



How biology became social, and what it means for social theory

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Abstract

In this paper I first offer a systematic outline of a series of conceptual novelties in the life-sciences that have favoured, over the last three decades, the emergence of a more social view of biology. I focus in particular on three areas of investigation: (1) technical changes in evolutionary literature that have provoked a rethinking of the possibility of altruism, morality and prosocial behaviours in evolution; (2) changes in neuroscience, from an understanding of the brain as an isolated data processor to the ultrasocial and multiply connected social brain of contemporary neuroscience; and (3) changes in molecular biology, from the view of the gene as an autonomous master of development to the ‘reactive genome’ of the new emerging field of molecular epigenetics. In the second section I reflect on the possible implications for the social sciences of this novel biosocial terrain and argue that the postgenomic language of extended epigenetic inheritance and blurring of the nature/nurture boundaries will be as provocative for neo-Darwinism as it is for the social sciences as we have known them. Signs of a new biosocial language are emerging in several social-science disciplines and this may represent an exciting theoretical novelty for twenty-first social theory.

Keywords: cooperation, social brain, epigenetics, extended inheritance, social turn in the life-sciences, sociology and biology, postgenomics

Introduction

The present renegotiation of the boundaries between realms commonly demarcated as ‘the social’ and ‘the biological’ is one of the most exciting phenomena of our time (Fuller, 2007; Rose, 2013; Meloni, 2013b; Ingold and Palsson, 2013). After the years of ‘mutual antagonism’ (Benton, 1991) between sociology and biology – a hostility well represented by debates on sociobiology, evolutionary psychology and genetic reductionism – we have rapidly moved over the last few years toward a new terrain, where there are visible signs that both sides of the dispute are significantly questioning their premises and implicit prejudices.

On one side, sociology and social theory (Meloni, 2011a, 2012) have started to problematize the implicit equation between the ‘progressiveness’ of their

theory and its distance from biology (Rose, 2013). To name just one phenomenon, the increasing frustration with the disembodied rhetoric and tropes of hermeneutics, social-constructionism and postmodernism has been crucial in the recent desire to produce a 'material-corporeal' (Newton, 2003), 'embodied' foundation (Shilling, 2001) for social theory and sociology (Shilling, 2001, 2003, 2005; Williams *et al.*, 2003). The growing irritation toward social constructionist positions that simply reiterate the predominance of the cultural over the natural (Inglis and Bone, 2006) has moved along three axes. (1) *Ontological*: there is an element of 'otherness' and 'irreducibility' of nature and the body (Newton, 2007; Shilling, 2001) that has been denied by social-constructionist accounts and has to be reconsidered in sociological accounts. (2) *Epistemological*: the postmodernist refusal to recognize what is *outside the text* produces an idealist reading of the world as if it were only a semiotic kingdom, in which material forces (and the same notion of experience) ultimately tend to disappear. (3) *Axiological*: the inability of social constructionism to conceptualize agency and the body as distinct from 'power relations' (Shilling, 2001) results in an amputation of 'the objective ground for challenging the authority of custom and convention . . .' (Soper, 1995: 138). The criticisms advanced against social-constructionism along these three axes reveal a change of attitude of sociological research towards the biological and corporeal level and to material issues of life and vitality in general.

The argument I want to address in my paper is that *sociology is becoming more open to biological suggestions, just at a time when biology is becoming more social*. My goal in this article is twofold.

In the first part, I aim to systematize a series of conceptual novelties that over the last three decades have interested the life-sciences, bringing about a more social rethinking of biology. These conceptual novelties are: (a) Technical changes in evolutionary literature that have made possible a rethinking of the possibility of altruism and cooperation in evolution (*prosocial view of evolution*); (b) Changes in neuroscience from the brain as an isolated data processor in neuroscience to a multiply connected device profoundly shaped by social influences (*the social brain*); (c) Finally, and probably more importantly, changes in molecular biology, from the view of the gene as an autonomous master of development to the 'reactive genome' (Keller, 2011; Griffiths and Stotz, 2013) of contemporary postgenomics (*the socialized gene*), a notion perfectly embodied in the new emerging field of molecular epigenetics.

These three transformations have a common conceptual point: in each of them the traditional separation between the biological and the social has become increasingly difficult to define: biology has become porous to social and even cultural signals to an unprecedented extent. Certainly, several traditions in the past have suggested going beyond the nature/nurture dichotomy and each of these three 'novelties' can rather be seen as the crystallization of more or less heterodox streams of research in biosciences. However, although it is right to play down the emphasis on the word 'novelty' here, and although it may be premature to speak of a paradigm-shift as many of these conceptualizations

have still to coalesce into a more integrated conceptual framework (Charney, 2012), I nonetheless argue that *the simultaneous concurrence of all these social tropes in biology is unprecedented*, and has never been favoured by scientific evidence to the extent that it is today (Meaney, 2001a; Laland *et al.*, 2010). This justifies claims that a ‘social turn’ in the life-sciences is taking shape.¹

In the second part of my paper I will start to bring these novelties back to the field of social theory and reflect on some of its possible implications. Focusing in particular on new extended views of inheritance carried out by movements such as niche-construction, Developmental System Theory and the return (via epigenetics) to a quasi neo-Lamarckian framework that reopens connections between experience and heredity, biology and culture, I investigate potential as well as problems that the present postgenomic agenda is likely to present to the social sciences.

My claim is that the novel language of extended inheritance and blurring of the nature/nurture boundaries will be as provocative for neo-Darwinism as it is for the social sciences (see also Ingold and Palsson, 2013), and that some of these new biosocial concepts may produce an important rethinking of the classic repertoire of social theory. However, this is not to be seen by social scientists as a triumph of a biologically minded style of thought over a social one. Rather, the opposite is true. With a political metaphor it can be said that the two extreme wings of the nature/nurture dichotomy are equally destabilized by the new biosocial terrain. The social turn here described is the success of heterodox traditions in biological thought as well as social theory that saw in advance the impossibility of neatly demarcating life and culture, inside and outside, the biological and the social. In this sense the new biosocial moment is driven by innovative thinking from both biosciences *and* the social sciences (for instance, tropes of ‘naturecultures’ or ‘biosociality’ in cultural anthropology, human geography, sociology, cultural studies, and STS), although the focus of this article will be more on the first, probably less known, of these two moments.

Evolution is pro-social: technical changes in evolutionary biology from the selfish gene to the return of altruism

Evolutionary theory seems to no longer believe only in selfishness. The utilitarian and individualistic view of biology that was characteristic of the 1970s is giving way to a more prosocial picture of evolution (Young, 2012; Meloni, 2013a): arguments for altruism and cooperation are today made in agreement with the mechanisms of natural selection and no longer against it. A good analogy to explain continuities and discontinuities between evolutionary thinking in the 1970s and the contemporary social/compassionate vogue is to think in terms of *an increasingly widening circle* encompassing the possibility of altruism, cooperation, and morality *within* natural selection (Meloni,

2013a). Altruism in evolutionary writings of the 1970s was conceived pretty narrowly, according to a radical individualism that mostly saw evolution in terms of selfish organisms/genes competing to maximize their individual fitness (Ghiselin, 1974; Dawkins, 2006 [1976]).

To explain the puzzle of altruism, two basic notions were employed: kin selection (Hamilton, 1964) and reciprocal altruism (Trivers, 1971). For kin selection, altruism was evolutionarily possible only to the extent that it favoured 'one's own genes in the bodies of others' (Wilson and Wilson, 2007): an organism was thought to act altruistically toward another to the extent that this other shared a genetic relation with the first (a view popularized afterwards by Dawkins' concept of the selfish gene).

For reciprocal altruism, an altruistic act could be explained in terms of a returning benefit in the near future: an organism could accept to momentarily reduce its own fitness in the expectation that it will receive a comparable future benefit – a rule that works especially in repeated interactions.

Both kin selection and reciprocal altruism conceived altruism primarily as a disguised form of self-interest (or the genes' interest). This extremely narrow view has been challenged since then. First, through the application of game theory to explain how cooperation can become stabilized in a selfish world (Axelrod and Hamilton, 1981; Axelrod 1984); indeed, these accounts have grown to such a point that, today, 'natural cooperation' has been labelled as 'a third fundamental principle of evolution beside mutation and natural selection' (Nowak, 2006: 1563; Nowak and Highfield, 2011). Secondly, through the return to a *more pluralistic or multilevel view* of natural selection. The notion of 'group selection' was banished in the late 1960s because it was found unconvincing (Williams, 1996 [1966]): there was no such a thing as the 'good of the species' and even if there was, altruistic groups are liable to 'be exploited by selfish "free-riders" who refrain from behaving altruistically' (Okasha, 2013), as Dawkins some years later pointed out with his notion of 'subversion from within' (2006 [1976]). Ten years before Dawkins, Williams (1996 [1966]), following Hamilton (1964), had already persuasively argued that, rather than thinking in terms of group selection, it is better to conceive evolution in terms of the maximization of the genes' representation in future generations. This 'genic view' founded neo-Darwinism and paved the way for Dawkins' popularization of the selfish gene. It was a paradigm shift (Seegerstråle, 2001): organisms started to be conceived as vehicles for genes selfishly competing to maximize their reproductive strength. However, since the late 1980s, the pendulum has started to oscillate back toward a multilevel approach to evolution: group selection in particular has again regained respectability (Borrello, 2005; Wilson and Wilson, 2007), especially *when reframed in terms of cultural group selection* (Boyd and Richerson, 1985, 2010). In particular, it was a book by Sober and Wilson, *Unto Others* (1998) that rehabilitated group selection and claimed that both the evolutionary and the psychological sense of altruism are in fact favoured by evolution, especially if we conceive evolution as a multi-level process.

Finally, a critique of the selfish view of evolution has found an additional confirmation, over the last few years, in a series of experimental works by behavioural economists who have further questioned the plausibility of kin selection and reciprocal altruism as an explanation for the large-scale and high-level cooperation that exists among humans. The most significant result of this array of experimental works is that unselfish behaviours are more extensive than previously expected and take the form of so-called ‘strong reciprocity’ (Fischbacher and Gächter, 2002; Fehr and Fischbacher, 2003; Gintis, 2000; Bowles and Gintis, 2004). In ‘public goods’ games, genetically unrelated individuals tend to exhibit levels of cooperation higher than would be expected in a selfish rationality model, even in non-repeated interactions, as well as a propensity to punish norm-violators at their own cost, what is called ‘altruistic punishment’ (Fehr and Gächter, 2002; Fehr and Fischbacher, 2003; de Quervain *et al.*, 2004). As Fehr and Fischbacher have significantly commented: ‘Human altruism goes far beyond that which has been observed in the animal world . . . repeated interactions, reputation-formation, and strong reciprocity are powerful determinants of human behaviour’ (2003: 790).

In sum, the purely self-interested model, which the behavioral sciences and evolutionary thinking makes abundant use of, does not work (Fischbacher & Gächter, 2002; Adami and Hintze, 2013). People appear to be willing to ‘sacrifice resources for rewarding fair behavior and punishing unfair behavior *even if this is costly and provides neither present nor future material rewards for the reciprocator*’ (McElreath *et al.*, 2003). Negative emotions against non-cooperators, and other prosocial emotions (Frank, 1988), are the proximate factors that motivate these kinds of unselfish behaviour (Fischbacher and Gächter, 2002).

What emerges from this overview is a case for the ultra-sociality of human beings: humans are seen today by evolutionary theorists less as selfish organisms and more as super-cooperators (Nowak and Highfield, 2011). This is a phenomenon that would remain a puzzle if one remained stuck to the evolutionarily explanations of three decades ago. In a recent literature, the cooperative capacities and specific exquisite sociality of human beings (cooperative communication or ‘working in “We-mode”’) have been emphasized in contrast to the mere competitive skills (individualistic communication) of other primates (Moll and Tomasello, 2007; Tomasello, 2009). A similar move toward a naturalistic form of ultra-sociality is paralleled by the last two decades of brain research.

The brain is social: from the isolated computer to the multiply connected social brain

The second important site of epistemic transformation in the life-sciences comes from the last two decades of research in neuroscience, where the brain has ceased to be represented as an isolated data processor, as it was in the

heyday of cognitive science, to become a multiply connected device profoundly shaped by environmental influences. In what, since the early 1990s, has emerged as the new discipline of *social neuroscience*, the argument is not only that the brain is sculpted by the external world; it is also that it is a device specifically designed to create social relationships, to reach out for human relationships and company (Cacioppo and Patrick, 2008; Hawkey and Cacioppo, 2010).

This shift in the understanding of the brain has become a popular hit in the last decade. However, underneath the surface of sometimes exaggerated claims, and alongside politically naive conjectures, there have been significant conceptual changes in neuroscience that are worth exploring to chart the profound dynamisms that have interested the biosciences since the 1990s.

From social intelligence to the social brain: sketch for a genealogy

The conceptual antecedents of what we know today as the social brain lie in scattered contributions in primatology and anthropology in the period between 1953 and 1976. These different contributions became known together in the 1970s and the 1980s as the ‘social intelligence hypothesis’ (SIH) or ‘Machiavellian intelligence’, with the latter focusing more on the manipulative and deceptive aspects of social life (Byrne and Whiten, 1988; Whiten and Byrne 1997). These two hypotheses point to the idea of a unique development of primate intelligence as a response to the solicitations of an exceptionally demanding cognitive social environment.

Following the classic reconstruction of Byrne and Whiten (1988), three pioneering papers can be seen behind this view. First, Chance and Mead’s (1953) work on the continuous sexual receptivity of females in primate society and the consequences of this in terms of mating strategies and social complexity. Secondly, Jolly’s (1966) paper on the crucial value of social context in developing primate intelligence, and the primacy of social intelligence over a technical, object-learning one. And thirdly, Nick Humphrey’s (1976) chapter on the ‘social function of intellect’, with his thesis that the practical problems of living are not sufficient to explain the evolution of the higher intellectual faculties of primates. In more detail, Humphrey’s thesis was that primates’ cognitive faculties ‘have evolved as an adaptation to the complexities of social living’ and that therefore primate intelligence is ‘primarily suited to social problem solving’ (1976: 310). Through these three papers, the route was traced toward the idea that there is something special about primate social cognition and that ‘such speciality represents a stepping stone to the unique intellectual powers of our own species’ (Byrne and Whiten, 1988).

However, for a more overtly neurobiological reframing of this social story we need to look at two later works: Leslie Brothers’ seminal paper on ‘The social brain’ (1990) and the ‘Social brain hypothesis’ elaborated in parallel by Robin Dunbar (1998) (this story is well covered by Matusall *et al.*, 2011, and Rose and Abi-Rached, 2013). Anticipating much of the research of the last two

decades, Brothers hypothesized in her pioneering paper that the unique capacity of primates to perceive ‘psychological facts (dispositions and intentions) about other individuals’ represents a special cognitive domain. This domain is ‘operationally distinct’ from other forms of knowledge, and possibly served by a discrete neural system. In order to probe the existence of this neural system, Brothers suggested exploring several brain regions, and in particular ‘the amygdala, orbital frontal cortex and temporal cortex as its major components’ (Frith, 2007).

Dunbar’s essay some years later (1998) labels the ‘social brain’ something different. Here the focus is not on the discrete neurological structure devoted to social cognition but on the unique relationship between the ‘neocortex size’ and ‘the cognitive group size’ in primates. Dunbar’s version of ‘the social brain’ emphasizes therefore the strict relationship between primate social life and primates’ larger brain in comparison to other vertebrates. This version of the social brain states, therefore, that the brain’s size and the complexity of social life (quantitative and qualitative) co-evolved (see also Dunbar and Shultz, 2007). The expression ‘the social brain’ started to circulate and found a fertile terrain in other intellectual developments in scientific programmes.

Enter social neuroscience

The emergence of social neuroscience in the early 1990s represented a convergence of all these different versions of the social intelligence hypothesis, and then later of the social brain. In an article written by social psychologists John Cacioppo (who would then go on to become a major figure in the field) and Gary Berntson as a ‘contribution to the Decade of the Brain’ (launched in 1990 by the US Congress) the expression ‘social neuroscience’ makes its first appearance in the neurobiological field, although in an interrogative form (Cacioppo and Berntson, 1992).

Social neuroscience, or its cousin social cognitive neuroscience (this latter emphasizing the proximity to cognitive neuroscience), can be defined as the ‘the empirical study of the neural mechanisms underlying social cognitive processes’ (Blakemore *et al.*, 2004: 216). It emerged mainly as integrative, multilevel, interdisciplinary efforts (Cacioppo and Berntson, 1992; Ochsner and Liebermann, 2001) at the crossroads of social psychology, cognitive neuroscience, behavioural studies and capitalizing on technologies such as functional magnetic resonance imaging (Matusall *et al.*, 2011).

The social brain at the confluence of four themes

There are mainly four research topics that have crucially contributed to the idea of a *peculiarly social dimension to our cognition*, as distinct from other forms of non-social thought. These four topics are at the core of social neuroscience, although not all of them originate from social neuroscience research.

- a) First, the discovery that infants show an early inclination to recognize faces and possess an ‘unlearned’ capacity to distinguish the social domain from physical objects. This discovery, which comes from studies in cognitive and developmental psychology (Goren *et al.*, 1975; Brothers and Ring, 1992), has contributed to a view where the social world is represented as innately presupposed not constructed by the infant (Wynn, 2008; Jenkins and Mitchell, 2011). The existence of a dedicated neural machinery to detect faces (what is called the ‘face-specificity hypothesis’: Kanwisher and Yovel, 2006) has been a critical contribution from social neuroscience to support this view.
- b) Secondly, lesion and pathology studies have contributed to the idea of selective impairments in social and moral cognition, for example, in patients with ventromedial prefrontal damage who are otherwise intact in their more general cognitive functions (Damasio *et al.*, 1990; Anderson *et al.*, 1999). The fact that *acquired personality deficits* are limited to the social and moral sphere has reinforced the notion of a dedicated, specific neurological network for dealing with social stimuli in the brain, mediated by emotional and affective responses (Damasio, 2006 [1994]).
- c) Thirdly, the discovery of mirror neurons, a class of neurons that is activated when doing something or when observing a conspecific (or a human) performing the same action (di Pellegrino *et al.*, 1992; Rizzolatti *et al.*, 1996; Rizzolatti and Craighero, 2004), has become enormously influential in the social neuroscience literature. Mirror neurons have been conceptualized mainly in terms of the existence of automatic circuitry for imitation and empathy in the brains of some apes and humans (Decety and Jackson, 2004; Rizzolatti and Craighero, 2004). In spite of the great popularity of the topic, the existence of mirror neurons in humans remains highly controversial. In particular the idea of an *automatic* mechanism of simulation of other people has been criticized by more sophisticated readings (Singer and Lamm, 2009).
- d) Fourthly, and finally, there are a growing number of empirical studies that have brought to light, respectively, how (1) positive social interactions and altruism may be experienced as rewarding and pleasant in the brain (Moll *et al.*, 2006; Lozada *et al.*, 2011) and how (2) the experience of social rejection and isolation is analogous to the experience of pain (Eisenberger, 2012). These arguments are usually read against the background of a broader evolutionary argument for which our neural structures have been designed to reinforce social connections and cooperation and discourage social isolation/rejection, respectively (Hawley and Cacioppo, 2011).

From these and other research topics, one can easily appreciate how distant we now are from understanding the brain as an isolated computing device. One of the magical membranes maintaining the boundary between biological and cultural/social factors, the skull (Hurley quoted in Noë, 2009), is becoming increasingly porous today to a two-way interaction.²

The genome is social

What has become increasingly evident in the last years, especially after the completion of the Human Genome Project, is that only a very small fraction of the genome (slightly more than 1 per cent in fact) is ‘devoted to protein-coding sequences’ – the orthodox definition of gene – whereas the large part of the genome is employed in regulation, that is, in responding to environmental signals, from the cell, the organism and the environment around it (Keller, 2011). In sum, the more genetic research has gone forward, the more genomes are seen to ‘respond in a flexible manner to signals from a massive regulatory architecture that is, increasingly, the real focus of research in “genetics”’ (Griffiths and Stotz, 2013; see also Barnes and Dupré, 2008).

The recent surge of interest in molecular epigenetics is probably the best example of this postgenomic appreciation of the complexities of genome structure and function (Baylin and Schuebel, 2007; Dupré, 2012). It is the climax of a two-decade long trend that no longer represents genes as absolutely sovereign in the process of development, but as contextually dependent (and elusive) entities that cooperate extensively with a large variety of postgenomic factors (Keller, 2000; Oyama *et al.*, 2001; Moss, 2003; Robert, 2004; Jablonka and Lamb, 2005; Griffiths and Stotz, 2007, 2013; Stotz, 2006, 2008; Dupré, 2012).

Epigenetics refers to the study of mechanisms of gene regulation beyond the genome that may transfer social-environmental information into genetic information. Through mechanisms like methylation, transient environmental factors can leave a biological trace and become parts of the ‘memory’ of the genetic material itself (and even be transmitted inter-generationally). From the viewpoint of evolutionary theory, epigenetic mutations are often seen as a case of developmental plasticity, the way by which a ‘fixed genome’ can respond in a more plastic and flexible way to the solicitations from a changing and dynamic environment (Meaney and Szyf, 2005; see also Robert, 2004; Gluckman *et al.*, 2009). Whatever the status of the controversy on epigenetics and the cautiousness of the sceptics about the supposed inter-generational stability of these epi-mutations (Bird, in Buchen, 2010; Ridley, 2012; Davey Smith, 2011; Maderspacher, 2010), a decade of epigenetic studies in neuroscience and epidemiology has profoundly undermined any residual dualism of nature and nurture, ‘biological’ and ‘social’ causes in developmental processes.

There might be discussion about the specific molecular mechanisms, or the number of generations through which these mutations can survive cellular resetting, but several important laboratory studies have had a strong influence in showing how transient environmental factors can leave a mark on the genome, and how this mark can be reversed by experience (Weaver *et al.*, 2004; Champagne *et al.*, 2006). A key example in this direction comes from the Meaney study (2001b) on how variations in maternal behaviour of rats alters methylation patterns in the offspring and how these epigenetic alterations

affect the next generations, but can be reversed by cross-fostering the pups to more 'affective mothers'.

Studies in humans cannot of course be so direct, but there are highly influential epidemiological studies that have focused on the impact of 'natural experiments' like the Dutch 'Hunger Winter' (1944–45) on the lifespan, decades later, of people prenatally exposed to it (Heijmans *et al.*, 2008) or the transgenerational effects of famine in the remote village of Overkalix, in North Sweden (Pembrey *et al.*, 2006). The induction of epigenetic changes in offspring through an alteration of maternal nutrition would be another classic case of 'indirect epigenetic inheritance' (Bateson and Gluckman, 2012). Another possible application of epigenetics to human life has come from a recent work on the level of methylation in postmortem hippocampal tissue from two groups of suicide victims, one of which had a history of abuse (McGowan *et al.*, 2009). The study found a different methylation pattern in the abused group compared to the non-abused and the control group. This work has been welcomed as biological evidence of how traumatic life experiences become part of the 'memory' of the genetic material itself and be transmitted inter-generationally. Molecular epigenetics is therefore celebrated as the study of how the social gets into the biological (Hyman, 2009), a proof of the neural and molecular 'mechanisms of nurturance' (Lonstein, 2003).

Epigenetics provides the best example of the genome's vulnerability to experience, demonstrating its novel and irreducible sensitivity to social and environmental contexts. The more scientists dig into the molecular meanderings of the genome, the more they meet 'the many ties that link the individual body and its molecules to the spatio-temporal contexts within which it dwells' (Niewöhner, 2011). The rise of a discipline like *environmental epigenetics* further highlights this constant co-production of body and its environment (Guthman and Mansfield, 2012).

In sum, even from these scattered examples, it is evident how many of the dichotomies of evolutionary and social thought between body and organism, gene and environment, innate and acquired, seem profoundly fallacious in the light of epigenetic research. Of course, it is not my goal to offer a unilaterally rosy or superficially celebratory view of epigenetics. Epigenetics remains an unsettled and contested terrain, where controversies, hypes and scepticism remain a major aspect of the epigenetic landscape (Pickersgill *et al.*, 2013). Biologists are aware that as a discipline epigenetics has an ambivalent status, hesitating between reductionistic and more holistic research strategies (Morange, 2006). Many voices in the social and the biological sciences have already highlighted the several epistemological and social problems that the rise of epigenetics may bring: from the emergence of a new determinism not so dissimilar from an old-fashioned genetic one (Lock, 2005; 2012; Richardson, in press), to an intense molecularization of sociological and psychological categories (Landecker, 2011; Niewöhner, 2011); from a new exaggerated rhetoric of plasticity and mastery of the genes via epigenetic factors, to the moralistic literature around the role of the maternal body, conceived as an

‘epigenetic vector’ (Richardson, in press) in the DOHAD literature. However, leaving aside for a moment these important social critiques, the cultural impact of epigenetics has been profound in showing how permeable the boundaries between nature and nurture, biological and social factors have become. A new dynamic in the relationships between sociology and the life-sciences can be within reach if epigenetic studies maintain some of their conceptual and empirical promises in a near future.

The new social biology and the social sciences: paradoxes and implications

Contextualizing the social turn

It is time now to bring these three conceptual novelties in the life-sciences back into the field of social theory and reflect on some of their possible implications. The recognition of changes in the life-sciences is no reason to deny that this is a terrain still dominated by hype and controversies and that these novelties remain, first of all, unsettled (transformations 1 and 3 especially are the site of heated debates and contested knowledge) and second, open to simplifications and unwarranted simplistic conclusions (see for instance for transformation 1 and 2, respectively: Young, 2012; Meloni, 2013a; Matusall, 2013). Talk of ‘Biology 2.0’ and epochal claims about a revolutionary rewriting of our understanding of medicine, inheritance and so on (Carey, 2012) are also widespread, but the mismatch between both the rhetoric surrounding these conceptual changes and their actual everyday practices also remains something to take into consideration (Davies, 2010; Candea, 2013; Tolwinski, 2013). Finally I am not addressing in this article the more biopolitical and governmental implications of this social turn. Studies on the biopolitics of each of these three transformations have already appeared, focusing on the ambivalent implications of the rhetoric of plasticity in the life-sciences, divided as it is between resonance with the neo-liberal imaginary and emancipatory instances (Malabou, 2008; Pitts-Taylor, 2010; Papadopoulos, 2011). Also arguments about the subsumption and shaping of contemporary biology in capital’s own image represent an important theoretical terrain (Dickens, 2001).

Even so, and given all the possible complications and ambiguities of my claim for a social turn in the life-sciences, it remains the case that the contemporary presence of genuine conceptual transformations in so many disciplines is unprecedented and has never been favoured by scientific evidence to the extent that it is today. The potential implications of this turn for social theory deserve therefore to be scrutinized for their own sake.

Exploring the new biosocial moment

What does it mean for the social sciences as we know them that the membrane separating the biological from the social has become increasingly difficult to

patrol? How do these changes in the conceptual outlook of the biosciences reconfigure the nature/culture, biology/society boundary? Since the 1990s, we have witnessed the emergence of important, though still fragmented, theoretical frameworks that, in my view, perfectly symbolize the spirit of the social turn as I have tried to describe it. I refer to a constellation of approaches that has made its core assumption an understanding of biological processes as increasingly open to social and cultural factors. This results in an entirely non-dichotomous view of biology that aims to blur (almost) any distinction between what is inside and what is outside the genome. Developmental systems theory (Oyama, 2000a, 2000b; Oyama *et al.*, 2001), comes to mind as the most radical endeavour to go beyond the dichotomy of nature and nurture and think of biological processes as radically embedded in environmental settings in which genetic factors have no privilege (parity thesis).

Alongside developmental systems theory, there have been other important strands such as multiple heredity systems (Jablonka and Lamb, 2005) and niche construction (Laland *et al.*, 2001; Odling-Smee *et al.*, 2003). What is common among all these movements is a radical extension of what counts as biological resources. Whereas the mainstream post-Weismannian biology circumscribed the range of the 'biological' around the membrane of the fertilized egg – the Weismannian barrier that severed any communication between phenotype and genotype – current theorizations take a much more liberal approach on this issue. This is probably best viewed in *the radical extension of the notion of biological inheritance* that, especially in the light of epigenetics, has been reframed as going beyond the mere transmission of nuclear DNA ('hard heredity' that is at the core of the modern evolutionary synthesis) to include many extragenetic resources 'dispersed throughout the developing system and environment' (Robert, 2004).

In these new theorizations, information is transferred from one generation to the next by many interacting inheritance systems (Jablonka and Lamb, 2005). Environmental, social and cultural factors are placed on an equal footing with genetic factors, as carriers of information in development (Oyama, 2000a; Griffiths and Gray 1994; Griffiths and Stotz, 2013; Schlichting and Pigliucci, 1998; West-Eberhard, 2003). In niche-construction terms this can be reframed by saying that what an organism inherits from previous generations is not (merely) DNA but the whole 'developmental niche' (West and King, 1987).

This radical step should not be confused with the superficial interactionist rhetoric that pays lip service to the role of the environment by trivially restricting it to 'activating alternative outcomes prefigured in a "disjunctive genetic program"' (Griffiths, 1997: 127). Experiential factors in this novel biosocial view are not merely permissive but instructive (Griffiths and Stotz, 2007). Culture, language, social learning and behaviours are channels for the trans-generational transmission of information *as* the genetic system (Jablonka and Lamb, 2005). In extending radically but not deterministically the boundary of biology so as to include social and cultural resources, these movements intro-

duce a conceptual discontinuity in previous biology/society debates whose consequences for the social sciences still remain unknown.

The novelty of the present intellectual situation is made evident for instance by the fact that these theorizations *all fall obliquely* with regard to the traditional alignment of the last three decades of debate at the social-sciences/life-sciences border. Since the 1970s, there have been fundamentally four possible strategies to deal with the entanglements of biology and society: two at the level of ontology (*what is there?*) and two at the level of epistemology (*how can we know it?*).

For ontology, we have had sociobiology, and its more contemporary descendants, sharing a common framework of modelling (and constraining) culture on the forms and metaphors of nature. The opposite and likewise productive movement came under the banner of Paul Rabinow's bio-sociality approach (1999 [1992]) that modelled nature in the fashion of culture and technique, reversing the temporal and logical priority of sociobiology (see also Haraway's 1991 nature-culture model).

At the level of epistemology we can chart a similar (but not thoroughly overlapping) two-way movement: the first claiming that time has come to model the knowledge of society on biological science (Runciman, 1998, 2008; Turner, 2007), making of social knowledge a form of natural knowledge, and the second that biological knowledge is irreducibly constructed and therefore *on the same plane* of social knowledge (Rheinberger, 2000; Rabinow, 1999 [1992]; Calvert, 2010).

The theoretical positions that embody the social turn in biology examined here share something with each of these four positions, but are ultimately *irreducible to this grid*. They are irreducible because the opposition within the grid – between the biological and the cultural – is no longer an opposition at all: *the two moments are increasingly melded one into another and their difference made redundant to an unprecedented extent*.

So at the ontological level, for instance, developmental systems theory or niche-construction movements start on the same side of sociobiology: their ontological commitment in describing the world depends, as for sociobiology, on taking seriously the conceptual structure of evolutionary theory, something that biosociality or other post-structuralist movements have never done. However, the new biosocial movements end up in a position that is much closer to Rabinow's or Haraway's in embedding biology in cultural and social factors, seen as active determinants not merely passive results of genetic activity. Nonetheless, this extreme sociality of biology is not an effect of the cultural logic of late modernity but *a realist sociality*, so to speak, something that is intrinsically part of the functioning of the facts of life.

Epistemologically, likewise, they share the naturalism and even mechanism of authors who want to biologize social theory, but this 'mechanism' is complicated by the irreducible ties with social and environmental signals that are found at the molecular level (for instance in gene expression, see Niewöhner, 2011). However, this does not amount to an imperialist dissolution of the

reality of biological knowledge in constructionist language, which aggrandizes the latter at the expense of the former (Inglis and Bone, 2006). It is still a properly biological and developmental framework, not a culturalist one that brings 'culture' to the centre of biosocial processes.

Even this formulation is inadequate, however, as there is no longer biology and culture but *hybrid resources* (interactants) in a unified developmental system. It is a post-dualist way of thinking that finds its closest analogy probably with the way in which STS aims to undermine any dualism between 'social' and 'natural' entities, in a logics of co-production.

A disconcerting terrain

The terrain of the new social biology may seem disconcerting for established social science categories, and justifiably so. Many authors have directed attention to the profound antinaturalistic *ethos* that was at the root of sociology and sister social disciplines in the early twentieth century (Haber, 2006; Meloni, 2011b). In his classic article, Benton (1991: 12–13) distinguished four different strands of antinaturalism in sociological thinking: (a) Durkheim's 'insistence on the status of the social as a causal order in its own right' that undercut 'at one stroke the thesis of a biological determination of social life'; (b) Max Weber's roots in the German neo-Kantian movement whose theoretical and methodological assumptions made unfeasible any 'biologically rooted approach to the human sciences'; (c) the radical antinomy between a naturalistic anthropology and the notion of human nature as the result of the 'complex of social relations' in key figures in Western Marxism, in particular Lukacs and Gramsci; (d) American cultural anthropology, from Boas to Kroeber and Lowie that increasingly stressed the autonomous role of culture with regard to physical and biological bases.

The American context is here particularly interesting because, as historians have emphasized (Cravens, 1988; Degler, 1991), it was the profound polarization of nature and nurture that in the early twentieth century represented the context in which sociology and anthropology took form as separated (and in a way, immunized) from biological knowledge, *then equated with hard heredity and eugenics*. Although Boas himself contributed to important biosocial research on the bodily form of descendants of immigrants (1910), the Boasian and the mainstream sociological tradition severed any significant link between biological bases and cultural/social forms.

Two main epistemological views were causes of such a dichotomous view on which it is important to reflect to see the discontinuity with the present: (1) first, in the wake of Galton, Weismann and the rediscovery of Mendel, there was in the early twentieth century a hardening of the notion of heredity, now reduced to the transmission of genetic material from one generation to another. The new restricted view of heredity was unprecedented (Muller-Wille and Rheinberger, 2007). By severing any channel of communication between social experience and biological inheritance (and between innate and learned

factors), it allowed implicitly both promoters of the hard hereditarian view and supporters of the role of culture to take separate and in the end non-communicable footpaths; (2) secondly, and particularly in Kroeber (1917, see Stocking, 1968), there was a rejection of a residual but still visible neo-Lamarckian legacy that, in spite of its discrediting in mainstream science, still obscured the boundaries between the biological and the cultural. To this confusing rhetoric, which he found horrifying ('heredity by acquirement is equally a biological and historical monstrosity'), Kroeber reacted with his notion of the super-organic, to severing any link between biology and cultural processes (quoted in Stocking, 1968).

Even from this schematic archaeology of the social/biological divide, one can see how specular have been the moves of hard hereditarianism and the more culturalist side of the social sciences. This symmetry has dominated much of the twentieth century in the opposition of neo-Darwinism and the social sciences but it is doubtful that this will live up to the terrain of the new social biology and the theoretical movements that are its representatives.

Conclusion

A breaching of the membrane between the biological and the social and/or the cultural is clearly implied in each of the three transformations charted in this article and surely has the potential to be as provocative and difficult to accommodate for neo-Darwinism (see, for instance, Pinker, 2004) as it is for the social sciences. In other words, the various neo-Darwinian variations (sociobiology included) and the super-organic culturalism or social-ism of the social sciences were part (though on opposite sides) of the *same epistemic space* and division of labour that the novel version of social biology is breaking.

This epistemic space relied on a certain view of the gene, of inheritance, and of biology in general that is becoming increasingly misleading today. The many consequences of this break remain to be seen. As with any change of paradigm this will be resisted, but concrete signs of the emergence of a novel vocabulary can already be seen in social science investigations. Disciplines such as cultural anthropology are moving more rapidly than sociology probably toward an integration of social and biological approaches (Lock, 1993; Ingold, 2004; Ingold and Palsson, 2013). In more sociologically oriented explorations too, however, a new vocabulary made of hybrid notions such as 'metabolic ghetto', 'maternal' or 'somatic capital' (Wells, 2010), 'molecular biology of the social position' (Niewöhner, 2011), 'social or environmental exposure' (Landecker, 2011; Landecker and Panofsky, 2013), 'embodiment of social and material environments through developmental and epigenetic processes' (Kuzawa and Sweet, 2009), starts to reflect this unprecedented temporalization and socialization of biological processes.

How successful these new explorations will be in producing a genuine new paradigm remains to be seen. Concerns that anti-dualist rhetoric may

collapse substantial conceptual differences in our ontology of the social world (Newton, 2003) and impoverish the fruitfulness and pluralism of the nature/society boundaries (Derksen, 2005) are legitimate and need to be addressed carefully. However preliminary and tentative these can be, claims for a realignment of the social and the life-sciences show a desire to revitalize social investigations that cannot be overlooked anymore as a reactionary move from the past. The great divide between the biological and the social is a historical accomplishment, but it does not have to remain an eternal curse. It worked well under certain political and epistemic conditions, but the time may have arrived to write a new chapter of this story.

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Notes

- 1 Talks of a *social turn in the life-sciences* have emerged with colleagues at Exeter University, and in particular John Dupré, Paul Griffiths and Karola Stotz, in the context of the preparation of an AHRC grant.
- 2 It is also important to underline that this socialization of the brain is part of a broader movement in cognitive science that has increasingly emphasized the role of social-environmental factors in shaping human cognition, culminating in the burgeoning literature on the socially extended mind and other so-called ‘embodied-enactive’ approaches. However, this can be mentioned here only in passing.

References

- Adami, C. and Hintze, A., (2013), ‘Evolutionary instability of zero-determinant strategies demonstrates that winning is not everything’, *Nature Communication*, 4: 1–7.
- Anderson, S., Bechara, A., Damasio, H., Tranel, D. and Damasio, A., (1999), ‘Impairment of social and moral behavior related to early damage in human prefrontal cortex’, *Nature Neuroscience*, 2: 1032–1037.
- Axelrod, R., (1984), *The Evolution of Cooperation*, New York: Basic Books.
- Axelrod, R. and Hamilton, W.D., (1981), ‘The evolution of cooperation’, *Science*, 211: 1390–1396.
- Barnes, B. and Dupré, J., (2008), *Genomes and What to Make of Them*, Chicago: University of Chicago Press.
- Bateson, P. and Gluckman, P., (2012), ‘Plasticity and robustness in development and evolution’, *International Journal of Epidemiology*, 41: 219–223.
- Baylin, S. and Schuebel, K., (2007), ‘Genomic biology: the epigenomic era opens’, *Nature*, 448 (7153): 548–549.

- Benton, T., (1991), 'Biology and social science: why the return of the repressed should be given a (cautious) welcome', *Sociology*, 25: 1–29.
- Blakemore, S., Winston, J. and Frith, U., (2004), 'Social cognitive neuroscience: where are we heading?', *Trends in Cognitive Sciences*, 8 (5): 216–222.
- Borrello, M., (2005), 'The rise, fall and resurrection of group selection', *Endeavour*, 29: 43–47.
- Bowles, S. and Gintis, H., (2004), 'The evolution of strong reciprocity: cooperation in heterogeneous populations', *Theoretical Population Biology*, 65: 17–28.
- Boyd, R. and Richerson, P., (1985), *Culture and the Evolutionary Process*, Chicago: University of Chicago Press.
- Boyd, R. and Richerson, P., (2010), 'Transmission coupling mechanisms: cultural group select', *Philosophical Transactions of the Royal Society B*, 365: 3787–3795.
- Brothers, L., (1990), 'The social brain: a project for integrating primate behaviour and neurophysiology in a new domain', *Concepts in Neuroscience*, 1: 27–51.
- Brothers, L. and Ring, B., (1992), 'A neuroethological framework for the representation of minds', *Journal of Cognitive Neuroscience*, 4 (2): 107–118.
- Buchen, L., (2010), 'In their nurture', *Nature*, 467: 146–148.
- Byrne, R. and Whiten, A. (eds), (1988), *Machiavellian Intelligence: Social Expertise and the Evolution of Intellect in Monkeys, Apes and Humans*, Oxford: Oxford University Press.
- Cacioppo, J.T. and Berntson, G.G., (1992), 'Social psychological contributions to the decade of the brain: doctrine of multilevel analysis', *American Psychologist*, 47: 1019–1028.
- Cacioppo, J.T. and Patrick, B., (2008), *Loneliness: Human Nature and the Need for social Connection*. New York: W. W. Norton & Co.
- Calvert, J., (2010), 'Synthetic biology: constructing nature', *The Sociological Review*, 58: 95–112.
- Candea, M., (2013), 'Habituating meerkats and redescribing animal behaviour science', *Theory Culture and Society*, online first 10 October.
- Carey, N., (2012), *The Epigenetics Revolution: How Modern Biology Is Rewriting our Understanding of Genetics, Disease, and Inheritance*, New York: Columbia University Press.
- Champagne, F.A., Weaver, I.C., Diorio, J., Dymov, S., Szyf, M. and Meaney, M.J., (2006), 'Maternal care associated with methylation of the estrogen receptor-alpha1b promoter and estrogen receptor-alpha expression in the medial preoptic area of female offspring', *Endocrinology*, 147: 2909–2915.
- Chance, M. and Mead, A., (1953), 'Social behaviour and primate evolution', *Symposia of the Society for Experimental Biology*, 7: 395–439.
- Charney, E., (2012), 'Behavior genetics and postgenomics', *Behavioral and Brain Sciences*, 35: 331–410.
- Cravens, H., (1988), *The Triumph of Evolution: American Scientists and the Heredity-Environment Controversy, 1900–1941*, Philadelphia: University of Pennsylvania Press.
- Damasio, A., (2006 [1994]), *Descartes' Error: Emotion, Reason, and the Human Brain*, London: Vintage.
- Damasio, A., Tranel, D., and Damasio, H., (1990), 'Individuals with sociopathic behaviours caused by frontal damage fail to respond autonomically to social stimuli', *Behavioural Brain Research*, 41 (2): 81–94.
- Davey Smith, G., (2011), 'Epidemiology, epigenetics and the "Gloomy Prospect": embracing randomness in population health research and practice', *International Journal of Epidemiology*, 40: 537–562.
- Davies, G., (2010), 'Captivating behaviour: mouse models, experimental genetics, and the reductionist return in the neurosciences', in Parry, S. and Dupré, J. (eds), *Nature after the Genome*, *Sociological Review*, 58, 53–72, Oxford: Blackwell.
- Dawkins, R., (2006 [1976]), *The Selfish Gene*, Oxford: Oxford University Press.
- De Quervain, D.J., Fischbacher, U., Treyer, V., Schellhammer, M., Schnyder, U., Buck, A. and Fehr, E., (2004), 'The neural basis of altruistic punishment', *Science*, 305: 1254–1258.
- Decety, J. and Jackson, P.L., (2004), 'The functional architecture of human empathy', *Behavior and Cognitive Neuroscience Reviews*, 3: 71–100.

- Degler, C., (1991), *In Search of Human Nature*, New York: Oxford University Press.
- Derksen, M., (2005), 'Against integration: why evolution cannot unify the social sciences', *Theory and Psychology*, 15 (2): 139–162.
- Di Pellegrino, G., Fadiga, L., Fogassi, L., Gallese, V. and Rizzolatti, G., (1992), 'Understanding motor events: a neurophysiological study', *Experimental Brain Research*, 91: 176–180.
- Dickens, P., (2001), 'Linking the social and natural sciences: is capital modifying human biology in its own image?' *Sociology*, 35: 93–110.
- Dunbar, R., (1998), 'The social brain hypothesis', *Evolutionary Anthropology*, 6: 178–190.
- Dunbar, R. and Shultz, S., (2007), 'Understanding primate brain evolution', *Philosophical Transactions of the Royal Society B*, 362: 649–658.
- Dupré, J., (2012), *Processes of Life: Essays in the Philosophy of Biology*, Oxford: Oxford University Press.
- Eisenberger, N.I., (2012), 'The pain of social disconnection: examining the shared neural underpinnings of physical and social pain', *Nature Reviews Neuroscience*, 13: 421–434.
- Fehr, E. and Fischbacher, U., (2003), 'The nature of human altruism', *Nature*, 425: 785–791.
- Fehr, E. and Gächter, S., (2002), 'Altruistic punishment in humans', *Nature*, 415: 137–140.
- Fischbacher, U. and Gächter, S., (2002), 'Strong reciprocity, human cooperation, and the enforcement of social norms', *Human Nature*, 13: 1–25.
- Frank, R.H., (1988), *Passions within Reason: The Strategic Role of the Emotions*, New York: W. W. Norton & Co.
- Frith, C., (2007), 'The social brain?', *Philosophical Transactions of the Royal Society* 362: 671–678
- Fuller, S., (2007), *Science v. Religion? Intelligent Design and the Problem of Evolution*, Cambridge: Polity.
- Ghiselin, M., (1974), *The Economy of Nature and the Evolution of Sex*, Berkeley, CA: University of California Press.
- Gintis, H., (2000), 'Strong reciprocity and human sociality', *Journal of Theoretical Biology*, 206: 169–179.
- Gluckman, P. et al., (2009), 'Towards a new developmental synthesis: adaptive developmental plasticity and human disease', *Lancet*, 373: 1654–1657.
- Goren, C., Sarty, M. and Wu, P., (1975), 'Visual following and pattern discrimination of face-like stimuli by newborn infants', *Pediatrics*, 56 (4): 544–549.
- Griffiths, P.E., (1997), *What Emotions Really Are: The Problem of Psychological Categories*, Chicago: University of Chicago Press.
- Griffiths, P.E. and Gray, R.D., (1994), 'Developmental systems and evolutionary explanation', *Journal of Philosophy*, 91 (6): 277–304.
- Griffiths, P.E. and Stotz, K., (2007), 'Gene', in Ruse, M. and Hull, D. (eds), *Cambridge Companion to Philosophy of Biology*, 85–102, Cambridge: Cambridge University Press.
- Griffiths, P.E. and Stotz, K., (2013), *Genetics and Philosophy*, Cambridge: Cambridge University Press.
- Guthman, J. and Mansfield, B., (2012), 'The implications of environmental epigenetics: a new direction for geographic inquiry on health, space, and nature-society relations', *Progress in Human Geography*, online 26 November.
- Haber, S., (2006), *Critique de l'antinaturalisme*, Paris: PUF.
- Hamilton, W.D., (1964), 'The genetical evolution of social behavior I and II', *Journal of Theoretical Biology*, 7: 1–52.
- Haraway, D., (1991), *Simians, Cyborgs and Women: The Reinvention of Nature*, New York: Routledge, and London: Free Association Books.
- Hawley, L. and Cacioppo, J., (2010), 'Loneliness matters: a theoretical and empirical review of consequences and mechanisms', *Annals of Behavioral Medicine*, 40: 218–227.
- Hawley, L.C. and Cacioppo, J.T., (2011), 'Perceived social isolation: social threat vigilance and its implications for health', in Decety, J. and Cacioppo, J.T. (eds), *The Oxford Handbook of Social Neuroscience*, 765–775, New York: Oxford University Press.

- Heijmans, B.T., Tobi, E.W., Stein, A.D., Putter, H., Blauw, G.J., Susser, E.S., Slagboom, P.E. and Lumev, L.H., (2008), 'Persistent epigenetic differences associated with prenatal exposure to famine in humans', *Proceedings of the National Academy of Sciences of the United States of America*, 44: 17046–17049.
- Humphrey, N., (1976), 'The social function of intellect', in Bateson, P. and Hinde, R. (eds), *Growing Points in Ethology*, 303–317, Cambridge: Cambridge University Press.
- Hyman, S., (2009), 'How adversity gets under the skin', *Nature Neuroscience*, 12 (3): 241–243.
- Inglis, D. and Bone, J., (2006), 'Boundary maintenance, border crossing and the nature/culture divide', *European Journal of Social Theory*, 9 (2): 272–287.
- Ingold, T., (2004), 'Beyond biology and culture', *Social Anthropology*, 12: 209–221.
- Ingold, T. and Palsson, G., (2013), *Biosocial Becomings: Integrating Social and Biological Anthropology*, Cambridge: Cambridge University Press.
- Jablonska, E. and Lamb, M., (2005), *Evolution in Four Dimensions*, Cambridge, MA: MIT Press.
- Jenkins, A. and Mitchell, J., (2011), 'How has cognitive neuroscience contributed to social psychological theory?', in Todorov, A., Fiske, S.T. and Prentice, D.A., *Social Neuroscience: Toward Understanding the Underpinnings of the Social Mind*, Oxford: Oxford University Press.
- Jolly, A., (1966), 'Lemur social behaviour and primate intelligence', *Science*, 163: 501–506.
- Kanwisher, N. and Yovel, G., (2006), 'The fusiform face area: a cortical region specialized for the perception of faces', *Philosophical Transactions of the Royal Society B*, 361: 2109–2128.
- Keller, E.F., (2000), *The Century of the Gene*, Cambridge, MA: Harvard University Press.
- Keller, E.F., (2011), 'Genes, genomes, and genomics', *Biological Theory*, 6: 132–140.
- Kroeber, A., (1917), 'The Superorganic', *American Anthropologist*, 19 (2): 163–213.
- Kuzawa, C. and Sweet, E., (2009), 'Epigenetics and the embodiment of race: developmental origins of US racial disparities in cardiovascular health', *American Journal of Human Biology*, 21 (1): 2–15.
- Laland, K.N., Odling-Smee, F.J. and Feldman, M.W., (2001), 'Cultural niche construction and human evolution', *Journal of Evolutionary Biology*, 14: 22–33.
- Laland, K., Odling-Smee, J. and Myles, S., (2010), 'How culture shaped the human genome: bringing genetics and the human sciences together', *Nature Reviews Genetics*, 11: 137–148.
- Landecker, H., (2011), 'Food as exposure: nutritional epigenetics and the new metabolism', *BioSocieties*, 6: 167–194.
- Landecker, H. and Panofsky, A., (2013), 'From social structure to gene regulation, and back: a critical introduction to environmental epigenetics for sociology', *Annual Review of Sociology*, 39: 18–25.
- Lock, M., (1993), *Encounters with Aging: Mythologies of Menopause in Japan and North America*, Berkeley, CA: University of California Press.
- Lock, M., (2005), 'Eclipse of the gene and the return of divination', *Current Anthropology*, 46: 47–70.
- Lock, M., (2012), 'The epigenome and nature/nurture reunification: a challenge for anthropology', *Medical Anthropology*, 32 (4): 291–308.
- Lonstein, J.S., (2003), 'Individual differences in maternal care reveal the neural mechanisms of nurturance', *Endocrinology*, 148: 1417–1418.
- Lozada, M., D'Adamo, P. and Fuentes, M.A., (2011), 'Beneficial effects of human altruism', *Journal of Theoretical Biology*, 289: 12–16.
- Maderspacher, F., (2010), 'Lysenko rising', *Current Biology*, 20: 835–837.
- Malabou, C., (2008), *What Should We Do With Our Brain?* New York: Fordham University Press.
- Matusall, S., (2013), 'Social behavior in the "age of empathy"? A social scientist's perspective on current trends in the behavioral sciences', *Frontiers in Human Neuroscience*, online 31 May, doi: 10.3389/fnhum.2013.00236.
- Matusall, S., Kaufmann, I. and Christen, M., (2011), 'The emergence of social neuroscience as an academic discipline', in Decety, J. and Cacioppo, J. (eds), *The Oxford Handbook of Social Neuroscience*, 9–27, Oxford: Oxford University Press.

- McElreath, R., Clutton-Brock, T.H., Fehr, E., Fessler, D.M.T., Hagen, E.H., Hammerstein, P., Kosfeld, M., Milinski, M., Silk, J.B., Tooby, J. and Wilson, M.I., (2003), 'Group report: the role of cognition and emotion in cooperation', in Hammerstein, P. (ed.), *Genetic and Cultural Evolution of Cooperation*, Cambridge, MA: MIT Press.
- McGowan, P., Sasaki, A., D'Alessio, A.C., Dymov, S., Labonté, B., Szyf, M., Turecki, G. and Meaney, M.J., (2009), 'Epigenetic regulation of the glucocorticoid receptor in human brain associates with childhood abuse', *Nature Neuroscience*, 12 (3): 342–348.
- Meaney, M., (2001a), 'Nature, nurture, and the disunity of knowledge', *Annals of the New York Academy of Sciences*, 935: 50–61.
- Meaney, M., (2001b), 'Maternal care, gene expression, and the transmission of individual differences in stress reactivity across generations', *Annual Review of Neuroscience*, 24 (1): 1161–1192.
- Meaney, M.J. and Szyf, M., (2005), 'Environmental programming of stress responses through DNA methylation: life at the interface between a dynamic environment and a fixed genome', *Dialogues in Clinical Neuroscience*, 7 (2): 103–123.
- Meloni, M., (2011a), 'Philosophical implications of neuroscience: the space for a critique', *Subjectivity*, 4: 298–322.
- Meloni, M., (2011b), 'Naturalism as an ontology of ourselves', *Telos*, 155: 151–174.
- Meloni, M., (2012), 'On the growing intellectual authority of neuroscience for political and moral theory: sketch for a genealogy', in Valk, F.V. (ed.), *Essays on Neuroscience and Political Theory: Thinking the Body Politic*, 25–49, London: Routledge.
- Meloni, M., (2013a), 'Moralizing biology: the appeal and limits of the new compassionate view of nature', *History of the Human Sciences*, 26 (3): 82–106.
- Meloni, M., (2013b), 'Biology without biologism: social theory in a postgenomic age', *Sociology*, online first 31 October.
- Moll, J., Krueger, F., Zahn, R., Pardini, M., Oliveira-Souza, R. and Grafman, J., (2006), 'Human fronto-mesolimbic networks guide decisions about charitable donation', *Proceedings of the National Academy of Sciences*, 103 (42): 15623–15628.
- Moll, H. and Tomasello, M., (2007), 'Cooperation and human cognition: the Vygotskian intelligence hypothesis', *Philosophical Transactions of the Royal Society B*, 362: 639–648.
- Morange, M., (2006), 'Post-genomics, between reduction and emergence', *Synthese*, 151 (3): 355–360.
- Moss, L., (2003), *What Genes Can't Do*, Cambridge, MA: MIT Press.
- Muller-Wille, S. and Rheinberger, J. (eds), (2007), *Heredity Produced: At the Crossroads of Biology, Politics, and Culture*, Cambridge, MA: MIT Press.
- Newton, T., (2003), 'Crossing the great divide: time, nature and the social', *Sociology*, 37: 433–457.
- Newton, T., (2007), *Nature and Sociology*, London: Routledge.
- Niewöhner, J., (2011), 'Epigenetics: embedded bodies and the molecularisation of biography and milieu', *BioSocieties*, 6 (3): 279–298.
- Noë, A., (2009), *Out of our Heads: Why You Are Not Your Brain, and Other Lessons from the Biology of Consciousness*, New York: Farrar Straus.
- Nowak, M., (2006), 'Five rules for the evolution of cooperation', *Science*, 314: 1560–1563.
- Nowak, M.A. and Highfield, R., (2011), *SuperCooperators: Evolution, Altruism and Human Behaviour, or, Why We Need Each Other to Succeed*, Edinburgh: Canongate.
- Ochsner, K. and Lieberman, M., (2001), 'The emergence of social cognitive neuroscience', *American Psychologist*, 56 (9): 717–734.
- Odling-Smee, F.J., Laland, K. and Feldman, M., (2003), *Niche Construction: The Neglected Process in Evolution*, Princeton, NJ: Princeton University Press.
- Okasha, S., (2013), 'Biological altruism', in Zalta, E. (ed.), *The Stanford Encyclopedia of Philosophy*, <http://plato.stanford.edu/archives/fall2013/entries/altruism-biological/>
- Oyama, S., (2000a), *The Ontogeny of Information: Developmental Systems and Evolution*, Durham, NC: Duke University Press.
- Oyama, S., (2000b), *Evolution's Eye: A Systems View of the Biology-Culture Divide*, Durham, NC: Duke University Press.

- Oyama, S., Griffiths, P.E. and Gray, R.D., (2001), *Cycles of Contingency: Developmental Systems and Evolution*, Cambridge, MA: MIT Press.
- Papadopoulos, D., (2011), 'The imaginary of plasticity: neural embodiment, epigenetics, and ecomorphs', *The Sociological Review*, 3: 432–456.
- Pembrey, M.E., Bygren, L.O., Kaati, G., Edvinsson, S., Northstone, K., Sjöström, M. and Golding, J., (2006), 'Sex-specific, male-line transgenerational responses in humans', *European Journal of Human Genetics*, 14 (2): 159–166.
- Pickersgill, M., Niewöhner, J., Müller, R., Martin, P. and Cunningham-Burley, S., (2013), 'Mapping the new molecular landscape: social dimensions of epigenetics', *New Genetics and Society*, online first, 9 December.
- Pinker, S., (2004), 'Why nature and nurture won't go away', *Daedalus*, Fall: 5–17.
- Pitts-Taylor, V., (2010), 'The plastic brain: neoliberalism and the neuronal self', *Health*, 14: 635–652.
- Rabinow, P., (1999 [1992]), 'Artificiality and enlightenment: from sociobiology to biosociality', in Biagioli, M. (ed.), *The Science Studies Reader*, 407–416, New York: Routledge.
- Rheinberger, H.-J., (2000), 'Beyond nature and culture: modes of reasoning in the age of molecular biology and medicine', in Lock, M., Young, A. and Cambrosio, A. (eds), *Living and Working with the New Medical Technologies: Intersection of Inquiry*, 19–30, Cambridge: Cambridge University Press.
- Richardson, S., (in press), 'Maternal bodies in the postgenomic order: gender and the explanatory landscape of epigenetics', in Richardson, S.S. and Stevens, H. (eds), *Postgenomics*, Durham, NC: Duke University Press.
- Ridley, M., (2012), 'No, your child won't inherit your acquired traits', *Mind and Matter*, 12 October.
- Rizzolatti, G. and Craighero, L., (2004), 'The mirror-neuron system', *Annual Review of Neuroscience*, 27: 169–192.
- Rizzolatti, G., Fadiga, L., Gallese, V. and Fogassi, L., (1996), 'Premotor cortex and the recognition of motor actions', *Cognitive Brain Research*, 3: 131–141.
- Robert, J.S., (2004), *Embriology, Epigenesis and Evolution: Taking Development Seriously*, Cambridge: Cambridge University Press.
- Rose, N., (2013), 'The human sciences in a biological age', *Theory, Culture and Society*, 30 (1): 3–34.
- Rose, N. and Abi-Rached, J., (2013), *Neuro*, Princeton, NJ: Princeton University Press.
- Runciman, W.G., (1998), 'The selectionist paradigm and its implications for sociology', *Sociology*, 32 (1): 163–188.
- Runciman, W.G., (2008), 'Forgetting the founders', *Sociological Review*, 56 (3): 358–369.
- Schlichting, C.D. and Pigliucci, M., (1998), *Phenotypic Evolution: A Reaction Norm Perspective*, Sunderland, MA: Sinauer Associates.
- Segerstråle, U.C., (2001), *Defenders of the Truth: The Sociobiology Debate*, Oxford: Oxford University Press.
- Shilling, C., (2001), 'The embodied foundations of social theory', in Ritzer, G. and Smart, B. (eds), *Handbook of Social Theory*, 439–457, London: Sage.
- Shilling, C., (2003), *The Body and Social Theory*, London: Sage.
- Shilling, C., (2005), 'The rise of the body and the development of sociology', *Sociology*, 39: 761–767.
- Singer, T. and Lamm, C., (2009), 'The social neuroscience of empathy', *Annals of the New York Academy of Sciences*, 1156: 81–96.
- Sober, E. and Wilson, D.S., (1998), *Unto Others: The Evolution and Psychology of Unselfish Behavior*, Cambridge, MA: Harvard University Press.
- Soper, K., (1995), *What Is Nature? Culture, Politics and the Non-human*, Oxford: Blackwell.
- Stocking, G., (1968), *Race, Culture, and Evolution: Essays in the History of Anthropology*, New York: Free Press.
- Stotz, K., (2006), 'With genes like that, who needs an environment? Postgenomics' argument for the ontogeny of information', *Philosophy of Science*, 73 (5): 905–917.
- Stotz, K., (2008), 'The ingredients for a postgenomic synthesis of nature and nurture', *Philosophical Psychology*, 21 (3): 359–381.

- Tolwinski, K., (2013), 'A new genetics or an epiphenomenon? Variations in the discourse of epigenetics researchers', *New Genetics and Society*, online first 30 October.
- Tomasello, M., (2009), *Why We Cooperate*, Cambridge, MA: MIT Press.
- Trivers, R., (1971), 'The evolution of reciprocal altruism', *Quarterly Review of Biology*, 46: 35–57.
- Turner, S., (2007), 'Social theory as a cognitive neuroscience', *European Journal of Social Theory*, 10: 357–374.
- Weaver, I.C., Cervoni, N., Champagne, F.A., D'Alessio, A.C., Sharma, S., Seckl, J.R., Dymov, S., Szyf, M. and Meaney, M.J., (2004), 'Epigenetic programming by maternal behavior', *Nature Neuroscience*, 7: 847–854.
- Wells, J., (2010), 'Maternal capital and the metabolic ghetto', *American Journal of Human Biology*, 22: 1–17.
- West, M.J. and King, A.P., (1987), 'Settling nature and nurture into an ontogenetic niche', *Developmental Psychobiology*, 20: 549–562.
- West-Eberhard, M.J., (2003), *Developmental Plasticity and Evolution*, Oxford: Oxford University Press.
- Whiten, A. and Byrne, R. (eds), (1997), *Machiavellian Intelligence II: Extensions and Evaluations*, Cambridge: Cambridge University Press.
- Williams, G.C., (1996 [1966]), *Adaptation and Natural Selection: A Critique of Some Current Evolutionary Thought*, Princeton, NJ: Princeton University Press.
- Williams, S., Birke, L. and Bendelow, G. (eds), (2003), *Debating Biology*, London: Routledge.
- Wilson, D.S. and Wilson, E.O., (2007), 'Rethinking the theoretical foundation of sociobiology', *Quarterly Review of Biology*, 82: 327–348.
- Wynn, K., (2008), 'Some innate foundations of social and moral cognition', in Carruthers, P., Laurence, S. and Stich, S. (eds), *The Innate Mind: Foundations and the Future*, Oxford: Oxford University Press.
- Young, A., (2012), 'The social brain and the myth of empathy', *Science in Context*, 25: 401–424.