Recording and Sending Digital EEG Data to CNS Response for Reporting

rEEG: A Brief Guide for EEG Technologists

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CNS Response

33171 Camino Capistrano, Suite C
San Juan Capistrano, CA 92675-4837
USA

949.248.5445 Voice
949.248.5449 Facsimile
info@cnsresponse.com E-mail

Recording and Sending Digital EEG Data to CNS Response

This Guide is intended for use by electroneurodiagnostic technologists to assist in recording digital EEG and sending the EEG data to CNS Response for rEEG analysis and reporting.

A brief consideration of instruments, settings and patient factors (level of arousal, EEG artifacts) are presented.

Two additional documents are attached at the end of the guide: the "rEEG Requisition Form and the American Clinical Neurophysiology Society's "Guidelines for Recording Clinical EEG on Digital Media."

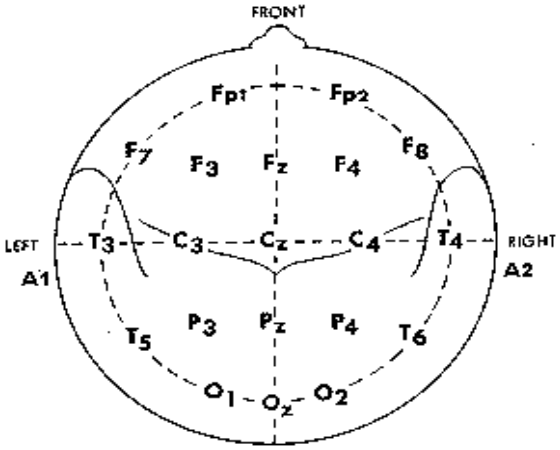
EEG Recordings

Instruments Used to Record

Recordings must be made in **digital format** using all electrodes in the International 10/20 System of electrode placement [see electrode diagram below]. Scalp recordings should be made using a **linked ear reference**. Electrode impedance should be 5 K Ω or less. Several commercially available digital EEG machines can be used for recording. Machines whose format is supported by Insight or exportable to Lexicor, EDF or EDF90 file formats are acceptable. For a complete list of compatible machines, please check:

http://www.eeg-persyst.com/web/FormatsSupported.html#notSupported

International 10/20 System of Electrode Placement



Digital EEG Instrument Settings

FOR - Cadwell Easy Windows: Please use the linked ears recording montage for the Cadwell Easy II Windows. The A1/A2 linked ears reference (USE THE EARLOBES – NOT MASTOID). It is important to use the International 10/20 system of electrode placement.

FOR - Lexicor: Please use the linked ears recording montage for Lexicor. The A1/A2 linked ears reference (USE THE EARLOBES – NOT MASTOID). It is important to use the International 10/20 system of electrode placement.

NOTE: Settings should not be changed during the portions of the recording intended for analysis.

EEG Recording Montage

Digital EEG Systems typically allow for scalp recordings to be made using an arbitrary monopolar reference. A variety of display montages for viewing and interpretation can then be constructed using software routines. The referenced EEG (rEEG) procedure requires a linked earlobe reference, A1A2 (NOT MASTOID).

Sensitivity

Recordings should be calibrated in microvolts (7uv).

Filters

Filter characteristics of recording instruments should be set to pass all data at frequencies between .53 and 35 Hz.

Digitizing Rates

Signals should be digitized at 200 Hz or less per channel, but cannot be less than 100 Hz per channel.

Length of Recordings

Recordings should be a minimum of 15 minutes long unless there is movement by the patient during the recording, in which case the recording should be 20-25 minutes. It is important that the patient remain alert and awake during the recording with eyes closed, minimizing any movement including the eyes. Otherwise, if only quantitative analysis is requested, a minimum of 3 minutes of artifact free, eyes closed, alert recordings, conforming to the guidelines outlined in this document, is required. Recordings should not include hyperventilation or photic stimulation.

Impedance Checking

Check electrode scalp impedance before starting the recording. If you must pause to check impedance be sure that the digital EEG system you are using DOES NOT CHANGE THE RECORDING REFERENCE FOLLOWING IMPEDANCE CHECKING. Changing the recording reference electrode will interfere with the quantitative analysis and reporting process.

Choosing a site for EEG recording

EEG signals are very sensitive to the amount of electrical noise that is present in the recording environment. It is critical to control the amount of electrical interference in EEG recordings that are made for the purposes of transmission to CNS Response for rEEG analysis.

CNS Response accepts EEG data from mobile EEG testing equipment (such as the Cadwell Easy II) that is designed to be set up temporarily in a physician's office. Once a site is qualified it is important that the EEG technician **always use that same site** unless a new one is properly qualified.

Electrical interference (noise) can came from a variety of sources including:

- Fluorescent lighting
- Computer equipment
- Microwave ovens
- Electrical equipment operating nearby such as building elevators or lab equipment
- Cordless phones
- Wireless networks
- Many others

Choose a site away from as many of these potential interference sources as possible. The source that is probably the most easy to influence is the type of lighting. Incandescent lighting should be used in the testing room wherever possible. Lighting can be provided by means of a desk lamp, which will enable overhead fluorescent lighting to be turned off (remember that the test subject must remain awake during recording for rEEG purposes). Other potential sources of interference should be turned off or moved as far away from the EEG recording equipment as possible. It may also be valuable to move electrical equipment that cannot be turned off to another outlet in the room provided that outlet is on a different electrical circuit other than the one being used for the EEG recording equipment.

Patient Factors

Medications

It is imperative that CNS Response has an accurate picture of any medications the patient is currently taking and/or has recently taken. This includes "over the counter" drugs.

The ideal situation is for the patient to have discontinued all medications for at least 5 half lives of the longest acting agent. All medications potentially influence the EEG and must be known so that the EEG can be properly interpreted. Note that some "medications" are really replacement of natural hormones, e.g. thyroid, insulin, or estrogen, and do not require potential discontinuation prior to baseline examination. Certain antihypertensive agents ARE included in the reference population for individuals over 50 years of age. Please contact us for details of the specific agents that do not have to be potentially discontinued for patients in this age group.

Patient State

Recordings are suitable for medication response correlation ONLY if the patient is **awake and alert** and free of muscle [body movement, jaw clenching, swallowing, EKG, eye-movement, etc.] artifact. Even EEG recorded during mild patient drowsiness will be edited from the record prior to analysis. It is important to instruct the patient to get a good night's rest prior to the day of testing. Further, it is useful to explain to the patient the need to remain motionless, **awake and alert** during testing. The technician will monitor the EEG for effects of drowsiness while the recording is in progress. Diminution of posterior alpha activity accompanied by an increase in slow activity, loss of occasional eye movement and loss of blinking are usually an indication of diminished alertness. When these signs are noted, the patient should be prompted to remain alert. If this is unsuccessful, the patient will need to be rescheduled for a time when they can maintain alertness.

Limiting Artifact

There are a number of potential "contaminants" that can obscure the EEG, which must be eliminated at the time of the recording. **The patient must be instructed to remain as still as possible, they may not talk, and they must minimize any eye movements, including blinking and lateral eye movement**. Often clenching the jaw produces muscle artifact over the temporal scalp, contaminating recording from over these regions. **Reports cannot be produced if the recording does not contain at least 120 seconds of artifact free data.**

EEG Data Transmittal

Secure FTP Site

In order to transmit the recordings to CNS Response's testing site electronically, it is strongly recommended that you have high speed Internet Service (DSL or Cable). You can also send Patient Data using CD Media.

Transfer of Patient Data Using CD Media

It is also possible to record the patient EEG onto a CD and send it to our processing site. You must provide a **rEEG Requisition Form** (see http://www.cnsresponse.com under physician information & Requisition Form) and send it to the following address:

CNS Response, Inc.
Attn: Michael
33171 Camino Capistrano, Suite C
San Juan Capistrano, CA 92675-4837

Please contact our office for further instruction on creating and sending CD's.

Also for technical questions please page our EEG Technician, Mike DeMarco at: (805) 807-1158.

EEG Technician's Responsibility for rEEG Requisition Form

The rEEG Requisition Form (appearing on following two pages) is the form that the physician completes to order an rEEG report. The physician gives the form to the patient with instructions to bring it to the EEG test appointment and give to the EEG tech. The EEG technician is responsible for reviewing the "Type I" or "Type II" "Medication List" and confirming with patient that all listed medications were discontinued as directed by the physician. If patient has not complied with discontinuation timeframes, the EEG appointment must be re-scheduled. The EEG tech initials in far right column if patient has been compliant. The EEG tech must also check with patient that no new medications (or alcohol, nicotine, caffeine, NSAID's, etc.) have been taken. If patient has taken any of these substances, the test must be re-scheduled. If patient is clean, the EEG tech signs their name at the bottom of the page. After the EEG recording has been completed, the EEG tech faxes the form to CNS Response at the number listed at the top of the form, (949) 248-5449). An rEEG report cannot be processed until receipt of the rEEG Requisition Form.

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Guideline Fourteen: Guidelines for Recording Clinical EEG on Digital Media

INTRODUCTION

With digital systems becoming widely available and relatively inexpensive, it has become practical to record EEG onto magnetic or optical long-term storage media. Such recording has several advantages. It can help reduce the space problem of storing original paper records over many years. It also allows review of selected portions of an EEG record using montages, filters, vertical scaling (gain or sensitivity), and horizontal scaling (e.g., paper speed) selected after the original recording. Finally, digital recording allows the possibility of further digital processing after the fact.

These recommendations describe only minimal technical standards for recording clinical EEG on digital media. Standardization of the structure and format of the data recorded, for free exchange o compatible recordings among EEG laboratories, is addressed separately by the American Electroencephalographic Society (AEEGS) document, "Standard Specification for Transferring Digital Neurophysiological Data Between Independent Computer Systems."

PATIENT INFORMATION

The electronically recorded information should include the patient's name and date of birth, date on which the test was run, and relevant patient and laboratory identification numbers. In addition, all the routine information that would normally be written onto the facesheet of the EEG should be recorded electronically along with the EEG signals. Preferably, the EEG report will also be stored and merged with the EEG signal after review of the record by a physician. Correction of errors or omissions in the patient-identifying information should be possible after the recording.

IDENTIFYING INFORMATION DURING THE RECORDING

Calibration signals should be recorded at the beginning and end of each recording, in the manner already conventional for EEG. Biocalibration signals should also be run at the beginning of the record. The time of day should be recorded along with the EEG data, as well as any other information that could be used for finding events in the stored record. The recording should contain all of the technologist's comments since they would ordinarily be written onto a conventional EEG paper record. The technologist should be able to enter event codes and comments even after the EEG is recorded. Codes recorded with the data can represent common events such as eyes closed or eyes open, beginning and end of hyperventilation, details of photic stimulation, or notation of the patient's alert, drowsy, or asleep state. Free text comments should be able to be entered by keyboard as well, and stored along with the EEG data on the recording medium. In addition, there should be provisions for automatically recording information, such as filter settings, gain, montage selections, and other technical amplifier control settings at the start of the recording, and any changes made during the recording should be immediately recorded with the data.

RECORDING

Acquisition of EEG data onto a digital storage medium should occur at a minimum sampling rate three times the high-frequency filter setting, e.g., 100 samples/s for 35-Hz high filter and 200 samples/s for 70-Hz high filter. Higher rates are preferable. The sample rate needs to be sufficient to prevent aliasing. Digitization should use a resolution of at least 11 bits per sample including any sign bit. A resolution of 12 or more bits is preferable, since the recording should be able to resolve EEG down to 0.5 pV and record potentials up to plus or minus several millivolts without clipping. For example, with a 0.5-pV resolution and a 12-bit analog-to-digital conversion, the maximum allowed excursion would be ± 1.023 mV. Interchannel crosstalk should be less than 1%, i.e., 40 dB down or better. Common mode rejection ratio should be at least 80 dB, preferably better, for each of the channels. Additional noise in the recording

should be less than 2 pV peak-to-peak, at any frequency 0.5-100 Hz, including 60 Hz.

RECORDING MEDIA

At the present time, several magnetic and nonerasable and erasable optical storage devices seem adequate for routine long-term recording and storage of EEG records. We recognize the uncertainty about durability, especially regarding magnetic recording media. We also recognize uncertainty regarding the availability of commercial transcription devices to replay the stored EEG years into the future. The present lack of standards for commercial nonerasable optical disk storage results in incompatibility between various commercially available devices and may lead to the impossibility of reading, repair, or replacement of some optical disk recordings and drives within a few years. Newly emerging standards for erasable optical media may make this type of storage less prone to this problem. At present, magnetic tapes can replay EEG adequately after 5 years of storage. However, degradation of the magnetic tape may become a serious problem by 10 years.

Note is made of the existence of statutes governing medical records in each of the individual states, as well as existence of local or hospital statutes regarding EEG record storage. These govern the duration of storage, and in some instances they may also dictate whether magnetic or optical storage is to be allowed.

DISPLAY

A recording system for clinical use should have the capability to review recorded EEG data on a video display or on paper, preferably with both types of displays available. Overall, review on paper or on a screen should approximate the temporal and spatial resolution of traditional analog paper recordings. Montages available for review should be consistent with those in standard use in the laboratory and with previous AEEGS recommendations, preferably allowing additional user flexibility. This should be done using bipolar or referential reconstruction techniques. Post hoc digital filtering should also be available. Playback systems should be able to display channel (montage) designations, gain or filter settings where appropriate, technologist comments, and event markers along with the raw or transformed EEG data. A time stamp on each screen or page of EEG data is essential.

A standard horizontal scaling should be available in which I s occupies between 25 and 35 mm with a minimum resolution of 100 data points/s on screen and 200 data points/s on paper. Other more compressed and more expanded horizontal scales should also be available, including scaling differing from standard by a factor of 2, e.g., 7.5, 15, 30, or 60 mm/s. Vertically, appropriate channel spacing between the baseline of each channel depends on the number of channels displayed. A standard vertical scaling with a minimum spacing of 10 mm per channels should be used for a display of up to 21 channels. Other choices for vertical scaling may be provided too. Larger gaps can be introduced where necessary to separate blocks of channels and increase readability. Occasional overlap of data between channels is acceptable. An adequate screen and paper display should have a minimum of 2 pixels resolution per vertical millimeter. The horizontal and vertical scales on screen and paper should be indicated on the display. For purposes of comparison between different devices, important considerations are the maximum number of channels and the maximum number of seconds that could be displayed on a single screen or on a piece of paper, using the standard scaling as defined above.

The system should allow simultaneous display of multiple segments of EEG, allowing side-by-side visual comparison of different segments within one recording as well as different segments from different recordings obtained on different days. If the playback system has hard-copy capabilities, however, one could also compare different EEG segments by printing them individually. Continuous, fan-folded paper is generally preferable for most EEG applications displaying long segments or the entire record.