Brain Screening: A Priority Based on Current Functional Brain Mapping Advances

2020 Position Paper by the Society for Human Brain Mapping and Therapeutics (SBMT)

Introduction: Improved Mental Health Through Neuroscience

In 1990 George H. Bush initiated the "Decade of the Brain" also called the National Institutes of Health "Human Brain Mapping Initiative" (HBMI) and approximately 2 Billion dollars in funding from 1990 to 2000 occurred which also continues today (1). The first decade of the HBMI focused on integrating different brain measures (PET, SPECT, MRI, EEG/MEG) into a common spatial coordinate system. In 1992 the Talairach atlas coordinate system was adopted at NIH as a standard for all neuroimaging methods and today used worldwide for co-registration (2). An advantage of the electroencephalogram or EEG is the high-speed time domain and high-speed measurements of network dynamics involved in the momentary recruitment of billions of neurons that mediate different functions. In contrast, other imaging methods such as Positron Emission Tomography (PET) and Single Photon Emission Computed Tomography (SPECT) require about 20 minutes with a radioactive tracer and functional MRI (fMRI) requires about 20 seconds or longer and all three cost about 2 or 3 million dollars for a hospital to purchase and with high monthly costs for liquid helium and other expenses.

Mental health disorders such as depression, addiction, anxiety and others are growing at an alarming rate as the Covid-19 pandemic continues (3). It is our position to apply new advances in Neuroscience and Neuroimaging that allow for inexpensive at-home screening of one's Electroencephalogram or EEG to identify dysregulated networks linked to symptoms and to monitor the course of treatment. Improved source localization accuracy and increased computational speeds provide for real-time evaluation of the health of a person's brain with the ability to link mental health disorders to dysregulation in regions of the brain and brain networks. Today the use of internet apps such as Zoom or Go-to-Meeting allow a professional to train people on how to obtain a 5-10 minute recording of one's brain at home where one can save the record and the analyses for future comparisons. A yearly screening will allow for comparisons over time or before the onset of a mental health problem such as PTSD or a traumatic brain injury or depression/anxiety disorders, etc. The goal is to link symptoms of mental health problems to the organ responsible for the problem. The use of computers to quantify EEG features is referred to as qEEG as opposed to non-qEEG which is visual examination of the EEG traces without the use of computer analyses. Clinicians and individuals can share their

functional brain mapping data with others and do so safely by adherence to HIPAA procedures to protect the confidentiality and one's identity.

Mental Health Crisis and Covid-19 Pandemic

Since March 2020 over 15 million Americans and over 68 million people world wide have contracted the Covid-19 virus (4). Often serious and long term neurological sequalae such as epileptic events and EEG sharp waves are present in Covid-19 patients (5). For example, Egbert et all (6) reported that the most frequent abnormalities were white matter hyperintensities on MRI (53% affected cases) followed by microhemorrhages, hemorrhages and infarcts with white matter abnormalities most frequently present in the bilateral anterior and posterior cerebral white matter (50% of the cases).

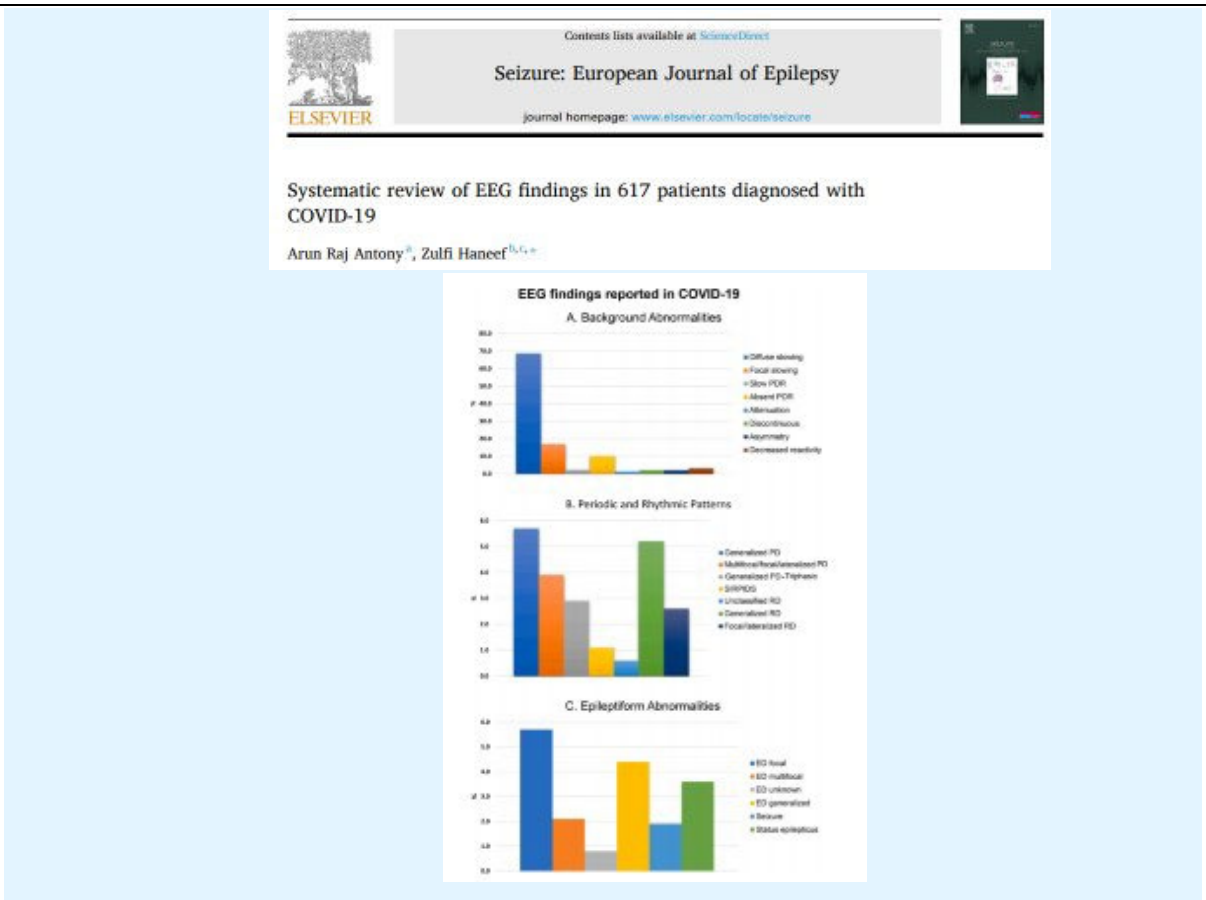


Fig. 1 – Neurological sequalae following Covid-19 infection (3)

Often patients with both mild and severe Covid-19 say they can't breathe. Unfortunately, after recovering from the infection, some of them report difficulty thinking. Even people who were never sick enough to go to a hospital, much less lie in an ICU bed with a ventilator, report feeling something as ill-defined as "Covid fog" or as frightening as numbed limbs. They're unable to carry on with their lives, exhausted by crossing the street, fumbling for words, or laid

low by depression, anxiety, or PTSD. It is estimate that as many as 1 in 3 patients recovering from Covid-19 could experience neurological or psychological after-effects of their infections, experts told STAT, reflecting a growing consensus that the disease can have lasting impact on the brain. Beyond the fatigue felt by "long haulers" as they heal post-Covid, these neuropsychological problems range from headache, dizziness, and lingering loss of smell or taste to mood disorders and deeper cognitive impairment. Dating to early reports from China and Europe, clinicians have seen people suffer from depression and anxiety. Muscle weakness and nerve damage sometimes mean they can't walk.

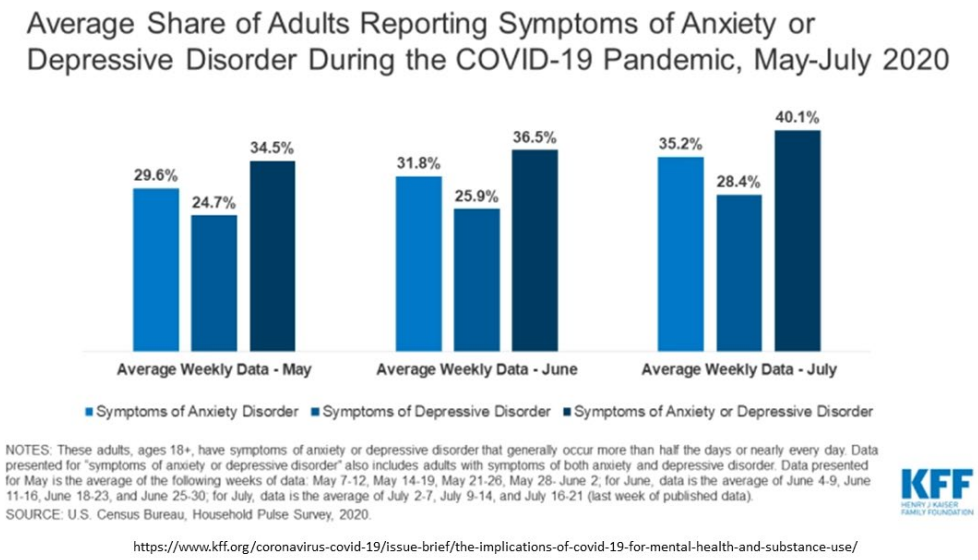


Fig. 2- Examples of the incidence of mental health disorder after Covbid-19 infection (7)

Given the evidence of serious neurological complications and mental health problems post Covid-19 the need for large scale screening of patient's mental status using inexpensive EEG neuroimaging. Once a person's brain is imaged and symptoms properly assessed then therapeuticprotocols and methods can be used to move brain network hubs and connections in the direction of improved health. Figure three illustrates a strategy for inexpensive and large scale brain screening using EEG Neuroimaging followed by targeted therapies (e.g., EEG amplifier costs less than $3,000). The efficacy of a given therapy can then be assessed by repeat EEG measures and smartphone symptom severity questionnaires.

Inexpensive and Portable Neuroimaging for Screening and Therapeutics

The quantitative measurement of the EEG and brain neuroimaging is the first step in the integration of technology for early detection of mental health disorders as well as effective and inexpensive treatments to help individuals with mental health challenges. For example, methods such as EEG Neurofeedback and Neuromodulation methods like Transcranial Magnetic and electrical stimulation (TMS) and deep brain stimulation as well as Photobiomodulation are used

to help many people today. A hub and spoke model illustrates how EEG brain measurement is the core hub and the spokes are various treatment methods by which changes in the brain and reduced symptom severity are evaluated using quantitative EEG.

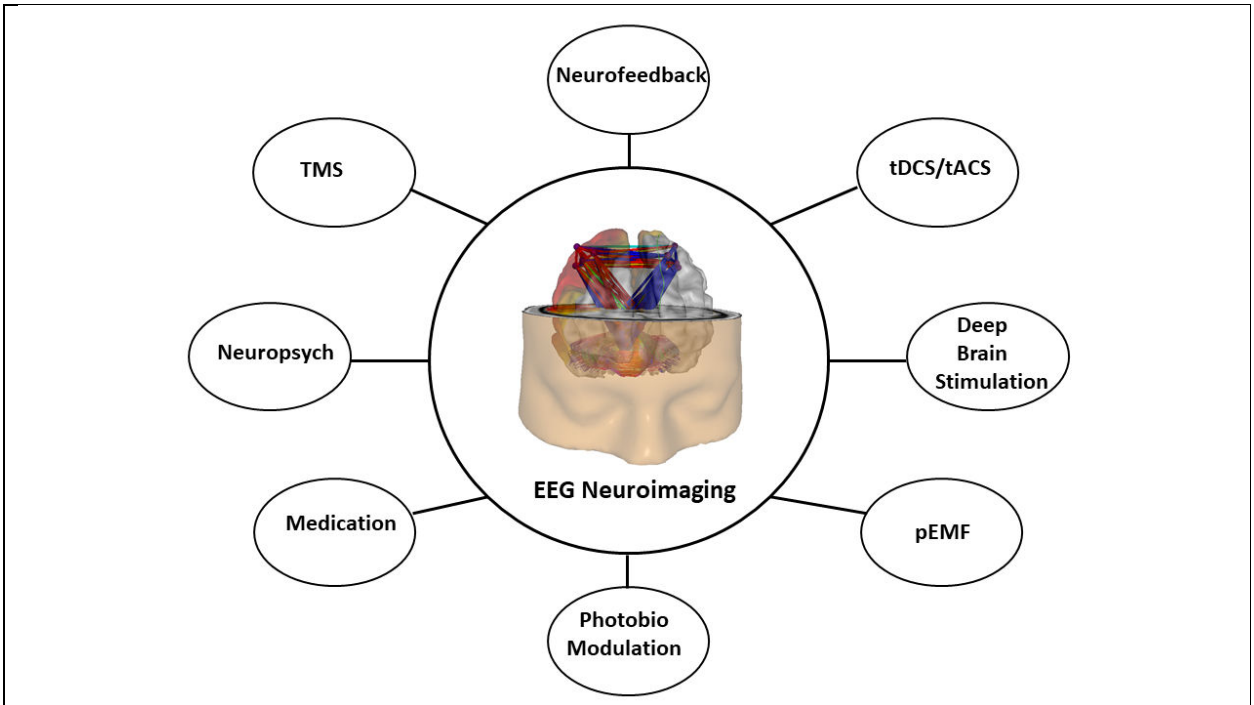


Fig. 3 – Hub and spoke illustration of EEG screening as a hub and core concept for early detection of mental health disorders and inexpensive and remote evaluation. The spokes are various treatment methods (TMS = Transcranial Magnetic Stimulation, tDCS = Transcranial Direct-Current Stimulation, tACS = Transcranial Alternating Current Stimulation, pEMF = Pulsed Electromagnetic Field therapy).

New Developments in Electrical NeuroImaging

Inexpensive EEG functional brain mapping is a first step in the application of various treatments such as "Neuromodulation" methods like tDCS (transcranial direct current stimulation), TMS (transcranial magnetic stimulation), EEG Biofeedback (Neurofeedback), deep brain stimulation, photo-biomodulation or medications, etc. A comprehensive approach is essential but must have at its core a noninvasive and inexpensive assessment of the brain itself (8 – 11).

Figure four is an example of EEG Neuroimaging using a Smartphone or Tablet or Laptop that allows one to evaluate brain network connectivity and EEG sources as well as a comparison to an FDA registered normative database from birth to senescence. Screening of an individual's EEG is available using inexpensive and portable software as a way to create an individualized database for comparison over time and for early detection of mental health problems such as

PTSD, traumatic brain injury, addictions, attention deficit disorder, memory problems, Parkinsonism, etc.

Figure four are also examples of EEG Neuroimaging on a laptop where an individual's brain electrical activity (EEG) is compared to an age-matched and FDA registered normative reference database. The laptop can be at home and/or in the clinician's office for real-time evaluation.

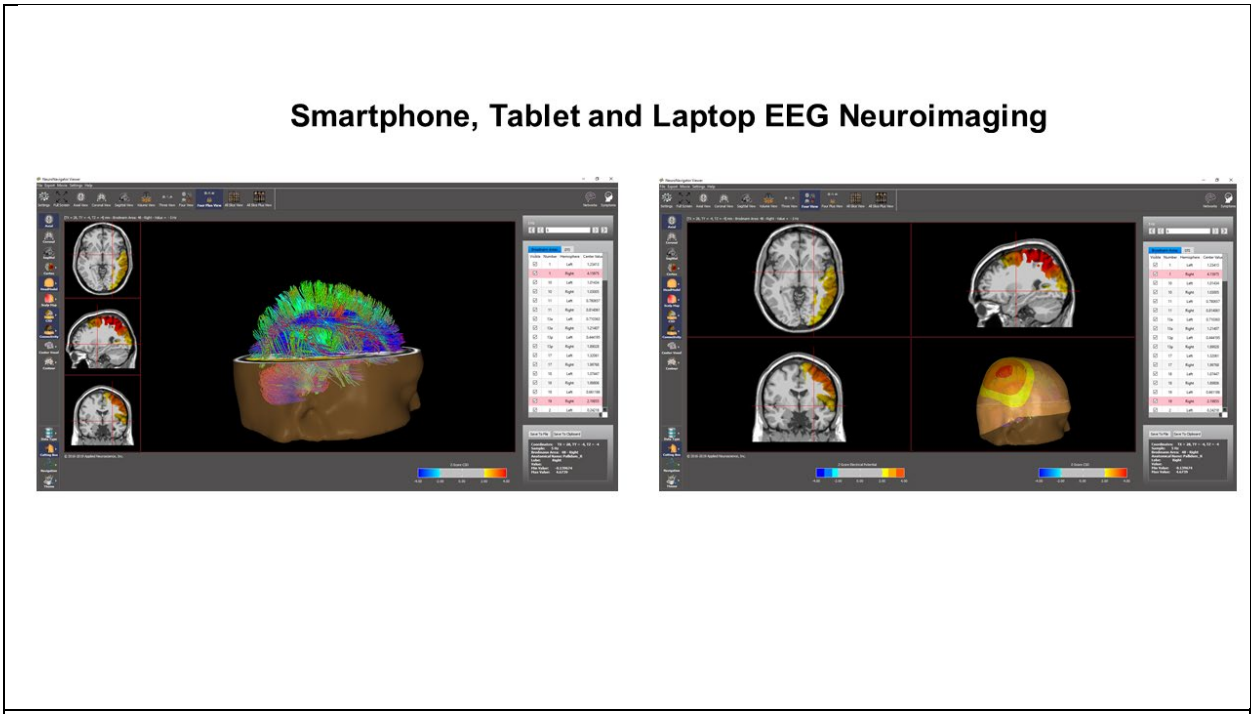


Fig. 4- Examples of a laptop measurement of EEG currents and network connectivity as compared to an age-matched and FDA registered normative database. Similar to a blood test each measurement is compared to a group of healthy individuals with no history of mental disorders. Real-time EEG neuroimaging is a standard in today's (2020) qEEG neuroscience (10, 11).

Figure five is a comparison of the localization accuracy of different neuroimaging technologies using mathematical source simulations. It can be seen that an inexpensive and portable 19 channel digital EEG (e.g., $800 for the EEG amplifiers) has essentially the same localization accuracy as the more expensive 128 channel EEG (e.g., $100,000 for the amplifiers) and the even more expensive and the non-portable148 channel Magnetoencepalography (MEG) (e.g., 2 million dollars). This further emphasizes the feasibility of brain screening given today's modern technology.

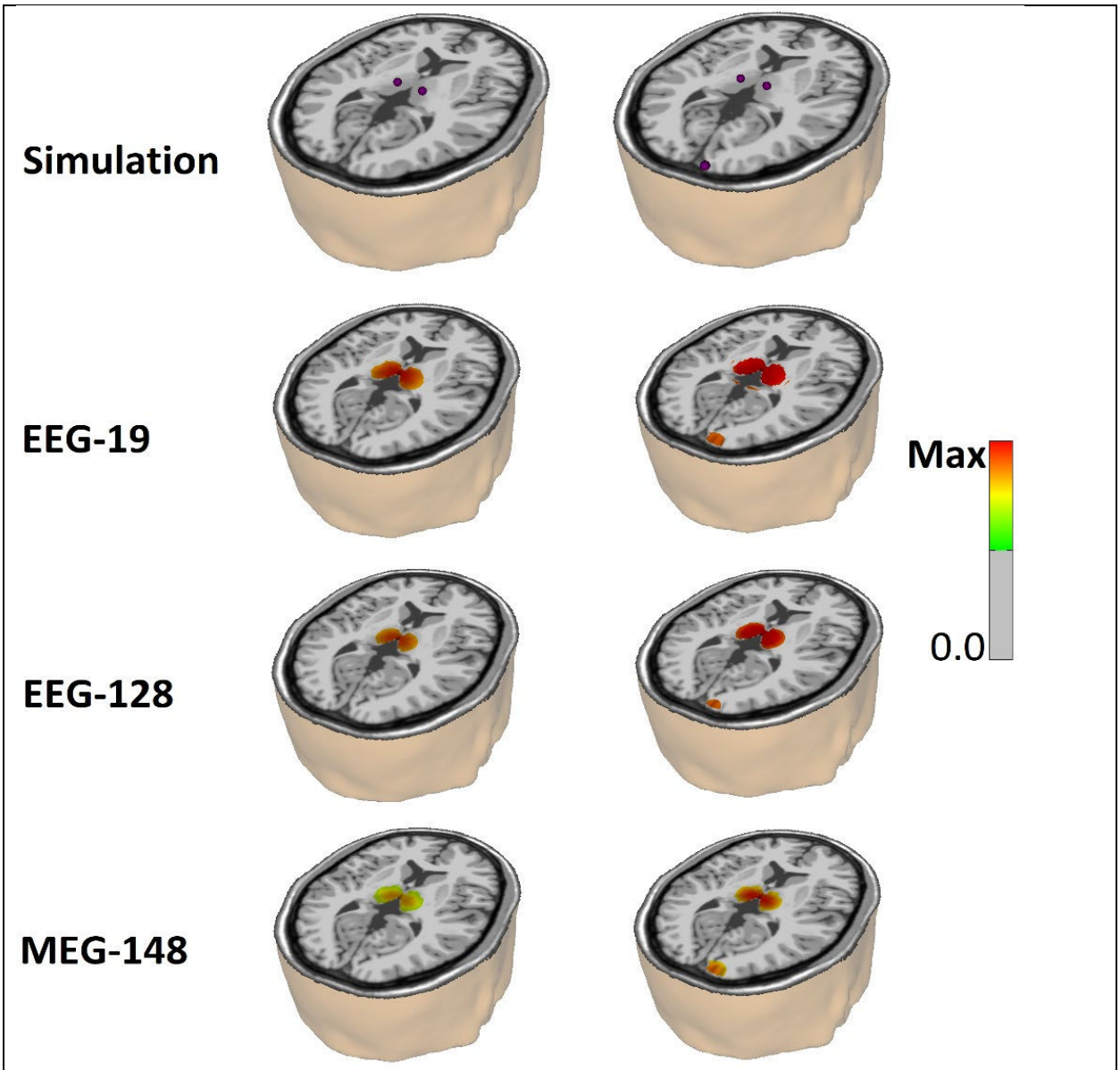


Fig. 5 – Simulations of the cerebral activity by deep sources are simulated using a linear combination of sine functions with frequency components evenly spaced in the alpha band (8–12 Hz). The amplitude of oscillation was the same for all the frequencies and it was set to 1.0. Left are two thalamic sources located at Talairach coordinates [-10 -20 8] and [10 -20 8]. Right is the same thalamic sources plus a right hemisphere occipital source located at [17 -100 5]**.** The 19 EEG channels use the 10-20 positions electrodes system, the 128 EEG channels use the 10-10 system and the MEG 148 follows the magnetometer configuration of the 4D Neuroimaging MAGNES 2500 WH system. In this system, 148 magnetometers are arranged in a uniformly distributed array with a mean inter-channel spacing of 2.9 cm. plus a right hemisphere occipital source located at [17 -100 5]**.** The error for the thalamic sources in both configurations are EEG -19 = 20 mm; EEG -128 = 18 mm; MEG -148 = 14 mm, while for the occipital source the error range from EEG – 19 = 7 mm; EEG -128 = 7 mm, MEG = 5 mm. (12).

There are over 10 million Americans with Parkinsonism and balance disorders. Early detection and monitoring of treatment methods may significantly reduce the severity of these disorders, especially when combined with Neuromodulation methods such as EEG Biofeedback and brain stimulation. Figure six is an example of EEG neuroimaging of the Cerebellum in a Parkinsonism patient as another example of new advances in EEG Neuroimaging that can be used to screen individuals in advance of the onset of mental health problems.

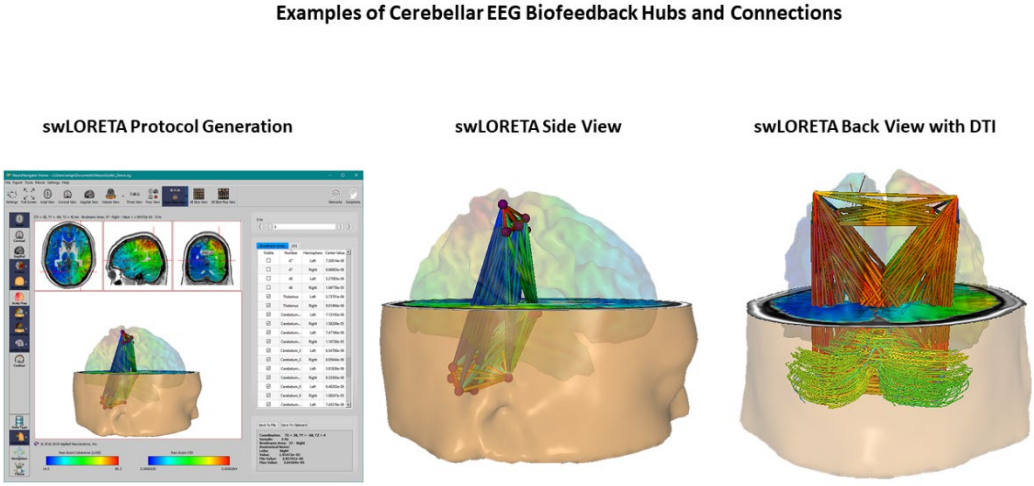


Fig. 6- Examples of standardized weighted Low-Resolution Electromagnetic Tomography (swLORETA) source localization and functional and effective connectivity between cerebellar sources and the sensory-motor cortex. These are some of the important circuits involved in Parkinsonism and also EEG Neurofeedback to increase the efficacy of compensatory networks. (12).

Remote Assessment and Treatments

Remote assessment and remote treatments of mental health disorders. Internet programs such as Zoom or Go-to-Meeting are free and there are also free apps to aid in the self-assessment screening of symptom severity and changes in symptom severity over time or treatment (e.g., download the free iPhone or Android app called: NeuroLinkQ).

Figure seven illustrates the use of a smartphone to assess symptom severity by self-assessment questionnaires that are HIPAA compliant. Clinician locations and contact information are available to connect an individual to a competent clinician and transfer the self-assessment information.

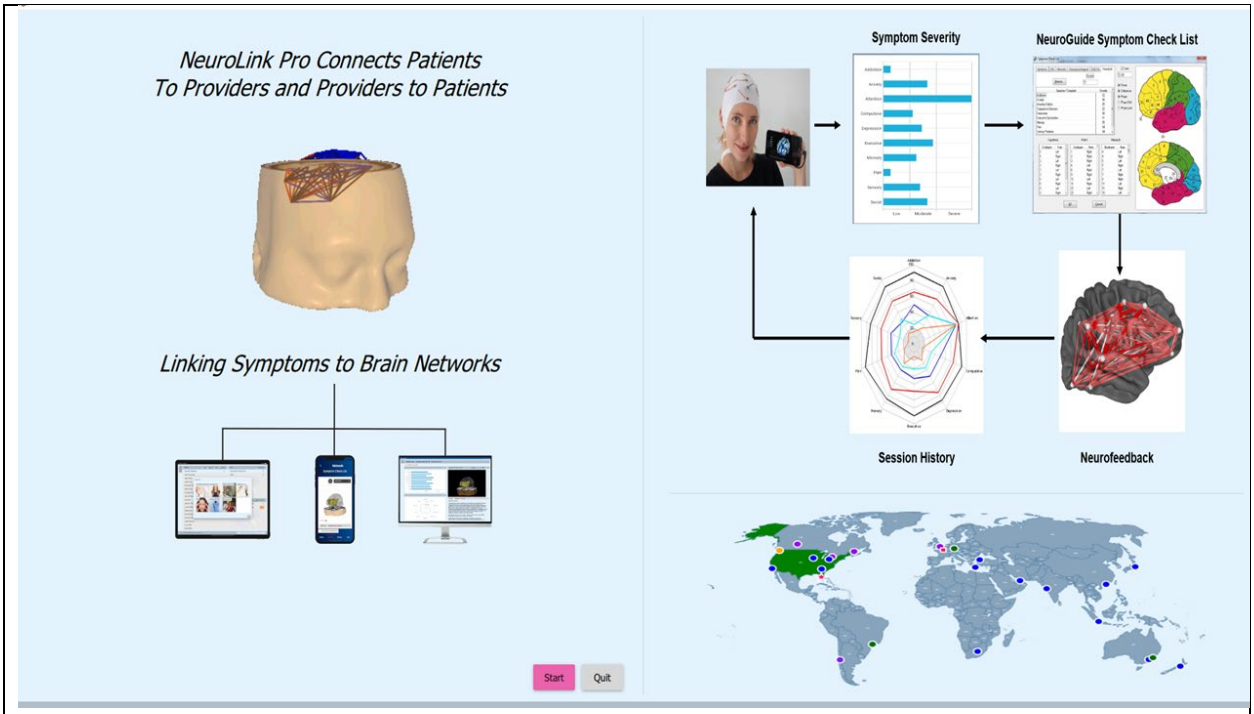


Fig. 7- The left shows a Smartphone brain image that changes depending on symptom category and severity. This information which can be anonymous and HIPAA compliant (especially crucial in suicide situations) is sent to a clinician. The right side illustrates the EEG screening and treatment protocol to address brain dysregulations linked to the symptoms. (10, 12)

The clinician then arranges an EEG brain screening either by an office visit or remotely and the EEG information is sent to the clinician where a linkage between symptoms and brain network dysregulation is evaluated. A treatment protocol is then developed based on symptom category and severity to move the brain in the direction of improved health.

Cost/Benefit Analysis of ANRI's Mass Screening During the Covid-19 Pandemic

It is useful to consider a "cost/benefit" estimate of early brain screening and treatment. For example, it is estimated that the Covid-19 pandemic will cost the US economy approximately 16 trillion dollars (17). Larry Summers and the Harvard University economist David Cutler wrote. "Approximately half of this amount is the lost income from the COVID-19–induced recession; the remainder is the economic effects of shorter and less healthy life," The authors estimated another $2.6 trillion in costs from long-term complications suffered by COVID-19 survivors and about $1.6 trillion in costs from mental health conditions related to the pandemic.

A major source of the economic impact of the Covid-19 virus is due to the negative effects on mental health resulting in depression, anxiety disorders, PTSD, and direct damage to axons and neurons, etc. Modern neuroscience and the SBMT is in a unique position to support the use of modern and inexpensive technologies to conduct mass screening on a large scale by remote "at-home" EEG neuroimaging and various treatments to reinforce improved brain function in victims of the pandemic. For example, the "Hub and Spoke" model where a clinician uses Zoom and/or Go-to-Meeting to record 5 to 10 minutes of EEG and then link symptoms to dysregulated brain networks using neuroimaging software is a proven technology that was successfully in use prior to the Covid-19 pandemic. The expense of each spoke is less than $5,000 and the hub expense is only slightly greater. Each Hub can simultaneously monitor and measure about 5 spoke EEG patients per hour or 40 per day x 5 days = 200/week x 4 weeks = 800 per month. This means that 100,000 "Hub and Spoke" systems can measure and treat about 8,000,000 covid-19 victims per month.

Scientific Literature

Below are the results of a search of the National Library of Medicine database (https://pubmed.ncbi.nlm.nih.gov/) using the search terms listed below. There are hundreds of peer-reviewed studies demonstrating the effect sizes and reliability of quantitative EEG (qEEG) for different categories of mental health problems as an example of the extent and depth of established science in support of the proposed EEG screening as the position of the SBMT.

National Library of Medicine (Pubmed) search (https://pubmed.ncbi.nlm.nih.gov/) of EEG Application of Functional Brain Mapping in Different Disorders Possibly Enhanced by Early Detection and Screening:

Alzheimer's (2,335 citations)

Dementia (4,360 citations)

Anxiety Disorders (3,432)

Autism (1,565)

Depression (7,708)

Memory Disorders (2,604)

EEG and Parkinsonism (2,285)

PTSD (419)

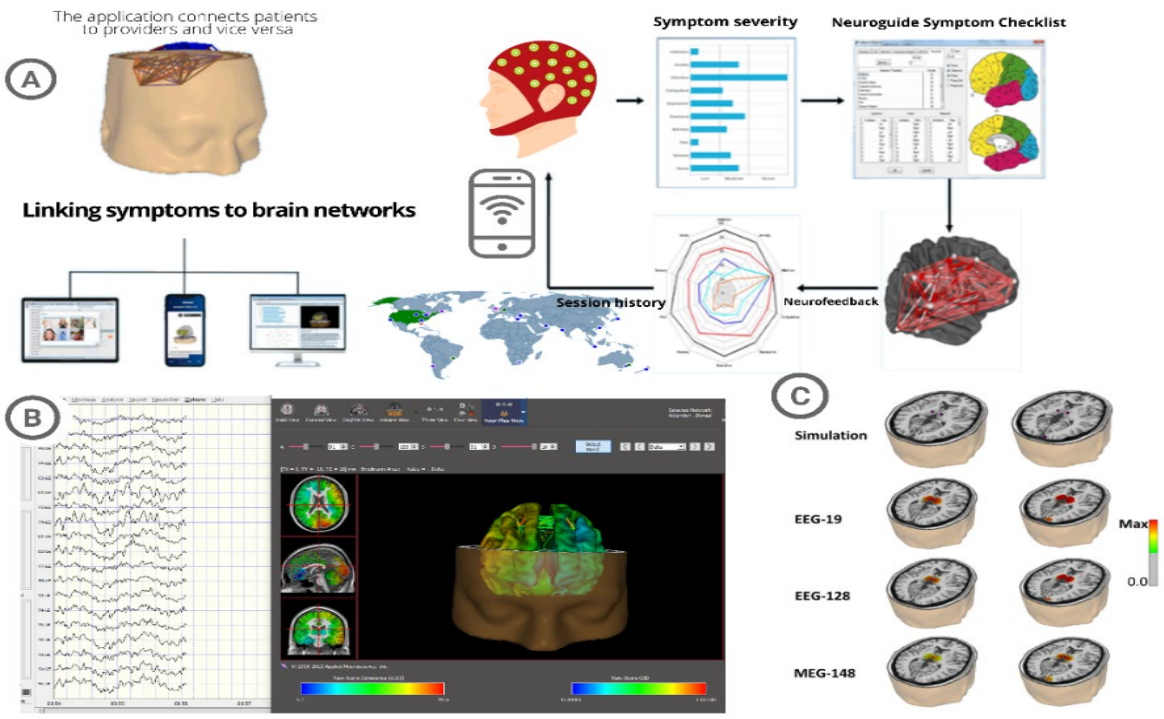
Traumatic Brain Injury (399)

AAN Opposition

Opposition to home health brain screening arises because of the misplaced criticism that EEG is too expensive and complicated. In 1977 Nuwer (13) wrongly claimed that quantitative EEG (qEEG) has low reliability. Several peer reviewed rebuttals to the Nuwer 1997 position paper were published that cite the scientific literature that was not cited by Nuwer, for example, Hoffman et al, (14); Hughes and John, (15); Thatcher et al, (16; 17). Also, the AAN criticism is easily dispelled by searching the National Library of Medicine's database (Pubmed) using the search terms "EEG and Reliability" where (on 10/25/20) there are 5,588 citations to peer reviewed studies showing test re-test reliability greater than 0.9 in the vast majority of the studies. Also, criticism as to cost is dispelled with the fact that a 19 channel EEG amplifier costs less than $800. The complexity argument has also been disproven by the increasing use of telemedicine and remote training via Go-to-Meeting, Zoom, Team Viewer, etc. that is commonly used by experienced clinicians to competently teach at home patients how to accurately measure their EEG and transmit to a HIPPA compliant professional. This is important for early detection of problems and to discuss and devise treatment for any stage of a mental health problem.

Summary

The need for inexpensive brain evaluation and screening is growing because of the Covid-19 virus and the mental stress of job loss and the loss of loved ones. This acute and growing need was present before the Covid-19 virus as evidenced by increases in addictions and mental health problems as the population ages. Improved mental health benefits the US economy and today's modern technology coupled with advances in Neuroscience stand ready to be deployed. Remote evaluation and training at home and in mental health facilities are inexpensive and effective and can reduce health care costs and improve the quality of life for many US citizens.



Integrated summary of new technologies. The mobile app-based resource linked to simple remote qEEG platforms. A: Illustration of the free smartphone app where individuals with PTSD and other similar problems can answer screening questionnaires to assess symptom severity over time. The App includes a map of clinicians and contact information to facilitate access to mental health treatment (www.anineurolink.com). B: Examples of a real-time 19-channel EEG source localization that can be measured in a clinician's office or remotely using online communication platforms. C: The left column are simulated sources in the bilateral thalamus and the right column are simulated sources from the bilateral thalamus plus one source in the right occipital lobe. A 19- and 128-channel qEEG produce similar localization accuracy and the magnetoencephalography (MEG) shows slightly improved localization accuracy. The 19-channel qEEG is inexpensive, portable, and suitable for large scale screening. Meanwhile, in certain cases such as epilepsy and especially when it comes to multiple onsets and the necessity to identify the spread of dipoles in the irritative zone, a 19-ch EEG/qEEG would not necessarily provide sufficient data. From (18).

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