THE PONTIFICAL ACADEMY OF SCIENCES

EXTRA SERIES

37

WORKING GROUP ON HUMAN NEUROPLASTICITY AND EDUCATION 27-28 OCTOBER 2010

Address of His Holiness Benedict XVI to the Participants in the Working Group

Clementine Hall

Thursday, 28 October 2010

Human Neuroplasticity and Education • Statement

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VATICAN CITY 2010

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ADDRESS OF HIS HOLINESS BENEDICT XVI TO THE PARTICIPANTS IN THE WORKING GROUP ON HUMAN NEUROPLASTICITY AND EDUCATION

Clementine Hall
Thursday, 28 October 2010

Your Excellencies,
Distinguished Ladies and Gentlemen,

I am pleased to greet all of you here present as the Pontifical Academy of Sciences gathers for its Plenary Session to reflect on 'The Scientific Legacy of the Twentieth Century'. I greet in particular Bishop Marcelo Sánchez Sorondo, Chancellor of the Academy. I also take this opportunity to recall with affection and gratitude Professor Nicola Cabibbo, your late president. With all of you, I prayerfully commend his noble soul to God the Father of mercies.

The history of science in the twentieth century is one of undoubted achievement and major advances. Unfortunately, the popular image of twentieth-century science is sometimes characterized otherwise, in two extreme ways. On the one hand, science is posited by some as a panacea, proven by its notable achievements in the last century. Its innumerable advances were in fact so encompassing and so rapid that they seemed to confirm the point of view that science might answer all the questions of man's existence, and even of his highest aspirations. On the other hand, there are those who fear science and who distance themselves from it, because of sobering developments such as the construction and terrifying use of nuclear weapons.

Science, of course, is not defined by either of these extremes. Its task was and remains a patient yet passionate search for the truth about the cosmos, about nature and about the constitution of the human being. In this search, there have been many successes and failures, triumphs

and setbacks. The developments of science have been both uplifting, as when the complexity of nature and its phenomena were discovered, exceeding our expectations, and humbling, as when some of the theories we thought might have explained those phenomena once and for all proved only partial. Nonetheless, even provisional results constitute a real contribution to unveiling the correspondence between the intellect and natural realities, on which later generations may build further.

The progress made in scientific knowledge in the twentieth century, in all its various disciplines, has led to a greatly improved awareness of the place that man and this planet occupy in the universe. In all sciences, the common denominator continues to be the notion of experimentation as an organized method for observing nature. In the last century, man certainly made more progress – if not always in his knowledge of himself and of God, then certainly in his knowledge of the macro- and microcosms – than in the entire previous history of humanity. Our meeting here today, dear friends, is a proof of the Church's esteem for ongoing scientific research and of her gratitude for scientific endeavour, which she both encourages and benefits from. In our own day, scientists themselves appreciate more and more the need to be open to philosophy if they are to discover the logical and epistemological foundation for their methodology and their conclusions. For her part, the Church is convinced that scientific activity ultimately benefits from the recognition of man's spiritual dimension and his quest for ultimate answers that allow for the acknowledgement of a world existing independently from us, which we do not fully understand and which we can only comprehend in so far as we grasp its inherent logic. Scientists do not create the world; they learn about it and attempt to imitate it, following the laws and intelligibility that nature manifests to us. The scientist's experience as a human being is therefore that of perceiving a constant, a law, a logos that he has not created but that he has instead observed: in fact, it leads us to admit the existence of an all-powerful Reason, which is other than that of man, and which sustains the world. This is the meeting point between the natural sciences and religion. As a result, science becomes a place of dialogue, a meeting between man and nature and, potentially, even between man and his Creator.

As we look to the twenty-first century, I would like to propose two thoughts for further reflection. First, as increasing accomplishments of the sciences deepen our wonder of the complexity of nature, the need for an interdisciplinary approach tied with philosophical reflection leading to a synthesis is more and more perceived. Secondly, scientific achievement in this new century should always be informed by the imperatives

of fraternity and peace, helping to solve the great problems of humanity, and directing everyone's efforts towards the true good of man and the integral development of the peoples of the world. The positive outcome of twenty-first century science will surely depend in large measure on the scientist's ability to search for truth and apply discoveries in a way that goes hand in hand with the search for what is just and good.

With these sentiments, I invite you to direct your gaze toward Christ, the uncreated Wisdom, and to recognize in His face, the Logos of the Creator of all things. Renewing my good wishes for your work, I willingly impart my Apostolic Blessing.

The Holy Father with the Pontifical Academicians and Conference Participants at the end of the Audience.

HUMAN NEUROPLASTICITY AND EDUCATION STATEMENT

Antonio M. Battro, Stanislas Dehaene, Wolf J. Singer,
Albert M. Galaburda, Helen J. Neville, Faraneh Varga-Khadem

The methods of brain and cognitive sciences have reached a stage such that we can now objectively monitor the developmental trajectory of the child's brain and document how this trajectory is being shaped by parenting, education and other environmental influences.

Non-invasive brain imaging methods can now be used, together with behavioral measurements, to examine the development of infant cerebral and mental organization and its growth. The results reveal both a highly structured early organization of brain networks for language, with hemispheric specialization, and its very fast maturation in the first months of life, which can now be indexed by objective measurement.

Brain maturation continues in adolescence and early adulthood, with remarkable changes in the dynamic interactions of distributed brain regions. The initially rather diffuse networks become more segregated and focused. The genetically determined layout of the connection architecture provides a universal neural platform, shared by all humans, but which will be later shaped by specific cultural experiences.

Schooling, in particular, is a major event in children's lives. Brain imaging results reveal the great impact caused by early education to domains such as language, literacy, arithmetic and reasoning. For instance, the brain of illiterate adults differs in several clearly identifiable features from the brain of alphabetized adults. The brain changes induced by education are made possible by the remarkable adaptivity that characterizes the developing brain. It results from the fact that brain development is associated with a continuous formation and

removal of neuronal connections, whereby experience determines which connections get consolidated. This extensive neuroplasticity is revealed in a particularly salient way by extreme cases such as hemispherectomized children. Another example comes from studies of blind children, where the intact but deprived visual cortex begins to respond intensely to touch, including Braille reading. Even in the normally developing brain, similar processes of "cortical recycling" are occurring also during normal development, as the novel acquisitions of reading and mathematics invade evolutionarily older cortical regions and reorient their operation towards the specific processing of new human inventions such as numbers or the alphabet.

Plasticity is massive in the child's brain, but continues to exist in many if not all brain pathways throughout life – brain-imaging shows, for instance, that adult alphabetization courses lead to brain changes that are similar to those seen in schooled children who learned to read during childhood. Recent evidence indicates that neural pathways, dendritic trees, synaptic pruning and even gene expression are being modified in millions of neurons as a function of learning experience.

The conditions under which learning occurs in young children are being clarified. Experiments in second-language learning demonstrate that passive exposure to language is ineffective – social interaction with an active tutor is essential. These experiments emphasize the importance of teachers and families as providing a social environment optimally conducive to learning. Early intervention programs that teach both children and parents the principles of attention focusing can be highly effective. These early interventions seem to be particularly effective for socially and economically deprived children and therefore have a potential to bring greater equity and justice to the education system.

Synaptic and genetic mechanisms of mental retardation are being elucidated in specific genetic disease such as fragile X, to such an extent that the tools of molecular medicine begin to open new strategies for possible intervention. Neuroplasticity begins at the point when the brain is beginning to be formed, before birth, and genetic variations or mutations, as well as early environmental influences, can lead to brain changes that may explain why some children develop learning disabilities. The cognitive science of education is leading to novel tools for assessing the progress of individual children and for detecting possible difficulties, hidden disabilities as well as individual differences. This can lead to new interventions specifically tailored to a given child. The use of adaptive computer software and online tutoring, carefully adjusted in difficulty, can play a special role here.

In summary, the bridges between brain science and education are numerous and quickly developing. Neuroplasticity is the key bridging process, and its molecular, neuronal and brain-wide mechanisms should be better investigated in the future. However, the state of scientific knowledge is already sufficient to conclude that investment in early education can have a profound impact on brain organization throughout life and therefore on health, economy, and social justice. While these insights concern mainly the development and acquisition of instrumental abilities, little is known to date about the mechanisms through which moral values, rules of social conduct and dispositions for ethical behavior are installed by education. Since these properties and abilities are also of utmost importance for the future of mankind, intensification of research in this domain is considered an important desideratum.

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... the Academy is unique in its structure, in its membership, in its aim, and in its efforts which are always directed at promoting the progress of the mathematical, physical and natural sciences, the study of epistemological and ethical questions and issues, the participation in the benefits of science and technology by the greatest number of people as well as at the interaction between faith and reason, encouraging the dialogue between science and spiritual, cultural, philosophical and religious questions. The plenary session on the scientific legacy of the 20th century demonstrated afresh the strengths of these objectives and of the way the Pontifical Academy of Sciences in its constitution and activities is realizing them.

BENEDICT XVI, Address to the Participants in the 2010 Plenary Session.