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The Culture-Bound Brain: Epigenetic Proaction Revisited

by

KATHINKA EVERS

Centre for Research Ethics & Bioethics (CRB), Uppsala University, Sweden

Abstract: Progress in neuroscience – notably, on the dynamic functions of neural networks – has deepened our understanding of decision-making, acquisition of character and temperament, and the development of moral dispositions. The evolution of our cerebral architecture is both genetic and epigenetic: the nervous system develops in continuous interaction with the immediate physical and socio-cultural environments. Each individual has a unique cerebral identity even in the relative absence of genetic distinction, and the development of this identity is strongly influenced by social and cultural environments leaving major traces in the connectivity of the brain. This interaction introduces important elements of variability and plasticity. Synaptic epigenetic theories of cultural and social imprinting on our brain architecture suggest the possibility that we can be "epigenetically proactive" and adapt our social structures, in both the short and the long term, to benefit and constructively interact with the ever-developing neuronal architecture of our brains. Epigenetic proaction can be described as a way to socially steer evolution by influencing the cultural imprints to be stored in our brains. The purpose of this article is to present, in a historical and ideological light, the idea that we may culturally shape the developing brain, and discuss some key risks and benefits of this endeavour. The article is a contribution to neuroethics.

Keywords: synaptic epigenesis, cultural imprinting, epigenetic proaction, neuroethics

1. Introduction

The structures of societies and cultures are importantly shaped by the structures of brains. The reverse is also the case: brains are intrinsically culture-bound, shaped through pre- and postnatal development by socio-cultural environments.

The neuronal organization of a human adult brain develops in the course of up to a 25-year-long period following birth during which, and, to a lesser extent, after which, it is subject to cultural influence, both at the individual level and at the social group level, across generations. Synaptic epigenetic theories of cultural and social imprinting on our brain architecture (Changeux, 1983/1997, 2004; Changeux et al., 1973; Changeux and Danchin, 1976; Edelman, 1987), which differ from less discriminative epigenetic modifications of nuclear chromatin, suggest a possibility, which has so far been underestimated; namely, that we can be "epigenetically proactive", which means that we adapt our social structures (for example, education and child-care), in both the short and the long term, to benefit, influence and constructively interact with the ever-developing neuronal architecture of our brains (the term "epigenetic proaction" was coined by Evers, 2015; cf. Evers and Changeux, 2016, 2017).

The purpose of this article is to present this idea that we may culturally and actively shape the developing brain, to describe the underlying science, and, against that background, to discuss some possible risks and benefits. By virtue of its interdisciplinarity (combining neuroscience with philosophy and social/historical perspectives), the article should be considered a contribution to neuroethics.

The fundamental idea of epigenetic proaction is to understand and influence human dispositions and the genesis of new ethical and social norms in the light of what we presently know about the brain. Epigenetic proaction can be described as a way to socially steer evolution by influencing the cultural imprints to be stored in our brains. It is in line with Lewontin (1993): while traditional Darwinism has portrayed the organism as a passive recipient of environmental influences, a correct understanding should emphasize humans as active constructors of their own environments, and in particular the social and cultural ones.

However, the idea that culture both shapes and is shaped by the brain is not ideologically neutral. Scientific theories develop in political and ideological contexts and are sometimes theoretically permeated by them. This is not least apparent in sciences purporting to explain the human mind and human behaviour, and before describing the scientific foundations of epigenetic proaction, I shall briefly explain their historical background.

When socio-political circumstances so permitted, empirical and theoretical studies have jointly produced an extraordinarily rich and mature science: physics, a true success-story, the main goal of which is to understand how the universe behaves. In contrast, when it comes to understanding how humans behave, academic development has been painful, bellicose and slow. It is an interesting historical fact that a species that has successfully explored its physical and logical universe through philosophy, mathematics, astronomy, physics and biology, and created magnificent architecture, art, poetry and music, has persistently shown itself resistant to understanding itself, its own mental world. The mind sciences have not achieved any comparably detailed, powerful, explanatory and applicable/useful scientific knowledge or understanding of the human mind and its disorders (sadly illustrated by the lack of efficient treatments for mental disorders), and the reason for this discrepancy is largely ideological.

By the end of the nineteenth century, after centuries of ideological (for example, religious) limitations, scientists were able to express their views with far fewer constraints than their predecessors. Interestingly, they instantly sought to eliminate from science the very thing that they were at last free to study: consciousness. Science developed "psychophobia" (Evers, 2009).

At the beginning of the twentieth century, the school of behaviourism arose as a revolt against the earlier introspectionist methods of explaining consciousness. However, this trend soon developed into a complete expulsion of consciousness from scientific inquiry. Any reference to "consciousness" was rejected by the behaviourists, who regarded that notion as no more credible, scientifically speaking, than the classic notion of a soul. "The time has come", claimed one of the founders of behaviourism, John Broadus Watson (in *Behaviourism*, 1928, p. 5): "when science must discard all reference to consciousness" and exclude "from its vocabulary all subjective terms such as sensation, perception, image, desire, purpose, and even thinking and emotion". Some decades later, Skinner developed similar views, claiming in his standard work *Science and Human Behaviour* (1953, p. 30) that "mind" and "ideas" are fictions "invented for the sole purpose of providing spurious explanations". The vast majority of psychologists followed the behaviourist lead, and "mind science" (borrowing a term from Ledoux, 1998) seemed to lie plunged into a modern version of the dark ages, where the legacy of behaviourism in psychology prevented certain forms of research. In the mid-twentieth century, cognitive science arrived on the scene, apparently to mind's rescue. Behaviourism was dethroned and mind brought back on stage. But not all of it: emotions were still left out in the cold, accompanied by the brain. Cognitive science developed the theory of functionalism, according to which the mind could be likened to a machine: intelligent functions carried out by different machines (organic or non-organic) were thought to reflect the same underlying processes. Psychological phenomena were described in terms of functional processes, and computation assumed to be largely independent of the structure and the mode of development of the nervous system. The physical nature of the nervous system was believed to place no constraints on the patterns of thought. Functionalists showed little interest in the brain, believing that the organization of the mind can be studied without reference to the hardware that produces it. This is strongly criticized by Edelman, who (in *Bright Air*, *Brilliant Fire*, 1992, p. 13) wrote that:

> the cognitivist enterprise is a scientific deviation as great as that of behaviorism it has attempted to supplant. The critical errors underlying this deviation are as unperceived by most cognitive scientists as relativity was before Einstein and heliocentrism was before Copernicus … the entire structure on which the cognitivist enterprise is based is incoherent and not borne out by the facts.

Today, the cleavage between "functional" and "neuroscientific" data is scientifically obsolete. Neuroscience has a major "physiological", that is, functional component which cannot be opposed to any "pure" functional studies. Contemporary neuroscience has moved away from modelling the brain as an input–output machine and rather emphasizes its plasticity and variability, purporting to offer scientific explanations of important aspects of thought and judgement, including normative (e.g., moral) evaluations. While understanding of social phenomena remains primarily a matter of studying cultural and social mechanisms, it is becoming increasingly apparent that knowledge of the brain is also relevant – maybe even necessary – in the context. Progress in neuroscience – notably, on the dynamic functions of neural networks – can deepen our understanding of decision-making, choice, acquisition of character and temperament, and the development of moral dispositions. There is no evidence of a dedicated moral-focused area in the brain, but ample evidence shows how brain dysfunctions or damage can underlie a multitude of cognitive, emotional and behavioural disabilities, such as memory loss, and attention deficit or personality disorders, including moral incapacity or the inability to experience morally relevant emotions, such as shame or guilt (cf., e.g., Damasio et al., 1994).

In this respect, neuroscience notably differs from other branches of life sciences, such as genetics. The natural sciences have different degrees of explanatory power with respect to thought and judgement. The explanatory gap between our minds, social structures, and our genetic structure is far larger than the explanatory gap between our minds and the architecture of our brains because the relationship between the latter two is closer than between the former in a manner that is explanatorily relevant. Simply phrased, neuroscience can explain more about how and why we think and feel the way we do than genetics does or can do. Even though an individual's genetic structure importantly determines who and what s/he becomes both physiologically and in terms of personality, genes only decide limited aspects of the individual's identity,[1] and, at least as far as the mind is concerned, less than his or her brain structures do. In contrast, the brain is the organ of individuality: of consciousness, intelligence, personality, behaviour and conscience; characteristics that brain science increasingly is able to examine and explain in significant ways. We are neuronal men and women (a term coined by Changeux: *Neuronal Man*, 1983/1997); everything we do, think and feel is a function of the architecture of our brains, even though this fact may not yet be quite integrated into our general world-views or self-conceptions.

Simultaneously, through its strong explanatory power, neuroscience could be regarded as no less, and possibly even more, controversial than genetics as a theoretical basis for social and ethical reasoning. If, say, humans learn to design their own brain more potently than we already do by, for example, selecting what we believe to be brain-nourishing food and pursuing neuronally healthy lifestyles, we *could* use that knowledge well – there is certainly room for improvements. On the

1 An attitude firmly expressed by Ian Wilmut (1997), who was the first to successfully clone a mammal, a sheep named Dolly.

other hand, the dream of the perfect human being has a sordid past, providing ample cause for concern over such projects. Science can be, and has repeatedly been, ideologically hijacked, and the more dangerously so the stronger the science in question is; I shall return to this in section 5. Here, let us merely observe that historical awareness is of utmost importance in assessing the risks versus the benefits of these scientific advances in a responsible and realistic manner, not least in order to acknowledge and usefully apply the socially crucial insight that the neuro-cultural relations are mutual and symbiotic.

2. The Brain: Uniquely Individual and Culture-Bound

Each individual has a unique cerebral identity even in the relative absence of genetic distinction, and the development of this identity is strongly influenced by social and cultural environments leaving major traces in the connectivity of the brain.

The evolution of our cerebral architecture is both genetic and epigenetic: the nervous system develops within a "genetic envelope" in continuous interaction with the immediate physical and socio-cultural environments.[2] This interaction introduces important elements of variability and plasticity. The human brain is variable in size, shape, weight and topology (see Gould, 1981/1996): not even monozygotic twins have identical brains (Hasnain et al., 1998; Steinmetz et al., 1995; Tramo et al., 1998; Kee et al., 1998). Experimental anatomical and behavioural studies of monozygotic twins have revealed epigenetic variability, and while the reasons for this variability are not well known, the studies suggest that the determination of genes on the brain's architecture has strong limitations (Sommer et al., 2002; Eckert et al., 2002; White et al., 2002; Thompson et al., 2001). Simply phrased: each brain is unique and not predetermined; its development is importantly but not exclusively shaped by genetic factors and remains in some measure open.

Our brains are characterized by extreme variability among individuals (phenotypic variation), and also between regions within the brain. Brain regions differ between each other with respect to cell types and distributions, receptors, neuromodulators, transcriptomes, synaptic densities, multiscale and nested connectomes, as well as morphological gradients across the cortex. This variability translates into a dynamic repertoire of cell populations, microcircuits and networks, accessible via invasive and non-invasive brain imaging and physiological methods, for instance, as expressed in the region-specific physiological patterns

2 The epigenetic evolutionary process of the brain's development is described well by Changeux (2004, ch. 6).

in iEEG (intracranial electroencephalography). Although there are invariants in the human behavioural repertoire and brain organization, the human brain is characterized by considerable inter-subject variability, including, for example, lifespan differences. The co-variation and ranges of physiological parameters span manifolds of normal and abnormal operation, which themselves map upon manifolds of brain states and network dynamics. Nature takes advantage of such variability to create individual brains operating and "living" within these manifolds.[3]

This scientific view of the brain is reminiscent of the philosophical position that while there is individual variation with respect to how the self and the world are experienced, certain structures are fundamental. These are of a "universal" character (as, for example, pre-specified in biological nature, notably the genome), in distinction from those relative to a given context, such as era, culture or symbolic system. One of the most famous illustrations would be Kant's position that human beings necessarily experience the world spatially and temporally (Kant, 1781); this is not individually variable but a fundamental feature of experience. If we express that in neuroscientific terms, spatio-temporal experience is a function of the way in which our brains are construed as a result of evolution. We all experience a spatiotemporal world in which states and events are spatiotemporally located. Space and time are, we can say, axiomatic brain constructs: everybody experiences them in some way, even though (also in accordance with Kant) different individuals may experience these structures differently, from their own unique perspective.

In the twenty-first century, several large Brain Initiatives have emerged that aim to understand and decode the human brain from different perspectives (in Europe, Asia, the US, Canada, etc.). One of the biggest challenges in decoding the human brain is precisely to decipher, or map, this invariance versus variability; constancy versus plasticity; universality versus individuality, taking the important cultural dimensions into account. This is a main focus of the European Flagship, the Human Brain Project, launched by the European Commission's Future and Emerging Technologies (FET) scheme in 2013 (Amunts et al., 2016; Salles et al., 2019).

Socio-cultural impacts on brain development are particularly important in *Homo sapiens*, who spend up to 25 years developing their brain in response to learning and experience: almost a third of their presently expected lifespan (once it was at least half of it). Socio-cultural influence is not unique to humans as such, but it is unique in its measure; our long postnatal gestation periods and our culture-bound brains distinguish us from other animals. During embryonic and postnatal development, the million billion (10^{15}) synapses that form the human

3 I owe this paragraph to Viktor Jirsa.

brain network do not assemble like the parts of a computer according to a plan that defines precisely the disposition of all individual components. If this were the case, the slightest error in the instructions for carrying out this programme could have catastrophic consequences. On the contrary, the mechanism appears to rely on the progressive setting of robust interneuronal connections through trial-and-error mechanisms that formally resemble an evolutionary process by variation selection (Changeux et al., 1973; Changeux and Danchin, 1976; Edelman, 1987). At sensitive periods of brain development, the phenotypic variability of nerve cell distribution and position, as well as the exuberant spreading and the multiple figures of the transiently formed connections originating from the erratic wandering of growth cone behaviour, introduce a maximal diversity of synaptic connections. This variability is then reduced by the selective stabilization of some of the labile contacts and the elimination (or retraction) of the others. The crucial hypothesis of the model is that the evolution of the connective state of each synaptic contact is governed globally, and within a given time window, by the overall message of signals experienced by the cell on which it terminates (Changeux et al., 1973). Abundant experimental studies are consistent with, or directly support, the model of synapse selection (see the brief review in Evers, 2015). In humans, about half of all adult connections are formed after birth at a very fast rate (approximately 2 million synapses every minute in the baby's brain). This process of synaptic selection by reward signals concerns the evolution of brain connectivity in single individuals but also exchange of information and shared emotions or rewards between individuals in the social group (Changeux, 2004; Gisiger et al., 2005). It may thus play a critical role in social and cultural evolution.

It is here worth noting that, so far as the presently available evidence goes, the human brain in itself – disconnected from body and environment – does not reveal gender, race or ethnicity: while there is extensive evidence showing individual variability (cf. above), there is no empirical evidence that allows one to determine whether an isolated "brain in a vat" is, for example, female or male, Caucasian or Afro-American, Christian or Hindu. Such group formations can only be performed or identified in a context, where the brain is in a body in a social and natural environment that jointly enable us to form and identify these groups. There is certainly a biological story to tell about how the identity of a Caucasian male Christian, or of an Afro-American female Hindu, developed, but it cannot be found by simply looking at their isolated brains. Studies of "brains in vats" can offer valuable scientific knowledge of singular aspects and they have certainly offered many amusing thought-experiments in philosophy, but from more holistic scientific perspectives striving to understand the brain in a more integrated way, they are of limited interest since brains can neither exist nor be understood independently of their physical and cultural contexts.

The social relevance of understanding the important cultural impact on brain function is immense, notably in the fields of improving childcare and education. In these contexts (and many others), contemporary neuroscience emphasizing the role of culture in shaping our brains can contribute to developing social (for example, educational) structures that are better suited for helping especially children and adolescents, who are cerebrally very vulnerable during development, but also adults, to achieve health and well-being, which may also improve social harmony.

3. A Naturalistic Responsibility

The dynamic models of the brain that dominate modern neuroscience depict the brain as an autonomously active, dynamic, plastic and variable organ that has evolved in biological-socio-cultural symbiosis. These models highlight the significance of social and cultural impacts on the brain's architecture; notably, through the gigantic weight of the cultural imprints epigenetically stored in our brains. The brain is culture-bound; it exists in contexts and cannot be understood independently of them.

It has been suggested that the close causal connections between "nature and nurture", between neurobiological and socio-cultural structures that these models emphasize, give rise to a "naturalistic responsibility" (Evers, 2009). Recognition that human individuals as well as human societies are products of both their cerebral architectures and the environments in which they have evolved, suggests a constructive interdisciplinary scientific programme laden with responsibility.

The naturalistic responsibility includes deciphering the network of existing causal connections between neurobiological and socio-cultural historical perspectives which lead to moral norms being enunciated at a given moment in human history, and evaluating their "universal" character as pre-specified in the genome and shared by all members of the human species in distinction from those relative to a given culture or symbolic system.

Epigenetic proaction is above all an educational programme, aiming to understand brains and their contexts better from interdisciplinary perspectives and to use that knowledge to adapt social structures to facilitate cerebral development and well-being. What distinguishes the epigenetic educational programme from others is mainly that it is explicitly aimed at favouring individual as well as cross-generational transmission of ethical/social norms on the basis of our present knowledge of the brain. This impacts, for example, how society might structure education (such as kindergarten/primary school education) taking knowledge of the child brain into account.

The naturalistic responsibility involved in epigenetic proaction is manifold, theoretical as well as practical, social as well as naturalistic. These perspectives and the academic disciplines that study them need to join forces if we are ever to reach an inter-theoretic and deeper understanding of the mind, the brain, and the highly diverse societies that intelligent species create. We may then choose to use our new knowledge of the culture-bound brain and the power that it gives us to develop, biologically as well as culturally, into whatever we regard as "better" creatures constructing more advanced societies.

4. Epigenetic Proaction Revisited

Certain areas of research are especially important to pursue with the "epigenetic proaction goal" in mind. They aim at integrating recent advances in neuroscientific research into the normative debate at the level of society. This can be illustrated by the following two examples: violence in adolescents in relation to their social environments, and the influence of poverty on the developing infant brain.

Violence in adolescents is a common phenomenon in our societies and it is frequently repressed through police and judiciary means, often resulting in incarceration. But this approach to juvenile violence simply omits the scientifically established fact that adolescence is also a neurodevelopmental crisis. Evidence from anatomical and functional imaging studies has highlighted major modifications of cortical circuits during adolescence. These include reductions of gyrification and grey matter, increases in the myelination of cortico-cortical connections and changes in the architecture of large-scale cortical networks including precentral, temporal and frontal areas (Klein et al., 2014). Uhlhaas et al. (2009) have used MEG synchrony as an indicator of conscious access and cognitive performance (Dehaene and Changeux, 2011). Until early adolescence, developmental improvements in cognitive performance are accompanied by increases in neural MEG synchrony. This developmental phase is followed by an unexpected decrease in neural synchrony that occurs during late adolescence and is associated with reduced performance. This period of destabilization is followed by a reorganization of synchronization patterns that is accompanied by pronounced increases in gamma-band power and in theta and beta phase synchrony. These remarkable changes in neural connectivity and performance in the adolescent are increasingly being explored and may lead to special unexpected proactive care from society. In turn, this requires active research, including a social educative environment adequate to their special needs. This may include adequate physical exercise, cultural games, educational training and the invention of many new kinds of therapies.

A careful discussion of these issues is a moral priority, particularly considering that, depending on the circumstances, in some countries young people can be transferred to the adult system (e.g., Canada, the US, the UK) and in others there is a strong political will for them to be treated as adults; for example, sentenced to adult prisons (Brazil). In view of the available evidence from neuroscience, social policies that treat and punish minors as adults may arguably not merely be ineffective, but also a clear breach of human rights (Salles et al., 2018). In this sense, neuroscientists can play an extremely useful role, providing and reinforcing the kind of scientific evidence needed to properly understand the delinquency of minors and how to manage it in a way that promotes well-being and respects the rights of all. In doing so, they could raise awareness of an important point made before: that scientific work is intrinsically socially and politically relevant.

This is one of many illustrations of how neuroscientific research can inspire systemic social change. That potential becomes equally evident when we turn our focus to contemporary neuroscientific studies on the influences of poverty on cognitive, emotional and stress regulation systems that propose to analyse how the different individual and contextual factors associated with material, emotional and symbolic deprivation (i.e., lack of food, shelter, education and healthcare) influence neural development (Lipina and Colombo, 2009). These studies have important ethical and public policy implications: they should play an important role in the discussion of a number of issues, such as identifying the structural conditions that are needed for the full exercise of human rights, the overt and covert ways in which citizens' rights can be violated, what respect for human dignity entails, the potential ways of depriving people of their identity as full citizens and of restoring such identity, and the determination of collective social responsibilities (Lipina and Colombo, 2009; Lipina and Posner, 2012). The specific evidence that neuroscience brings to analyses of poverty and its implications is then not only of great interest in itself but also relevant to policy-making. However, this evidence needs to be spelled out in detail and clarified conceptually, notably in terms of causes of and attitudes toward poverty, implications of poverty for brain development, and the possibilities of reducing and reversing these effects.

There are additional related issues. One of them has to do with the causes of and attitudes to poverty (Lipina and Evers, 2017). For example, what does neuroscience concretely contribute to the debates over individualistic versus systemic or social explanations of poverty? What is implied by considering the neural and behavioural differences due to poverty as a deficit rather than as an adaptation? If a normative aim of this scientific research is to reduce poverty, should it not focus rather (or equally) on studying the brains of those who cause it rather than those who suffer the consequences? The problem of poverty is on the one hand a practical, political question of, for example, distribution of wealth and access to social services. However, there may also be a biological background to why humans create or remain indifferent to poverty; we may have biological predispositions to develop certain types of social hierarchies (Changeux, 1983/1997, 2004). Is there – as suggested by Koestler (1967) and Lorenz (1966) – some inherent (mal)function in the human brain making us prone to aggression or indifferent to the suffering of out-group individuals? On that assumption, (how) can that be empirically investigated in the context of neuroscience?

Another issue is related to the impacts of poverty on brain development. The interpretation of evidence and the identification of ethical and social issues that arise might provide the means for reducing poverty's negative impacts. We also have questions about reversibility. Which impacts of poverty can be reversed, and how? What does the concept of "reversibility" mean, or entail? The evidence available in this area raises specific ethical challenges that should also be considered in the interpretation of results and the planning of future research.

5. Broadening the Perspective: Epigenetic Proaction and Ideology in Science

The scientific idea that brains are open to cultural shaping can be heralded as a welcome opportunity to strengthen social progress in a desired direction. However, such shaping may challenge dominant social group-hierarchies, which is not necessarily welcome even in scientific communities that may be permeated with ideologies (e.g., political or religious) that reject such social change. In order to develop epigenetic proaction and establish a scientifically and socially fruitful brain–culture interaction, it is important to be aware of and try to understand this latter attitude.

Science is normatively relevant; scientific knowledge can enrich and inspire changes in our world-views, self-conceptions, and existential or ideological attitudes. The latter should, ideally, harmonize with science, to the extent that this is relevant, and minimally, not flatly contradict it. Vigilance is required to prevent scientifically informed world-views (here understood in a very broad sense) from becoming socially destructive and quite unscientific forms of ideological "scientism". Historically, scientific knowledge has often been distorted to serve ideologies with detrimental consequences, such as versions of evolutionary ethics of the nineteenth and twentieth centuries that were inspirational factors for genocide in several continents, including Europe; or the "psychophobic" mind sciences (described earlier) that blocked scientific research on consciousness for almost a century (cf., e.g., Evers, 2007, 2009).

Evolutionary ethics, developed in the nineteenth century and inspired by Charles Darwin's theory of evolution and natural selection (1859, 1871), can summarily be described as an attempt to base ethics on presumed facts about evolution. An interesting humanistic version was proposed by John Dewey (*Evolution and Ethics*, 1898), who suggests that if, through our advancing knowledge about the world, we develop evolutionary control, then we also need to develop and define a corresponding and equally powerful evolutionary ethics. In other words: we need to expand our moral capabilities and accountability to include evolutionary perspectives. Dewey's humanistic evolutionary ethics stands in sharp contrast to other forms of evolutionary ethics, notably those that connected presumed evolutionary "facts" to race. This latter movement is often associated with the philosopher Herbert Spencer, who, in his work *Social Statistics* (1851), lauded imperialism for having exterminated sections of humanity that in their alleged inferiority blocked the way for civilization. However, it was not only racial exclusion that was on the evolutionist agenda at that time, but also social exclusion. Social Darwinism can be seen as misuse of the theories that Darwin had put forward, to the extent that it would be unjustified to describe Darwin himself as a "social Darwinist". This movement, which was strongly in vogue in England during the Industrial Revolution, recommended evolution by social selection that would favour the survival of the fittest and the extermination of the weak. A forerunner of this movement was the English economist David Ricardo (1772–1823), an icon of economic liberalism, who suggested, with strong political implications, that wages be measured by subsistence level, allowing workers barely to survive while preventing them from reproducing freely, an idea that was embraced by the philosopher Henry Sidgwick.

Of course, distortions of evolutionary theories did not give rise to either racism or class oppression, which had been present for centuries in human societies. Rather, racist currents already present in society made certain distortions of evolutionary theory palatable to some people. The applications of the distorted evolutionist racist theories proved fatal for those races that were considered of "lesser" human worth. During the private reign of terror of the Belgian king Leopold II in the Congo, for example, ten million people (half the population) were slaughtered in one of the darkest chapters in European colonialism. (Approximately 1,500 Scandinavians, many of them officers and soldiers, participated in this genocide, which was the subject of a 2005 exhibition at the Ethnographic Museum in Stockholm: "Kongospår".) Distorted science was surely not necessary for this genocide to take place, but it was a non-negligible inspirational element, and it is important for modern scientists to be aware of such risks and help combat them. In this respect European colonialism had an ideology that was not unlike that of National Socialism, which would develop in Germany some decades later.

Indeed, Spencer became as popular a writer in the Nazi ideology as he had been in Victorian England, though in the two cases different races were *de facto* subject to extermination. While the genocides of European colonialism were not enough to set moral alarm bells ringing in Europe, the discovery of concentration camps within Europe itself did so, and directly after the Second World War, evolutionary ethics became almost impossible to discuss except in negative terms. The movement of evolutionism, associating the changes of evolution with positive attitudes to competition and aggressive relations between people within a society or between societies, became totally discredited.

Such mistakes must not be repeated today; however, this historically justified precaution need not and should not prevent us from allowing our world-views, existential attitudes and self-conceptions to be enriched by scientific enlightenment.

Sometimes, ideological distortions are blunt and easily detected – as when specific groups of people are described as uniformly possessing biologically determined psychological or cognitive features without considering socially unequal circumstances between the individuals belonging to the group (classical examples, when groups are compared from an erroneous biological view, pit the qualities of different races, classes or genders against each other). Although coarse and scientifically inadequate, such distortions can and do still cause considerable damage in society, for example, by contributing to prejudice and stigmatizations.

However, even without distortions, the scientific process can also be inherently normative and this may be far more difficult to detect. Motivation to pursue science comes from a desire to understand and learn, but it can simultaneously be ideological, and this may influence how we select themes, identify data, interpret results, formulate theories and suggest applications – for better or for worse. The scientific process will not be the same if we research new drugs to help save a maximum number of lives, or to earn money, but the science involved may from a scientific perspective be equally excellent in either case. Ideological motivation is not tantamount to distortion of science, and "bad" motivations may lead to excellent science (as described, e.g., in Kitcher's important work, *Vaulting Ambition*, 1985).

Modern neuroscientific theories of cultural imprinting on brain architecture, with their emphasis on plasticity and individuality, will not necessarily be well received in groups whose ideologies favour a status quo of power-division or hierarchies (for example, the dominance of a particular gender, ethnicity or social class). It is interesting to compare this to previous centuries' discussions in genetics of the human possibility to influence, change and progress. Genetic theories such as Mendelism, the theory of heredity deriving originally from the work of Gregor Mendel (1866), emphasizing the innate characteristics of human beings, were most enthusiastically endorsed by those adhering to a conservative ideology motivated to preserve the privileges of some specific class, race or gender (if some individuals could be said to be "born to poverty and servitude", social reforms would make less sense). In contrast, Jean-Baptiste Lamarck (1809) and his doctrine allowing for the inheritance of acquired characteristics and, by extension, of social flexibility, was more inspiring to progressive ideologies. Attempts in the 1970s to establish socio-biology[4] spurred intense controversies, and were attacked for joining the long line of biological determinists. "The reason for the survival of these recurrent determinist theories", argued its critics, "is that they consistently tend to provide a genetic justification of the status quo and of existing privileges for certain groups according to class, race or sex" (Allen et al. 1975).[5] That discussion became polarized to the extreme in cases when sociologists and biologists would reject all attempts to explain human identity and social life in any terms other than their own.[6] With reference to the point made above, that ideological motivations need not distort science, we should also note that it would be false to assume that nothing good ever came out of the socio-biological discussions (see, e.g., Kitcher, 1985).

Today, biological determinism has lost most of the ground it once possessed, and the symbiotic "nature–nurture" relationship has been widely established, at least in scientific circles. Biological and sociological explanations of human beings and the societies they create develop in parallel relations of complementarity rather than in stark opposition. While some cases necessitate choices between the two perspectives (for example, when determining whether a specific disorder should primarily be medically or sociologically explained and treated), they are not seen as mutually conflicting generally. In some instances, of course, that peace may be frail. The ideological (and sometimes financial) interests in finding facts that suit a certain set of values are no less strong than they used to be, and their power to influence the scientific communities, through conditioned funding, political regulations, or other methods, has not diminished. Nevertheless, the all-out war of the trenches between biology and sociology appears to ebb away. In contemporary neuroscience, the biological and socio-cultural perspectives dynamically interact in a theoretical symbiosis, which should reduce the tension further. This is particularly true of dynamic models of the brain emphasizing plasticity and variability.

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4 Edward O. Wilson coined the term in his book *Sociobiology: The New Synthesis* (1975).

5 A very similar idea was expressed in the fifth century BC by the Chinese philosopher Mo Tzu, who vigorously attacked fatalism on social grounds, as an obstacle to the social development of human welfare. See Mo Tzu, *The Mo Tzu* (n.d., part I, ch. 35).

6 The die-hard idea of biology as destiny, of innate determination, is criticized in great detail and deflated by Stephen Jay Gould in his now-classic *The Mismeasure of Man* (1981/1996).

6. Conclusion

Contemporary neuroscience is far more closely connected to philosophy and other disciplines from the humanities and social sciences than was the case during the previous century.

The realization of the extent to which the human brain develops in response to learning and experience and is shaped by cultural influences has profoundly influenced contemporary neuroscientific models of the brain that emphasize its plasticity and individual variability. The mutual relevance of humanities or social sciences and neuroscience has thereby increased. Adequate understanding of the brain must take the shaping context, the environment in which it operates and develops, into account, whereas understanding the brain as culture-bound, that is, importantly shaped by culture, actualizes the need for understanding this influence, and how we may use this knowledge to our benefit. The discussion in this article has been theoretical, combining philosophical analysis with scientific descriptions and historical perspectives, explaining the concept of epigenetic proaction and its scientific basis against a historical background. Practical questions now arise: if we decide to adapt our social structures to better suit what we today know about our cerebral architecture and functions, *which* values should we strive to develop and strengthen, by what justification, and by whose or what authority? Epigenetic proaction is an educational programme that can be used for a variety of purposes to suit different ideals, and in the literature on epigenetic proaction these normative issues remain to be discussed. This challenge is raised by Salles (2017, p. 1271), who, while favourable to epigenetic proaction as such, calls for concretizations and further normative discussions, and expresses the hope that "joint work on this issue inspires empirical and theoretical research from different disciplines to further examine proactive epigenesis and its possibilities for addressing the difficult task of moral change".

In order to pass from theory to practice, and apply epigenetic proaction in actual societal contexts, such as nurseries or schools, many areas of research and professional activities need to be involved. Modelling the brain taking plasticity and variability into account is presently a key focus of the European Human Brain Project (see above) in its quest to develop brain models – including personalized brain models – for application and use in clinical and social practices, and these research groups include philosophers.

The Human Brain Project's foundational interdisciplinarity, linking research in the natural sciences with the social sciences and humanities, has inspired other major Brain Initiatives (e.g., in China, Japan, Korea, the US, Canada and Australia) to consider similar research collaborations with social applications. Indeed, if several major brain research projects conducted in such culturally varied contexts jointly study the culture-bound brain and possible social applications of that knowledge, and collaborate in the process, the results may be quite outstanding.

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References

Allen, E. et al. (1975) "Letter to the Editors." *New York Review of Books*, 13 Nov.

Amunts, K., Ebell, C., Muller, J., Telefont, M., Knoll, A., and Lippert, T. (2016) "The Human Brain Project: Creating a European Research Infrastructure to Decode the Human Brain." *Neuron* 92(3): 574–581.

Changeux, J.-P. (1983/1997) "Neuronal Man." *The Biology of Mind*. Princeton, NJ: Princeton University Press.

Changeux, J.-P. (2004) "The Physiology of Truth." *Neuroscience and Human Knowledge*. Cambridge, MA: Belknap, Harvard University Press.

Changeux, J.-P., Courrège, P., and Danchin, A. (1973) "A Theory of the Epigenesis of Neural Networks by Selective Stabilization of Synapses." *Proceedings of the National Academy of Sciences of the United States of America* 70: 2974–2978.

Changeux, J.-P. and Danchin, A. (1976) "Selective Stabilisation of Developing Synapses as a Mechanism for the Specification of Neuronal Networks." *Nature* 264: 705–712.

Damasio, H., Grabowski, T., Frank, R., Galaburda, A. M., and Damasio, A. R. (1994) "The Return of Phineas Gage: Clues about the Brain from the Skull of a Famous Patient." *Science* 264: 1102–1105.

Darwin, C. R. (1859) *The Origin of Species by Means of Natural Selection*. London: John Murray.

Darwin, C. R. (1871) *The Descent of Man*. London: John Murray.

Dehaene, S. and Changeux, J.-P. (2011) "Experimental and Theoretical Approaches to Conscious Processing." *Neuron* 70(2): 200–227.

Dewey, J. (1898) "Evolution and Ethics." Originally published in *The Monist* VIII, 321–341.

Eckert, M., Leonard, C., Molloy, E., Blumenthal, J., Zijdenbos, A., and Giedd, J. (2002) "The Epigenesis of Planum Temporale Asymmetry in Twins." *Cerebral Cortex* 12: 749–755.

Edelman, G. M. (1987) *Neural Darwinism: The Theory of Neuronal Group Selection*. New York: Basic Books.

Edelman, G. M. (1992) *Bright Air, Brilliant Fire. On the Matter of the Mind*. New York: Basic Books.

Evers, K. (2007) "Toward a Philosophy for Neuroethics." *EMBO Report* 8: 48–51.

EVERS, K. (2009) *Quand la matière s'éveille*. Paris: Éditions Odile Jacob.

EVERS, K. (2015) "Can We Be Epigenetically Proactive?" In T. Metzinger and J. M. Windt (eds), *Open Mind: Philosophy and the Mind Sciences in the 21st Century*, pp. 497–518. Cambridge, MA: MIT Press.

EVERS, K. and CHANGEUX, J. P. (2016) "Proactive Epigenesis and Ethical Innovation: A Neuronal Hypothesis for the Genesis of Ethical Rules." *EMBO Reports* 17: 1361–1364.

EVERS, K. and CHANGEUX, J. P. (2017) "Response by the Authors." *EMBO Reports* 18: 1272.

GISIGER, T., KERSZBERG, M., and CHANGEUX, J.-P. (2005) "Acquisition and Performance of Delayed-Response Tasks: A Neural Network Model." *Cerebral Cortex* 15(5): 489–506.

GOULD, S. J. (1981/1996) *The Mismeasure of Man*. New York: Norton & Co.

HASNAIN, M. K., FOX, P. T., and WOLDORFF, M. G. (1998) "Intersubject Variability of Functional Areas in the Human Visual Cortex." *Human Brain Mapping* 6: 301–315.

KANT, I. (1781) *Kritik der Reinen Vernunft*. Riga: Verlag Johan Friedrich Hartknoch.

KEE, D., CHERRY, B., MCBRIDE, D., NEALE, M., and SEGAL, N. (1998) "Multi-Task Analysis of Cerebral Hemisphere Specialization in Monozygotic Twins Discordant for Handedness." *Neuropsychology* 12: 468–478.

KLEIN, D., ROTARSKA-JAGIELA, A., GENC, E., SRITHARAN, S., MOHR, H., et al. (2014) "Adolescent Brain Maturation and Cortical Folding: Evidence for Reductions in Gyrification." *PLoS One* 9(1): e84914.

KOESTLER, A. (1967) *The Ghost in the Machine*. London: Arkana Books.

LAMARCK, J.-B. (1809) *Philosophie zoologique*, 2 vols. Paris.

LEDOUX, J. (1998) *The Emotional Brain*. London: Phoenix.

LEWONTIN, R. (1993) *The Doctrine of DNA: Biology as Ideology.* London: Penguin Books.

LIPINA, S. J. and COLOMBO, J. A. (2009) *Poverty and Brain Development during Childhood: An Approach from Cognitive Psychology and Neuroscience*. Washington, DC: American Psychological Association.

LIPINA, S. and EVERS, K. (2017) "Neuroscience of Childhood Poverty: Evidence of Impacts and Mechanisms as Vehicles of Dialog with Ethics." *Frontiers in Psychology*, 8: 61.

LIPINA, S. and POSNER, M. (2012) "The Impact of Poverty on the Development of Brain Networks." *Frontiers in Human Neuroscience* 6: 238.

LORENZ, K. (1966) *On Aggression*. London: Methuen.

MENDEL, G. (1866) *Versuche über Pflanzen-Hybriden*. Verhandlungen der Naturforschenden Vereines in Brünn.

MO, TZU (n.d.) *The Mo Tzu*.

SALLES, A. (2017) "Proactive Epigenesis and Ethics." *EMBO Reports* 18: 1271.

SALLES, A., BJAALIE, J., EVERS, K., FARISCO, M., FOTHERGILL, T., GUERRERO, M., MASLEN, H., MULLER, J., PRESCOTT, T., STAHL, B. C., WALTER, H., ZILLES, K., and AMUNTS, K. (2019) "The Human Brain Project: Responsible Brain Research for the Benefit of Society." *Neuron* 101(3): 380–384.

SALLES, A., EVERS, K., and FARISCO, M. (2018) "Neuroethics and Philosophy in Responsible Research and Innovation: The Case of the Human Brain Project." *Neuroethics* 12: 201–211.

SKINNER, B. F. (1953) *Science and Human Behaviour.* New York: Macmillan.

SOMMER, I. E., RAMSEY, N. F., MANDL, R. C., and KAHN, R. S. (2002) "Language Lateralization in Monozygotic Twin Pairs Concordant and Discordant for Handedness." *Brain* 125: 2710–2718.

SPENCER, H. (1851) *Social Statistics*. London: John Chapman.

Steinmetz, H., Herzog, A., Schlaug, G., Huang, Y., and Jäncke, L. (1995) "Brain Asymmetry in Monozygotic Twins." *Cerebral Cortex* 5: 296–300.

Thompson, P. M., Cannon, T., Narr, K., van Erp, T., Poutanen, V.-P., et al. (2001) "Genetic Influences on Brain Structure." *Nature Neuroscience* 4: 1253–1258.

Tramo, M. J., Loftus, W., Stukel, T., Green, R., Weaver, J., and Gazzaniga, S. (1998) "Brain Size, Head Size and Intelligence Quotient in Monozygotic Twins." *Neurobiology* 50: 1246–1252.

Uhlhaas, P. J., Roux, F., Singer, W., Haenschel, C., Sireteanu, R., and Rodriguez, E. (2009) "The Development of Neural Synchrony Reflects Late Maturation and Restructuring of Functional Networks in Humans." *Proceedings of the National Academy of Sciences of the United States of America* 106(24): 9866–9871.

Watson, J. B. (1928) *Behaviourism*. London: Harper & Bros.

White, T., Andreasen, N., and Nopoulos, P. (2002) "Brain Volume and Surface Morphology in Monozygotic Twins." *Cerebral Cortex* 12: 486–493.

Wilmut, I. 1997) "Interview (Gespräch)." In *Der Spiegel*, 10.

Wilson, E. O. (1975) *Sociobiology: The New Synthesis*. Cambridge, MA: Belknap Press.