Facts related to modern qEEG analysis performed at the KalpaTaru tests

qEEG (quantitative electroencephalogram) provides quantitative information about brain activity related to anatomical integrity, developmental maturation, and mediation of sensory, perceptual, and cognitive processes. qEEG contains diagnostically valuable information that can be made accessible by advanced quantitative analysis.

The argument that is still held by some clinicians and researchers is that "EEG best suits just for epilepsy diagnostics and changes in brain recources should be studied by cognitive tests" is the old point of view which is based on visual inspection of the conventional EEG which have been regarded as too nonspecific. Funny as it may sound, visual analysis of raw EEG recordings is still predominantly the state of the art in electroencephalography. Visual analysis of paper recordings was replaced by visual analysis of digital recordings displayed on computer screen.

Modern quantitative analysis of EEG (qEEG) which is used in scientific research is very different from visual analysis; and results of such advanced qEEG analysis have additional utility beyond simply ruling out "organic brain lesions" or epilepsy:
Digital EEG recording and leaps in computational power have spawned a revolution in qEEG analysis. The use of computers in EEG enables real-time denoising, automatic rhythmic analysis, and more complicated quantifications. Current qEEG analysis methods have gone far beyond the quantification of amplitudes and rhythms. With advances in neural signal processing methods, a wide range of linear and nonlinear techniques and higher-order statistical analysis have been implemented to analyze more complex nonstationary and nonrhythmic activity. All this offer new insights into functional neural networks, neurophysiology of cognitive processes and disease processes in the brain.

Neurometric qEEG has excellent test–retest replicability within an individual and has been demonstrated to have extremely high specificity as well as extremely high sensitivity to a wide variety of cognitive processes, as well as developmental, neurologic, and psychiatric disorders. This became possible due to the development of qEEG-based discriminant functions — i.e., statistically-derived analyses of complex data sets produced by qEEG which identify electrophysiological patterns that have high discriminate power for different cognitive processes and various brain pathologies.

Below are only a few examples derived from numerous scientific research:

• Sensitivity of the inattentive index was found to be 86%, and specificity - 98%
• The specificity and sensitivity of some qEEG parameters to identify/diagnose some disorders/dysfunctions of the brain are much better than for example blood tests or MRI.
• qEEG patterns of brain activity has shown predicting outcome better than a syndrome based diagnosis in Major Depressive Disorder or Attention-Deficit/Hyperactivity Disorder (ADHD)
• Sensitivity and specificity are high for detection of ischemia-related diffuse or focal impairment: sensitivity generally greater than 80%, false-positive rates below 5% to 10%, and correlations of r.0.7 between EEG and blood flow in ischemic and nonischemic regions. qEEG can detect reliable focal features that are missed in the routine EEG and can be quite abnormal even when the CT is still normal.

• Using qEEG measures, it has been possible to discriminate replicably attention deficit disorders with or without hyperactivity (ADHD/ADD) versus normal children, with a specificity of 88% and a sensitivity of 94% and ADD versus specific developmental learning disorders (SDLD) children, with a sensitivity of 97% and a specificity of 84.2%.
• The sensitivity and specificity for the qEEG diagnostic of dementia are 91.9% and 92.2%, respectively. The positive predictive value and negative predictive value for dementia are 94.4% and 88.7%, and the global efficiency is 92.0%.
• With qEEG indexes as the sole predictor of relapse to alcohol and drug abuse, the sensitivity, specificity, and positive and negative predictive value parameters for discriminating outcomes were 61%, 85%, 75%, and 74%, respectively.
• Discriminant analysis between mild and severe traumatic brain injuries groups showed classification accuracy of 96.39%, sensitivity 95.45%, and specificity 97.44%

If one were to require that the qEEG evaluation be performed on two separate samples and that any significant finding deviant at the $P<0.05$ level be replicated in each of these two samples, the probability that this would occur by chance would be approximately P x P, or 0.05 x 0.05, or 0.0025. If such a replication were required, false positives would seem rather unlikely. Such a high level of specificity is beyond the confidence level achieved by many routinely used clinical tests, such as mammograms, cervical screenings, or CT brain scans.

It is important to keep in mind that according to numerous studies the resting EEG of healthy, normally functioning individuals is highly predictable and is regulated by a complex neuroanatomical and neurochemical homeostatic system. This system is genetically based and normative data across a wide age range have been established and repeatedly replicated in many countries. The results are independent of age, language, ethnic, or cultural background. In addition results show high test–retest reliability, temporal stability, sensitivity, and specificity. Other advantages of qEEG examinations are that they are objective, require no overt cooperative behavior, and are independent of language. Further, they are also economical, non-invasive, rapid to administer (in contrast to MRI, MEG and others).

Why fMRI is not the best choice for cognitive processes testing in non-experimental settings:

• fMRI has only indirect relation to the neuronal signaling
• the time resolution of fMRI image sequences is very low (in contrast cognitive processes are very fast and can be reliably tested only by qEEG)
• many types of mental activities, cognitive processes, brain disorders, and malfunctions of the brain cannot be registered using fMRI since their effect on the level of oxygenated blood is low
• the accessibility to fMRI systems is limited and very costly (which is not the case for EEG)

Although the EEG has some limitations with respect to its use as a method for fine-grain 3D anatomical localization of neurofunctional systems, it has clear advantages relative to other neuroimaging techniques as a method for tracking cognition and brain function over time. That is, the EEG provides a sensitive, unimposing, portable, and low-cost monitor of cognition for research, clinical assessment, and other applications. The compactness of EEG technology also means that, unlike other functional neuroimaging modalities (which require massive machinery, large teams of technicians, and complete immobilization of the subject) EEGs can even be collected from an ambulatory subject. The same factors that make the EEG useful as a continuous monitor of cognitive status also make it ideal for incorporation into a test of cognitive function administered repeatedly to track changes in neural function.

Traditionally, behavioral measures (cognitive tests) have been almost exclusively relied upon as a means to detect cognitive processes. However, compensatory efforts by subjects might mask real, functionally relevant, changes in brain state. Conversely, a low level of test performance may reflect motivational rather than ability factors. Since EEG measures can provide independent evidence of variations in alertness and attentiveness or mental effort, incorporating them into tests of cognitive function might lead to more sensitivity and less ambiguous assessment tools.

And, finally, the advanced qEEG analysis will be performed by experienced neuroscientists with Ph.D. in psychophysiology. They have published 123 scientific papers in professional journals and 3 chapters in the books in areas of neuroscience and applied psychophysiology. Their areas of expertise include neuroinformatics, quantitative EEG diagnostics, advanced methods of EEG/MEG analysis and systemic psychophysiology. They are personal members of Brain Research Society of Finland (BRSF), Society for Complex Systems in Cognitive Science (SCSCS), Russian Neuroscience Society (RNS), Russian Society for Biological Psychiatry (RSBP), Neuroinformatics Organization (NIO), Organization of Human Brain Mapping (OHBM), New York Academy of Sciences (NYAS) and International Brain Research Organization (IBRO).

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The results of the measurements will be mapped on **Brain Audit form** which contains the following parameters:

Tonus level (activation/arousal/vigilance) Refers to the adequate loading of the regulatory systems of the brain (requred to fulfill the task).
min values: state of the brain fatigue - the lack of the needed loading of the regulatory systems of the brain
max values: state of the exhaustion as a result of overloading of the regulatory systems of the brain with the lack of protective and adaptive mechanisms

Speed of cognitive and memory performance Reveals the speed of information processing (information encoding and retrieval). At the behavioral level this factor determines a speed of reaction time.
min values: state of the mental decline, slowness, passivity and apathy
max values: state of the over-reactivity, over-impulsivity and irritability

Internal concentration Reveals the cognitive process of selectively concentrating on one aspect of the environment while ignoring others. Indicates the intensity of a person's level of mental "focus" or "attention", such as that, which occurs during intense concentration and directed (but stable) mental activity.
min values: state of the inability to focus - constant and frequent shifts between the tasks and stimuli, restlessness and chaotic behavior
max values: state of the mental and behavioural rigidity - difficulties in disengaging attention and thus shifting away and between stimuli and tasks

Positive emotional experience Reveals tendency to experience positive emotions (pleasant feelings induced by commonplace events or circumstances).
min values: state of the negative information processing - elevated responsiveness to negative stimuli and interpretation of positive information as negative

max values: state of the mania - abnormally elevated or irritable mood and arousal

Sociability Reveals tendency of interacting well with others (being sociable or social).
min values: state of the withdrawn, closeness and inhibition
max values: state of the addiction to companionship with others, over-sensation-seeking and over-dominance

Anxiety Reveals readiness to process information and mobilize resources in anticipation of difficult task or threat. Indicates the individual predisposition to overreact to external stimuli, by the unspecific excitement patterns of behaviour
min values: state of the detachment from yourself, others, or your environment
max values: state of the overreaction to external stimuli by the unspecific excitement patterns of behaviour and directedness toward future negative events or threat

Stress-resistance Reveals the person's adaptability to stress and his/her ability to recuperate after the stress.
min values: state of brain's inability to adapt to stress and inability to recuperate after stress
optimum value: state of brain's high ability to adapt to stress and high ability to recuperate after stress

Overall brain resources Reveals the capability to execute or complete a required function quick, effective (with minimum mistakes) and energy wise, or to work effective for a long time without tiredness. Demonstrates how optimal the information processing is and how much energy is lost during processing.
min values: state of exhaustion of the overall brain's physiological and mental resources
max values: state of the individual maximum of brain's physiological and mental resources

Deviation from optimal brain state

min values: state of absolute norm - optimal functioning of the brain
max values: state of brain dysfunction - pathological functioning of the brain