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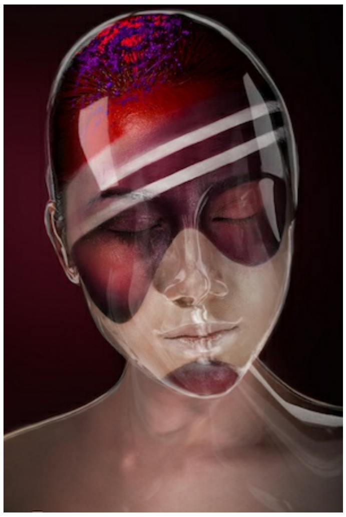
Unlocking the Power of Brain Machine Interfaces



By: Nick Maynard

BMIs (Brain Machine Interfaces) are one of the most promising fields of emergent technology, with many exciting and truly transformative use cases potentially being enabled by the technology. To many, BMI technology would be considered the stuff of science fiction, identified with *Robocop* or *Star Trek: The Next Generation*. In practice, basic forms of BMI technology have already been utilized in the medical field for a number of years. This existing use principally focuses on the cochlear implant, a medical device which uses BMI technology to provide a sense of sound to a person who is profoundly deaf or severely hard of hearing.

However, further applications in the medical field and in other areas —for example, as an entertainment device, for use in industry, for integration with automobiles or as a control mechanism—are becoming increasingly possible as the science and research develops.

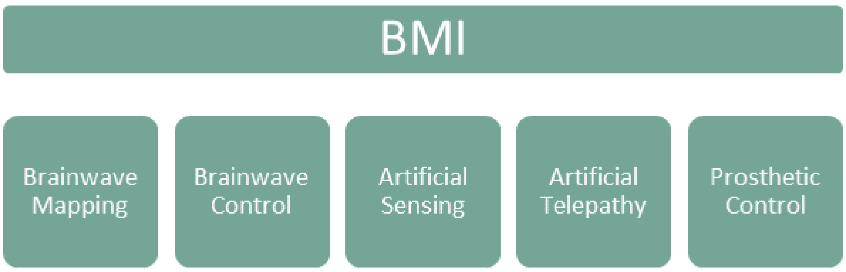
This article examines in a detailed way these emerging use cases and the impact these developments will have on existing industries. This is based on our recent research piece, *Brain Machine Interfaces: Impact Assessments, Opportunities & Use Cases 2018-2027.*

Defining BMI

BMI, sometimes referred to as a BCI (Brain-Computer Interface), is a field which has been under active research since the 1970s. This research, carried out at the University of California, was the first to envision BMIs in their current form and was directly funded by the U.S. DARPA (Defense Advanced Research Projects Agency). Since that time, there has been a huge amount of investment and research, primarily into the technology's medical applications but also into the consumer and military applications.

Juniper Research defines a BMI as: *a device that translates neuronal information into commands capable of external software or hardware, or that translates external commands into neuronal information.*

Principal Goals of BMI Research



Source: Juniper Research

BMIs in Use Today

BMIs, while a high-potential technology, are mostly in use only in medical settings at this point. There have been, however, forays into uses outside the medical area, such as in consumer entertainment devices or fatigue monitoring systems. These deployments are highly limited at this stage. The most common present uses of BMIs are outlined below:

EEGs: The most common use for BMI technology is the basic EEG. This is where signals are recorded from the brain, with the analysis of said signals being utilized to diagnose many medical conditions, primarily those that are neurological.

Cochlear Implants: The most prevalent BMI deployment outside EEG machines, cochlear implants can enable some sensation of hearing in some of those who have lost it. Early deployments date to the 1990s, with the cost only recently starting to fall enough to make them viable on a large scale.**Visual Prosthetics:** There have been experiments using BMIs for visual prostheses, which have seen varying degrees of success. Research is still ongoing.

Brain Stimulation: BMIs are being developed to enable the treatment of certain neurological conditions. Chief among these are ADHD (Attention Deficit Hyperactivity Disorder), epilepsy and Alzheimer's.

Limb Prosthetics: BMIs are being developed as an interface for controlling prosthetic limbs, by interpreting signals from the brain as a control interface. Current research is based on providing feedback to create the sensation of feeling in the prostheses.

Consumer Applications: Various new consumer applications are being created for BMIs. These range from headsets that can be used in the home for entertainment purposes to devices that aim to track and improve sleep.

Military Applications: One of the leading sources of research has been from the military, primarily funded in the U.S. by DARPA. This ranges from the initial research on BMI as a technology to approaches such as artificial telepathy, threat detection and performance enhancement. The uses are still, however, all experimental.

Trends in BMI

EEG Technology Dominating Most BMI Use Cases

Despite the well-documented shortcomings in EEG (Electroencephalography) technology, it remains the 'go-to' technology for most BMI use cases. While EEG technology lacks the accuracy and clarity of signal of other technologies, it has one major advantage: its non-invasive nature. Most of the use cases outside the medical area are not transformative enough that they warrant the use of direct brain implantation. This is in part due to the risks associated with the more invasive approaches so, for the most part, EEG will remain popular. As medical research advances BMI technology further, it is likely that other non-invasive methods with higher accuracy will become available, or the risks associated with more invasive approaches will decrease.

US Leading BMI Research & Development

Since BMI's initial inception, the U.S. has been a leading force in the development of practical applications. This is despite the FDA's somewhat restrictive rules concerning the use of new technologies in the medical arena.

There are several reasons for this domination of the field, which include:

- **Talent Availability** – The U.S. has a high-quality university education system, which produces a reliably large number of academic researchers. This ensures the availability of appropriate staff.
- **DARPA** – DARPA has consistently funded various elements of BMI research, catalyzing what may otherwise be described as a relatively low-priority research field.

- **Increasing Health Insurer Acceptance** – In the U.S., new treatments are dependent on acceptance from health insurers and their willingness to pay for them. To date, health insurers have shown high levels of support for cochlear implants, which encourages their increasing adoption.

Top 3 BMI Use Cases

Juniper has examined the emerging market, analyzing key metrics such as expected user impact, key barriers to adoption and surrounding ecosystem readiness. It identified three use cases with the highest potential, which are:

Concentration Monitoring

In many industrial and military processes, fatigue or a loss of concentration can be a big risk. On a production line, a lapse in concentration could result in the production of hundreds of incorrect products or an accident. In the military, a lapse in concentration could result in the injury or death of service personnel. Another area where this problem is widespread is in the transport and logistics sector, where drivers often travel long distances with significant risks.

At present, concentration and fatigue monitoring are carried out via wearables using optical sensors, which can be inaccurate, or via a complex system of cameras, which can be expensive to install and maintain as well as monitor.

Therefore, strategies leveraging BMI technology—primarily EEG—to monitor and improve concentration are important and a potentially vast source of revenue.

This approach is already proving popular in the mining industry, where health and safety risks due to lapses in concentration are extreme. It is likely that this approach will rapidly become popular elsewhere.

Cochlear Implants

A cochlear implant is a medical device which is used to restore hearing to those who are hard of hearing or profoundly deaf. The interface is partially invasive, with an electrode connected to the cochlea nerve in the inner ear. The electrode then interfaces with this nerve, simulating the sensation of hearing. The success rate of cochlear implants is impressively high, with an average of 80 percent sentence understanding in audiology tests, compared with 10 percent sentence understanding for standard hearing aids.

The cochlear implant is now a readily accepted medical device, which has been in use for a reasonably lengthy time. The first device was implanted in a patient in 1964, with the modern multichannel device being developed from the late 1970s. However, it was not until the early 2000s that these devices have been available through health insurers or public health systems

For those who have additional damage to the auditory nerve or the cochlea, a device can be fitted which transmits feedback straight to the brainstem, called an ABI (Auditory Brainstem Implant). This system is much more difficult to fit, with more advanced brain surgery required.

ABI devices are also more expensive than traditional cochlear implants, due to their more difficult implantation and lower volumes of production. There is also a smaller addressable market, due to the lower number of patients with damage to their cochlea or auditory nerve. The number of centers which can implant the device is also limited, with only 3 centers in the UK.

Sleep Modification Tools

Sleep disorders affect many people and provide another use case in the medical field. The statistics for sleep disorders are stark: 50-70 million US adults have a sleep disorder, with drowsy driving responsible for 1,550 fatalities and 40,000 non-fatal injuries annually in the US.

As sleep disorders are such a wide-ranging problem, the area is of significant interest for research on improvements. BMIs are one potential solution for this issue. BMI devices using EEG can be leveraged to accurately map sleep status and identify ways to alter sleep, primarily through the use of targeted biofeedback. This is where music is used to alter the sleep state into a more restful one. One example of just such a device is the Dreem headband.

Future Outlook: Juniper’s View

Juniper forecasts that that global hardware sales revenue from BMIs will reach $18.9 billion per annum by 2027, up from an estimated $2.4 billion in 2018.

Medical uses will account for 78 percent of shipment revenues by 2027. This will be due to development of advanced medical uses, such as artificial vision and prosthetic control.

Shipments of BMI devices for consumer use, such as guided meditation, account for a very low proportion of device shipments, presently under 1 percent in 2018. This proportion will reach over 6 percent of a much larger market in 2027 as technology, acceptance and additional use cases evolve.