Brain Platform

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What is it?

"Brain Platform" is a Head Mounted Sensing and Stimulating Device (HMSSD) developed to diagnose and treat neurological and mental disorders. The Brain Platform can be divided into two sub-projects:

1) Head Mounted Sensing Device (HMSeD)

2) Head Mounted Stimulating Device (HMStD) in Closed-Loop with the HMSeD.

The Need

Taken together, some 30% of world population suffers from some kind of debilitating neurological or mental illness which is currently incurable.

The Problem

The brain is the unconquered frontier of science; as a result mental disorders are conceptualized descriptively rather than etiopathologically, i.e., based on signs and symptoms instead on actual causes. Neurological illnesses where the causes are known typically lack the pathological resolution to guide effective interventions. Consequently treatment of neurological disease is lacking and treatment of mental disorders is ineffective, serious mental disorders such as Schizophrenia are incurable.

The Solution

Develop the technology that deciphers and discovers the underlying mechanisms of mental disorders, and use it to guide therapeutic brain interventions that will cure mental and neurological illnesses.

Three components / phases are required to develop the "Brain Platform" for diagnosing and curing mental neurological disorders.

The 1) "Sensing Phase," the 2) "Discovery Algorithms," and the 3) "Stimulating Phase," the latter is dependent in closed-loop on the former phases.

The Sensing Phase:

In recent years sensor technologies have been rapidly developing. The "Brain Platform" is a Head Mounted Sensor Device whose sensors are divided into two types, Phenomenology Sensors and Brain-Imagery Sensors

Phenomenology	Sensors
Appearance (facial expressions)	Face-recognition infrared camera
Behavior (including restlessness)	Navigation-detection & oscillometer
Speech (thoughts)	Voice speech analysis
Concentration goal directedness	The above combined with eye-tracking

Brain–Imagery	Sensors
Brain Electrophysiology	Dry EEG electrodes
Brain Metabolic activity	Blood flow fMRI sensors

The Discovery Algorithms

The discovery algorithms begin by on-going coupling in real-time of phenomenology-sensing and brain-imaging, to generate a personalized large data-set for each patient.

Large data mining can use bottom-up machine-learning algorithms to map psychopathological phenomenology onto their related brain disturbances, thus revealing the underlying brain-pathologies for the different phenomenological clinical manifestations of the mental disorders.

It is predicted that in addition to machine-learning algorithms the data will need a theory-driven (top-down) approach to make sense of the resulting findings. Clinical Brain profiling (CBP,1,2) is such a theoretical testable-prediction.

CBP is a neuro-computational scientific approach (1,2) bringing physical mathematical science into the workings of the brain in mental disorders. With CBP 1) schizophrenia spectrum disorders can be re-conceptualized as disturbances to Connectome (i.e., brain network organization) stability caused by related disturbances to connectivity and hierarchy imbalances, 2) mood and anxiety disorders can be associated with altered plasticity that reduces brain optimization dynamics (ability to change with computational needs) and 3) personality disorders can be related to developmental disturbances of the Default-Mode, Resting-State neuronal networks of the brain. These neural-computation formulations are titled CBP as they represent the profiles of brain disturbances as they map to clinical phenomenology of mental disorders. The following table summarizes these mappings.

Symbol	**Brain dynamic disturbance**	**Assumed clinical correlate**
DMN	Undeveloped disturbed DMN organization	Personality disorders
Cs	Disconnectivity dynamics	Psychosis and positive signs schizophrenia
Ci	Overconnectivity dynamics	Repetitive poverty ideation perseverations
Hbu	Hierarchical bottom-up insufficiency	Avolition and negative signs schizophrenia
Htd	Hierarchical top-down shift	Systemized organized delusions
D	Deoptimization dynamic shift	Symptoms and signs of depression
O	Hyper-optimization dynamic shift	Symptoms and signs of mania
CF	Constrain frustration	Symptoms and signs of anxiety
CFb	Stimulus bound Constrain frustration	Symptoms and signs of phobias

The critical task of finding the causes of mental disorders involves detecting and extracting relevant measurable, replicable brain signals of the subtle connectivity and plasticity changes characterizing the different mental disorders (i.e., structural and functional matrices/graphs).

Due to the network organization of the brain such changes are presumed to inflict the dynamics of small-world-network parameters and other similar brain organizations, the dynamic entropy measurements and other information processing measurements. Stability measures and their vulnerability will also become relevant using assessments of phase-transitions and avalanche dynamics and vulnerability to random and structured "node deletions."

Schizophrenia spectrum disorders will probably involve fast, millisecond-range plasticity changes. Mood and anxiety disorders would probably involve plasticity and optimization dynamics developing over days to weeks, finally personality disorders will probably involve biased resting-state networks due to developmental disturbances caused by altered experience-dependent-plasticity lasting years, from infancy to adulthood. The following table summarizes the relevant methods of detection for the various brain disturbances.

Symbol	Brain dynamic disturbance	Detecting signal processing
DMN	Undeveloped disturbed DMN organization	Life-long assessment of small-world parameters, hierarchy and hub formation, attempt attractor space-state assessments
Cs	Disconnectivity dynamics	Connectivity matrices and small-world graphs will show disconnection dynamics and tendency to randomness.
Ci	Overconnectivity dynamics	Connectivity matrices and small-world graphs will show over-disconnection dynamics and tendency to reduced dynamics and increase fixations .
Hbu	Hierarchical bottom-up insufficiency	Reduced hierarchy demonstrated by reduction of hub degrees and numbers and by K-shell decomposition. Susceptibility to node attack
Htd	Hierarchical top-down shift	Demonstrated by increase of hub degrees and by K-shell decomposition. Resilience to node attack
D	Deoptimization dynamic shift	Reduced plasticity detected by time-related tardiness of connectivity dynamics, and by slow rest-to-task transitions
O	Hyper-optimization dynamic shift	Increased plasticity detected by time-related increase of connectivity dynamics, and by fast rest-to-task transitions
CF	Constrain frustration	Destabilized millisecond-range connectivity dynamics susceptibility to node attack
CFb	Stimulus bound Constrain frustration	Specific stimulus-bound destabilized millisecond-range connectivity dynamics susceptibility to node attack

The discovery phase is completed by achieving the daunting task of discovering the causes of mental disorders. Without knowing the exact algorithm of disturbance of the diverse mental disorders, therapy cannot be planned to correct the disturbances and cure patients.

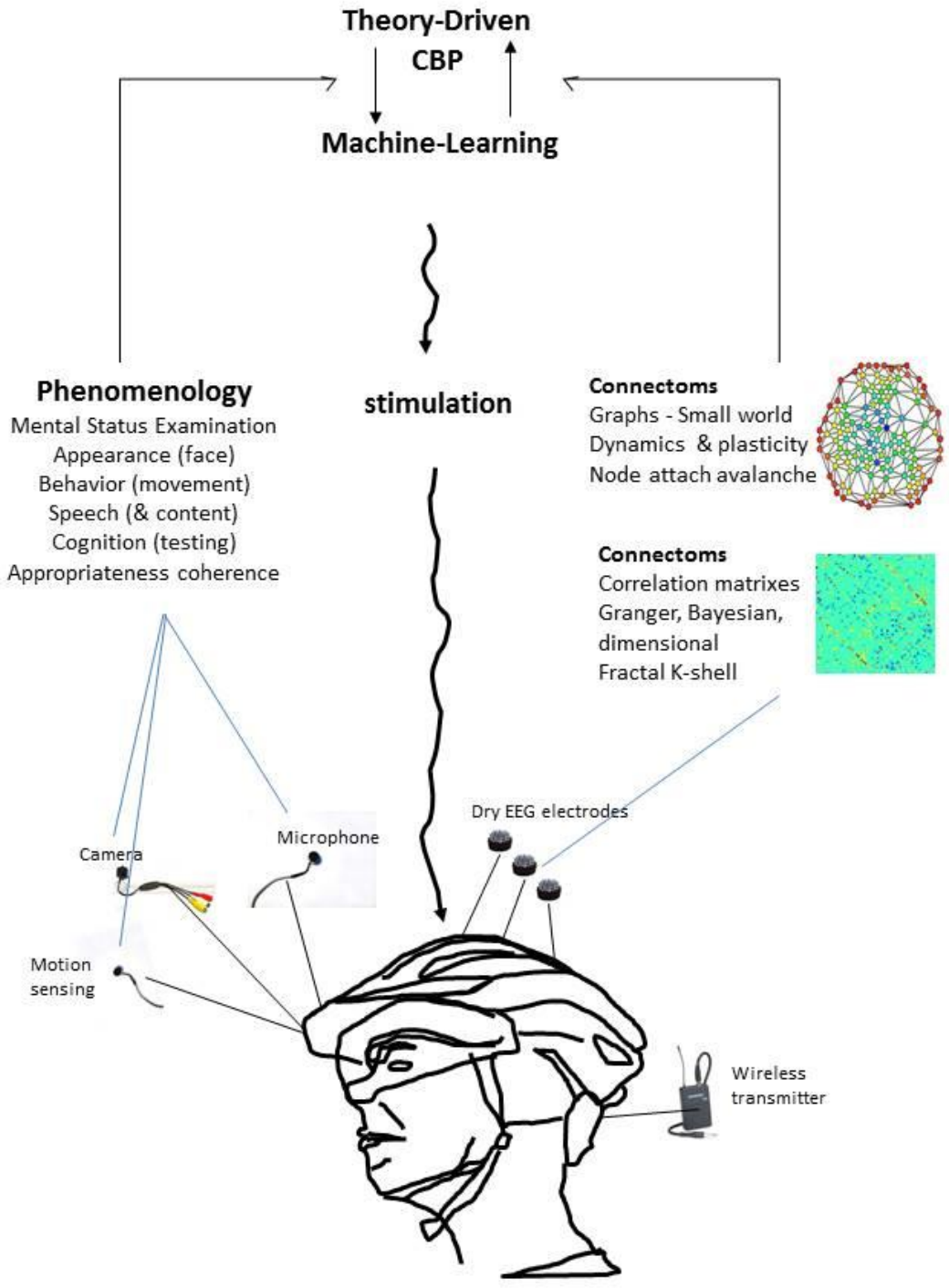
The Stimulating Phase:

The stimulating therapeutic phase is totally dependent on the discovery phase, to the extent that therapy and disturbances must be coupled in a closed loop. Ongoing detection of brain distances serves as the guiding algorithm for ongoing disturbance-coupled intervention.

Currently the most promising technology for non-invasive effective brain stimulation is that of Focused Ultrasound, portable head-mounted ultrasound devices will be a technological challenge. Other non-invasive technologies could involve transcranial electrical current or magnetic stimulations. Invasive technologies could involve deep brain stimulation with penetrable electrodes or Optogentics (3) using light with genetically engineered brain preparations. In the near future magnetically activated probes or transplants can be used and phrmacogenetics, where innate molecules could become vectors of brain stimulation after proper engineering of the brain is achieved.

The stimulation phase, being coupled with the sensing phase will acquire detailed algorithmic specificity after the two pervious phases are successfully executed.

The following figure schematize the phases of solution



The Uniqueness

The uniqueness of the “Brain Platform” lays in the Discovery Algorithms the CBP (Clinical Brain Profiling).

Why Now?

Development of sensing devices coupled with computer storing (cloud) and analyzing capabilities offer the large-data accumulation needed to decipher subtle changes underlying mental disorders in a noisy-brain with heterogynous and mostly variable activity. The CBP conceptualization (1,2) of mental disorders offers the roadmap for breakthrough.

Who? The Team

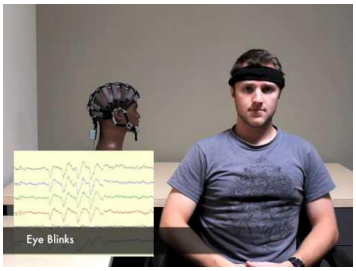
Clinicians, neuro-computational and computer engineers, physicist and mathematicians will need to team up with the author of CBP (1) to achieve this daunting feat.

Milestones & Phases

The sensing phase is first, large data acquisition is a prerequisite. This can begin with preliminary sensing devices developed further as experience is accumulated.

A pilot, an initial preliminary project, can use existing (even if partial limited) technology to test on patients and look at data acquisition, storage, analysis and results, experience with such initial steps can become a platform for further development toward a fully operating “Brain Platform.”

Existing technology developed for EEG monitoring and smartphones sensors is available on the market, here are some examples.



References

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