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The Myth of Brain-Computer Interface

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Editorial

After the greatest moment for a couple, the birth of their baby, it takes tremendous effects to educate this baby from a human-shaped animal to a civilized modern human who can not only survive but also make significant contribution to the society. This education process may take twenty years, sometimes even thirty years. Therefore, it has been a beautiful dream for centuries, that one day we create ways to install instantly most important knowledge and skills into the brain of a child, thus remarkably reducing the period for education and training processes.

The so-called Brain-Computer-Interface (BCI) is one of the dreaming approaches. As a brain memories and deals daily with a huge volume of information, the functions of BCIs are not limited to input external information to a brain. They are used to monitor or capture the information of activities of a brain, and even to read information memorized in brain. A BCI may also be applied as a clinical therapy to adjust or interfere particular brain functions.

Currently, many techniques have been developed to obtain information and activities of a live brain. Among them, non-invasive methods such as MRI, fMRI, MEG, PET and SPET, etc., work well for diagnosing diseases or disorders of the brain, and for determining the size and location of a brain tumor. But they all have a poor spatial resolution, not capable of obtaining detailed information of the brain at the cell level. Various electrode-based techniques, such as non-invasive EEG, and invasive or partially invasive electrode families [1], such as neuropixel electrodes [2], neurotassels [3], dense 3D silicon probe [4], highly scalable mesh electronics [5], Utah array [6], transparent intra-cortical microprobe array [7], injectable mesh electronics [8], Flexible ECoG electrode array [9], etc., have been developed to obtain real time information of the brain under test. It is expected to monitor the neural signals of thousands of neurons simultaneously. Yet the obtained data are still by far not sufficient for analyzing the details of what is seen, what is heard, what is tasted, or what is memorized in a brain.

The main reason is that we do not know much about the memory mechanism, what the exact form of information data is and how the data are processed and stored in the brain. The cortex of an adult human brain consists of a few tens of billions of neurons, and around two hundred different functional areas have been recognized in the cortex [10]. When stretched out, the cortex looks like a three-millimeter thick sheet of with six layers of distinguishable neurons and a surface area over a thousand square centimeter.

We suggested that memory functions of the brain for human and other animals might share the same or similar mechanism, and the basic information data of memory in a brain are stored in the form of *2D Codes*. Each *2D code* consists of a number of neurosomes that are strongly connected with electrical synapses, forming a 2D pattern. Any one neurosome in this pattern triggered to excite will lead to excitement of the whole pattern shortly. An echoing mechanism between two neighboring layers of neurosomes was proposed to establish temporary memory, and repeating the echoing process was suggested to enhance the temporary memory and to develop long-term memory. To avoid interference between neighboring 2D networks of strongly connected neurosomes, it was assumed that each neurosome is only involved in one *2D code*, thus leading to limited storage capacity of a brain [11].

The data recorded by techniques of EEG, Utah array or ECoG show either collective weak signals of the whole brain, i.e., from billions of neurons, or, signals of limited number of neurons (tens to thousands). If *2D Code* mode is valid, then one need up to millions of electrodes to obtain the detailed status of the memorized or processing data carried by the neurosome patterns. The number of electrodes used in current recording techniques is insufficient.

On the other hand, several kinds of DBS techniques [12,13] have been developed for curing Parkinson's disease and depression, and made remarkable achievements, though it is far away from realizing the dream of inputting knowledge into a brain. For the purpose to mutual communication between a human brain and a computer or internet, many proposals were presented in scientific fiction movies. In *Matrix*, the BCI device was imagined as a centimeter thick, finger size long plug that could be inserted directly through a socket embedded at the back of head. Well, in reality this configuration could cause immediate death of Neo, the hero in the movie. In *Inception*, the BCI device was presented as a flat electrode wrapped on the wrists of several persons, and via a receiving instrument, they shared a common dream of one of them. However, the wrist is too far away from the brain and most likely; no information of the brain could be captured at this point. With a deep belief in the concept of cyborg, Mr. Elon Mask set up the company *Neuralink* in 2016, aiming at finding the cures for Alzheimer's disease, Parkinson's disease, etc., as well as obtaining enhanced brain functions via implantation of "AI chips" into a brain. This is one of many similar companies set up recently.

The myth of BCI may still last for years. The dream for instant installing knowledge and reading memory may last for years. Based on the *2D Code* model we suggest that a piece of memory may involve a large number of individual neurons, and the detailed patterns (*2D codes*) of groups of strongly connected neurons that carry, information and memory are personalized and are different

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between any two brains. Thus, it is very hard to read the memorized information, for which optical method capable of observing a large number of neurons at the cell scale seems more hopeful than current electrode-based BCI techniques.

It is feasible to interfere the functions of neurons in the limbic system by BCI (such as DBS devices) or chemicals (such as drugs). It is also feasible to erase part of memorized information at the neocortex and/or limbic system by BCI and chemicals, e.g., through changing the connection status of synapses, and it may work like a refreshment to related groups of neurons, leaving more memory space for new events and recovering the disordered part of a brain.

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