NEW TECHNOLOGIES TO DIAGNOSE AND TREAT MENTAL HEALTH PROBLEMS

Abraham Peled[1,2]* and Irit Peled[3]

[1] *Adult Psychiatric Department at Shaar-Menashe Mental Health Center, Hadera, Israel*
[2] *Bruce and Ruth Rappaport Faculty of Medicine, Technion - Israel Institute of Technology, Haifa, Israel*
[3] *Lesley University, Boston, MA, United States*

YOUNG REVIEWERS:

ITAY
AGE: 11

This article introduces three novel approaches and technologies to the field of mental health and psychiatry, these are: digital sensors, neural network computing, and neuromodulation pacemakers to the brain. Sensors built into devises such as smartphones and smart watches can monitor and diagnose mental disorders. Neural computing simulate how the brain may function in health and disease, thus offering valuable information about possible causes for these disorders. Finally therapeutic interventions can be achieved with brain-pacemakers technologies. Have you ever wondered what technologies such as smartphones could have to do with mental health? When we talk about mental health problems, we are usually referring to difficulties with emotions and thoughts that can affect our daily functioning. There are three new technologies that are revolutionizing how we diagnose and treat mental disorders. The first is the smartphone. Smartphone-based technology enables continuous monitoring of a patient's mental state and allows doctors

to diagnosis, evaluate, and even treat patients from afar. The second technology is neural computing, which seeks to understand the physical, brain-based causes of mental illnesses. Finally, brain pacemaker technologies may make it possible to cure mental illnesses in the same way that pacemakers currently cure heart problems. Keep reading to hear the details of each of these fascinating advances in mental healthcare!

USING SMARTPHONES TO DIAGNOSE AND TREAT MENTAL HEALTH PROBLEMS

Some of you young readers may be familiar with this line: "You are on your cell phone all day! Enough with the screens already!" You may be surprised to hear that, in recent years, we have seen that smartphones can help doctors diagnose and treat **mental health** problems. Did you know that our phones contain sensor-based technology that can "observe" and measure our daily activity in a way that can provide clues about our mental health?

Changes in human behavior can be detected, measured, and monitored to help diagnose the development of a **psychiatric illness**. Psychiatrists are doctors who specialize in the field of psychiatric illness. Because psychiatrists have little information about the *causes* of psychiatric diseases, they must rely on symptoms and signs to diagnose their patients. The symptoms include the subjects' complaints, and the signs are based on the doctor's observations of the patient, including the patient's appearance, facial expressions, behavior, movements, speech, judgment, and **cognition**.

Every psychiatric illness has unique signs and symptoms. Today, signs can be "observed" by a smartphone! Appearance and facial expressions can be seen through the smartphone camera; behavior and movements can be measured using GPS; and analysis of keypad response times may tell us about cognition. Any symptoms of a psychiatric illness can be learned from questionnaires that patients answer at their convenience, using an app. Using the smartphone, symptoms can be monitored, collected, and analyzed to enable the psychiatrist to assess the disease and its severity, monitor its development from afar, and even treat it remotely.

The introduction of artificial intelligence (AI) systems combined with devices like smartphones is only recently becoming available. Such technology could make psychiatric care even better than what a single psychiatrist can provide today—particularly when it comes to monitoring how the patient is responding to a treatment. For psychiatric illnesses, it is very important to notice as soon as possible whether the disease is worsening or responding welling to treatment. In standard psychiatric care, patients must often wait a long time

MENTAL HEALTH

Feeling good about yourself, getting along with others, and being able to handle life's ups and downs. Poor mental health can result in psychiatric illnesses.

PSYCHIATRIC ILLNESS

A disease that affects human emotions and mental state. Common examples include anxiety and depression.

COGNITION

All the ways your brain helps you think, learn, remember, pay attention, and solve problems. It is how your brain makes sense of everything around you.

between doctor's visits, which may lead to wrong diagnoses or treatment that comes too late. With smartphones and AI, however, patients can be continuously monitored, and doctors can be alerted to any problems in real time.

Furthermore, continuous monitoring saves patients valuable time and money, as they need fewer in-person doctor visits. It also increases the effectiveness of treatment, as doctors will quickly get the information needed to assess whether the treatment is working, and they can decide whether to continue or change it. Overall, these technologies will save patients a lot of pain and suffering [1].

NEURAL COMPUTING

Neural computing is a developing field of brain research that involves brain simulations.

Neural computing will help us to understand what are called **higher mental functions**, like emotions, thoughts, and cognition. The brain is built from billions of interconnected nerve cells, also called **neurons**, that function as a complex system called a **neural network**. The brain's neural networks are what allows higher mental functions. To illustrate the intricate neural networks in the brain that lead to higher mental functions, think of an orchestra (Figure 1). Through complex coordination and synchronization between the musicians, the orchestra creates beautiful music. Similarly, the neurons coordinate and synchronize through neural networks to produce higher mental functions.

Figure 1

When the neural network is damaged in any way, the higher mental functions are also damaged. This may negatively affect a person's emotions and moods, interfere with higher mental functions. These

NEURAL COMPUTING

A scientific field in which computers are designed to work like the brain's neural networks. This lets computers learn from experience like humans do.

HIGHER MENTAL FUNCTIONS

Those are functions such as consciousness, feelings, cognition motivation and personality.

NEURON

The cell that makes up the brain substance or tissue.

NEURAL NETWORK

Aggregates of neuronal cells that interact with each other to create brain organization.

Figure 1

Brain activity can be compared to the performance of an orchestra. Just as all the musicians must play together in a synchronized, coordinated way to make beautiful music, the activity of the brain's neural networks must also be coordinated to allow for higher mental functions, consciousness volition and motivation.

are all symptoms of psychiatric illnesses. In our orchestra analogy, without coordination between the musicians, the music will suffer. The same goes for the brain—the more the coordination of the neural network is impaired, the more the higher mental functions will be affected. If the coordination between musicians is lost, the music will become noise. Similarly, in the brain, severe damage to the neural networks can cause a loss of higher mental functions, as seen in severe psychiatric diseases [2, 3].

THE PACEMAKER REVOLUTION

You may have heard that when a person has problems with their heart rhythm, doctors can implant an electronic device called a pacemaker, which regulates the heartbeat and keeps the heart pumping blood as it should. Psychiatric illnesses can be thought of in a similar way—as diseases caused by disturbances in the rhythm of the brain's neural networks. A type of brain pacemaker may make it possible to correct these brain rhythm problems and reduce the symptoms of mental illness. The basic technology for this treatment already exists and is developing very quickly.

There are two main technologies in this field. The first is called direct electrical brain stimulation, in which tiny wires called electrodes that can detect or deliver electrical signals are implanted into the brain. Implantation of electrodes has been used for many years to treat several brain diseases, including Parkinson's disease (in which the nervous system breaks down and impairs body movements).

The other technology, called non-invasive brain stimulation, involves activating the brain from the outside. Non-invasive treatments include weak electrical stimulation through the scalp, which has proven to be effective in improving brain activity and in reducing the symptoms of medical conditions like Depression and anxiety. Another type of non-invasive technology is based on **neural dust**, tiny sensors the size of dust particles. Neural dust can be injected into the blood so that it spreads throughout the brain tissue; then it can be activated from outside the patient by weak magnetic fields or ultrasound. The particles in neural dust can both measure and stimulate the neurons around them. In this way, neuron dust could be the basis for a future brain pacemaker [4, 5].

SUMMARY

Now you know about three new areas that can improve mental health in the future: digital sensors, neural network computing, and neuromodulation pacemakers to the brain.

NEURAL DUST

Tiny sensors, smaller than dust specks, that are injected into the brain to stimulate and measure brain activity.

According to an ancient proverb by the Chinese philosopher Confucius, "the beginning of wisdom is the ability to call things by their proper names." The time has come to call psychiatric diseases by their correct names, too; that is, by the names of the mechanisms in the brain that cause them. Scientists are just starting to understand the brain-based causes of psychiatric illness, which is why, when it comes to diagnosis, psychiatrists still rely on signs and symptoms and not on the laboratory tests and imaging procedures used in other fields of medicine. For example, a diagnosis such as "depression" is not linked to a particular place in the body and does not describe the physical cause of the disease.

The three advances described in this article may work together to change all of this, helping doctors and scientists to understand the brain-based causes of psychiatric illnesses. This new knowledge will not only allow us to call them by their proper names, but it will also help advance treatment for psychiatric illnesses into the realms of the future.

REFERENCES

1. Roth, C. B., Papassotiropoulos, A., Brühl, A. B., Lang, U. E., and Huber, C. G. 2021. Psychiatry in the digital age: a blessing or a curse? *Int. J. Environ. Res. Public Health* 18:8302. doi: 10.3390/ijerph18168302

2. Peled, A. 2012. Neuroanalysis: a method for brain-related neuroscientific diagnosis of mental disorders. *Med. Hypotheses* 78:636–40. doi: 10.1016/j.mehy.2012.01.043

3. Peled, A., and Geva, A. B. 2014. "Clinical brain profiling": a neuroscientific diagnostic approach for mental disorders. *Med. Hypotheses* 83:450–64. doi: 10.1016/j.mehy.2014.07.013

4. Schnitzler, A., and Hirschmann, J. 2012. Magnetoencephalography and neuromodulation. *Int. Rev. Neurobiol.* 107:121–36. doi: 10.1016/B978-0-12-404706-8.00007-3

5. Temel, Y., Hescham, S. A., Jahanshahi, A., Janssen, M. L., Tan, S. K., van Overbeeke, J. J., et al. 2012. Neuromodulation in psychiatric disorders. *Int. Rev. Neurobiol.* 107:283–314. doi: 10.1016/B978-0-12-404706-8.00015-2

YOUNG REVIEWERS

ITAY, AGE: 11
I am very sociable, and for now I am quite short. I love flying, physics and chemistry, and enjoy reading very much.

AUTHORS

ABRAHAM PELED
I am a psychiatrist, head of a department in the field of mental health, and I treat difficult psychiatric patients. I serve as a clinical adjunct professor in the Faculty of Medicine at the Technion as a brain researcher. Since the causes of psychiatric illnesses are unknown, I participate in studies designed to discover them. Most psychiatrists do not specialize in neural computing, but I was lucky enough to study it in the US, and here I am one of the only ones in the field. In my free time, I like to travel and swim. *neuroanalysis@gmail.com

IRIT PELED
I am a psychodrama therapist, a short-term focused psychotherapist and therapist instructor. I work with teenagers with ADHD and learning disabilities and in a psychiatric clinic. In my free time I am mainly involved in sports and music—singing and playing—and I really like to bake delicious cakes and pastries.