Neuro-Technologies : from neurons to brain-machine interface

Driss BOUSSAOUD, PhD

Institute of Systems Neuroscience, U1106 Inserm & Aix-Marseille University - Marseille (France)
driss.boussaoud@univ-amu.fr
http://ins.univ-amu.fr/research-teams/team-member/d.boussaoud/

Abstract

Neuroscience research seeks to unravel how the brain works and how it dys-functions in a variety of neurological and psychiatric diseases. Advances in this area are crucial, not only for medical intervention in patients, but also for education, social sciences and humanities in general. For example, how your brain makes decisions to buy things in the supermarket is relevant to economy. Thus new research fields have merged: neuro-economy, neuro-marketing, neuro-esthetics, neuro-education, neuro-rehabilitation, neuro-robotics... Because of the complexity of the brain as an organ (about 10^{-11} brain cells, and 9 times glial cells, with trillions of connections between them), a multidisciplinary approach is required. Thus, the neurosciences interact intensively with a wide rang of disciplines including cognitive science, psychology, medical and educational sciences, electrical engineering, robotics, computer science, mathematics and physics. The cross talk between biologically driven questions and mathematical modeling, in particular, has led to important scientific breakthroughs. I will summarize the research path that has taken neuroscientists from basic questions aimed at understanding how neurons work in the brain using animal models, to applications such as brain-machine interfaces (BMI; see Krucoff et al., 2016 for a review). Nowadays, these applications are helping amputees to efficiently use prosthetic devices, i.e. *neuroprosthetics*, or handicapped patients to re-gain their autonomy. In brief, over 40 years of neurophysiological research aiming to understand information processing by single neurons individually and collectively as a network, chart the functions of the brain in various domains (action, perception, cognition and emotion), and draw links between structure and function/dysfunction, have led to major advances. In particular, the fact that thoughts, desires and intentions can exist independently from their physical expression (e.g. Allami et al., 2014), and the discovery in the monkey brain of neurons that discharge long before an action is produced (e.g. during the preparation to reach and grasp objects), have sparkled the idea of using brain activity to control artificial devices. Together with the knowledge that the brain of disabled people can still produce motor commands, this research has ultimately led to the capability to read peoples' thoughts and to use them for controlling artificial devices.

Related references:

Krucoff, Max O.; Rahimpour, Shervin; Slutzky, Marc W.; Edgerton, V. Reggie; Turner, Dennis A. (2016-01-01). "Enhancing Nervous System Recovery through Neurobiologics, Neural Interface Training, and Neurorehabilitation". *Neuroprosthetics*: 584.doi:10.3389/fnins.2016.00584

Allami N, Brovelli A, Hamzaoui E.M, Paulignan Y, Boussaoud D. (2014) Neurophysiological correlates of visuo-motor learning through mental and physical practice. *Neuropsychologia*, 55:6–14