Why brain imaging will soon play an important role in your everyday life

Brain imaging is a booming business. New systems are springing up all over the world and promise a new way of interacting with technology. While today's systems are still limited in their usability, the applications seem endless. Domains such as entertainment, healthcare, security and, yes, even marketing can all benefit from consumer imaging devices. When can we expect these devices in our homes and what are the consequences of using them? Let's go for a tour!

Weighing the brain

Neuroimaging has been around for a long time. In 1884, Angelo Mosso created the first, rudimentary, brain imaging device called the 'human circulation balance' (Sandrone et al., 2013).

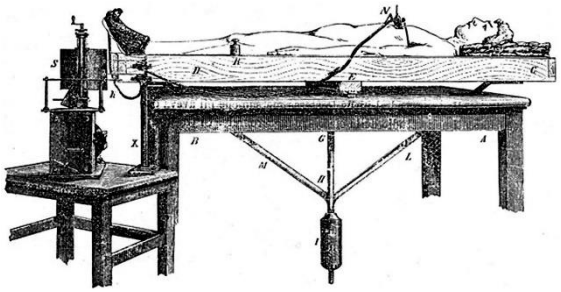

Figure 1. *Brain imaging in the eighteen hundreds consisted of lying on a scale that measured changes in the weight of your brain.*

The device, in essence a large scale, measured changes in the blood distribution along the test subject's body. During a careful calibration phase, the scale was balanced by altering the position of the counterweights, test subject and even a glass of water. Next the subject's brain activity was estimated by plotting the tilting motion of the scale. This was based on the claim that increased brain activity produces a shift in weight distribution towards the brain due to the increased amount of blood.

Sounds too good to be true? You are probably right! Luckily neuroimaging has come a long way since these early years.

Neuroimaging, the modern way

Brain imaging has evolved since the first attempts in the late 19th century. Neuroimaging methods have become more and more detailed as processing power of computers increased and new technologies were developed.

Today, a multitude of brain imaging techniques are in use. These techniques, with their well-known abbreviations, such as CT (computed tomography), EEG (electroencephalography) and fMRI (functional magnetic resonance imaging) have all earned their place in both clinical and research environments.

Non-invasive imaging methods have revolutionized the healthcare industry. Yearly, millions of people get treated based on diagnoses made, in part, using these crucial scans. They provide the doctor with a free pass to the brain, the skull does not even have to be penetrated (Magnetica, 2010; Park, 2012).

But it is not all good news. Brain imaging is both cost and labour intensive. Globally, healthcare budgets are soaring and forcing us to rethink our ways. Providing adequate healthcare for an increasingly older population requires a dramatic change in our care sector if we do not want medical care to become a luxury (De la Maisonneuve, & Oliveira Martins, 2013).

New brain imaging applications, such as functional near-infrared spectroscopy (fNIRS),

are becoming more and more portable and easier to setup. In time, these devices could play a very important role in the adjustment of the healthcare sector.

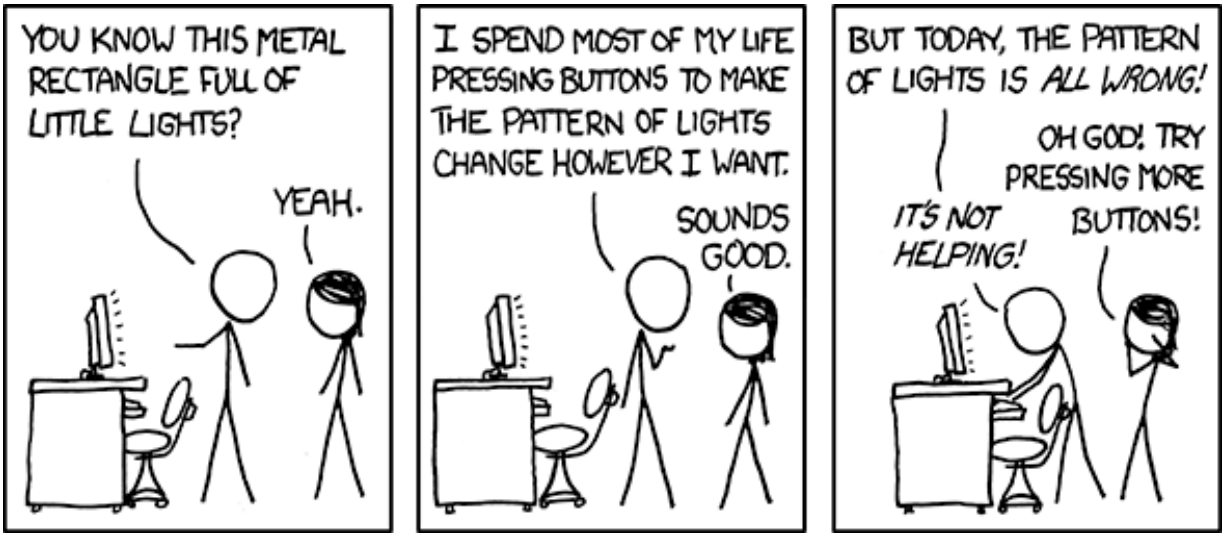

Figure 2. *Sounds familiar does it not? Mind control would be such a beautiful thing in these situations. Image by Munroe (2010).*

Imagine a future, were you no longer have to go to the doctor to get a health assessment. Instead of a doctor, a bunch of smart sensors are constantly tracking your behaviour and bodily functions to warn you if something goes wrong. This would dramatically change the way we deal with our health. The field of medicine would become more personalised, proactive and cheaper. It would also increase the life expectancy, by providing tailored health plans for each individual.

But brain imaging is certainly not limited to the obvious clinical applications. It can also be applied in a lot of other applications, both good and bad.

Technology that makes sense

As long as technology has been around, people have struggled with the abstract interfaces through which it is controlled. Each new device imposes a learning curve on the user and problems arise because we cannot correctly translate our thoughts to computer commands and controls. We long for an interface that is trying to understand what we want to do, so that we do not have to waste time figuring it out ourselves.

New smart phone applications such as Siri and Google Now are starting to close this technology gap by using speech recognition and smart algorithms to predict what you want. But voice commands are boring and worse, they require you to say things out loud. If you have something intimate to share with your partner, you would better know how to whisper. Gesture recognition systems hold the same problem. Nobody is really willing to make large gestures out in public to control his device. In the end, I believe only one communication channel will be effective enough: the brain-computer interface or BCI.

Interface to your brain

Brain-computer interfaces are, simply put, a gateway into your brain. They allow communication between the human brain and a device. They could allow devices to discover exactly what you are thinking and feeling, rather than letting them rely on advanced heuristics to try and guess it. This would be a tremendous improvement over the technology we use today. People with locked-in syndrome would finally be able to communicate with the outside world. The rest

of us would probably waste the technology on less noble or useful actions.

But first the good news. Brain-computer interfaces could indeed improve your life standard, safety and personal health by taking actions when your stress or fatigue level has risen too high. This means you will no longer be dozing off behind the wheel or be involved in a work accident due to inattentiveness because the technology will have taken corrective actions to prevent so. Our communication would also speed up, as we no longer have to spell out our thoughts to the computer. Those annoying passwords would become a thing of the past, as we could use the brain as a biometric key (Mohanchandra, Lingaraju, Kambli, & Krishnamurthy, n.d.).

However, there are some serious drawbacks. Privacy will always be a huge concern. Most importantly there is a big risk for data theft. If this were to happen, each and every detail about your life would be revealed. Another related and annoying aspect would be *very* personal advertisements. By looking at your state of mind, marketeers could start adjusting their campaigns on a person to person basis. This is not science-fiction, it is already happening today. The field of neuromarketing is all about measuring people's emotions when they see or hear about a product (Nobel, 2013). Whereas these 'devious' businessmen are now still limited by the currently available technology, this could change dramatically in the future. An ethical question also has to be raised when it comes to using these technologies on locked-in patients. As these patients cannot give their consent, the decision is completely taken by the caregiver which is not favorable.

The future is now

All positives and negatives aside, technology still has a long way to catch up to our dreams. Current BCI's are just too slow, big, expensive and complicated (Nicolas-Alonso & Gomez-Gil, 2012; Padierna Sosa, Quijano, Doniz, & Chong-Quero, 2011).

The perfect BCI would be a device which is cheap, accurate and unobtrusive. It would also have to sport a long battery life. This technology does not exist yet, but it has not stopped some daring entrepreneurs to dream out loud and develop amazing consumer devices and applications revolving around brain imaging.

Figure 3. *The Emotiv offers consumers access to a technology which was, until recently, confined to medical environments. Image by Emotiv (2014).*

The Emotiv (see Figure 3) is one of these devices. Not only does it allow anyone to buy and own an EEG headset. It is also enabling users around the world to experiment with their brain data and create applications that use it to their advantage.

OpenBCI takes things a step further by developing a low cost and open-source platform for EEG imaging (OpenBCI, 2014). This way, anyone with an interest in electronics can get acquainted with the development of an EEG device and the algorithms needed to run a BCI. They even provide detailed instructions to develop your own model.

The way I see it, these are the first steps towards a future where man and machine are more tightly connected than ever before. I do hope that we will do this with thought and

reason, as otherwise the negative impact could be enormous.

Nobody knows when the next big step towards a smarter future will be taken, but things are certainly moving in the right direction. What most people do not realize, is that research on reading thoughts has already shown promising results.

In an article for Scientific American, Pogue (2012) described the unique experience he had in the Carnegie Mellon University. He was pushed into an fMRI scanner and was shown twenty images on a screen. For each, he had to imagine some qualities of the object. Then the machine went to work and tried to determine in which sequence the images were shown. Guess what… the machine got the sequence completely right.

A subject that captures our attention even more is the possibility to record dreams. BCI's have also been proven to effectively decode thoughts into basic images. Researchers at UC Berkeley reconstructed moving images that test subjects were looking at by measuring their brain activity (Nishimoto et al., 2011).

Judging from the capabilities that BCI's seem to offer, only one conclusion can be drawn. The possibilities are endless, we just have to dare imagine them.

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