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Synopsis

BRAIN HEALTH FROM GENES TO BEHAVIOR, IMPROVING OUR LIFE

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BRAIN HEALTH

FROM GENES TO BEHAVIOR, IMPROVING OUR LIFE

Thanks to advances in medicine and public health in recent decades, we're living longer lives, however new challenges have appeared, like curbing the impact of cognitive deterioration associated with ageing and neurodegenerative diseases.

To do so, neuroscientists are committed to a strategy that has been a resounding success in other fields of medicine: prevention. A healthy, active brain is better prepared to face the passing of time and the possible injuries or illnesses it may encounter.

Furthermore, advances in the fields of biomedicine, neuroscience, robotics and computers promise to revolutionize our understanding of this organ, which is still little known, and contribute new strategies to keep it healthy and help it recover after an injury.

Some of the top international experts in this field presented the results of their research at B-Debate, an initiative of Biocat and the "la Caixa" Foundation, co-organized in this case by Institut Guttmann and sponsored by BILAT USA 2.0, a project that promotes cooperation between Europe and the United States.

CONCLUSIONS:

- ✓ The biomedical challenge facing societies with longer life expectancy in the 21st century will be to maintain brain health.
- ✓ The adage *mens sana in corpore sano* is true, but it goes both ways: some conditions accelerate cognitive deterioration and preventing them can improve brain health, but the brain also has an effect on body health, so a healthy brain helps better regulate our metabolic system and keeps us healthier.
- ✓ Neuroscientists are committed to prevention as the best way to fight neurodegenerative diseases and dementia. As a key tool in this, they call for the creation of an objective index, to be included in medical check-ups, measuring brain health at each age and in each individual.
- ✓ Genetics plays a key role in brain health, and some genetic profiles can protect us or make us more prone to a specific disease, but there are many ways to keep the

nervous system healthy. Exercise, years of schooling, diet, sleep and socializing are some of the factors involved.

- ✓ Doing exercise has an overall effect on the brain, but we can also exercise specific cognitive functions using computer software. In fact, some types of videogames stimulate specific cognitive abilities, although they should only be used for appropriate periods of time without sacrificing the other aspects mentioned, such as physical exercise and social activities.

“The great biomedical challenge of the 21st century is for humans maintain a healthy brain throughout life”

Josep M. Tormos, B·Debate scientific coordinator

The brain is the organ that defines us as a species and as individuals. It is the most complex of all of those in the human body, the newest from a phylogenetic standpoint and the least understood. “We know more about the genome than about how the nervous system works,” admits Tormos, “and this lack of understanding makes it difficult to know what has gone wrong and how to fix it.”

Now, with people living longer and longer lives, this organ is taking center stage. “The crisis we are facing is that we are ageing with healthy hearts but can't remember who we are,” says Álvaro Pascual-Leone, professor of neurology at Harvard Medical School and member of the scientific committee for the event.

Properly understanding and studying the brain's complexity requires a multidisciplinary approach. On this Europe and the United States agree, bringing together the most advanced researchers in neuroscience, artificial intelligence and information and communication technology in two strategic projects: The Human Brain Project and BRAIN, respectively. Both of these are aimed at discovering how the brain works using cutting-edge strategies, methods and equipment. And this was also the philosophy of this B·Debate, where researchers from all of these disciplines debated the future of brain health.

To do so, according to Tormos, we can look to successful biomedical research methods to tackle problems with huge repercussions on society, with perhaps the best example being the study of risk factors associated with cardiovascular disease. “A combination of descriptive epidemiology studies, incorporating the most advanced technology available at any time, made it possible to identify risk factors, launch prevention campaigns and define new therapeutic targets and treatments. Thanks to this, over the past 60 years deaths from heart disease have dropped not a little, not by half, but to one third of the previous levels,” says the coordinator of research at Institut Guttmann, the benchmark hospital in Catalonia in treatment and comprehensive rehabilitation for people with neurological disabilities.

IN SEARCH OF A BRAIN-HEALTH INDEX

For Pascual-Leone, a healthy brain “has the necessary network of connections to enjoy a full life.” And this network, like the needs it responds to, changes over time. “It’s not about having a 17-year-old brain in a 90-year-old body. It’s about having the best, healthiest brain possible at any age,” says the neuroscientist.

One of the intrinsic properties of the “most important organ of the 21st century”, in the words of Montserrat Bernabeu, head of the Acquired Brain Injury Unit at Institut Guttmann, is plasticity: its ability to adapt to changes around it, whether environmental or due to illness, by modifying its structure (and its functional capacity) based on experience. Pascual-Leone’s [hypothesis](#) is that extreme changes in this ability may be the cause of mental illnesses like autism and schizophrenia and that one way to treat these conditions would be to modify this capacity for plasticity using non-invasive brain stimulation techniques such as transcranial magnetic stimulation.

In addition to any possible conditions a person may develop, the brain’s capacity for plasticity also changes naturally over time and, along with it, so does their cognitive ability. Therefore the aim is to learn about these changes in order to boost or direct them to benefit individuals and their health. According to Pascual-Leone, it is important to have reliable measurements of brain health for each age and individual and include them in medical check-ups. “Just like we measure blood pressure or monitor diabetes, we need an objective index of brain health,” he says.

10 factors to keep in mind

10 factors that impact brain health, according to scientific evidence:

- A balance diet
- Aerobic physical exercise
- Meditation and other practices of mindfulness
- Positive social relations
- Type and number of recreational activities
- Sleep quality
- Work activity (in terms of demand for cognitive activity)
- Years of schooling
- Stress management
- Cognitive training

PUSH-UPS FOR THE BRAIN AS WELL

The healthier the brain is, the better it can face injury, illness and ageing. We now know that genetics plays a key role in brain health. Geneticist John Harvey, of the Institute of Neurology in London, has identified numerous genes associated with neurological conditions like dementia or diseases like [Parkinson](#). As he himself says, “Genetic and epidemiological studies with thousands of people are expensive and boring, but they yield incredible results.”

Beyond genetics, scientists have shown that there are many ways to maintain a healthy nervous system. “It’s as easy as it sounds,” says Arthur Kramer, director of the Beckman Institute at the University of Illinois Urbana-Champaign (USA). “[Exercise](#) is one of the best ways to achieve physical and mental health.”

This researcher has shown the molecular mechanisms behind the beneficial effects of physical activity. “Exercise has incredible effects on the brain: it improves memory, increases the number of synapses, boosts production of neurotransmitters, angiogenesis and the expression of genes associated with plasticity and decreases that of others associated with oxidative stress...” he lists. The evidence is so overwhelming that Kramer can't help showing his surprise at how difficult it sometimes is to get people to act in their own best interest. “We’re becoming a sedentary, obese society. Even children!”

FROM THE GYM TO VIDEOGAMES

Exercise has an overall effect on the brain, but there are also ways to improve specific cognitive functions. This is the aim of computer programs like the one developed in Catalonia by Institut Guttmann and its clinical and technology partners: Guttmann, [NeuroPersonalTrainer®](#). It is also the goal of the [Brain Fit Club](#) initiative, from Boston Medical School, which aims to emulate a conventional gym but for cognitive capacities. “We want to transfer advances in neuroscience research to clinical programs,” says Bonnie Wong, neurophysiologist and head of the project.

Another strategy to optimize specific brain functions can already be found in most households and causes a surprising amount of concern in society: action video games. Daphne Bavelier, neuroscientist at the University of Rochester (USA), has been using these games as a tool to better understand brain plasticity and how we learn for years now. “When your 15-year-old is spending hours in front of a screen killing zombies, the first thing that comes to mind isn't that he's boosting his executive functions, but he is,” she says.

Bavelier's [research](#) shows that people who play action video games (like the popular [Call of Duty](#) or [Medal of Honor](#) sagas) react faster and more decisively than those who play more social video games (like [The SIMS](#) or [Restaurant Empire](#)). The molecular explanation behind these effects lies in the fact that action videogames “seem to directly stimulate the neuronal network that controls attention,” says the expert.

These results are backed up by numerous [studies](#) with surgeons that have demonstrated that action videogames help them improve their surgical practice. In any case, it is *vox populi* that young people who spend many hours playing videogames do poorly in school, which led Bavelier to conclude her talk stressing that we don't know whether video games stimulate certain abilities to the detriment of others, like for example long-term memory. “There is still much to learn,” concluded the researcher.

Learning from the immature brain

“Despite having a small, immature brain, children are great learners,” says Ghislaine Dehaene-Lambertz, head of the Cognitive Neuroimaging Laboratory (France). In order to understand the human brain, we must know both how it works and how it develops. Thanks to new non-invasive examination techniques, neuroscientists can study the brains of children, babies and even unborn fetuses.

It has been shown that prenatal development is equally or more important than postnatal development, and that the brain is highly sensitive to alterations in its environment in utero. According to Elisenda Eixarch, of the Fetal Medicine Research Center (Barcelona), “Two out of three cases of intellectual disability have prenatal origins.”

This scientist analyzes the cerebral consequences of the delay in intrauterine growth that occurs when a fetus doesn't get enough oxygen and nutrients from the placenta during pregnancy. It has been said that this phenomenon is associated with a lower IQ, learning difficulties and inferior job conditions. Eixarch and her team are working on postnatal interventions to reverse some of these consequences.

Another field of interest in developmental neuroscience is learning how human beings acquire language. Janet Werker, professor at the University of British Columbia (Canada), believes there are critical periods in infant development when the brain is most sensitive. “As babies grow, they become less sensitive to unknown sounds and more sensitive to those they recognize,” she says. Werker believes that attention should focus on how to control these periods, keeping them opening, closing them or even reopening them.

MENS SANA IN CORPORE SANO

In addition to exercise and videogames, positive social relations, meditation, mentally stimulating jobs, sleeping well and a [healthy](#) diet also have an impact on brain health. Regarding eating habits, Emilio Ros, a researcher at Hospital Clinic Barcelona presented the results of the [PREDIMED](#) (Prevention with Mediterranean Diet) study at B·Debate. This study shows that a Mediterranean diet, with extra virgin olive oil and walnuts, decreases the risk of cardiovascular events. Plus, according to Ros, “Foods rich in polyphenols typically found in this type of diet may curb age-related cognitive deterioration.”

Just as good habits and exercise affect brain health and increase cognitive reserve (the brain's ability to deal with illness), it has been shown that conditions like type-2 diabetes accelerate brain deterioration. "We now know that both the adage *mens sana in corpore sano* and its mirror image are true, because the brain also has an impact on body health," says Álvaro Pascual-Leone.

In a society with an ever-increasing lifespan, the aim so far has been to cure neurodegenerative diseases. However, according to Pascual-Leone, this strategy is wrong because when we start to see symptoms, the illness has already been in motion for years. "The only solution is to encourage prevention on a personal level. Working to keep the brain healthy throughout life," explains the expert. "And this paradigm shift affects not only the foundation of neuroscience but also public health and healthcare policy."

Technological momentum

Thanks to advances in the fields of neuroimaging, robotics and informatics, neuroscience has changed radically in recent years. “To understand how our brain works, we have to study how it interacts with the world around it. A still snapshot of a moment in time isn't enough,” explains Gustavo Deco, ICREA researcher at Pompeu Fabra University.

Deco studies how the brain behaves in silico, using computer models. The greatest advantage is being able to analyze disturbances that it wouldn't be ethical to test in humans or animal models because their effects are not yet known. “We're still in the experimental phase but we can already do computer simulations of how a specific person's brain works and try to improve plasticity by stimulating specific regions,” says Deco.

Computers also allow us to manage an enormous amount of information (big data) in the two large neuroscience projects currently underway: in Europe, The Human Brain Project, and in the United States, the BRAIN initiative. These two initiatives have different approaches but, according to Richard Frackowiak, professor at the École Polytechnique Fédérale De Lausanne (Switzerland), “They will revolutionize how we understand neuroscience in a magical way.”

New technology is also having a huge impact in the field of rehabilitation, where advances in robotics are moving millions of dollars every year. “We've shown that the benefits of robot-assisted rehabilitation last even after the treatment has ended,” explains Hermano Igo Krebs of the Massachusetts Institute of Technology (USA). “In the United States, robotics therapy isn't any more expensive than the standard treatment over 36 weeks.”

So far the results of using robotics has been very positive in terms of improved mobility of the upper limbs, but not so much for the lower limbs. Krebs and his team have invented a new approach for the latter. “Our latest ‘toy’ is called MIT-Skywalker and it changes the paradigm on how to improve leg mobility,” he explains.