into account that: 'First, my own body (to which my mental activity is so very directly and intimately linked) forms part of the object (the real world around me) that I construct from my sensations, perceptions and memories. Secondly, the bodies of other people form part of this objective world [...] [and are] the seats of spheres of consciousness' (Schrödinger 1958 [1992, p. 118]).

In spite of these aspects (and besides the never ending search for better formalization), refusing judgements and their intrinsic subjectivity in economic theory lead to the advent of 'cold' processes: 'As economics became increasingly mathematized, the appreciation of affect waned commensurately' (Loewenstein & O'Donoghue 2004, p. 44). Emotions were, for a long while, evicted from economic analyses, being the collateral victims of economic rationality and reasoning and, more largely, of the '[...] slavish imitation of the method and language of Science' (Hayek 1952 [1979, p. 24]).

One has to remember that economics was not about explaining decision-making or justifying the preferences of an economic agent (see Camerer 2006 about Pareto's position on psychology in economics). This was not only one side of pure walrasian political economics. In *The counter-revolution of science*, Hayek (1952 [1979, p. 68]) known for his leaning towards theoretical psychology, made the following statement: 'It is a mistake, to which careless expressions by social scientists often give countenance, to believe that their aim is to *explain* conscious action. This, if it can be done at all, is a different task, the task of psychology'. Hayek's view can be explained (at least partially) by his concept of *spontaneous order*: market tendencies as social phenomena are not the by-product of our will, but an order emerging from the interaction between individual economic components. The concept of emergence refers to something that is not hierarchically prescribed. As such Hayek's spontaneous order depicts the market as a self-organizing dynamical system (Atlan 1969; Kelso 1995).

Does rejecting psychology automatically mean excluding the influence of the body and its dynamics? The answer would be 'yes', undoubtedly, according to Mises who points out his *praxeology*'s principles by stressing that economics deals with '*will*' and '*purposive behaviour*' (or '*human action*'). In his view, economics does not consider '[...] a reactive response to stimuli on the part of the bodily organs and of the instincts, which cannot be controlled by volition' (von Mises 1944, pp. 533–534). *De facto*, Mises rejects *visceral factors* from economic theory while recognizing their influence on cognition. To some extent, he was right: visceral factors have been of particular interest for psychologists, not for (most of the) economists. But since then, several authors have considered them in their economic analyses to better understand why certain decisions deviate from what economic agents wish and/or rational choice theory predicts (cf. Loewenstein *et al.* 2001).

2. MENTAL IMAGES: A FIRST STEP TOWARDS CONSIDERING BODILY FACTORS IN ECONOMICS

At some point, economic theory opened a little bit to psychology and to bodily influences on decision-making. This tendency can be attributed to Herbert Simon, known to have criticized the unrealistic positions of neo-classical economics by introducing the

concept of *bounded rationality* (Simon 1955). He explored the determining importance of the body ('s sensory and motor systems) in behaviour, emotions and decision-making (Simon 1967). Along with this view, emotions suspend judgement, they allow sorting of information and retention of only what is necessary to make a decision. Ultimately, he claimed that 'in order to have anything like a complete theory of human rationality, we have to understand what role emotion plays in it' (Simon 1983; p. 29).

Ever since, the bodily illustrations of emotions have been further considered by behavioural economics. For example, Loewenstein and colleagues developed the *risk-as-feelings hypothesis*. This conceptual framework includes both *anticipated* and *anticipatory emotions*; the latter often being neglected by '*cognitive and consequentialist theories*' (Loewenstein *et al.* 2001). The risk-as-feelings hypothesis is close to Damasio's *somatic markers* in spite of not having exactly the same goals (Bechara & Damasio 2005). Both assume that the affect plays an informational part in decision-making. However, the risk-as-feelings hypothesis addresses why emotions experienced when making a decision often result in deviation from individual decisions that would be considered the best solution in a traditional (and rationality-based) economic model. This divergent effect of emotions on decision-making is mainly ascribable to visceral factors, i.e. to anticipatory emotions. In addition, there is an obvious conceptual proximity between the risk-as-feelings hypothesis and the *affect-as-information-hypothesis* (Schwartz & Clore 1983), or the *affect heuristic* (Slovic *et al.* 2004). Affect heuristic is classified by its promoters as the *experiential system* that is to be distinguished from the *analytical system* in an individual's apprehension of risk. This constitutes an alternative to Epstein's (1994) typology as it distinguishes the experiential system from the rational one. However, as Slovic emphasized, thanks to Damasio's work we know precisely that both the experiential and the analytical systems take part in individual rationality. Slovic *et al.* (2004, p. 6) summarize the difference between analytical and experiential systems as follows: 'The *rational* system is a deliberative, analytical system that functions by way of established rules of logic and evidence (e.g. probability theory). The *experiential* system encodes reality in images, metaphors and narratives to which affective feelings have become attached'. It is noteworthy that they consider affect heuristics together with the risk-as-feeling hypothesis given their role in experiential thinking. Besides, Slovic *et al.* (2004) showed that, in people's mind, contrary to what actually occurs, risks and benefit are negatively correlated. In addition, these concepts converge with Damasio's hypothesis that humans rely on mental images (Loewenstein *et al.* 2001), and therefore raise several questions.

First of all, one can wonder to what extent mental images are a representation (or picture) of the environment in which we evolve. Francisco Varela (1996) refused to consider the mind as a simple mirror reflecting the world we live in.[1] In this perspective, the brain does not build up a (re)presentation of the world. Common knowledge of the world is therefore *embodied*: the world does not exist independently of the actor. It seems to us that Damasio is not to be considered among those who reject Varela's theory of representation (Damasio 1999). Consequently, the risk-as-feeling hypothesis as well as the affect heuristic can be viewed in terms of embodied cognition or 'enaction' (Varela *et al.* 1992). By extension, one can wonder if relying on mental images as by-products of our body interferes with our representation of the world. This is not what we have taken from both articles (Loewenstein *et al.* 2001; Slovic *et al.* 2004). It is noteworthy, however, that Loewenstein & O'Donoghue (2004, p. 28) consider bodily responses (e.g. heart rate, skin conductance) and mental images in the nonlinear probability weighting of risk preferences and conclude that 'because such images are largely invariant with respect to probability [...] emotional responses tend to be insensitive to probabilities'.

Hence, the importance of the body in our perception of the world is not to be neglected. This position is defended, among others, by Lakoff & Johnson (1980). They argue that our body is used, through *ontological metaphors*, to provide us with representations of things, scenes or people. Along a similar line, Jonathan Haidt (2001, p. 825) advanced that: 'Whereas Damasio focuses on the role of automatic nervous system in thinking, Lakoff and Johnson have shown how the entire range of physical and emotional experience may underlie our "embodied cognition" '. As such the human mind does not correspond to the rationality usually described by Western philosophy. Our thoughts (or, may we say, our *profane rationality*) are not literal, logical, conscious, transcendent or dispassionate but *'fundamentally embodied'* (Lakoff & Johnson 1999, p. 514). With respect to the links between what we refer to as profane rationality and, in particular to the 'mathematization' of rational choice, they further add: '[...] what Kahneman, Tversky and their coworkers have actually shown is not that people are irrational [...]. [But] that people really do reason using metaphors, frames, and prototypes' (Lakoff & Johnson 1999, p. 527).

3. ON METAPHORS, CATEGORIZATION AND EMBODIED RATIONALITY

One's rationality can therefore be considered as embodied, 'in-corporated' in other words, supporting the hypothesis that we reason with our body. According to Lakoff & Johnson (1999, p. 537), our volition is not independent from our corporeity for two reasons: 'First, many of our concepts arise from built-in constraints on the body, for example, spatial-relations concepts. Second, as we learn our concepts, they become parts of our bodies. Learned concepts are embodied via permanent or very long-term changes in our synapses'. Such a line of thinking resonates with Jean-Pierre Changeux's '*neuronal habitus*' a concept grounded in *epigenesis* to translate Pierre Bourdieu's work in neuroscientific terms (Changeux 2006; see also Basso & Oullier in press, for an extensive treatment). This conception also echoes Hayek's views on the human mind. Indeed, Lakoff & Johnson's

(1980) theory of metaphor refers to categorization in human perception and explains learning 'via the Hebbian principle that *Neurons that fire together wire together*' (Lakoff 2008, p. 26). Precisely, Hayek defines the mind as a process of classification (Hayek 1952 [1976, p. 48]) and is considered as the co-discoverer of the *Hebbian rule* by Nobel laureate Gerald Edelman (2004, p. 22).

Hayek's position regarding the functioning of the mind as a classification process is coherent with his subjectivist approach to economics: the market is a place of incertitude i.e. a *locus* of radical ignorance. Categorization permits us to find (and to create) regularities in the world and so '*Rules are a device for coping with our constitutional ignorance*' (Hayek 1976 [1982, p. 8]) for our actions to make sense. Not so far from Hayek's analysis, Edelman states that: '*One of the most basic processes in higher brains is the ability to carry out perceptual categorization—to 'make sense' of the world*' (Edelman 2004, p. 49).

Hence, categorization is based on our interaction with the world. Categories are not arbitrary but primarily determined by our sensorimotor coordination with the world (Rosch *et al.* 1976). We identify environmental regularities in order to simplify the information that reaches us, and ultimately to make sense of it. This process is a by-product of our bodily experience not only in our physical, cultural and social environments but also in our economic one. Indeed, Lakoff and Johnson show how *personification* is an extension of ontological metaphors. They allow us 'to make sense of human phenomena in human terms' and are, for instance, applied to '*INFLATION IS AN ADVERSARY*' for fighting against it (Lakoff & Johnson 1980, pp. 33–34). In spite of what Epley & colleagues (2007, p. 967) consider a '*weak version of anthropomorphism*', this (ontological) metaphor clearly impacts economic behaviour.

We can find numerous examples where metaphors are used in finance (e.g. Morris *et al.* 2007). Practices in finance also reveal bodily influences in order for activity on the market to make sense. For example, *technical analysis* (also known as *chartism*) is intrinsically anthropomorphic: bodily metaphors are used to describe graphical representations of financial trends and to identify archetypal patterns such as '*head and shoulders*' when a peak on a chart is higher than the previous and the following ones (e.g. Osler & Chang 1995). Here, we are going even further in the use of anthropomorphism. Bodily influences in reasoning are also present in orthodox economics where diagrams are used (e.g. IS-LM-BP, WS-PS, etc.). As Bauer & Johnson-Laird (1993) stressed, diagrams can '*improve reasoning*'. Alain Berthoz's (2003) interpretation is that graphical representations are fulfilling our need to spatialize problems and link them to our body.

This form of subjectivism (i.e. the search for meaning and making sense of economic events) is not isolated in economics (Butos & Koppl 1997). For instance, in a somewhat different perspective, the analysis on Keynes' 'Animal Spirits' reveals the importance of bodily experience in decision-making: 'in presence of such an uncertainty "it is reasonable [...] to be guided to a considerable degree by the facts we *feel* somewhat confident about" ' (Keynes cited in Marchionatti 1999, p. 421). The concept of animal spirits refers not only to 'feelings'[2], but also includes many other aspects such as *confidence*, *fairness*, *corruption*, *bad faith*, *money illusion* and *stories* (Akerlof & Shiller 2009, p. 5). They are all important to understand why human reason is not a 'carbon copy' of what the rational choice theory predicts. Furthermore, it seems to us that *stories* are very close to metaphors because they reveal our strong tendency and repeated attempts to make sense. Indeed, as Akerlof & Shiller (2009, p. 51) wrote: 'The human mind is built to think in terms of narratives, of sequences of events with an internal logic and dynamic that appear as a unified whole'. We make sense of economic events with storytelling and interpreting actions of others. Applied to confidence this consideration gives rise to a theory of mind: 'Confidence is not just the emotional state of an individual. It is a view of other people's confidence, and of other people's perceptions of other people's confidence' (Akerlof & Shiller 2009, p. 55). Here, confidence is clearly speculative by nature and meets the Hayekian analysis of subjective value (Basso & Oullier in press). In spite of these similarities between Keynes and Hayek[3], in the following section, we would like to focus on Hayek's singular contribution to this bodily aspect of economics.

4. HAYEK AND THE BODY: EPISTEMOLOGICAL FOUNDATIONS FOR SOCIAL NEUROSCIENCE

Many years before Lakoff & Johnson's (1980) analysis of personification, economist and social scientist Friedrich Hayek expressed pioneer views in his work exploring the anthropomorphism of language: 'Our tendency to personify (to interpret in anthropomorphic or animistic terms) the events we observe is probably the result of such an application of schemata which our own bodily movements provide' (Hayek 1963 [1967, p. 52]).

Our interpretation of Hayek's positions is that (the consequence of) the anthropomorphism forces us to depart from an analysis solely based in terms of *correlations* and to favour one expressed in terms of *causality*. Motivated by a logic of manipulation and intervention (Sloman 2005), individuals seek causality in the world. They try to reach it mostly by rebuilding *a posteriori* a phenomenon thanks to profane theories (or *speculative opinions*[4]). They try to make sense of their environment and, therefore, their subjectivity imprints the world (Gazzaniga *et al.* 1977; Nisbett & Wilson 1977). Our environment is an 'elaboration of a surplus signification': the world is 'enacted' in a fashion that reveals the 'brain as a generator of neural "narratives" ' (Varela 1999, pp. 56–57).

In *The sensory order*, Hayek argues that the body modifies the way *impulses of the physical order*[5] are perceived and therefore allows perception to be sensory in nature (Hayek 1952 [1976], p. 9, §1.28). For him, the human body is not to be separated from the brain, as he clearly explains this monism: '[...] we shall have to examine not only the effects of the sensory on the

motor processes, but also have to give much greater attention than we have yet done to the sensory impulses set up by the various processes in the body, that is to the registration of stimuli which originate in what has appropriately been called the *milieu intérieur*, the internal environment, within which the central nervous system functions' (Hayek 1952 [1976, p. 80, §4.3]).

Besides, Hayek pointed to the circularity of the relation between sensory and motor processes as human behaviour is associated with motor responses and the body interplays with the conscience (or the attention; Hayek 1952 [1976, p. 81, §4.8; p. 89, §4.34]). He clearly deduced that 'Behaviour has to be seen in a double rôle: it is both input and output of the activities of the higher nervous centres' (Hayek 1952 [1976, p. 90, §4.38]). In contemporary words, it means that 'Even a change in posture that is not accompanied by any change in sensorial stimulation will alter the neural responses [...]' (Varela 1999, p. 47).

5. EMBODIED COGNITION

One could see Hayek's stance as the inheritance of William James's (1890) views on the tight links between sensory, motor and emotional processes. Hayek's vision of the sensory order can also be connected to many modern concepts that were developed in psychology, social and brain sciences. This is the case with James Gibson's (1979) ecological approach to (the interdependence of) perception and action, a psychological view that has been echoed at the neurophysiological level in the 1990s with the discovery of *mirror neurons*.[6] Jean Piaget's work can be considered along this line of thinking as well, since he studied the links between sensorimotor and cognitive processes in child development thanks to the concept of *schemes*: a representation of perceptions, ideas and action in the mind (Piaget 1978). At a different level of analysis, *reentries* that are at the core of spatio-temporal consistency in our coordination with the environment (Edelman 1978) can be viewed as a biological illustration of some of Hayek's postulates (see Herrmann-Pillath (1992) and Basso & Oullier (in press) for a detailed investigation and analysis of the links between Hayek and Edelman).

To a certain extent, all these developments have participated in the advent of *embodied cognition*. Promoters of this theory argue that cognitive dynamics cannot be separated from, and are grounded in, the way our body interacts with its physical and social environments (see Wilson (2002) and Goldman & de Vignemont (2009) for reviews). As reminded by Wilson (2002, p. 625): 'Traditionally, the various branches of cognitive science have viewed the mind as an abstract information processor, whose connections to the outside world were of little theoretical importance'. The novelty is that cognitive processes can now be expressed in sensorimotor terms. Embodied cognition bolsters the historic, tenacious and false dichotomy between 'high level' cognitive processes and 'low level' sensorimotor ones. As brutal as it may sound for traditional neurophysiologists, this dichotomy is obsolete: our bodies, and our sensorimotor system, play a key role in sha(r)p(en)ing our minds (Oullier *et al*. 2008*b*).

Goldman & de Vignemont (2009) define and interpret embodied cognition with a particular emphasis on the 'cognizer's body'. It is the functional anatomy of the human sensorimotor system (e.g. which kind of sensors and effectors can be used), stressing the prevalence of some modalities with respect to others (e.g. vision over olfaction in most humans), that constrains our perception and representations of the world. By extension it also constrains the way we act within and/or upon the word, either overtly or mentally (Oullier *et al*. 2005*b*).

When considered in a social context, these advances in psychology and neuroscience participated in the birth of *motor cognition*, an approach that 'refers to the way in which we think about and conceive of our own and others' actions. [...] much of how we think about others' actions, and in turn engage in social interaction, arises from the activation or simulation of our own motor representations' and those representations rely on similar distributed neural systems' (Sommerville & Decety 2006, p. 179). Social motor cognition affords imitation, joint action, emotional and motor contagion (e.g. yawning), empathy and language understanding (see Goldman & de Vignemont (2009) for a critical view on the embodied properties of some of these behaviours). In addition, they also allow a person to 'mindguess'[7] what others are thinking, feeling or intending to do. Of course, we can think of facial expressions that can be a good indicator of someone's mood, but (whole-body) movements are also of interest.

Thanks to shared neural representations allowed, among other things, by the mirror system, the way other people move happens to convey important information that can be used by others to predict their intentions and goals (Schubotz & von Cramon 2008). Most of these findings can extend to economic decision-making (see Frith & Singer (2008) for a review and Teschl & Kirman (2009) in this issue for a focus on empathy in (neuro)economics). Hence, we have no doubt that the theory of embodied cognition needs to be integrated in economic studies; see Oullier *et al*. (2008*b*) for early suggestions, especially in the light of recent findings in *social neuroeconomics* (Fehr & Camerer 2007).

6. VISCERAL FACTORS AND SOCIAL NEUROECONOMICS

Experimental economics is built upon a strong contradiction. On the one hand, everything is done to standardize procedures and control for unwanted factors that could influence the behaviour of the agents—such as avoiding players to know and/or meet each other in person prior or during the experiment. By preventing some aspects of social interactions to occur, including being in the presence of each other physically, experimental economists acknowledge the potential bias bodily information could introduce to economic decisions. On the other hand, the bodily effect never appears in economic models in spite of

its influence being implicitly admitted by all the cautions taken when designing experiments in economics. All these cautions are justified given that something like physical appearance can influence decision during an economic game (Solnick 1999).

But acknowledging (explicitly or not) the importance of the body in designing realistic experimental paradigms in (neuro)economics is not sufficient. It does require some theoretical and methodological rethinking. Including bodily influences at the behavioural and brain levels in models of economic decision-making is a clear departure from Friedman's instrumentalism that has dominated economics for more than 50 years (Friedman 1953). The lack of realism of the *consequentialist model* is often imputed as one of the causes of the weakness of its predictive nature (e.g. Loewenstein *et al.* 2001).

Methodologically, *behavioural economics*, that has considered cognitive factors in the understanding of economic decision-making, is forced to acknowledge the role of emotions. As Russell stressed, emotions are necessary to run experiments: '[...] I have heard those who question the concept of emotion called *anti-emotion* theorists. Without everyday emotion words, how could researchers frame questions, propose answers, or even communicate with the participants in their experiments? I too must use these words to write this article' (Russell 2003, p. 146). Experimental economic settings such as the ultimatum game (UG; Güth *et al.* 1982) illustrate that economic decisions are the expression of *social intentions* that are translated into emotions.

Sanfey and colleagues (2003) used functional magnetic resonance imaging (MRI) to estimate brain activity of the *responder* in (a single shot version of) the UG—i.e. the player who decides whether to accept or reject the share of money proposed by another player depending on the level of fairness he grants it given that if he rejects, both players lose their respective shares. Among the network of brain areas distinguishing rejection from acceptance of an unfair offer in the UG, the dynamics of the anterior insula enables the experimenter to find out the responder's decision when facing an unfair offer. A study used electrodermal measures (skin-conductance) of emotional arousal to investigate the bodily reactions of the responder in the UG (van't Wout *et al.* 2006).[8] Patterns of electrodermal activity resembled closely those of the insula reported in the functional MRI study (Sanfey *et al.* 2003). They also revealed whether an unfair offer would be rejected or not. Taken together these two UG studies confirm what had been reported in previous contexts: among other functions to which it participates, the anterior insula is involved in processing visceral sensations and participates in the associated autonomic responses (Rilling *et al.* 2008). In addition, the insula exhibits significantly higher activity when pain is inflicted, or in contexts of hunger, anger or dislike. It happens to be a locus of cerebral coding for visceral factors known to influence economic decision (see Loewenstein *et al.* 2001); hence the similarities between insular and electrodermal patterns do not come as a surprise. Moreover, the insula also participates in processing and sharing primary emotions (anger, disgust; e.g. Wicker *et al.* 2003) that lead Mises to reject bodily organs and the instincts in economics (von Mises 1944). Disgust is a primary emotion and also a moral one: 'Our analysis suggests a cultural evolution of disgust that brings it to the heart of what it means to be human. [...] In this evolution the function of disgust shifted: A mechanism for avoiding harm to the body became a mechanism for avoiding harm to the soul. [...] At this level, disgust becomes a moral emotion and a powerful form of negative socialization' (Rozin *et al.* 2000, p. 650; Rozin *et al.* 2009). In the context of social interactions, Wicker *et al.* (2003) somewhat extend Rozin's stance by showing that observing faces of confederates expressing disgust activated the anterior insula of the observer similarly to what would occur if he were disgusted himself. They showed that, in order to understand the expression of disgust displayed by a peer, a feeling of disgust must be experienced by the observer himself (Wicker *et al.* 2003). Of particular interest in this context is the occurrence of *rapid facial responses* that participate in emotional contagion (Moody *et al.* 2007). Hence, not only sensations but also emotions are perceived and sometimes shared by the observer. They can also influence the decision made during the UG (Harlé & Sanfey 2007).

In light of all these studies, the insula (and its network) clearly appears as one of the areas of interest (in the brain) that constitutes a true interface between the bodily and more cognitive factors, including decision-making in social contexts.

7. ON MIMICRY, PROSOCIAL BEHAVIOUR AND GIVING

In the previous section, we discussed one example of biological processes related to body reactions that participate in decision-making (see also Frith & Singer 2008). Now, we would like to address another aspect that is particularly illustrative of the role of bodily information in social economic exchange: mimicry and the chameleon effect (Chartrand & Bargh 1999). Tanner *et al.* (2008) explored the impact of mimicry on choices and preferences in different contexts: when one is mimicking or is being mimicked. They showed that the previously reported tendency to mimic others extends to consumption-oriented behaviours. For instance, they observed that choices made by participants in their experiments were strongly influenced by choices of other people that they had previously attended. Moreover, the mimickers exhibited a strong tendency not only to choose the same goods as their peers but also to rate them higher. *A posteriori* interviews revealed that participants were unaware of the influence of social interaction and mimicry on their preferences. Tanner *et al.* (2008) also showed that participants who were physically and verbally mimicked tended to exhibit a significantly higher positive attitude towards a good presented by the mimicker as revealed by behavioural, affective and cognitive measures.

Mimicry can also modify the appreciation of confederates (Chartrand & Bargh 1999). During an interaction, a person (either) mimicked (or not) the participants' postures and physical mannerisms.

Compared with those who were not, mimicked participants reported greater liking for the other person, and perceived their interaction with her as having gone more smoothly. This finding is of particular interest in the context of economic exchanges since being more appreciative of a person can certainly affect decision-making, such as the evaluation of the level of (un)fairness of an offer made during the UG.

Two other studies connect even more closely mimicry, and therefore bodily influence, with economic exchange. Van Baaren *et al.* (2004*a*) explored how being mimicked modulates the amount of money one can give to the mimicker. They found that customers tend to increase the size of their tips if they are mimicked by the person waiting on them.[9] These results demonstrate that mimicry could be economically advantageous for the imitator. On can see tipping as a first form of *in vivo* dictator game (Zak *et al.* 2007) just like the 'pay-as-you-wish commerce' trend that has flourished all over the world in various forms (bagel shops, restaurants, etc.; Levitt & Dubner 2005). Another form is giving to a charity, a situation that van Baaren and colleagues have also investigated. In three studies, they consistently found that mimicry increased pro-social behaviour. Results clearly evidenced that a person who has been mimicked is more likely to be helpful and generous toward others compared with people who were not. Moreover, the beneficial consequences of mimicry were not restricted to behaviour directed towards the mimicker, but included behaviour directed towards people who did not participate in the mimicry situation. Hence, the effects of mimicry are not simply restricted to the mimicker, but may have a broader impact, i.e. they may very well change one's economic behaviour with respect to other people in general (van Baaren *et al.* 2004*b*).

8. EMBODIED (NEURO)ECONOMICS

As illustrated in the previous section, studies that have investigated the influence of mimicry on people's preferences and economic decisions—during or after physical social interactions occurred—hint at the role of bodily actions in economics. One possibility to better understand how our motor behaviour influences economic decision could be to cross social neuroeconomics with 'mimicry' experimental paradigm. This could be a first step. But a caveat would still remain as data and analyses obtained in mimicry studies generally rely on qualitative observation and categorization of motor behaviour that might lack a shared behavioural and brain dynamics (Kelso 1995). Given that a person's environment and state of mind are subject to rapid and often unpredictable changes during the decision-making process, the brain must be able to exhibit adaptive features on a sub-second time scale. Any paradigm that would claim to focus on economic decision-making should therefore be able to collect data at multiple levels of analysis (integrated brain, neuronal, behavioural, social, ...) and their shared dynamics in the same conceptual and empirical framework (see Oullier & Kelso 2006). Following previous theoretical developments and modelling, running social neuroeconomics experiments within the *social coordination dynamics* (SCD) paradigm could be an option to consider for that purpose (Oullier *et al.* 2005*a*, 2008*a*).

SCD is a novel paradigm by which to assess real-time spontaneous body attraction/motor bonding while individuals exchange information (see Oullier & Kelso 2009, for a review). Dyads execute movements, each at their own preferred frequency and amplitude and without any external pacing. Participants are not given any instructions regarding the way to move with respect to each other: the patterns of interpersonal coordination that might emerge are therefore unintended. When (visual) information is not exchanged, individuals produce movements independently at their own frequency. However, when sharing information about each other, they unintentionally adopt an in-phase interpersonal coordination pattern, their movements matching spontaneously in both the spatio-temporal and frequency domains (Oullier *et al.* 2005*a*). When they stop sharing information, individual movement frequencies diverge. Interestingly, participants do not return to their initial movement frequency when information exchanged is over. A closer look at the data reveals that their respective individual movements remain influenced by the physical social interaction they attended. The results clearly exhibit a consistent effect of the temporary phase- and frequency-locked coupling on subsequent behaviours when people are no longer in the presence of each other: some kind of motor *social memory* (Oullier *et al.* 2008*a*).

Hence, the SCD paradigm not only serves as a measure of bonding between people during and after social encounters. Depending on initial properties of each person's individual movement, it is possible to predict which one will end up with the motor behaviour the further from their initial one. One may therefore wonder if the way people spontaneously synchronize when they exchange information and/or physically influence each other *a posteriori* alters the way they make economic decisions, and for example to what extent they trust each other.

Economists and game theorists have developed the so-called, *trust game* that we crossed with the SCD paradigm. In this game, an *investor* sends a certain amount of money to a *trustee* who receives a multiple of the sum sent (like a bank interest during the transfer). The trustee is then free to send some (or none) of the money back to the investor (Berg *et al.* 1995). Round after round, the amount of money exchanged provides information about the level of economic trust that is established (or not). Better spontaneous synchronization and social memory should be accompanied by higher levels of money exchanges and emotional responses during the trust game (Oullier *et al.* 2009). To our knowledge this constitutes the first experimental instalment of embodied economics.

In addition, a neurophysiological replication of the SCD paradigm, thanks to a dual-electroencephalographic system revealed a new brain rhythm, some kind of 'neuromarker' of social interactions (Tognoli *et al.* 2007*a*). Termed Phi_2, this rhythm in the 10 Hz

frequency range is located over the right centro-parietal cortex and (dis)appears with the emergence/dissolution of coordinated behaviour between individuals. This clearly illustrates at brain level, the transition from uncoordinated to coordinated social interaction. In a subsequent study, they found that the magnitude of Phi_2 was higher when people intentionally coordinated (Tognoli *et al.* 2007*b*). This neural version of the SCD paradigm offers novel perspectives in providing potential insights on whether transitions from uncoordinated to coordinated behaviour previously reported at motor level are accompanied by a similar event at brain level by virtue of shared neural and behavioural SCD (Kelso 1995). Such a result might be of great relevance in social neuroeconomics when studying the neural correlates of individuals participating in social economic games.

The presence of neuromarkers of social coordnation might indicate whether people coordinate or not. Its magnitude might reveal their intention to coordinate or to imitate (Oullier & Kelso 2009) and open brand new perspectives for *embodied neuroeconomics*.

9. A SENSORY THEORY OF VALUE?

At the core of embodied neuroeconomics is our *sensory theory of value* (STV) connecting the *theory of mind* and the *subjective theory of value*. In STV, prices are considered as sensory data that carry out anticipations in the spontaneous order of the market. In our interpretation of Hayekian sensory and spontaneous orders, apprehending the economic behaviour of prices might rely on the same behavioural and neural processes that underlie bodily social interactions (Basso & Oullier in press; Basso *et al.* in press).

STV articulates the neurophysiological views developed by Hayek on the sensory order with his work on the spontaneous order of the market with a particular emphasis on how highly connected his concepts of *map* and *model* (Hayek 1952 [1976]) are with those of *speculative* and of *constitutive opinions* (Hayek 1952 [1979]). This parallel between the sensory order of the mind and the spontaneous order of the market is made possible by considering the subjective theory of value under the scope of sensory neurophysiology back then and social neuroeconomics nowadays. Given that economic actors are not able to access directly the mental states of other actors on the market, they are therefore forced to interpret their behaviour. Their interpretation is based on what they perceive (and to some extent imagine), meaning that every one builds a speculative opinion (map) on the constitutive opinions (model) of others (cf. the discussion on mindguessing in §5). This way, other actors rationalize the behaviour of their conspecifics and somewhat come to imitate it. Imitation is essential to our understanding of interpersonal exchanges on the market. Hayek had already stressed the fundamental role played by imitation of gestures and posture on learning processes and the cognitive role of prices in a decentralized economy. We consider imitation as a basic and fundamental mechanism of knowledge transmission—as tacit knowledge cannot be accessed through verbalization (Polanyi 1966 [2009], p. 4). In interpersonal exchanges, movements and postures are the medium for information exchange. In the disembodied interactions happening on the market, the information is only exchanged through prices. Apprehending the economic behaviour of prices might rely on the same processes that one can find in bodily social interactions (Basso & Oullier in press). For instance, prices convey an intention because each one interprets the value of a good or a service according to the rationale (particular information, a know-how, etc.) that is attributed to the one who determined the price of such good or service. Price determination on the market is an intentional behaviour likely to rely on brain networks that are similar to those involved in social interactions that can be revealed thanks to a (neuro)economic game involving virtual reality (Basso *et al.* in press). Our views on imitation and interpersonal interactions are sustained by recent discoveries in the emerging field of *social neuroscience*, among which the *mirror system* is of prime interest (Rizzolatti & Craighero 2004), together with the concept of perception–action coupling (Gibson 1979) and the *metastable* properties of the brain (Kelso 1995; Oullier & Kelso 2006).

In order to understand the extent to which rationalization lies at the core of imitation, one needs to take narration into account. In this perspective, the (Hayekian) map, i.e. the neural anatomy of our sensory order, is 'the theory of how the world works' (Hayek 1952 [1976], p. 131, §5.89). And given that, in Hayek's view, economics is a '[...] *meta*theory, a *theory about* the theories people have developed to explain how most effectively to discover and use different means for diverse purposes' (Hayek 1991 [1989], p. 98). We can deduce that considering a STV in a 'first-person approach' is linked with metaphors and surplus signification and leads to a neuroscience of storytelling (Basso & Oullier in press).

10. CONCLUSION

Over the past decade, cognitive neuroscientists interested in the neural foundations of the states-of-mind at stake in social interactions have taken note of and used the strong body of results coming from well-controlled empirical paradigms that experimental economics has been offering.

The first wave of findings from neuroeconomics has already forced economists to re-consider emotions in economic reasoning and for neuroscientists to rethink their views on the connections between emotion and reason (e.g. Knoch *et al.* 2006; Tassy *et al.* 2009). In a nutshell, what neuroscience suggests today is that the mind might discriminate emotional from rational behaviours but the workings of the brain reveal that this dichotomy is hard to find at the biological level (Oullier 2010). Thanks to recent findings using measures of functional connectivity, what used to be considered the more cognitive and more emotional parts of the brain turned out to be highly interconnected, continuously exchanging information and relying on each other in an interdependent fashion (Pessoa 2008). Hence, the emotional versus rational dichotomy might be dropped to favour the

emorationality hypothesis to more realistically study (and understand) the neural correlates of social interactions, including economic ones (Oullier 2010).

But economics is not immune to *a posteriori* rationalizations (naive causality) and speculative opinions (making sense) of all stakeholders. Let us hope that the illusion of 'pure' objectivity that neuroscientific tools seem to generate in some scientists' minds will not lead to the same mistakes made more than a century ago with the advent of mathematical formalization (Oullier *et al*. in press). As sometimes (neuro)biological results do not provide all the information necessary to explain what the agents report they experienced: 'During debriefing, women reported that they disliked being distrusted, but we did not find a physiological signature for this' (Zak *et al*. 2005, p. 363), this gap between results in first-person and third-person approaches paves the way for the *neuroscience of storytelling*.

One of the hardest things for a scientist is to explain what the man on the street considers evidence. Tell someone that 'body language' matters in our relation to others and one reaction you are most likely to face is: *'Yes, I know that, what's the big deal?'* The rationale behind our proposal for developing the field of embodied economics further is pretty straightforward: *why prevent economic agents being physically in the presence of each other during experiments if bodily influences do not have a significant effect on decisional dynamics*.

What might also be harder for a scientist is to convince his peers that a topic bears some relevance, especially when they have been eluding it from theories and models for decades (see Michel-Kerjan & Slovic in press for several illustrations in decision sciences). We strongly believe that economics will get closer to real life by considering the role of the entire body, not just the brain, in economic exchanges. In other words, *When the body speaks* (or tells a story), economists might be well advised to listen. . . .

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ENDNOTES

[1]His radical views regarding mental representations were strongly influenced by French phenomenologist Maurice Merleau-Ponty (1945).

[2]Krugman cited in Loewenstein & O'Donoghue (2004, p. 43).

[3]Other parallels between Keynes and Hayek can also be made with respect to their views on imitation (Dupuy 2004).

[4]In social sciences, Hayek suggested distinguishing ideas that form a social phenomenon (*constitutive opinions*) from ideas that result from them (*speculative opinions*; Hayek 1952 [1979]).

[5]Impulses in Hayek's work refer to what we would call stimuli nowadays.

[6]Brought to light at the end of the twentieth century by Giacomo Rizzolatti and his colleagues, these neurons discharge similarly whether one monkey performs an action or observes the same action performed by a confederate (Rizzolatti & Craighero 2004).

[7]Although many articles use the term *'mindreading'*, we found it more accurate to use *'mindguessing'* since what people do is an inference about the mental states of others. Even if sometimes they read the emotions of others on their bodies, it remains emotion reading. Mindreading is a whole different story and, to our knowledge, the brain is not a crystal ball.

[8]Some have argued that since Damasio and colleagues used skin conductance to understand somatic markers, the body has been effectively considered in economics. This is true to a certain extent. However, although there is indeed a measure of bodily reaction with skin conductance, the signal measured cannot be perceived *as such* by someone else in everyday life; hence our emphasis on observable bodily features such as movements in embodied economics.

[9]Although it was not his main goal, this study reminds us of Jean-Paul Sartre's (1943) vision of the waiter and clearly illustrates how advanced his writings were for his time.

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