Neurogenomics from the Catholic tradition

A succinct anthropological perspective taking into account nowadays developments in the fields of genetics and neuroscience

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articolo

There was a time in which genes played a central role in scientific and popular scenarios. Now it is the time of another principal character: the human brain. More than 10 years ago, prominent neuroscientist Steven Rose portrayed with these words the raise of the so call 'golden neurocentric age':

> 'Better brains' shouted the front cover of a special edition of *Scientific American* in 2003, and the titles of the articles inside formed a dream prospectus for the future: 'Ultimate self-improvement'; 'New hope for brain repair'; 'The quest for a smart pill'; 'Mind-reading machines'; 'Brain stimulators'; 'Genes of the psyche'; 'Taming stress'. These, it seems, are the promises offered by the new brain sciences, bidding strongly to overtake genetics as the Next Big Scientific Thing. The phrases trip lightly off the tongue, or shout to us from lurid book covers. There is to be a 'post-human future' in which 'tomorrow's people' will be what another author describes as 'neurochemical selves'. But just what is being sold here? How might these promissory notes be cashed? Is a golden 'neurocentric age' of human happiness 'beyond therapy' about to dawn? So many past scientific promises – from clean nuclear power to genetic engineering – have turned out to be so perilously close to snake oil that one is entitled to be just a little sceptical. And if these slogans do become practical technologies, what then? What becomes of our self-conception as humans with agency, with the freedom to shape our own lives? What new powers might accrue to the state, to the military, to the pharmaceutical industry, yet further to intervene in, to control our lives?'[1].

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From the Human Genome Project (HGP) era to the Human Brain Project (HBP) one

'The human brain is the most complex biological entity in the known universe and understanding how it works—that is, how its molecules, cells, circuits and systems enable behaviour, perception, thought and emotion—is the overarching goal of neuroscience. This goal remains elusive, although not from a lack of collective drive or intellectual curiosity on the part of researchers. Rather, progress frequently has been limited by the technologies available during any given era. Over the past decade, however, remarkable technological advances have created entirely new possibilities for studying and understanding the brain. Just as the advent of the microscope enabled Ramón y Cajal to lay the foundation for the 'neuron doctrine', innovative technologies from diverse but increasingly convergent disciplines will spur groundbreaking discoveries that will change how we think about the brain'[2].

'The US government designated the 1990s as The Decade of the Brain. Some four years later and rather reluctantly, the Europeans declared their own decade, which therefore is coming to its end as I write these words.

Formal designations apart, the huge expansion of the neurosciences which has taken place over recent years has led many to suggest that the first ten years of this new century should be claimed as The Decade of the Mind. Capitalising on the scale and technological success of the Human Genome Project, understanding –even decoding– the complex interconnected web between the languages of brain and those of mind has come to be seen as science's final frontier. With its hundred billion nerve cells, with their hundred trillion interconnections, the human brain is the most complex phenomenon in the known universe – always, of course, excepting the interaction of some six billion such brains and their owners within the socio-technological culture of our planetary ecosystem!

The global scale of the research effort now put into the neurosciences, primarily in the US, but closely followed by Europe and Japan, has turned them from classical 'little sciences' into a major industry engaging large teams of researchers, involving billions of dollars from government –including its military wing– and the pharmaceutical industry. The consequence is that what were once disparate fields –anatomy, physiology, molecular biology, genetics and behaviour– are now all embraced within 'neurobiology'. However, its ambitions have reached still further, into the historically disputed terrain between biology, psychology and philosophy; hence the more all-embracing phrase: 'the neurosciences'. The plural is important. Although the thirty thousand or so researchers who convene each year at the vast American Society for Neuroscience meetings, held in rotation in the largest conference centres that the US can offer, all study the same object –the brain, its functions and dysfunctions– they still do so at many different levels and with many different paradigms, problematics and techniques'[3].

In the last years, since 2013, several projects in deciphering the mysteries of the human brain have raised. The famous US BRAIN Initiative and the European Union's Human Brain Project are the most popular and important. But there are also the Japan's Brain/MINDS (Brain Mapping by Integrated Neurotechnologies for Disease Studies) project, and the CanadaBrain—to name just a few. Planning is also underway for a national brain project in China[4].

The envisioned long-term pay-off of these projects is a more comprehensive understanding of how the brain mediates complex thoughts and behaviours that will provide an essential guide to progress in diagnosing, treating and potentially curing neurological and psychiatric diseases and disorders that devastate so many lives. Translating into a short sentence, the main purpose of these scientific *consortia* is: 'giving scientists the tools they need to get a dynamic picture of the brain in action' by 'catalyzing an interdisciplinary effort of unprecedented scope' that will 'accelerate the development and application of new technologies to construct a dynamic picture of brain function that integrates neuronal and circuit activity over time and space'[5].

'An image is worth a thousand words'. Cerebral cartography in the modern sense means much more than anatomy (maps) or cerebral connections (routes). Rather, the aim is to generate atlases that use anatomical frameworks to organize and convey spatially and temporally distributed functional information about the brain at all organizational levels, from genes to cognition, and at all the relevant spatial and temporal scales. The ultimate brain atlas will, therefore, be an instantiation of a comprehensive multi-scale understanding of the brain'[6].

We are at a unique moment in the history of neuroscience - a moment when technological innovation has created possibilities for discoveries that could cumulatively lead to a revolution in our understanding of the brain. For some of our goals, novel technologies are already in place and simply need to be exploited at scale and in a highly coordinated fashion. In other cases, however, entirely new technologies need to be envisioned and created, especially for non-invasive, high-resolution recording and modulation of human brain circuits[7].

Genetics and Neurosciences

'It is clear that the weight of human suffering associated with damage or malfunction of mind and brain is enormous. In the ageing populations of Western industrial societies, Alzheimer's disease, a seemingly irreversible loss of brain cells and mental function, is an increasing burden. There are likely to be a million or so sufferers from Alzheimer's in the UK by 2020. There are certain forms of particular genes which are now known to be risk factors for the disease, along with a variety of environmental hazards; treatment is at best palliative. Huntington's disease is much rarer, and a consequence of a single gene abnormality; Parkinson's is more common, and now the focus of efforts to alleviate it by various forms of genetic therapy'[8].

'Inputs into the neurosciences come from genetics – the identification of genes associated both with normal mental functions, such as learning and memory, and the dysfunctions that go with conditions such as depression, schizophrenia and Alzheimer's disease'[9].

Capitalising on the scale and technological success of the Human Genome Project, understanding the complex interconnected web between the languages of brain and those of mind has come to be seen as science's final frontier

'Where drug treatments have hitherto been empirical, neurogeneticists are offering to identify specific genes which might precipitate the condition, and in combination with the pharmaceutical industry to design tailor-made ('rational') drugs to fit any specific individual – so called psychopharmacogenetics'[10].

'Understanding the brain is a worthy goal in and of itself. But, in the longer term, new treatments for devastating brain diseases are likely to emerge from a deeper understanding of the brain. For example, treatment of Parkinson's disease has been greatly enhanced by circuit-level understanding of the brain's motor systems. Our front-line treatment for Parkinson's is the dopamine precursor drug, L-DOPA, but its efficacy decreases over time while severe side effects increase. In response, teams of neurophysiologists, engineers and physicians fused an understanding of the brain's motor circuits with technological advances to create deep brain stimulation, which can restore motor circuit function in many Parkinson's patients for up to several years. Current research into brain circuits for mood and emotion has the potential to advance psychiatry in similar ways'[11].

'Much of brain space remains terra incognita*'*

'Advances in computer science, informatics, statistics and mathematics have helped industrialize the neuroscientific process. […] Recent years have seen enormous progress.

Nonetheless, much of brain space remains terra incognita and most mammalian species have yet to be investigated. Furthermore, the resolution and depth of many pioneering maps are still limited by technology.

Despite the advances of the last half century and the extraordinary methodological developments, information and knowledge relevant to aspects of brain physiology and anatomy have yet to be integrated into a comprehensive multi-scale brain model. The reason is simple: no adequate and comprehensive repository of such data and knowledge exists. Even if technologies continue to improve exponentially, it seems very unlikely that it will be possible to map more than a tiny part of brain territory in this detail at any time in the foreseeable future'[12].

Focus on the contemporary neurogenomics

On June 2014, *Nature Neuroscience* published a volume dealing with 'neurogenomics'. In the Editorial this new neologism was ex-

plained as such: 'Previously intractable to the approaches of human genetics, disorders of the brain are seeing accelerated gene discovery that was, until now, restricted to other branches of medicine. The driving force behind this progress is recent technological and analytical innovations that allow the interrogation of genetic variation at unprecedented resolution and scale and diminishing costs. With these plus collaborations among international consortia needed to reach adequate sample sizes, the past few years have suggested that robust gene discovery is possible for brain disorders. What is starting to emerge from these recent advances is that the genetic architecture of common brain disorders is exquisitely complex and heterogeneous. Translating these discoveries into a better understanding of disease etiology and the generation of new drug targets represent important challenges for neuroscience research'[13].

Neurogenomics deals with 'the success of genome-wide association and whole-exome sequencing studies in identifying genetic variants associated with neurodevelopmental, neurological and psychiatric disorders'[14], which will catalyze future endeavors to decipher, prevent and cure brain diseases.

10 years before

10 years before 2014 *Nature Neuroscience Focus on Neurogenomics*, the same review published an article depicting neurogenomics 'at the intersection of neurobiology and genome sciences'. The authors M. S. Boguski and A. R. Jones defined neurogenomics as 'the study of how the genome as a whole contributes to the evolution, development, structure and function of the nervous system. It includes investigations of how genome products (transcriptomes and proteomes) vary in time and space. Neurogenomics differs markedly from the application of genome sciences to other systems, particularly in the spatial category, because anatomy and connectivity are paramount to our understanding of function in the nervous system'[15].

The raise of neuroethical questions

'The neurogenetic-industrial complex thus becomes ever more powerful. Undeterred by the way that molecular biologists, confronted with the outputs from the Human Genome Project, are beginning to row back from genetic determinist claims, psychometricians and behaviour geneticists, sometimes in combination and sometimes in competition with evolutionary psychologists, are claiming genetic roots to areas of human belief, intentions and actions long assumed to lie outside biological explanation. Not merely such long-runners as intelligence, addiction and aggression, but even political tendency, religiosity and likelihood of mid-life divorce are being removed from the province of social and/or personal psychological explanation into the province of biology. With such removal comes the offer to treat, to manipulate, to control. Back in the 1930s, Aldous Huxley's prescient *Brave New World* offered a universal panacea, a drug called Soma that removed all existential pain. Today's Brave New World will have a multitude of designer psychotropics, available either by consumer choice (so called 'smart' drugs to enhance cognition) or by state prescription (Ritalin for behaviour control).

These are the emerging neurotechnologies, crude at present but becoming steadily more refined. Their development and use within the social context of contemporary industrial society presents as powerful a set of medical, ethical, legal and social dilemmas as does that of the new genetics, and we need to begin to come to terms with them sooner rather than later. To take just a few practical examples: if smart drugs are developed ('brain steroids' as they have been called), what are the implications of people using them to pass competitive examinations? Should people genetically at risk from Alzheimer's disease be given life-time 'neuroprotective' drugs? If diagnosing children with ADHD really does also predict later criminal behaviour, should they be drugged with Ritalin or some related drug throughout their childhood? And if their criminal predisposition could be iden-

tified by brain imaging, should preventative steps be taken in advance of anyone actually committing a crime?

More fundamentally, what effect do the developing neurosciences and neurotechnologies have on our sense of individual responsibility, of personhood? How far will they affect legal and ethical systems and administration of justice? How will the rapid growth of human-brain/machine interfacing – a combination of neuroscience and informatics (cyborgery) – change how we live and think? These are not esoteric or science fiction questions; we aren't talking about some fantasy human cloning far into the future, but prospects and problems which will become increasingly sharply present for us and our children within the next ten to twenty years. Thus yet another hybrid word is finding its way into current discussions: neuroethics'[16].

What effect do the developing neurosciences and neurotechnologies have on our sense of individual responsibility, of personhood?

From neuroethics to anthropology

'Ethical problems resulting from [genetic and] brain research have induced the emergence of a new discipline termed neuroethics. Critical questions concern issues, such as prediction of disease, psychopharmacological enhancement of attention, memory or mood, and technologies such as psychosurgery, deep-brain stimulation or brain implants. Such techniques are capable of affecting the individual's sense of privacy, autonomy and identity. Moreover, reductionist interpretations of neuroscientific results challenge notions of free will, responsibility, personhood and the self which are essential for western culture and society. They may also gradually change psychiatric concepts of mental health and illness. These tendencies call for thorough, philosophically informed analyses of research findings and critical evaluation of their underlying conceptions of humans'[17].

The Catholic perspective on human being

The Catholic perspective on human being can be summarized as followed. First of all, the Bible points out the origin of man.

'But what is man? About himself he has expressed, and continues to express, many divergent and even contradictory opinions. In these he often exalts himself as the absolute measure of all things or debases himself to the point of despair. The result is doubt and anxiety. For Sacred Scripture [the Bible] teaches that man was created to the image of God'[18].

Then God said, 'Let us make man (*adam*) in our image, after our likeness. And let them have dominion over the fish of the sea and over the birds of the heavens and over the livestock and over all the earth and over every creeping thing that creeps on the earth.' (Genesis 1:26)

'So God created man in his own image, in the image of God he created him; male and female he created them.' (Genesis 1:27)

The second main evidence about man is his/her unity as a living being, in his/her intrinsic dual composition of co-principles, namely 'body' (the material co-principles) and 'soul' (the immaterial and transcendence co-principle).

'Though made of body and soul, man is one. Through his bodily composition he gathers to himself the elements of the material world; thus they reach their crown through him, and through him raise their voice in free praise of the Creator. For this reason man is not allowed to despise his bodily life, rather he is obliged to regard his body as good and honorable since God has created it and will raise it up on the last day'[19].

The Catechism of the Catholic Church goes deep in describing man. In the session titled 'body and soul but truly one', from number 362 up to number 368, one can read: 'The human person, created in the image of God, is a being at once corporeal and spiritual.

The biblical account expresses this reality in symbolic language when it affirms that "then the Lord God formed man of dust from the ground, and breathed into his nostrils the breath of life; and man became a living being." (*Gen* 2:7) Man, whole and entire, is therefore *willed* by God.' (n. 362)

The same Catechism of the Catholic Church specifies the meaning of the two co-principles that constitute the human person. 'In Sacred Scripture the term "soul" often refers to human *life* or the entire human *person*. (Cf. *Mt* 16:25-26; *Jn* 15:13; *Acts* 2:41) But "soul" also refers to the innermost aspect of man, that which is of greatest value in him, (Cf. *Mt* 10:28; 26:38; *Jn* 12:27; *2 Macc* 6:30) that by which he is most especially in God's image: "soul" signifies the *spiritual principle* in man.' (n. 363).

'The human body shares in the dignity of "the image of God": it is a human body precisely because it is animated by a spiritual soul, and it is the whole human person that is intended to become, in the body of Christ, a temple of the Spirit. (Cf. *1 Cor* 6:19-20; 15:44-45) Man, though made of body and soul, is a unity. Through his very bodily condition he sums up in himself the elements of the material world. Through him they are thus brought to their highest perfection and can raise their voice in praise freely given to the Creator. For this reason, man may not despise his bodily life. Rather he is obliged to regard his body as good and to hold it in honor since God has created it and will raise it up on the last day.' (*GS* 14 § 1; cf. *Dan* 3:57-80; n. 364).

Every interpretation of the Catholic vision of man (anthropology) along history has to take into account what the Church really beliefs:

> 'The unity of soul and body is so profound that one has to consider the soul to be the "form" of the body (Cf. Council of Vienne, 1312: DS 902): i.e., it is because of its spiritual soul that the body made of matter becomes a living, human body; spirit and matter, in man, are not two natures united, but rather their union forms a single nature.' (n. 365).
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> 'The Church teaches that every spiritual soul is created immediately by God – it is not "produced" by the parents – and also that it is immortal: it does not perish when it separates from the body at death, and it will be reunited with the body at the final Resurrection.' (Cf. Pius XII, *Humani Generis*: DS 3896; Paul VI, *CPG* § 8; Lateran Council V, 1513: DS 1440; n. 366).
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> Another point helps to understand better the Catholic anthropology: 'Sometimes the soul is distinguished from the spirit: St. Paul for instance prays that God may sanctify his people "wholly", with "spirit and soul and body" kept sound and blameless at the Lord's coming. (*1 Thess* 5:23) The Church teaches that this distinction does not introduce a duality into the soul. (Cf. Council of Constantinople IV, 870: DS 657) "Spirit" signifies that from creation man is ordered to a supernatural end and that his soul can gratuitously be raised beyond all it deserves to communion with God.' (Cf. Vatican Council I, *Dei Filius*: DS 3005; *GS* 22 § 5; *Humani Generis*: DS 3891; n. 367)

The principle that sustains the emergence of such integrated activity of the living being is synthetized with the concept of 'form'

A Catholic perspective on neurogenomics

Taking into account this anthropological perspective, we can state a Catholic perspective on neurogenomics moving from a realistic account on technology.

First of all, technology, in particular, neurogenomics has to be considered a product of a God-given human creativity in order to modify nature for useful purposes and then overcome material limitations.

'Humanity has entered a new era in which our technical progress has brought us to a crossroads. We are the beneficiaries of two centuries of enormous waves of change:

steam engines, railways, the telegraph, electricity, automobiles, aeroplanes, chemical industries, modern medicine, information technology and, more recently, the digital revolution, robotics, biotechnologies and nanotechnologies. It is right to rejoice in these advances and to be excited by the immense possibilities which they continue to open up before us, for "science and technology are wonderful products of a God-given human creativity". The modification of nature for useful purposes has distinguished the human family from the beginning; technology itself "expresses the inner tension that impels man gradually to overcome material limitations". Technology has remedied countless evils which used to harm and limit human beings. How can we not feel gratitude and appreciation for this progress, especially in the fields of medicine, engineering and communications? How could we not acknowledge the work of many scientists and engineers who have provided alternatives to make development sustainable?"[20]

Second, neurogenomics can produce important means of improving the quality of human life.

'Technoscience, when well directed, can produce important means of improving the quality of human life, from useful domestic appliances to great transportation systems, bridges, buildings and public spaces. It can also produce art and enable men and women immersed in the material world to "leap" into the world of beauty. Who can deny the beauty of an aircraft or a skyscraper? Valuable works of art and music now make use of new technologies. So, in the beauty intended by the one who uses new technical instruments and in the contemplation of such beauty, a quantum leap occurs, resulting in a fulfilment which is uniquely human'[21].

Third, neurogenomics can give us tremendous power that needs to be well directed because it is overwhelmed evident that technological products are not neutral.

'Yet it must also be recognized that nuclear energy, biotechnology, information technology, knowledge of our DNA, and many other abilities which we have acquired, have given us tremendous power. More precisely, they have given those with the knowledge, and especially the economic resources to use them, an impressive dominance over the whole of humanity and the entire world. Never has humanity had such power over itself, yet nothing ensures that it will be used wisely, particularly when we consider how it is currently being used. We need but think of the nuclear bombs dropped in the middle of the twentieth century, or the array of technology which Nazism, Communism and other totalitarian regimes have employed to kill millions of people, to say nothing of the increasingly deadly arsenal of weapons available for modern warfare. In whose hands does all this power lie, or will it eventually end up? It is extremely risky for a small part of humanity to have it'[22].

'We have to accept that technological products are not neutral'[23]. 'Science and technology are not neutral; from the beginning to the end of a process, various intentions and possibilities are in play and can take on distinct shapes'[24].

From these premises, a general and main practical principle for neurogenomics emerges: Any legitimate intervention will act on nature only in order 'to favour its development in its own line, that of creation, as intended by God'[25].

In order to fulfill it, the anthropological background on neurogenomics has to avoid all kind of reductionism, in particular, the mechanistic understanding of human life, and the neurological reductionism.

'*The social question has become a radically anthropological question*, in the sense that it concerns not just how life is conceived but also how it is manipulated, as bio-technology places it increasingly under man's control. […] Technology's supremacy fosters a materialistic and mechanistic understanding of human life'[26].

The Catholic anthropological view is consistent with nowadays *embodied* and *embedded* perspective on modern concept of mind.

The brain is not a solitary organ that in a certain mysterious way 'creates' the mind and the experienced world, but, instead, is to

be considered as 'a plastic system of open loops that are formed in the process of life and closed to full functional cycles in every interaction with the environment'[27], 'an intrinsically multi-scale, multi-level organ operating across spatial scales ranging from nanometres (proteins) to metres (the human body) and temporal scales from picoseconds (atomic interactions) to years (the lifespan of a human being)'[28].

'The brain is certainly a central organ of the living being, but it is only an *organ* of the mind, not its seat. For the mind is not located in any one place at all; rather, it is an activity of the living being which integrates at any moment the ongoing relations between brain, body and environment. Assuming such an embodied, extended and dynamic view of the mind (Clark and Chalmers, 1998; Thompson and Stapleton, 2009), the brain loses its mythological powers and turns into a still fascinating, yet far more modest *mediator* of human experience, action and interaction'[29].

'The brain integrates all bodily functions, giving vital unity to the organism, acting as the neural central driving force of existence, but as an organ is a so called "secondary principles of unity, of coordination and of operation". The individual, the human being, the human person as a whole, is the first principle of action and attribution'[30].

So, in this 'ecological view of mind and brain as both being embedded in the relation of the living organism and its environment'[31], the principle that sustains the emergence of such integrated activity of the living being is what Aristotle and the Scholastic philosophical tradition have synthetized with the concept of 'form'. The Catholic theological tradition refers to the 'human form' as the 'human soul'[32].

As the Italian philosopher Enrico Berti pointed out, 'the term "mind" and the term "soul" both derive from the ancient Greek word *psychê*, […] which have the advantage of not alluding to existing entities in the same manner ad bodies, but rather indicate properties, or dispositions, or behaviours, or processes, in short, phenomena without an existence of their own but belonging, so to speak, to subjects that are generally human beings or even animals, and therefore bodies'[33]. 'One of the major concept of *psychê* developed in antiquity is one contained in Aristotle's *De anima*, according to which *psychê* is not a substance distinct from the body, but is the "form" or "first act" of an organic body, that is of a body that is formed by organs, equipped with life in potency, that is, capable of living (*De anima* II 1). As we pointed out before, the Aristotelian concept of *psychê* was embraced by the Catechism of the Catholic Church which refers explicitly to the Aristotelian definition of the soul as *forma corporis*, accepted by the Council of Vienne in 1312'[34]. 'So the human soul is the way a certain matter, human matter (including the human DNA and the human brain), is organized and functions'[35]; 'is the ability of the entire organism through the brain, to carry out these processes, ranging from the most basic functions, called physical, to the higher and more complex ones, called psychic (including thinking and willing)'[36]. The human soul is also called "intellectual soul".

One of the main contemporary difficulties deals with the propter understanding of human soul's ontological depths.

'One aspect of the contemporary technological mindset is the tendency to consider the problems and emotions of the interior life from a purely psychological point of view, even to the point of neurological reductionism. In this way man's interiority is emptied of its meaning and gradually our awareness of the human soul's ontological depths, as probed by the saints, is lost. *The question of development is closely bound up with our understanding of the human soul*, insofar as we often reduce the self to the psyche and confuse the soul's health with emotional well-being. These over-simplifications stem from a profound failure to understand the spiritual life, and they obscure the fact that the development of individuals and peoples depends partly on the resolution of problems of a spiritual nature. *Development must include not just material growth but also spiritual growth*, since the human person is a "unity of body and soul", born

of God's creative love and destined for eternal life. The human being develops when he grows in the spirit, when his soul comes to know itself and the truths that God has implanted deep within, when he enters into dialogue with himself and his Creator. When he is far away from God, man is unsettled and ill at ease. Social and psychological alienation and the many neuroses that afflict affluent societies are attributable in part to spiritual factors. A prosperous society, highly developed in material terms but weighing heavily on the soul, is not of itself conducive to authentic development. The new forms of slavery to drugs and the lack of hope into which so many people fall can be explained not only in sociological and psychological terms but also in essentially spiritual terms. The emptiness in which the soul feels abandoned, despite the availability of countless therapies for body and psyche, leads to suffering. *There cannot be holistic development and universal common good unless people's spiritual and moral welfare is taken into account*, considered in their totality as body and soul'[37].

Sometimes 'the supremacy of technology tends to prevent people from recognizing anything that cannot be explained in terms of matter alone. Yet everyone experiences the many immaterial and spiritual dimensions of life. Knowing is not simply a material act, since the object that is known always conceals something beyond the empirical datum. All our knowledge, even the simplest, is always a minor miracle, since it can never be fully explained by the material instruments that we apply to it. In every truth there is something more than we would have expected, in the love that we receive there is always an element that surprises us. We should never cease to marvel at these things. In all knowledge and in every act of love the human soul experiences something "over and above", which seems very much like a gift that we receive, or a height to which we are raised'[38].

Finally, we can summarize this Catholic perspective on neurogenomics as followed:

- Man in his nature is a unity, composed of two co-principles, namely 'body' and 'soul'.
- In the Catholic tradition, both the human DNA and the human brain are parts of man's bodily composition that are not allowed to despise, and that man is obliged to regard as good and honorable since God has created them and will raise them up on the last day.
- As bodily components, the DNA and the brain are fragile and perishable.
- Many neurological disorders have a genetic underpinning.
- Previously intractable to the approaches of human genetics, disorders of the brain are seeing accelerated gene discovery that was, until now, restricted to other branches of medicine. The driving force behind this progress is recent technological and analytical innovations that allow the interrogation of genetic variation at unprecedented resolution and scale and diminishing costs.
- What is starting to emerge from these recent advances is that the genetic architecture of common brain disorders is exquisitely complex and heterogeneous. Translating these discoveries into a better understanding of disease etiology and the generation of new drug targets represent important challenges for neuroscience research.
- The potential of neurogenomic advances to improve the diagnosis, treatment and management of neurological disorders right now.
- To understand the brain and its disorders, we needed to get data.
- Because of the intrinsic unity of the human being, all risk variants for psychiatric and neurological disorders must ultimately affect the functioning of the brain, and elucidating the affected neural circuits in humans is a high priority.
- So, for a Catholic perspective, neurogenomics interventions have to be focused on the diagnosis, treatment and management of neurological dis-

orders, and not to foster idealistic perspectives on man's nature evolution, such as, those promoted by the Trans and Post-Humanism Project.

- Genetic and neuroscientific research and their clinical applications will really benefit our society and the developing countries if it will be taken into account an integrative, non-reductionist and non-materialistic perspective of human being.

A final remark

As a final remark I want to quote what A. M. Battro, S. Dehaene, M. Sánchez Sorondo and W. J. Singer wrote in the Prologue of an important volume edited by the Pontifical Academy of Sciences in 2013:

> Neuroscientists have made fundamental improvements since the last meeting in 1988 with the introduction of advanced neurobiological and genetic technologies — and a corresponding new language — which deserve analysis in order to have a better understanding of the status of the human being that is in line with these new scientific discoveries. Philosophers and theologians, in their turn, are increasingly aware of the particular discoveries, epistemologies and languages that science has developed and try to interpret this new significant data in the light of the Socratic principle 'know yourself'. It follows that man's knowledge is not derived from a single perspective — that of external observation, explanation, and experimentation: this knowledge develops in the interface between the observation of nature and reflective understanding. The human being is an observable entity, like all organisms but at the same time it reflects on itself, it is a 'self-interpreting being'. Thus, understanding the human condition requires analysis of the various levels of knowledge and descriptions involving reconciliation between insights derived from the first, second and third person perspective in this age of rapid scientific progress[39].

NOTE

[1] S. Rose, *The Future of the Brain. The Promise and the Perils of Tomorrow's Neuroscience*, Oxford University Press, New York, 2005, 1.

[2] L.A. Jorgenson - W.T. Newsome - D.J. Anderson - C.I. Bargmann - E.N. Brown - K. Deisseroth et al., "The BRAIN Initiative: developing technology to catalyse neuroscience discovery," *Philosophical Transactions of the Royal Society B: Biological Sciences* 370/1668, 2015, 1.

[3] S. Rose, *The Future of the Brain,* 3.

[4] L.A. Jorgenson, et al., "The BRAIN Initiative…", 9.

[5] L.A. Jorgenson, et al., "The BRAIN Initiative…", 2.

[6] R. Frackowiak - H. Markram, "The future of human cerebral cartography: a novel approach," *Philosophical Transactions of the Royal Society B: Biological Sciences* 370/1668, 2015, 2.

[7] L.A. Jorgenson, et al., "The BRAIN Initiative…", 2.

[8] S. Rose, *The Future of the Brain. The Promise and the Perils of Tomorrow's Neuroscience*, Oxford University Press, New York, 2005, 5.

[9] *Ibid,* 3.

[10] *Ibid,* 6.

[11] L.A. Jorgenson, et al., "The BRAIN Initiative…", 10.

[12] R. Frackowiak - H. Markram, "The future of human cerebral cartography…", 2.

[13] Editorial. "Focus on neurogenomics," *Nature Neuroscience* 17/6, 745. doi: 10.1038/nn.3735, 2014.

[14] *Ibid.*

[15] M.S. Boguski - A.R. Jones, "Neurogenomics: at the intersection of neurobiology and genome sciences," *Nature Neuroscience* 7/5 (2004), 429-430.

[16] S. Rose, *The Future of the Brain,* 6-7.

[17] T. Fuchs, "Ethical issues in neuroscience," *Current Opinion in Psychiatry* 19/6 (2006), 600.

[18] Second Vatican Council. "Pastoral Constitution on the Church in the Modern World," *Gaudium et spes.* Acta Apostolicae Sedis 58, 1025-1115, n. 12. From now on, this text will be abbreviated as followed: GS 12. 1966.

[19] GS 14.

[20] Pope Francis. *Encyclical Letter Laudato sì On Care for Our Common Home.* Vatican City: Vatican Press, n. 102. From now on, this text will be abbreviated as followed: LS 102, 2015.

[21] LS, 103.

[22] LS, 104.

[23] LS, 107.

[24] LS, 114.

[25] LS, 132.

[26] Pope Benedict *XVI. Encyclical Letter Caritas in Veritate. Acta Apostolicae Sedis 8, 641-709, n. 75*. From now on, this text will be abbreviated as followed: CV *75. 2009*.

[27] T. Fuchs, "The Brain–A Mediating Organ," *Journal of Consciousness Studies* 18/7-8 (2011), 196.

[28] R. Frackowiak - H. Markram, "The future of human cerebral cartography…", 2.

[29] T. Fuchs, The Brain – "A Mediating Organ." *Journal of Consciousness Studies* 18 (7-8), 2011, 197.

[30] A. Battro - S. Dehaene - M. Sánchez Sorondo - W. Singer, (eds.), *Neurosciences and the Human Person: New Perspectives on Human Activities*, PAS Scripta Varia 121, Vatican City, 2013, 310-311.

[31] T. Fuchs, "The Brain…", 196.

[32] Our personal identity is shaped on the basis of something that sustains its development. CV 68. No one shapes his own conscience arbitrarily, but we all build our own "I" on the basis of a "self" which is given to us.

[33] E. Berti, "Mind and Soul? Two Notions in the Light of Contemporary Philosophy," in A. Battro et al, *Neurosciences and the Human Person*…, 41.

[34] *Ibid,* 43.

[35] *Ibid.*

[36] *Ibid,* 44-45.

[37] CV *76*.

[38] CV *77*.

[39] A. Battro, et al., *Neurosciences and the Human Person*…, 12-13.