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Computerized Electroencephalogram Parameters Recording Protocol

Wichian Sittiprapaporn
Faculty of Medicine, Mahasarakham University, Maha Sarakham, Thailand

ABSTRACT

Many design and interpretation in electroencephalography issues are unique to a given content area. Many principles apply to virtually all Electroencephalograms (EEGs), Evoked Potentials (EPs) and Event-Related Potentials (ERPs) studies and these common principles are the focus of this article. The central issues in the design and interpretation of EEGs, Fast Fourier Transforms (FFTs), Visual Evoked Potentials (Visual EPs), Auditory Evoked Potentials (Auditory EPs) and Auditory P300 Event-Related Potentials (Auditory P300 ERPs) testing have been discussed. This article discusses the principles of computerized electroencephalogram parameters recording protocol in relation to the file numbering system for all topographic brain mapping tests assigned by the Brain Atlas III (BA-III) module. Throughout the article, the most significant points are focus into a set of experimental paradigms done in the Electro-Neurophysiological Laboratory for designing and interpreting EEGs, FFTs, EPs, and ERPs tests.

Key words: Electroencephalogram, fast Fourier transform, evoked potential, event-related potential, topographic brain mapping

INTRODUCTION

As many design and interpretation in electroencephalography issues are unique to a given content area, it is most essential to discuss the file numbering system if the topographic brain mapping tests has been assigned. Therefore, a set of experimental paradigms designed and interpreted Electroencephalograms (EEGs), Fast Fourier Transforms (FFTs), Evoked Potentials (EPs) and Event-Related Potentials (ERPs) tests must be done with the file number system in every Electro-Neurophysiological Laboratory.

ELECTROENCEPHALOGRAM

Electroencephalogram (EEG), or spontaneous brain electrical activity, source is within the cerebral cortex. Voltage is attached by meninges, skull and scalp tissue and is measured in microvolts (μV). Electrodes placed on scalp surface are diffuse physiological electrodes, and their field areas of underlying cortex overlaps (Spehlmann, 1981; Clenney and Johnson, 1983; Frances, 1989). First rabbit EEG was introduced by Caton in 1875. In 1924, the first EEG of Man was introduced by Hans Berger, a German psychiatrist, who named the field and early activities discovered, using Greek nomenclature (Clenney and Johnson, 1983; Tyner *et al.*, 1983; Frances, 1989). EEG signal is the summation of the various neuronal populations beneath it and is a composite of various frequencies, designed Delta (0-3.5 Hz), Theta (4-7 Hz), Alpha (8-13 Hz) and beta (13+Hz). EEG is analyzed according to voltage, frequency, location, degree of symmetry and coherence between left and right hemispheres and specific waveform morphology and patterns. Certain specific morphologies and patterns have been correlated with specific pathology, such as epileptic "Spikes" and metabolic encephalopathy "Triphasic Waves". Duration is often used to

describe waveforms and to estimate the frequency of non-repeating waves (Spehlmann, 1981; Persson and Hjorth, 1983; Tyner *et al.,* 1983; Frances, 1989).

The major controversies in the field of EEG have involved disputes regarding: (a) the methods and terminology of electrode placement systems (how many electrodes, where they are placed and what they are called) and recording derivations (bipolar vs. referential/monopolar/unipolar), (b) the use of clinical diagnostic descriptors to name EEG waveforms and/or patterns (petit mal variant, psychomotor variant), (c) continuous changing of EEG descriptors without standardization (dart and dome->3 per second wave and spike->3 per second spike and wave and flat-topped waves-> RMTDs) and (d) clinical significance/correlation of certain EEG patterns (14 and 6/sec positive spikes, B-Mitterns, small sharp spikes [BETS] and 6/sec Phantom Spike/wave), respectively (Remond and Offner, 1952; Spehlmann, 1981; Hjorth, 1982).

In monitoring EEG with Brain Atlas III (BA-III) system, the electroencephalographer must enable "Disking" function otherwise the electroencephalographer will only write just a few seconds' data to the hard disk. Moreover, the electroencephalographer should leave the data acquisitions rate a lone at 128 Hz. It works very well at this data acquisitions rate whereas the other choices have some problems. In the beginning of EEG recording, the electroencephalographer should try to obtain a minimum of at least 2-3 min good-quality namely the artifact-free data in both the Eyes Open (E/O) and Eyes Closed (E/C) conditions. BA-III will automatically assign the prefix letter "E" to all EEG files, for instances, E960058 for E/O, E960059 for E/C), and E96005H for Hyperventilation, if it is clinically warranted. It is important to keep in mind that Hyperventilation (HV) is usually occurring with the patients who have a history of coronary heart disease, heart attacks, sub-dural hematoma or intracranial aneurysm(s). In the case of HV recording, the electroencephalographer should start the HV recording right after the E/C data set. The electroencephalographer must explain to the patient first what the electroencephalographer will want the patient to do. This will help the electroencephalographer to get a smooth transition from resting, pre-HV to HV and afterwards again back to post-HV recording, respectively. The electroencephalographer always warns the patient of dizziness, faint headedness, numbing or tingling around the mouth or in his/her fingers/toes. The electroencephalographer should explain to the patient that these are perfectly normal reactions, and just mean the patient is doing a good job of HV and that they will all go away within about a minute or so after the patient has stopped. As assigned by the Brain Atlas III, the file number of this test will be "E960058" for E/O, "E960059" for E/C and "E96005H" for Hyperventilation if it is clinically warranted (Buchsbaum *et al.,* 1981; Spehlmann, 1981; Clenney and Johnson, 1983; Frances, 1989).

Quantified electroencephalogram (QEEG): It includes the following (mostly research) areas of study:

- Topographic Brain Mapping (TBM, BEAM) of both EEG and EP data, based on multichannel data, to increase accuracy in identification of abnormalities (e.g., mapped Flash VER)
- Fast Fourier Transform (FFT) or frequency spectral analysis of both EEG and EP data, either mapped or stacked sequentially (CSA), to follow the course of a changing condition (e.g., intraoperatively)
- Digital filtering of data to eliminate phase shifts due to conventional hardware analog filtering
- Off-line montage re-formatting capability for viewing the data re-plotted in different montages
- Studies of coherence, global power, individual and combined frequency band ratios and comparisons, etc.

- Statistical comparison of patient/subject data to normative data banks, including those made from the subject's own baseline condition data (before administration of a drug or other experimental charge)
- Re-referencing of patient/subject data to either the Common Average or Hjorth's Source (Laplacian) Derivation, for detailed analysis of scalp voltage field distributions
- Equivalent Dipole determinations for possible solutions to Helmholtz's inverse problem of What unique source (within the brain) gave rise to this particular (scalp) voltage field distribution?
- Computerized recognition and (on-line) correction of various types of EEG artifacts that either obscure the recording or otherwise interfere with its interpretation
- Exert system for automated EEG analysis and interpretation, to do-away with the human subjective element, inter-rater variability, over-reading and under-reading, etc.
- Single trial EPs, adaptive filters, zero-crossing analysis, frequency averaging, steady-state EPs (Remond and Offner, 1952; Hjorth, 1982; Persson and Hjorth, 1983; Frances, 1989).

Computerized EEG parameters recording protocol [eyes-open]: It is used for a Comparison of Average vs. superior intelligence students:

Recording duration	: 1-2 mins, 30 sec's artifact-free data for FFT'ing
Approximate time	: 2 min
Gain	: 30,000
Low pass filter	: 1.0 Hz
High pass filter	: 30.0 Hz

Computerized EEG parameters recording protocol [eyes-closed]: It is used for a comparison of average vs. superior intelligence students:

Recording duration	: 1-2 min and 30 sec artifact-free data for FFT'ing
Approximate time	: 2 min
Gain	: 30,000
Low pass filter	: 1.0 Hz
High pass filter	: 30.0 Hz

EVOKED POTENTIALS

Evoked Potentials (EPs), in contrast to spontaneous EEG activity, may have their source in any location within the neuraxis, depending on what specific EP component is being recorded. EPs are time-locked to the stimulus where the short-latency EPs are deterministic (stereotyped) by possessing the same latency, amplitude, polarity and waveform every time. On the other hand, the longer-latency EPs are less so, with more latency jitter (especially cognitive ERPs), which increases with increasing latency (Celesia, 1985; Spehlmann, 1985). ERPs are more subject to state (of consciousness) variations (Owen and Davis, 1985; Spehlmann, 1985). Testing modalities and EP test types include (a) Auditory: BAER, AER, (b) Visual: VER (Pattern Shift and Patterned/Unpatterned Flash) (Full-field, Half-field and Quadrants), (c) Somatosensory: SER (Median, Ulnar, Radial, Peroneal, Posterior Tibial), and (d) Cognitive: ERP (Contingent Negative Variation, P300 or Late Positive Complex, "Probe"), respectively. This testing is a relatively new field, NOT as yet standardized with differing nomenclature, stimulating and recording methods, polarity convention and a very confusing literature; how many electrodes/channels and derivations;

recent recognition of the benefits of multichannel EP recording with full 10-20 electrode set, especially with brain mapping; EP usefulness; both clinical (Dx and OR monitoring) and research, respectively (Sato *et al.*, 1971; Pfurtscheller and Aranibar, 1977; Buchsbaum *et al.*, 1982; Federico, 1984; Lehmann and Skrandies, 1984; Celesia, 1985; Owen and Davis, 1985; Spehlmann, 1985).

Flash visual evoked response (F.VER): It was critically to try to get the strobe light centered on the patient's face/eyes as much as possible, especially in a left/right orientation, so as not to differentially stimulate one occipital lobe at the expense of the other. The distance from Strobe light to the patient's eyes should be about 10 inches and ambient room lighting should be mesopic. The Grass photostimulator should be used in the currently-set setting. The test could be done with patient' eyes either open or closed but closed is generally preferable from the patient's point of view. In addition, the prettier colors seen through closed eyelids. It was preferable to start the test run, then clear average, to dump the first few responses, which, due to the strength of the stimulus, might be contaminated with artifact. Generally, most patients seem to settle-down fairly quickly to this strobe light stimulus. So, just dumping the first 10-or-so responses should be sufficient to get a good, clean recording (Sato *et al.*, 1971; Buchsbaum *et al.*, 1982; Celesia, 1985; Clark *et al.*, 1995; Spehlmann, 1985; Luck and Hillyard, 1994; Thorpe *et al.*, 1996). As assigned by the Brain Atlas III, the file number for this test would be "T 960050" similar to PSVER and HFVER.

Pattern-shift visual evoked response (PSVER): This was an inherently more difficult test to do, and absolutely required full patient cooperation and compliance, as well as heavy operator involvement for the full duration of the study. As with virtually all of the EPs done with the topographic brain mapping techniques, the main response will be quite easily visible fairly early-on, but it is best to get a fair number of repetitions into the average. It was preferable to start the test run, then clear average to dump the first few responses which, due to the sudden appearance of the stimulus on the monitor screen, may be contaminated with artifact. Most patients seem to settle-down fairly quickly to this black and white Checkerboard stimuli, so just dumping the first 10-or-responses should be sufficient to get a good, clean recording. For best results, the black and white monitor screen should be positioned 100 cm (1 m) from the patient's eyes. The testing should be carried-out Monocularly always, as binocular testing is well-known to mask abnormalities. Place the black eye patch over one of the patient's eyes; stimulate the other eye twice, saving each trial, then move the eye patch over to the other eye. It is usually tested the patient's left eye first (patch over the right eye), followed by his right eye (patch over the left eye). Allow a couple of minutes for the previously-patched eye to accommodate to ambient room lighting, which should be mesopic. Importantly, it should never fiddle-around with or change the brightness or contrast setting on the black and white monitor, as these settings can differently change response waveform latencies (Sato *et al.*, 1971; Buchsbaum *et al.*, 1982; Celesia, 1985; Clark *et al.*, 1995; Spehlmann, 1985; Luck and Hillyard, 1994; Thorpe *et al.*, 1996).

Many patients would be unable to fixate on the fixation point, a little red dot in the middle of the monitor screen, for the full 300 repetitions. This was especially true of people with Optic Neuritis, an early and common symptom of Multiple Sclerosis. It was to cut the recording into 3 equal segments (100 repetition each), keeping the stimulus going, but giving the patients a little (15 sec-or-so) rest break, before asking the patient to fixate his gaze once more on the fixation point. It should be allowed the patient to set the pace which is agreeable to him/her. This is a test that the faster the electroencephalographer tries to go, the slower the electroencephalographer will wind-up going as well as getting lousy and may be even non-replicative data into the averages.

This break procedure is usually accomplished by averaging "OFF", telling the patient to close his/her eyes or look away the monitor screen, waiting for the patient to report back that the patient is ready to proceed, telling the patient to fixate again of the little red dot, then turning averaging "ON" when the electroencephalographer could clearly see that the patient is complying with the testing paradigm (Sato *et al.,* 1971; Buchsbaum *et al.,* 1982; Celesia, 1985; Clark *et al.,* 1995; Spehlmann, 1985; Luck and Hillyard, 1994; Thorpe *et al.,* 1996). As assigned by the Brain Atlas III, the file number for this test would be "T 960050" similar to F.VEP and HFVER.

Pattern-shift and flash visual evoked response (PSVER and F.VER): The actual recording parameters, technical tips are given above in the specific individual sections. As assigned by the Brain Atlas III, the file number for this test would be "T960050" similar to all other VERPs.

Half-field pattern-shift visual evoked response (HF-PSVER): This test is necessary to further elucidate an abnormality that shows up of full-field monocular testing, in the form of a Left/Right response asymmetry. Asynchronies are much rarer and tend to indicate a probable Optic Neuritis, or possibly a sella turcica tumor with compressive effect on the optic nerve (Sato *et al.*, 1971; Buchsbaum *et al.*, 1982; Celesia, 1985; Clark *et al.,* 1995; Spehlmann, 1985; Luck and Hillyard, 1994; Thorpe *et al.*, 1996).

It is basically done the same way as the Full-field PSVER including the test monocularly, black eye-patch over the eye not being tested, all basically the same as enumerated above. However, one important change is to the stimulus being presented to the patient's eye. As assigned by the Brain Atlas III, the file number for this test would be "T960050" similar to all other VERs.

Computerized visual evoked potentials (VEPs): VEPs Parameters Recording Protocol [Unpatterned Flash VEPs] for a Comparison of Average vs. Superior Intelligence Students:

Number of Repetitions	:	300/trial, 2 trials, Grand
Average	:	600
Approximate time	:	15 min
Gain	:	30,000
Low pass filter	:	1.0 Hz
High pass filter	:	70.0 Hz
Rate	:	0.8 sec
Epoch	:	1024 msec
Stimulus	:	Single, External (Grass P/S)
Artifact Rejection	:	On

AUDITORY EVOKED POTENTIAL

Auditory evoked potential response (AER): It is a fairly simple, straight-forward test with few caveats to remember. Although the stimulus is always presented binaurally, it is a good habit to get into always position the headphones to the proper ear. A standard level of decibel stimulation should be achieved. For this purpose, the electroencephalographer should use 85 dB Rarefaction 2 KHz Pure Tone bursts, with Rise/Fall = 10 msec and Plateau = 40 m sec. It will be necessary during the test to view the results on-line similar to all other EPs. As assigned by the Brain Atlas III, the file number of this test would be "T960053". (Sato *et al.,* 1971; Buchsbaum *et al.,* 1982; Celesia, 1985; Clark *et al.,* 1995; Spehlmann, 1985; Luck and Hillyard, 1994; Thorpe *et al.,* 1996).

Auditory P300 event-related potentials (A.P300-ERPs): It is somewhat more complicated type of test due to the fact that there are 2 stimuli, #1 being the Frequent, Non-target tone and No. 2 being Rare, Target tone. It is absolutely essential that the patient/subject be able to discriminate between these 2 tones and respond accordingly. It is easily done by means of a short trial run with the patient/subject told to raise his/her finger or hand when the patient/subject hears the high-pitched tone.

In the event of a great amount of Alpha interference, the electroencephalographer can try having the patient/subject open his/her eyes, then re-run the test, or the electroencephalographer can try changing the Interstim Variance, say to 50%; either way will help to unlock the electroencephalographer off of the patient's Alpha Rhythm. By the way, the interstim variance must be set at "0" for the missing stimulus paradigm as it renders the exact timing of the next stimulus variable rather than predictable. It will be necessary during the test to view the results on-line, especially to estimate the amount of Alpha contamination and the patient/subject's overall compliance with the testing paradigm. If the patient/subject is unable or unwilling to so comply, the test can not be performed. If in doubt, break-in every 20-30 rep's and asks the patient/subject "How many have you heard so far?" If is a reasonable number, then just tell the patient/subject to continue on from that number. This will probably throw-off the count accuracy a little bit but will save the electroencephalographer a lot of wasted time if the patient/subject has just drifted-off to sleep (Pfurtscheller and Aranibar, 1977; Rosler and Manzey, 1981; Federico, 1984; Hansen and Hillyard, 1984; Johnson, 1986; Woldorff, 1988).

This oddball paradigm, at the relatively fast rep rate of 0.8 sec^{-1}, seems to work fairly well with most patients/subjects, except with the elderly who have a lot of difficulty keeping-up with it all. In the case of elderly, it is recommended to follow the following changes: (1) Stimulus Repetition Rate: 0.2 sec^{-1} (1 tone every sec's) and (2) P300 Ratio: 1 (1:1) (Hansen and Hillyard, 1984; Johnson, 1986; Woldorff, 1988). Actually, the running time for this test paradigm will be about the same as for the laboratory standard. That is to say, 20 min/trial, or 40 min for the complete test procedure. Additionally, a break-in Questions and Answers for the current count is not as likely to throw the count accuracy off and can be done much more frequently every approximately 10-15 stimuli. Importantly, the most profoundly demented elderly should be able to comply with this testing paradigm. What the electroencephalographer is doing is to make the test a little bit easier for the patient/subject in keeping with their mental abilities at the time of testing. As assigned by the Brain Atlas III, the file number for this test would be "T960052" (Federico, 1984; Woldorff, 1988; Hansen and Hillyard, 1984; Johnson, 1986; Pfurtscheller and Aranibar, 1977; Rosler and Manzey, 1981).

Auditory P300 event-related potentials (A.P300-ERPs): Instructions to the patient/subject: "You are going to hear a series of tones, some high-pitched ("Beeps") and some low-pitched ("Boops"). There will be many more low tones than high ones. I want you to keep and on-going mental count of the number of high tones you hear. Just ignore the low-pitched tones. After the test, I will ask you how many you heard. The test can be done with either eye-open or eye-closed, although most people find it easier to concentrate with eyes-closed. Please do not count aloud or on your fingers. Count in any language you wish."

Auditory event-related potentials (ERPs) peak-picking system: Peak-picking of the early peaks (N1, P2, N2) is accomplished by means of moving an enhanced point cursor through the waveforms displayed on the computer screen, while simultaneously paying attention to the

resultant changes in the topographic maps. Latency and amplitude figures for waveforms are picked at their point of maximal deflection (whether positive or negative) as seen at their electrode site of maximal voltage distribution, for instance, N1 is picked at the Fz electrode site whereas P2 and N2 are picked at the Cz electrode site.

The foregoing procedure for peak-picking is usually rather simple and straightforward for the early peaks. However, for the Late Positive Complex (LPC) components, due to their inherent but limited morphological identification had to be used, in order not to confuse and admix together different LPC components from different patients/subjects (Federico, 1984; Spehlmann, 1985). The peak-picking system for LPC is as follows: It is assumed that there are a maximum of three components in a person's LPC, which we call "P3a", "P300" and "P3b". "P3a" is the earliest and "P3b" the latest such component, while "P300" falls somewhere in the middle. P300 is usually assumed as the waveform's "center of gravity", where a distinct peak cannot be ascertained (Spehlmann, 1985). The range of LPC morphological variability which is seen in a general population including both healthy and sick people is usually considered to represent a kind of gradient of LPC degeneration or deterioration, and can be classified as such (Buchsbaum *et al.,* 1981; Tyner *et al.,* 1983; Spehlmann, 1985; Owen and Davis, 1985). The procedure for peak-picking of LPC components used at the Clinical and Research Electro-Neurophysiological Laboratory, Neuro-Behavioral Biology Center, Mahidol University, refers to the an initial, simplistic scale of 0-8 with "0" representing a total absence of response and "8" representing maximal good health or normality (Table 1).

In order to "flesh-it-out" to accommodate variations in component complexity, especially as regards the P3a/P3b amplitude balance, as well as to accommodate "equivocality" of peaks, it would appear as in Table 2.

Since this system's instruction at the Clinical and Research Electro-Neurophysiological Laboratory, Neuro-Behavioral Biology Center, Mahidol University, several years ago, they believe they have been able to prospectively use it to identify all LPC variants recorded, and that it therefore adequately describes the full range of LPC variability so far encountered. Although somewhat complicated to learn at first, it is rather quickly and easily mastered, and has the great benefit of preventing the mixing-up of different components between subjects or patients, thereby facilitating interindividual comparisons (Tyner *et al.,* 1983; Spehlmann, 1985).

Computerized auditory P300 event-related potential (ERP): ERP Parameters Recording Protocol [Oddball Paradigm] for a Comparison of Average vs. Superior Intelligence Students:

Number of repetitions : 125 Target Repetitions/trial, 2 Trials
Grand average : 250 Targets, approximately 1500 Non-Targets

Table 1: Scales representing an absence and normality

Scale	LPC component description
8	LPC evident, comprised of a simple, "monophasic" waveform (P300), with no identifiable P3a or P3b components visible
6	LPC evident, comprised of compound waveform with clear-cut P3a and P3b components, with the wave's "center-of-gravity" in-between, where P300 is estimated
4	LPC evident, comprised of P3a and P3b components, separated by a deep "notch", where P300 is estimated
2	LPC evident, comprised of P3a component only
0	No LPC evident, although the patient/subject reportedly was able to adequately comply with the testing paradigm

LPC: Late positive complex

Table 2: Scales representing an absence and normality according to variations in component complexity

Scale	LPC component description
8.0	LPC evident, comprised of a simple, "monophasic" waveform (P300), with no identifiable P3a or P3b components visible
7.0	LPC evident, comprised of (equivocally) compound waveform, with clear P300 (the wave's "center-of-gravity"), bracketed either side by equivocal P3a and P3b component estimates
7.1	Same as No. 7.0 but with clear-cut P3a and equivocal P3b, with the wave's "center-of-gravity" coincident with P3a, where P300 is estimated. Fused P3a/P300>equivocal P3b in amplitude OR: with the wave's "center-of-gravity" in-between, where P300 is estimated. P3a>equivocal P3b in amplitude
7.2	Same as No. 7.0 but with equivocal P3a and clear-cut P3b, with the wave's "center-of-gravity" coincident with P3b, where P300 is estimated. Fused P300/P3b>equivocal P3a in amplitude OR: with the wave's "center-of-gravity" in-between, where P300 is estimated. P3b>equivocal P3a in amplitude
6.0	LPC evident, comprised of compound waveform with clear-cut P3a and P3b components, with the wave's "center-of-gravity" in-between, where P300 is estimated
6.1	Same as No. 6.0, P3a > P3b in amplitude OR: Same as No. 6.0, but with the wave's "center-of-gravity" coincident with P3a, where P300 is estimated. Fused P3a/P300>P3b in amplitude.
6.2	Same as No. 6.0, P3b>P3a in amplitude OR: Same as No,. 6.0, but with the wave's "center-of-gravity" coincident with P3a, where P300 is estimated. Fused P300/P3b>P3a in amplitude
5.0	LPC evident, comprised of P3a and P3b components, separated by a medium-sized "notch", where P300 is estimated
5.1	Same as No. 5.0, P3a>P3b in amplitude
5.2	Same as No. 5.0, P3b>P3a in amplitude
4.0	LPC evident, comprised of P3a and P3b components, separated by a deep "notch", where P300 is estimated
4.1	Same as No. 4.0, P3a>P3b in amplitude
4.2	Same as No. 4.0, P3b>P3a in amplitude
3.0	LPC evident, comprised of P3a and equivocal P3b components, separated by a deep "notch", where P300 is estimated
2.0	LPC evident, comprised of P3a component only
1.0	Equivocal LPC may be present, perhaps comprised of P3a component only
0.0	No LPC evident, although the patient/subject reported was able to adequately comply with the testing paradigm

LPC: Late positive complex

Approximate time	:	40 min
Gain	:	30,000
Low pass filter	:	1.0 Hz
High pass filter	:	70.0 Hz
Rate	:	0.8 sec
Epoch	:	1024 msec
Ratio	:	6:1
Artifact Rejection	:	On
Stimulus	:	Dual, Auditory (Target: 2 kHz, Non-Target: 1 kHz, Level: 85 dB, Rise/Fall time: 10 msec, Plateau: 40 msec)
Instruction to Subjects	:	You will be hearing 2 different tones, one high-pitched (Beep) and one low (Boop). We want you to completely ignore the low-pitched tones, but listen for the high ones --- keep an ongoing 'mental count' of those. We will do this twice, and wee will be asking you after each trial 'how many of those high-pitched "Beep" tones did you hear?"

Auditory P300 ERP

(Protocol: _____/sec, N= _____)

	Non-target			Target					
L.M.R.									
	N1	P2	N2	N1	P2	N2	P3a	P300	P3b
Latency									
Amplitude									
C.A.R.									
	N1	P2	N2	N1	P2	N2	P3a	P300	P3b
Latency									
Amplitude									

Computerized Auditory Probe Event-Related Potential (ERP): ERP Parameters Recording Protocol [Attend/Ignore Paradigm] for a Comparison of Average vs. Superior Intelligence Students:

Number of Repetitions	:	375 Repetitions/trial per condition
Grand Average	:	1500 each
Total	:	4 trials for the 2 conditions
Condition Order	:	"Attend" --- "Ignore" --- "Ignore" --- "Attend"
Approximate time	:	40 min
Gain	:	30,000
Low pass filter	:	1.0 Hz
High pass filter	:	70.0 Hz
Rate	:	0.8 sec^{-1}
Epoch	:	512 msec
Artifact Rejection	:	On
Stimulus	:	Single, Auditory (2 kHz)
Level	:	85 dB, Rise/Fall time: 10 msec, Plateau: 40 msec
Instruction to Subjects	:	Attend Condition: "I want you to listen to the tones, you don't have to count them, just listen to them very carefully, tune into them, try to hear them all" Ignore Condition: I want you to ignore the tones, try not even hear them, tune them out, ignore them completely"

Attend/Ignore Auditory Probe ERP

(Protocol: _____/sec, N= _____)

	"Attend		"Ignore"		"Attend"minus "Ignore"	
L.M.R.	N1	P2	N1	P2	N1	P2
Latency						
Amplitude						
C.A.R.						
Latency						
Amplitude						

Table 3: The file numbering system assigned by the Brain Atlas III

File Name	Description
T 9 6 0 0 5 0 . DAT	Visual evoked potential data: Flash, pattern-shift and both
F 9 6 0 0 5 1 . DAT	Processed FFT spectral analysis data of EEGs and EPs
T 9 6 0 0 5 2 . DAT	Auditory P300 event-related potential data
T 9 6 0 0 5 3 . DAT	Auditory evoked potential data: Long-latency auditory
T 9 6 0 0 5 4 . DAT	These terminal digits have not as yet been used for
T 9 6 0 0 5 5 . DAT	Specific tests; they are envisioned for SEPs in future
T 9 6 0 0 5 6 . DAT	No. 4 and 5 for Upper Limbs and No. 6 and 7 for Lower Limbs
T 9 6 0 0 5 7 . DAT	No. 4: Median, No. 5: Ulnar, No. 6: Peroneal, No .7: Posterior Tibial
E 9 6 0 0 5 8 . DAT	Raw EEG data, eyes open
E 9 6 0 0 5 9 . DAT	Raw EEG data, eyes closed
E 9 6 0 0 5 H . DAT	Raw EEG data, eyes closed, hyperventilation

FILE NUMBERING SYSTEM

The file numbering system for all topographic brain mapping test data, assigned by Brain Atlas III (BA-III) system, is shown Table 3. As can be seen in Table 3, the initial letter character is assigned based on the type of data it contains, for instance, E = EEG data, F = FFT data and T = EP/ERP data, respectively. Also, the suffix .DAT will be changed according to the EEG module.

CONCLUSION

Many design and interpretation in electroencephalography issues are unique to a given content area. Many principles apply to virtually all Electroencephalograms (EEGs), Evoked Potentials (EPs) and Event-Related Potentials (ERPs) studies. The principles of computerized electroencephalogram parameters recording protocol in relation to the file numbering system for all topographic brain mapping tests assigned by the Brain Atlas III (BA-III) module have been demonstrated.

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