Quantitative Electroencephalography (QEEG) is the measurement, using digital technology, of electrical patterns at the surface of the scalp which primarily reflect cortical activity or “brainwaves”. A multi-electrode recording of brain wave activity is recorded and converted into numbers by a computer. These numbers are then statistically analysed and can be converted into a colour map of brain functioning.

1. Introduction -QEEG

Some kinds of quantification are always involved in signals EEG analysis, even in visual inspection. As digital computer technology developed large amounts of data manipulated and new concepts as pattern recognition and event-related desynchronization/synchronization arrived, “eyeballing” EEG interpretation became inappropriate. The problems rose to widespread acceptance and use of QEEG methods for clinical purposes (different filters cutoffs, lack of reproducibility between various software and hardware platforms etc.) are not fundamentals but solvable issues. It rather is the dogmatic reports, such that of American Academy of Neurology and the American Clinical Neurophysiology Society (1987, 1997) was responsible for that. Because of simplicity and noninvasive character of collection data, EEG remains a powerful tool in clinician hands, yet with a vast unexplored territory. Data mining analysis must provide a clear way to clinical diagnosis, and here demanding efforts are required. Our aim is directed to pattern recognition methods and neural network models in order to specific characterize diseases quite different like Alzheimer, epilepsy or Parkinson disease.
Advantages of QEEG

The amount of data generated by multi-electrode recording is so enormous it is difficult for clinicians to interpret all the data. QEEG’s address this data analysis and summarisation of data in the form of coloured topographic maps of the brain, spectral analysis and graphs. Other advantages are: Data Base Comparisons, Pharmacological Activation Test Dose, Discriminating Functional and Organic Disorders, Simplicity of the Procedure, Coloured Dynamic Brain Map.

2. QEEG in clinical practice discussions

Despite the fact that the following definitions are present:

I. Digital EEG is the paperless acquisition and recording of the EEG via computer-based instrumentation, with waveform storage in a digital format on electronic media, and waveform display on an electronic monitor or other computer output device. The recording parameters and conduct of the test are governed by the applicable standards of the ACNS guidelines and are identical to or directly analogous to those for paper EEG recordings.

II. Quantitative EEG (QEEG) is the mathematical processing of digitally recorded EEG in order to highlight specific waveform components, transform the EEG into a format or domain that elucidates relevant information, or associate numerical results with the EEG data for subsequent review or comparison.

in the American Academy of Neurology and the American Clinical Neurophysiology Society Report [1] it is stated that “QEEG’s clinical usefulness is now quite limited, although it has substantial potential for future applications. At this time, most scientific reports more convincingly have demonstrated research applications rather than clinical applications. Among the reports suggesting clinical utility, few have been prospectively verified or reproduced, and some conflict with others. Techniques used in QEEG vary substantially between laboratories, and any clinical usefulness found with one specific technique may not apply when using a different technique.”
Even the AAN/ACNS report is misleadingly negative regarding the current status of quantitative EEG and tends to discourage its development and use with other related clinical problems, in [2] the nonphysicians' efforts are recognised as “It is well known that many QEEG methods, procedures, and published studies are based on the efforts of non neurologists.”

However the vary between used techniques remain a discussion issue and former approaches suggests collaborative work between large group of specialists such as the Biopattern Network of Excellence.

3. Dementia and EEG – a clinical approach

Definition of dementia

Clinical dementia is a fairly broad-based decline of brain function; most definitions center on the patient intellectual decline and memory dysfunction. This is, however, a fairly simplistic approach; dementia is much more than these fundamental deficits. Criteria from Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV) should be used in the diagnosis of dementia. The essential feature of dementia is “the development of multiple cognitive deficits that include memory impairment and at least one of the following cognitive disturbances: aphasia, apraxia, agnosia, or a disturbance in executive functioning. The cognitive deficits must be sufficiently severe to cause impairment in occupational or social functioning and must represent a decline from a previously higher level of functioning”.

Classification of Dementia

Dementia may be classified in many ways. From practical approach it can be divided in CORTICAL and SUBCORTICAL forms. The former include: Alzheimer disease (AD), Pick’s disease, Creutzfeld-Jacob disease (CJD) and vascular dementia (multi-infarct dementia) characterized clinically by aphasia, apraxia, agnosia. The subcortical dementias (Parkinson disease-PD-, Huntington disease-HD-, lacunar state, normal pressure hydrocephalus-NPH-, and progressive supranuclear palsy-PSP-) are characterized by forgetfulness, slowing of thought processes, apathy, and depression. Cortical features are usually not prominent in the subcortical
dementias, which, in addition to the mental changes noted above, are often also associated with movement disorders (Katzman, 1986) and less frequent EEG abnormalities when compared with cortical dementias, such as AD (Verma 1987). Furthermore, some forms of cortical dementia may have subcortical pathology or vice versa (ex. vascular dementia and CJD may present with both cortical and subcortical dysfunction (Cummings and Benson, 1992).

**EEG Changes in Dementia**

The EEG can be helpful in the evaluation of dementia for 3 classical reasons:

1. It may confirm an abnormality in “cerebral hardware”, particularly when the differential diagnosis with a “cerebral software” problem exists (ex. AD vs. depressive pseudodementia).
2. It may indicate the focal or diffuse character of dementive syndrome.
3. May suggest the presence of an alternate (ex. seizure disorder) or specific pathology (ex.CJD).

The following clinical rule has been suggested (Cummings and Benson 1992): if the EEG looks much worse than the patient’s mental state, there is a high probability that a treatable cause exists. On the other hand, if the EEG is normal or near normal while the degree of cognitive impairment is marked, either a cortical dementia or a depressive pseudodementia is probable.

In early dementia, the resting alpha frequency declines. Most authors agree that the lower limit of normal alpha frequency is 8.5 cycles per second. Medications can slow the posterior dominant rhythm; therefore, medication effect should always be excluded. In assessing the frequency of the alpha rhythm, alerting maneuvers are essential in order to ensure that the patient is in the best awake state and not drowsy. Computerized methods, such as EEG spectral analysis, coherence, and complexity (i.e., correlation dimension), have been demonstrated to correspond to cognitive function.

Stevens et al recorded EEGs during 2 resting conditions (eyes closed and eyes opened) and 2 tasks (mental arithmetic and a lexical decision). The goal of the study was to evaluate which temporal and spatial EEG descriptors change with cognitive decline and normal aging. The EEGs were analyzed
by using EEG microstates. The primary findings were a significant increase in the number of ultrashort EEG microstates and a reduction in the average duration of EEG microstates in cognitively impaired and demented patients. Cognitive impairment was associated with a reduction or loss of EEG reactivity. In contrast, no alterations in temporal or spatial EEG descriptors were found in normal aging. Cognitive tasks did not add to the information already obtained during the resting states. The reduction in EEG microstate duration correlated with loss of cognitive function.

Therefore, temporospatial analysis of the EEG record is a useful indicator of cortical dysfunction in dementia and correlates with degree of cognitive impairment. Apparently, temporospatial analysis may be useful in distinguishing patients with dementia from those experiencing normal aging. These data are largely preliminary; whether they contribute additional information to the clinical data in evaluating dementia is unclear.

ALZHEIMER Disease

AD is the most common dementing illness, accounting for approximately 50% of cases in several clinical series (Chui 1989). Typical features include an insidious onset, a progressive course, and involvement in multiple areas of cognition in a patient who is otherwise alert, healthy, and free of motoric or other neurological signs. The first symptoms characteristically are problems with recent memory and remembering names, or language or visuospatial complaints (Katzman 1986). There are criteria for the diagnosis of AD, which include the categories of possible, probable, and definite AD (McKhann et al., 1984).

EEG is the only clinical diagnostic instrument directly reflecting cortical neuronal functioning. Although the EEG may be normal or minimally disturbed in a number of patients in the initial stages of Alzheimer disease (AD), an abnormal EEG usually is recorded later in the course. A large percentage of patients with moderately severe to severe AD exhibit abnormal EEGs.

EEG findings in AD, using conventional visual analysis, may include:
- Slowing of the dominant posterior rhythm
- Increase in diffuse slow (delta and theta) activity and/or generalized bursts of slow activity that are usually maximal anteriorly
- Reduction in alpha and/or beta activity.
With mild impairment, early in the illness, the EEG can be normal. In some patients, although the dominant posterior rhythm is still within the alpha frequency (8-13Hz), if previous EEGs are available, it may be evident that the frequency has slowed. Prominent focal slowing is not a feature of the EEG in patients with AD. Epileptiform discharges, triphasic waves and generalized periodic patterns are rare in AD.

There is a good correlation between the severity of EEG abnormalities and cognitive impairment, and the sensitivity of the EEG in discriminating AD patients from normal elderly individuals, is dependent on the severity of the dementia.

In the hope of increasing the diagnostic value of EEG, interest has developed in computerized EEG spectral analysis, which provides more quantitative data than does conventional visual EEG analysis. Findings with spectral analysis are similar to those reported with conventional EEG analysis. Several studies (Coben et al., 1983, 1985; Brenner et al., 1986; Miyauchi et al., 1994) have shown a shift of the spectrum to slower frequencies, with an increase in theta activity and a decrease in beta activity, in patients with AD compared to normal elderly subjects. There is a correlation between spectral EEG measures, such as mean frequency and severity of dementia (Canter et al., 1982; Sloan and Fenton, 1993). In mild dementia, there is an increase in theta and a decrease in beta activity (Coben et al., 1983, 1985), whereas with greater severity of dementia there are also decreases in alpha and increases in delta activity (Stigsby et al., 1981; Coben et al., 1985; Hier et al., 1991).

In a study comparing the diagnostic efficacy of computerized spectral versus visual EEG analysis in elderly normal and AD subjects, Brenner et al. (1988) found that spectral analysis afforded only modest advantages over visual EEG analysis in differentiating AD patients from elderly controls. However, computerized spectral data was derived from only 4 channels, while 16 channels and a longer recording time were used for visual analysis. Schreiter-Gasser et al. (1994) found quantitative data, particularly absolute power of delta activity, to be the best predictor of degree of dementia.

What is the role of the EEG as a predictor of progression in dementia? Berg et al. (1984), using spectral measures, did not find this test to be predictive of progression of dementia in AD patients at a one-year follow-
up. Helkala et al. (1991), using both conventional visual EEG analysis and spectral measures, found that AD patients with an abnormal EEG at an early stage of the disease had a different pattern of cognitive decline than AD patients (matched for severity of dementia) with a normal EEG. Those with deteriorating EEGs during the initial one-year follow-up subsequently showed a greater decline in praxic functions, as well as a tendency toward a higher frequency of extrapyramidal symptoms and a greater risk of institutionalization than AD patients with stable EEGs during the first year.

Lopez et al. (1991) found more marked EEG abnormalities (conventional visual and spectral analysis) in AD patients with delusions and hallucinations compared to AD patients matched for severity of dementia, but without delusions and hallucinations. Patients with these psychotic symptoms had a more rapid rate of decline as measured by the Mini-Mental-State examination (Folstein et al., 1975). In a subsequent study, Lopez et al. (1997) found both abnormal EEG and psychosis to be independent predictors of disease progression. Rodriguez et al. (1996) in a pilot study of 31 AD patients felt that quantitative EEG may have prognostic relevance and be useful for clinical purposes such as predicting loss of activities of daily living, incontinence and death.

4. PRELIMINARY APPROACH ON ALZHEIMER DISEASE DEMENTIA EARLY DETECTION BY MEANS OF QEEG PARAMETERS and RESULTS

Considerable variation remains in the reported effects of disease, age and gender on high frequency electroencephalographic activity. Following the results presented in [3] and [4], we examined the topographic differences in relative and absolute beta (1, 2 and 3) power in the 14-54 Hz range in 7 subjects with dementia of the Alzheimer’s type. Subjects with dementia showed global decreases particularly in relative power. The used parameters were computed by the following formula:

\[
\text{Relative value in one band} = \frac{\text{Absolute value in that band}}{\text{(delta+theta+alpha+beta)}}
\]

Further preliminary inspection was carried by topographical maps on each frequency range. Each Brain Map report includes extensive statistical tables of univariate and multivariate measures of absolute power and relative
power, power asymmetry and synchronization (coherence), and color-coded topographic brain maps. This data is used to help identify normal and abnormal brain electrical activity.

Results on how a typical topographical map of Alzheimer or suspect Alzheimer are shown in the Figure 1, compared to normal subjects in Figure 2.

Another results among the stages in Alzheimer diseases, into early stages the delta power, seems lower than into severe dementia.

![Figure 1. Topographical map for confirmed Alzheimer subject in frequency ranges power.](image1)

![Figure 2. Topographical map for normal subject in frequency ranges power.](image2)

5. CONCLUSIONS

The QEEG and the area of Topographical Brain Mapping should be used and developed to overcome the opinions regarding its limitations. In the EEG and QEEG research, mainly done by non-neurologists, many parameters were found to be defined as patterns of interest in specific disease. We believe that a first step towards the integration of such a research is to agree with some simple and wide used parameters changes trend as the bands power or relative power in QEEG, and then to move forward with more specific indicators definitions.
6. REFERENCES


*Corresponding author:
e-mail: ibigan@pcnet.pcnet.ro
Postal Address: Unirii 15, bl. 3 ap. 9 sect. 5 Bucharest, Romania
Phones: 0040213362939, 0040722920009