Empirical Research on Brain and Behaviour, and Agent-Based Modelling, will Have a Deep Impact on Investigations on Well-Being (and on Economics)

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In the eighteenth century one of the major exponents of the economic doctrine of utilitarism, Jeremy Bentham (1789), proposed that the major drive of human action is the attempt to seek pleasure and avoid pain, and that happiness depends on the outcome of this effort. He also tried to build a science of happiness on the basis of the idea that pleasure and pain can be measured along specific dimensions such as intensity, duration, and uncertainty. Moreover, he proposed to regard this science as a guide for economic policy. In his epistemological reorganisation of welfare economics, Lionell Robbins (1932) completely rejected these ideas and the possibility of having a *cardinal* measure of utility, and in place of them proposed new founding principles that later became the core of *ordinal* theory of utility and the pillars of modern neoclassical welfare economics (Screpanti & Zamagni, 1989): (1) subjective quantities such as happiness and utility cannot be the object of rigorous scientific observation and measurement: the only information we can get on people utility can be acquired through the observation of their behaviours, in particular the observation of the way they *rank* things according to their preferences, revealed by their observable choices (e.g., if an agent chooses A we cannot know the exact value it assigns to it, but if she chooses A in alternative to B, this means that it assigns to A a higher value than B); (2) for the same reasons, it is impossible to carry out any inter-agent utility comparison on an objective basis (as a corollary, this withdraw any scientific justification to redistribution policies). These principles were in line with the tendency, henceforth generally accepted in economics, to deny any possibility of accessing and modelling people's mental processes (in line with the *behaviourist paradigm* that dominated psychology at that time), and hence to consider agents' preferences and cognitive processes as being out of the scope of investigation of economics (Camerer, 2006). Technically, this implied that models had to treat all such factors as a *black box* with *exogenous* variables.

The paper presents a number of claims that point out how this state of affairs is radically changing due to important empirical, technical, and theoretical innovations taking place in various disciplines such as psychology, neuroscience, artificial intelligence and computer science. The paper will present detailed arguments, corroborated by a review of the relevant literature, in support of these claims (cf. also Kahneman et al., 1999; Layard, 2003; Camerer, 2006). For space constraints, these arguments and the related literature can be only briefly listed and sketched here.

1) The advent of new neuroscientific techniques, and the research carried out with traditional ones, is boosting the possibility of understanding brains' neural correlates of people's behaviours, decision making, and emotional processes, and of subjective phenomena such as pleasure, pain, attribution of value to things, happiness, and well-being. For example the techniques of single-cells recording, brain targeted lesioning, and psychopharmacology are building a coherent broad picture of the network and functioning of brain systems (e.g., insula, amygdala, orbitofrontal cortex, basal ganglia and in particular nucleus accumbens) that underlie animal and human behaviour guided by pleasure and pain (Cardinal et al., 2002; cf. Klein, 2003, for a gentle introduction), the attribution of value to things (Schioppa & Assad, 2006), and decision making processes (Bechara et al., 1999). Other non-invasive techniques, such as the new brain imaging techniques (as fMRI, PET) and the classic neuropsychological techniques based on accidental/pathological brain damages (but also the new TMS), are furnishing important knowledge on the neural correlates of well-being (Davidson, 2004) and decision making (Sanfey et al., 2003).
2) The knowledge from neurosciences will also give new strength to previous and current psychological investigations carried out on people's behaviours relevant for economics. Psychology has been producing important knowledge relevant for microeconomic assumptions on agent's cognitive processes (e.g., Kahneman & Tversky, 1981; Simon, 1982; Simon, 1997; Kahneman, 2003), but until recently they have been considered marginal by mainstream economics, probably because psychological empirical evidence, for the difficulty of the object of its study, is not so compelling as that of the "hard sciences". Now the insights of neuroscientific research are giving new strength to psychology's results. For example the interview-based works investigating the relation existing between income and well-being (Inglehart & Klingemann, 2000) are assuming a more solid scientific reliability because of the studies on the high correlation existing between reported well-being the neural correlates behind it (Davidson, 2004); similarly behavioural studies on attribution of value to things (Schioppa et al., 2006) are being corroborated by studies using single cell recordings (Schioppa & Assad, 2006).
3) These empirical outcomes give the opportunity to, and at the same time urge, economics to adopt new micro-economic foundations, in particular by developing models of agent's cognitive and emotional processes based on empirical evidence (Simon, 1982; Simon, 1997; Kasser, 2002; Kahneman, 2003; Camerer, 2006), so as to overcome the no-more-acceptable limitations and simplifications of "perfect rationality", "representative agent" and "as if" assumptions (Friedman, 1953) adopted by mainstream economics so far.

4) Mathematical models, the main tool used by economics for presenting, formalising, and testing the soundness of theories, are ill suited for integrating, in an interdisciplinary framework, the knowledge generated by neuroscience and psychology related to agents' cognitive and emotional processes and the knowledge generated by social sciences related to the functioning of socio-economic (complex) systems: agent-based models and simulations have to be used for this purpose (Baldassarre, 1997). In fact, agent-based simulation models: (a) allow representing and studying non-linear complex adaptive systems, such as brains and socio-economic systems (Arthur et al., 1997), that cannot be studied analytically; (b) they have a huge representational capacity of phenomena, limited only by the (steadily increasing) computational power of computers: this allows representing in the same model complex socio-economic systems and agents with sophisticated cognitive and emotional processes.
5) With respect to the latter point, the modelling of agents' cognitive and emotional processes can be greatly enhanced by the use of architectures and algorithms proposed by artificial intelligence (in particular the "new" artificial intelligence based on neural-networks, cf. Rumelhart & McClelland, 1986) and computational neuroscience (the theoretical branch of neuroscience that formulates theories on brain based on computational models, cf. the "Journal of Computational Neuroscience"). These areas of investigation are presenting very interesting computational models, for example the actor-critic reinforcement learning architectures (Sutton & Barto, 1998) that can be used to mimic trial-and-error learning and decision making (Houk et al., 1995; Mannella & Baldassarre, in press), or emotional and motivational processes (Daw et al., 2005), in animals and humans.
6) Altogether, and most important for this conference, these trends open again the possibility of pursuing the policy-making agenda proposed by the classic exponents of utilitarism: "aiming for the greatest happiness for the greatest number". Indeed, this goal was abandoned by neoclassic economics because of the aforementioned technical limitations, not for its lack of moral desirability. With this respect, the analyses presented in the paper demonstrate that people's happiness *can* be now be (re-)considered the possible ultimate goal of policy making on the basis of rigorous scientific grounds (cf. also Kahneman et al., 1999; Seligman et al., 2000; Frey & Stutzer, 2002).

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