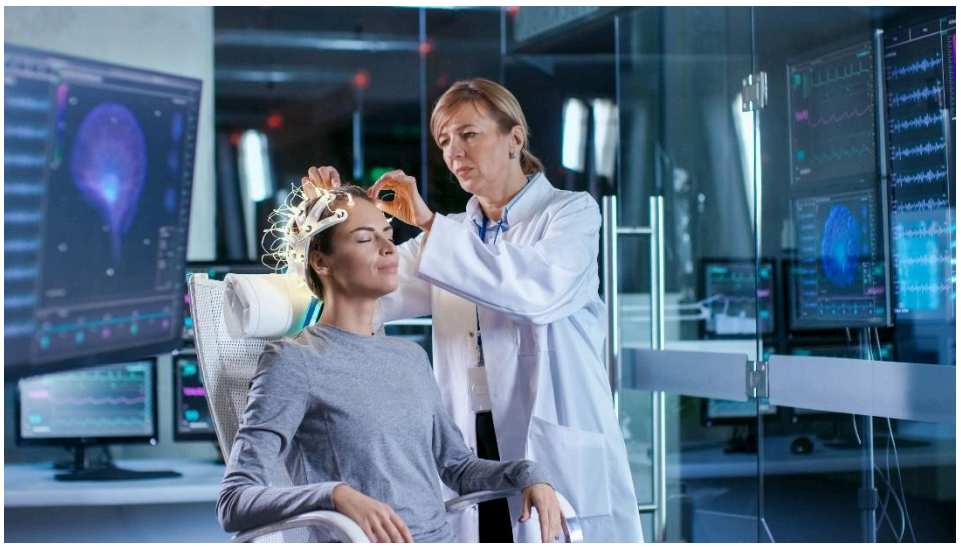
Neuroethical considerations on how neuroscience, neurotechnologies and artificial intelligence can help in times of health crisis.

Laure Tabouy, PhD in Neurosciences ; Scientist Project Manager,

E-mail : laure.tabouy@gmail.com ; laure.tabouy@optictechnology.org



" *Face aux pratiques sociales, la science montre ses limites et laisse seul au citoyen le pouvoir de choisir son destin*". Pr. Alain Prochianz. (Extrait d'une interview avec Antoine Spire - Le Monde de l'éducation - Mai 2001)

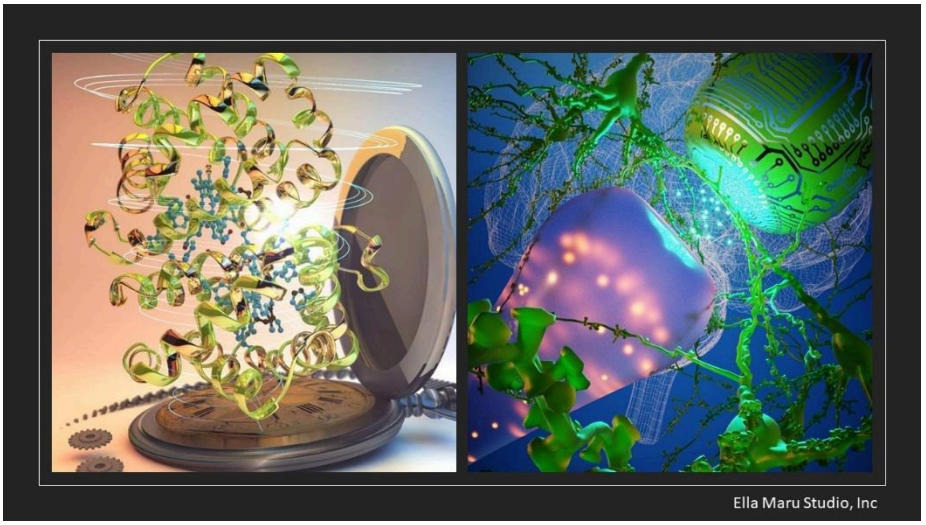
Abstract:

This time of confinement highlights the urgency of considering neuroscience as a discipline that can help everyone to live it. Understanding and studying human behaviour will make it possible to measure the impact of such confinement on each one of us and to identify those who need help. Neurotechnologies, which are intended to be at the interface between the brain and the machine, can be very interesting tools for understanding these behaviours. On the other hand, it is becoming clear that the boundaries between the medical and non-medical uses of these neurotechnologies are becoming very porous, inviting us to reflect on neuroethical issues in order to put safeguards in place for these uses.

Key words:
Neurotechnologies, neurosciences, public health, brain-machine interface, artificial intelligence, coronavirus, COVID19, personal data, neuroethics, liability, stress, social isolation, containment.

The turning point that the Covid-19 health crisis has brought us to is colossal, it invites us to reflect on our human condition, man is vulnerable. Reflections on bioethical and neuroethical issues allow us to take an adjusted turn, centred on benevolence and the common good.

The confinement that we experience is a real psychological trial, which can sometimes lead to very serious states of anxiety, depression or addiction[1]. It is likely that we feel differently as time passes, we may have difficulty sleeping, reorganizing our time, prioritizing things. Our brain has to adapt very quickly to this change of pace of life, to which we are not at all accustomed. Our synaptic connections, which are used to adapting to stimulating environments, have to reorganize themselves. Our brain is plastic and adaptable to change, but it is possible that the uncertainty we are currently experiencing about our work or our relationships may leave traces within our neural network and that our behaviours and our vision of the world may change with this confinement.



Neurosciences and behavioural sciences are essential to anticipate the deconfinement [2] of a population in a progressive way by allowing us to take care of the people who will need it. Neuroscience encompasses all areas of study of the brain, from the molecule, the cell to behaviour, and goes hand in hand with the development of techniques for exploring the brain: neurotechnologies. Neurotechnologies are devices developed at the interface between the brain and the machine to visualize, decipher and modulate brain function and pathological dysfunctions. What rules link the brain's autonomy and physiology to the actions of perceiving or acting? This frontier is one of the major challenges in neuroscience today.

However, since the beginning of the pandemic, several companies have been offering neurotechnologies that make it possible to detect different cognitive and affective states in order to experience confinement, without any rules being imposed on their use. The possibility of acting directly on the brain through them should invite us to be cautious. The neuroethical issues that are opening up to us must challenge us to create safeguards for these applications, which go far beyond the framework of medicine. The boundaries between medical and non-medical uses are becoming very porous, with commercial applications aimed at the healthy general public, necessarily involving different forms of regulation and monitoring. It is also very easy to envisage military, cybersecurity applications.



Neuroethics covers several very broad fields of reflection, as much scientific, philosophical as legal: the ethics of neurosciences and the neurosciences of ethics. Its singularity lies in the heterogeneity and complexity of existing technologies, interventions, and knowledge, which are scientifically founded, and in the capacity of free will that the individual can maintain over such technologies. Its specificity is this personal link that we "*sense 1) between our brain and our behaviours and 2) between our brain and what underlies our principle of individualization, autonomy, and existence as a human being recognized in his dignity*"[3]. Some artificial intelligence (AI) is part of neurotechnologies, in this case, AI is integrated into neuroethical issues and does not raise the same problems as, for example, the AI of Facebook or Google. In other words, neuroethics includes neurotechnologies without and with AI.

Neuroscience, neurotechnologies and artificial intelligence are on the verge of making it possible, in the not too distant future, to read thoughts and control them, to manipulate people to make decisions in an insidious way. It is becoming important in France to intensify and structure reflections on the ethical and legal issues of neuroscience and neurotechnology. This is what researchers are doing in the United States, within the "NIH Brain Initiative "[4] , at Emory University, within the "Emory Center for Ethics"[5] but also within the international consortium, the "International Brain Initiative "[6], in which France is represented by its very active participation in the "Human Brain Project "[7].

Neurosciences, neurotechnologies and AI to "fight Covid-19".



These proposed neurotechnologies focus on the detection of stress, anxiety, emotions, attention at work, through recordings of brain activity by capturing brain waves to translate them into digital signals, which are then processed by algorithms. They offer headsets, headphones, technologies with interesting and attractive shapes for users. These portable forms make it possible to take them everywhere, which raises many questions about the monitoring of individuals but also about the continued use of these neurotechnologies. They use Bluetooth and Wi-Fi to connect to mobile applications, they are rechargeable, they have mini EEG scanners that can detect brain waves and head movements. The resulting brain data, which has yet to be fully understood by the general public in understandable language, can be recorded under any circumstances. Collecting and analyzing this brain data in real time seems to be becoming increasingly simple and accessible to everyone.

From a molecular neuroscience perspective, the use of neurotechnologies, whether for medical or non-medical purposes, has the potential to change synaptic connections in the longer or shorter term. This would have a significant impact on the behaviour and other brain functions of users (such as learning, memory, concentration or attention). The excitation/inhibition balance is maintained in the brain by the dialogue between the different neurotransmitters, this balance is indispensable[8],[9] and these neurotechnologies have a significant impact on the latter[10],[11]. In the context of the treatment of a pathology, the action of these neurotechnologies rebalances this balance. In a non-medical context, their use raises many questions. Under the pretext of focusing on the detection of emotions in order to improve the daily life of users, these neurotechnologies are used by healthy people, possibly disturbing this balance.

As for AI, coupled or not with neurotechnologies, it is a remarkable tool in this time of containment, which is invading the medical sector, whose applications are taking up more and more space on a daily basis. We use it to maintain social links, it helps research to make progress on the implementation of a treatment, allows us to telework, to provide remote medical consultations, to consider the evolution of the pandemic. The monitoring of non-symptomatic carriers ("backtracking"), via digital technologies and mobile applications, is under study. It must be recognized that it is an interesting companion and we must be really aware of it today. However, it is not a human intelligence. It corresponds to a form of computational intelligence that can access a large amount of data but not to an understanding of the living, which combines emotion and reason.

As we can see, neurotechnology and AI can be used for both medical and non-medical purposes. However, it should be noted that they are often originally designed for one purpose and then move on to another. On the one hand, neurotechnologies were initially thought for medical use and are now increasingly being used for non-medical purposes (anxiety management, emotional state, etc.). On the other hand, artificial intelligence was first conceived from a non-medical perspective and is now used for health purposes (management of the epidemic). This shift from one purpose to another is insidious. And the most serious thing remains the fact that because the technology already exists and is already in use, there is no longer any real question of purpose.

Neuroethics, Neurolaw ... where are we in France and Europe?

Not everything is testable, not everything is desirable ... or even feasible. The development of innovations, technologies and neurotechnologies that have an impact on the lives of users requires ethical limits. The more we learn about the brain and how it works, the more powerful and precise neuromodulation methods and neurotechnologies become, and the more we must question the effect of these manipulations on mental states and behaviour. The incredible results obtained can no longer hide the need to formalize it. Appropriate protections of private spaces and individual identity must be integrated into our understanding of human rights. These

neurotechnologies generate staggering amounts of data, which we need to understand, and their use, which can significantly alter a person's personality, thoughts and sensorimotor experience, requires attention to individual and societal protections.



This justifies the question of how the application of new neurotechnologies to humans should be guided and regulated. To date in France and in Europe, there is a beginning of reflections on common guidelines to guide the development and application of these new neurotechnologies in a responsible manner. OECD recommendations of December 2019 on "responsible innovation in the field of neurotechnologies"[12] are the first international normative stones in these fields, which will enable inventors, users, researchers, and public authorities to create and use these neurotechnologies with ethical, legal and societal limits.

In France, even if the 2011 bioethics law, currently under revision, is beginning to integrate these notions into Art16-14 of the Civil Code[13], nothing has yet been decided concerning new generation neurotechnologies. There is an urgent need to create interdisciplinary research teams, composed of scientists, jurists, sociologists, philosophers, who would work on these neuroethical issues.

The European RGPD is considering similar recommendations to regulate the learning machine, CEW and personal data, generating tensions with innovators using CEW. Regulation will become indispensable, it is time for legal and ethical frameworks to be established, but this should not hinder innovation and creativity of researchers.

UNESCO's International Bioethics Committee drafted a declaration on Covid-19 and ethical considerations on 26 March 2020[14]. Chapter 9 talks about these digital technologies, including IA, and recognizes their importance in combating the pandemic, but adds that it is imperative to ensure that the ethical, legal and social issues related to their uses are 'adequately addressed'.

And now what do we do...



We need neuroscience and neuroethics now. We need to understand how these neurotechnologies and advances in neuroscience affect the future, their impact on humans, relationships, the labour market ... What is this brain data, which is stored with the use of neurotechnologies? Do we have the right to have data from our fellow citizens, simply because they are carriers of a virus? Do we have the right to use these neurotechnologies at all costs to detect and measure stress, a person's attention at work, emotions, a person's well-being, by scanning brain activity without informing users of the risks and possible abuses?

Public confidence in science should be based on responsible deployment of scientific advances. And these advances must be shaped by our collective moral sensitivities to ensure that they are harmoniously integrated into our culture and effectively contribute to the common good. It is very important that citizens clearly understand, without any exaggeration, the potential benefits of these neurotechnologies, as well as their risks and limitations. This global race for technological innovation is becoming more sophisticated as the neurosciences advance and opens the door to many ethical abuses. It is undeniable that the prospect of reading thoughts and controlling them raises hopes as well as fears and calls for real caution. Attention should rather be focused on what is achievable and what is desirable to do for the common good because the consequences for human identity and society will be significant. The boundaries between medical and non-medical uses are becoming very porous, with commercial applications aimed at the healthy general public, but also military or cybersecurity applications, necessarily involving different forms of regulation and oversight.

There is therefore an urgent need to consider whether the use of neurotechnologies stimulating brain activity in a period of confinement where the brain is already under strain would not be counterproductive in some people. Moreover, several recent studies suggest that Covid-19 may affect the central nervous system. At present, it is difficult to say whether there will be any long-term repercussions on the behaviour of patients who have had these symptoms. And it would be interesting to ask whether the use of these neurotechnologies could lead to worsening of neurological symptoms in people who have been infested with Covid-19.

The strength of neuroethics is that it is an interdisciplinary field, bringing together philosophies, neurosciences, law, medicine and these reflections bring and will bring much to understand the unprecedented situation that the world is currently experiencing. The neuroethical issues that are opening up to us must challenge us in order to create safeguards for these applications, which go far beyond the framework of medicine. This interdisciplinary field will be able to contribute a great deal to understanding the health crisis. It would be interesting to adopt a set of principles similar to the Belmont report for neuroethics and that interdisciplinary research teams at the interface of the humanities and hard sciences could be set up to work on these issues, perhaps within a new Institute of Technology for the Humanities similar to the one in Canada or the United States. These principles should provide guidelines for the protection of users, so that humans can be put back at the heart of public health decisions, while guaranteeing the freedom of ongoing neuroscience research

[1] Brooks, S. K. et al. The psychological impact of quarantine and how to reduce it: rapid review of the evidence. Lancet 395, 912–920 (2020).

[2] Bavel, J. J. Van et al. COVID-19 pandemic response. Nat. Hum. Behav. doi:10.1038/s41562-020-0884-z.

[3] Traité de Bioéthique 2018, " Neurosciences et neuroéthique ", Hervé Chneiweiss. Ed. Cairn.

[4] Ramos, K. M. et al. The NIH BRAIN Initiative: Integrating Neuroethics and Neuroscience. Neuron 101, 394–398 (2019)

[5] http://www.ethics.emory.edu/pillars/health_sciences/neuroethics.html

[6] Adams, A. et al. International Brain Initiative: An Innovative Framework for Coordinated Global Brain Research Efforts. Neuron 105, 212–216 (2020).

[7] Rose, N. The human brain project: Social and ethical challenges. Neuron 82, 1212–1215 (2014).

[8] Bannai, H. et al. Bidirectional Control of Synaptic GABAAR Clustering by Glutamate and Calcium. Cell Rep. 13, 2768–2780 (2015).

[9] Mapelli, J., Gandolfi, D., Vilella, A., Zoli, M. & Bigiani, A. Heterosynaptic GABAergic plasticity bidirectionally driven by the activity of pre- and postsynaptic NMDA receptors. Proc. Natl. Acad. Sci. U. S. A. 113, 9898–9903 (2016).

[10] Lajoie, G., Krouchev, N. I., Kalaska, J. F., Fairhall, A. L. & Fetz, E. E. Correlation-based model of artificially induced plasticity in motor cortex by a bidirectional brain-computer interface. PLoS Computational Biology 13, (2017).

[11] Zheng, Y., Mao, Y. R., Yuan, T. F., Xu, D. S. & Cheng, L. M. Multimodal treatment for spinal cord injury: A sword of neuroregeneration upon neuromodulation. Neural Regen. Res. 15, 1437–1450 (2020).

[12] https://www.oecd.org/science/recommendation-on-responsible-innovation-in-neurotechnology.htm

[13]https://www.legifrance.gouv.fr/affichTexte.do;jsessionid=AD0F08EF8F2473C93B688D227222A58B.tplgfr43s_2?idSectionTA=JORFSCTA000024323111&cidTexte=JORFTEXT000024323102&dateTexte=20110708

[14] https://unesdoc.unesco.org/ark:/48223/pf0000373115.locale=fr'.