

American Clinical Neurophysiology Society's Standardized Critical Care EEG Terminology:
2012 version

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Background:

Continuous EEG Monitoring is becoming a commonly used tool in assessing brain function in critically ill patients. However, there is no uniformly accepted nomenclature for EEG patterns frequently encountered in these patients such as periodic discharges, fluctuating rhythmic patterns, and combinations thereof. Similarly, there is no consensus on which patterns are associated with ongoing neuronal injury, which patterns need to be treated, or how aggressively to treat them. The first step in addressing these issues is to standardize terminology to allow multicenter research projects and to facilitate communication. To this end, we gathered a group of electroencephalographers with particular expertise or interest in this area in order to develop standardized terminology to be used primarily in the research setting. One of the main goals was to eliminate terms with clinical connotations, intended or not, such as “triphasic waves”, a term that implies a metabolic encephalopathy with no relationship to seizures for many clinicians. We also avoid the use of “ictal”, “interictal” and “epileptiform” for the equivocal patterns that are the primary focus of this report.

A standardized method of quantifying interictal discharges is also included for the same reasons, with no attempt to alter the existing definition of epileptiform discharges (sharp waves and spikes [Noachtar et al 1999]). Moreover, we are not necessarily suggesting abandoning prior terms such as Periodic Lateralized Epileptiform Discharges (PLEDs) and triphasic waves for clinical use. Finally, we suggest here a scheme for categorizing background EEG activity.

The revisions proposed here were based on solicited feedback on the initial version of the Report [Hirsch LJ et al 2005], from within and outside this committee and society, including public presentations and discussion at many venues. Inter- and intra-observer agreement between expert EEG readers using the initial version of the terminology was found to be

moderate for major terms but only slight to fair for modifiers. [Gerber PA et al 2008] A second assessment was performed on an interim version after extensive changes were introduced. This assessment showed a significant improvement with an inter-rater agreement superior to 95% for main terms and superior to 80% for the evaluated modifiers (amplitude, frequency and plus modifiers). [Mani R et al 2012] Minor modifications were introduced after this second assessment to further improve reliability.

Objective: To standardize terminology of periodic and rhythmic EEG patterns in the critically ill in order to aid future research involving such patterns. Our goal is to avoid terms with clinical connotations and to define terms thoroughly enough to ensure adequate inter-rater reliability.

Not included in this nomenclature: Unequivocal electrographic seizures including the following: Generalized spike-wave discharges at 3/s or faster; and clearly evolving discharges of any type that reach a frequency $>4/s$, whether focal or generalized. These would still be referred to as electrographic seizures. However, their prevalence, duration, frequency and relation to stimulation should be stated as described below when being used for research purposes.

Corollary: The following patterns are included in this nomenclature and would not be termed electrographic seizures for research purposes (**whether or not these patterns are determined to represent seizures clinically in a given patient**): Generalized spike and wave patterns slower than 3/s; and evolving discharges that remain slower than or equal to 4/s. **This does not imply that these patterns are not ictal, but simply that they may or may not be.** Clinical correlation, including response to treatment, may be necessary to make this determination.

N.B.: This terminology can be applied to all ages, but is not intended for use in neonates.

PROPOSED NOMENCLATURE

A. RHYTHMIC OR PERIODIC PATTERNS

All terms consist of main term # 1 followed by #2, with modifiers added as appropriate.

Main term 1: G, L, BI, or Mf:

- **Generalized (G;** for this purpose, the term “generalized” refers to any bilateral, bisynchronous and symmetric pattern, even if it has a restricted field [e.g. bifrontal])
- **Lateralized (L;** includes unilateral and bilateral synchronous but asymmetric; includes focal, regional and hemispheric patterns)
- **Bilateral Independent (BI;** refers to the presence of 2 independent [asynchronous] lateralized patterns, one in each hemisphere)
- **Multifocal (Mf;** refers to the presence of at least three independent lateralized patterns with at least one in each hemisphere)

a. Additional localizing information

i. For Generalized patterns

1. Frontally predominant (defined as having an amplitude in anterior derivations that is at least 50% greater than that in posterior derivations on an ipsilateral ear, average, or non-cephalic referential recording),
2. Occipitally predominant (defined as having an amplitude in posterior derivations that is at least 50% greater than that in anterior derivations on an ipsilateral ear, average, or non-cephalic referential recording),
3. Midline predominant (defined as having an amplitude in midline derivations that is at least 50% greater than in parasagittal derivations on an average or non-cephalic referential recording),
4. Generalized, not otherwise specified.

ii. For Lateralized patterns

1. Specify unilateral vs. bilateral asymmetric

- a. Patterns that are purely unilateral are termed “Lateralized, unilateral”.
 - b. Patterns seen bilaterally and synchronous but clearly more prominent on one side would be called “Lateralized, bilateral asymmetric”
 2. Specify lobe(s) most involved (F, P, T, O, or hemispheric if more specific localization is not possible)
- iii. For Bilateral Independent and Multifocal patterns:
 1. Specify symmetric vs. asymmetric
 - a. Patterns that are bilateral and asynchronous but clearly more prominent on one side would be called “Bilateral Independent, asymmetric”, or “Multifocal, asymmetric”
 - b. Patterns that are bilateral, asynchronous and symmetric would be called “Bilateral Independent, symmetric”, or “Multifocal, symmetric”
 2. Specify lobes most involved in both hemispheres (F, P, T, O, or hemispheric if more specific localization is not possible).

Main Term 2: PDs, RDA or SW:

- **Periodic Discharges (PDs):** **Periodic** = repetition of a waveform with relatively uniform morphology and duration with a quantifiable inter-discharge interval between consecutive waveforms and recurrence of the waveform at nearly regular intervals.
Discharges: These are defined as waveforms with no more than 3 phases (i.e. crosses the baseline no more than twice) *or* any waveform lasting 0.5 seconds or less, regardless of number of phases. This is as opposed to bursts, defined as waveforms lasting more than 0.5 seconds and having at least 4 phases (i.e. crosses the baseline at least 3 times).
 - “Nearly regular intervals” is defined as having a cycle length (i.e., period) varying by <50% from one cycle to the next in the majority (>50%) of cycle pairs.
- **Rhythmic Delta Activity (RDA):** **Rhythmic** = repetition of a waveform with relatively uniform morphology and duration, and without an interval between consecutive waveforms. RDA = rhythmic activity ≤ 4 Hz. The duration of one cycle (i.e., the period) of the rhythmic pattern should vary by <50% from the duration of the subsequent cycle for the majority (>50%) of cycle pairs to qualify as rhythmic.
- **Spike-and-wave or Sharp-and-wave (SW)** = polyspike, spike or sharp wave consistently followed by a slow wave in a regularly repeating and alternating pattern (spike-wave-spike-wave-spike-wave), with a consistent relationship between the spike (or polyspike or sharp wave) component and the slow wave; and with no interval between one spike-wave complex and the next (if there is an interval, this would qualify as PDs, where each discharge is a spike-and- wave).

NOTE 1: A pattern can qualify as rhythmic or periodic as long as it continues for at least 6 cycles (e.g. 1/s for 6 seconds, or 3/s for 2 seconds).

NOTE 2: If a pattern qualifies as both GPDs and RDA simultaneously, it should be coded as GPDs+ rather than RDA+ (see modifier 8 below for description of “+”).

Most of the following sections can be applied to research on any EEG phenomenon. Although many of the categorizations are arbitrary, our hope is that standardization will allow systematic, scientific and collaborative investigation of these EEG features.

Modifiers:

1. **Prevalence:** Specify percent of record or epoch that includes the pattern (see section B below). This should be based on the percent of seconds that include or are within the pattern. The time between widely spaced periodic discharges counts as part of the pattern duration. For example, 2Hz LPDs present for 1 minute every 10 minutes is 10% prevalence, and a 0.25 Hz. pattern present for 1 minute every 10 minutes is also 10% prevalence. When categorizing or using qualitative terms, follow the cutoffs listed below for each term. Suggested equivalent clinical terms are given as well. If 2 or more patterns are equally or almost equally prevalent (e.g. ~30% GRDA, 30% GPDs, and 40% BIPDs) record the presence and prevalence of each one.
 - a. $\geq 90\%$ of record/epoch (“Continuous”)
 - b. 50-89% of record/epoch (“Abundant”)
 - c. 10-49% of record/epoch (“Frequent”)
 - d. 1-9% of record/epoch (“Occasional”)
 - e. $< 1\%$ of record/epoch (“Rare”)
2. **Duration:** Specify typical duration of pattern if not continuous. When categorizing or using qualitative terms, follow the cutoffs listed below for each term. Also record the longest continuous duration.
 - a. ≥ 1 hour (“Very long”)
 - b. 5-59 minutes (“Long”)
 - c. 1-4.9 minutes (“Intermediate duration”)
 - d. 10-59 seconds (“Brief”)
 - e. < 10 seconds (“Very brief”)
3. **Frequency** = rate per second: Specify typical rate and range for all patterns, e.g., 1/s and 0.5-2/s;

When categorizing, use the following (record typical, minimum and maximum frequency).

<0.5/s, 0.5/s, 1/s, 1.5/s, 2/s, 2.5/s, 3/s, 3.5/s and $\geq 4/s$

4. **Number of phases** = number of baseline crossings of the typical discharge (in longitudinal bipolar and in the channel in which it is most readily appreciated). Applies to PDs and the entire spike-and-wave or sharp-and-wave complex of SW (include the slow wave). This does not apply to RDA. Categorize as follows:
- a. 1, 2, 3 or >3.

5. **Sharpness:** Specify for both the predominant phase (phase with greatest amplitude) and the sharpest phase if different. For both phases, describe the *typical* discharge. Applies only to PDs and the spike/sharp component of SW, not RDA. Categorize as one of the following:

- a. Spiky (duration of that component, measured at the EEG baseline, is <70 ms)
- b. Sharp (duration of that component is 70-200 ms)
- c. Sharply contoured: used for theta or delta waves that have a sharp wave morphology (steep slope to one side of the wave and/or pointy at inflection point[s]), but are too long in duration to qualify as a sharp wave.
- d. Blunt: having smooth or sinusoidal morphology.

6. **Amplitude:**

a. Absolute: Typical amplitude measured in standard longitudinal bipolar 10-20 recording in the channel in which the pattern is most readily appreciated. For PDs, this refers to the highest amplitude component. For SW, this refers to the spike/sharp wave. Amplitude should be measured from peak to trough (not peak to baseline). Specify for RDA as well.

Categorize amplitude as:

- i. <20 μV (“very low”)
- ii. 20-49 μV (“low”)
- ii. 50-199 μV (“medium”)

iii. $\geq 200 \mu\text{V}$ (“high”)

b. Relative: For PDs *only* (PDs require 2 amplitudes, absolute and relative). Typical ratio of amplitude of the highest amplitude component to the amplitude of the typical background between discharges, measured in the same channel and montage as absolute amplitude. Categorize as ≤ 2 or > 2 .

7. **Polarity:** Specify for the predominant phase (phase with the greatest amplitude) only. Should be determined in a referential montage. Describe the *typical* discharge. Applies only to PDs and the spike/sharp component of SW, not RDA. Categorize as one of the following:

- a. Positive
- b. Negative
- c. Dipole, horizontal/tangential
- d. Unclear

8. **Stimulus-Induced (SI)** = reproducibly brought about by an alerting stimulus, with or without clinical alerting; may also be seen spontaneously. If *never* clearly induced by stimulation, report as *spontaneous*. If unknown, unclear or untested, report as “unknown”. Specify type of stimulus (auditory, light tactile, patient care and other non-noxious stimulations, suction, sternal rub, nostril tickle or other noxious stimulations).

9. **Evolving OR Fluctuating:** both terms refer to changes in either frequency, location or morphology. If neither term applies, report as *static*.

Evolving is defined as follows: at least 2 unequivocal, sequential changes in frequency, morphology or location defined as follows: Evolution in *frequency* is defined as at least 2 consecutive changes in the same direction by at least 0.5/s, e.g. from 2 to 2.5 to 3/s, or from 3 to 2 to 1.5/s; Evolution in *morphology* is defined as at least 2 consecutive changes to a novel morphology; Evolution in *location* is defined as sequentially spreading into or sequentially out of at least two different standard 10-20 electrode locations.

- In order to qualify as present, a single frequency or location must persist at least 3 cycles (e.g. 1/s for 3 seconds, or 3/s for 1 second). Thus, the following

pattern would qualify as evolving: 3/s for ≥ 1 second, then 2/s for ≥ 1.5 seconds (the first change), then 1.5/s for ≥ 2 seconds (the 2nd change). To qualify as evolution in morphology, each different morphology or each morphology plus its transitional forms must last at least 3 cycles. Thus the following examples would both qualify as evolving in morphology:

- spiky 4-phase PDs for 3 cycles then sharp 2-3 phase PDs for 3 cycles then blunt diphasic PDs for 3 cycles

- 1 blunt triphasic PD then 2 blunt biphasic PDs then 2 sharply contoured biphasic PDs then 2 sharp biphasic PDs then 3 sharp monophasic PDs.

- The criteria for evolution must be reached without the pattern remaining unchanged in frequency, morphology or location for 5 or more minutes. Thus, the following pattern would *not* qualify as evolving: 3/s for 1 minute, then 2/s for 7 minutes, then 1.5/s for 2 minutes.

Fluctuating is defined as follows: ≥ 3 changes, not more than one minute apart, in frequency (by at least 0.5/s), ≥ 3 changes in morphology, or ≥ 3 changes in location (by at least 1 standard inter-electrode distance), but *not qualifying as evolving*. This includes patterns fluctuating from 1 to 1.5 to 1 to 1.5/s; spreading in and out of a single electrode repeatedly; or alternating between 2 morphologies repeatedly.

- The following would *not* qualify as fluctuating: 2/s for 30 seconds, then 1.5/s for 30 seconds, then 2/s for 3 minutes, then 1.5/s for 30 seconds, then 2/s for 5 minutes. The changes are too far apart (>1 minute).
- The following *would* qualify as fluctuating: 2/s for 10 seconds, then 2.5/s for 30 seconds, then 2/s for 5 seconds, then 2.5/s for 5 seconds.

Change in amplitude alone would not qualify as evolving or fluctuating.

- a. For data entry, if evolving or fluctuating, a minimum and maximum frequency should be specified under the “frequency” modifier above. For non-generalized patterns, specify degree of spread (none, unilateral, or bilateral).

10. **Plus (+)** = additional feature which renders the pattern more ictal-appearing than the usual term without the plus. (Does not apply to SW)

Periodic discharges (PDs): includes superimposed fast activity (theta or faster, rhythmic or not) with each discharge (+F), or superimposed rhythmic or quasi-rhythmic delta activity (+R).

Rhythmic delta activity (RDA): includes superimposed fast activity (+F) or frequent intermixed sharp waves or spikes (+S; “frequent” is defined as more than one sharp wave or spike every 10 seconds, but not periodic and not SW) or RDA that is sharply contoured (also +S). If absent, indicate as “no +”.

a. **Subtyping of “+”:** all cases with “+” should be subtyped as follows into

+F, +R, +FS, or +FR:

- i. “+F”: superimposed *fast* activity. Can be used with PDs or RDA.
- ii. “+R”: superimposed *rhythmic* or quasi-rhythmic delta activity; applies to PDs only.
- iii. “+S”: superimposed *sharp waves or spikes, or sharply contoured*; applies to RDA only.
- iv. It is possible to have “+FR” for PDs, or “+FS” for RDA

NOTE 3: Re: Bilateral “+” vs. unilateral: If a pattern is bilateral and qualifies as plus on one side, but not on the other, the overall main term should include the plus (even though one side does not warrant a plus). For example, bilateral independent periodic discharges with fast activity superimposed in one hemisphere only (PD on one side, and PD+F on the other) would qualify for BIPDs+F. Similarly, generalized rhythmic delta activity with superimposed spikes in one hemisphere only (RDA on one side and RDA+S on the other) would qualify for GRDA+S.

NOTE 4: Re: +F: If a pattern qualifying as RDA or PDs has superimposed continuous fast frequencies (theta or faster), this can and should be coded as +F if the fast activity is not present in the background activity when the RDA or PDs is not present. In other words, code as +F if the superimposed fast activity is part of the RDA or PD pattern and not simply part of the background activity.

Minor Modifiers:

1. *Quasi-*: Used to modify rhythmic or periodic, as in *quasi-periodic* or *quasi-rhythmic*. (Quasi preferred over pseudo- or semi-). This distinction between quasi- and not quasi is *to be applied only if determined by quantitative computer analysis* (not by visual impression). Quasi is defined as having a cycle length (i.e., period) varying by 25-50% from one cycle to the next in the majority (>50%) of cycle pairs. If >50% variation in the majority of cycles, the pattern would not qualify as rhythmic or periodic and would not be included in this nomenclature. If the variation is <25%, the modifier quasi- would not be appropriate. When not using computer analysis, quasiperiodic is coded as periodic, and quasirhythmic as rhythmic.
2. *Sudden onset OR gradual onset* (sudden onset preferred over paroxysmal). Sudden onset is defined as progressing from absent to well developed within 3 seconds.
3. *“Triphasic” morphology*: Applies to PDs and SW. Either two or three phases, with each phase longer than the previous, and the positive phase of highest amplitude. If three phases, this must be negative-positive-negative in polarity; if two phases, positive-negative. Note that a biphasic waveform may be categorized as “triphasic” by this definition.
4. *Anterior-posterior lag or posterior-anterior lag*: Applies if a consistent measurable delay of > 100 ms exists from the most anterior to the most posterior derivation in which is seen; specify typical delay in ms from anterior to posterior (negative = posterior to anterior) in both a longitudinal bipolar and a referential montage, preferably with an ipsilateral ear reference.

B. Minimal time epochs to be reported documented separately:

1. First ~30 minutes (equivalent to a “routine” EEG).
2. Each 24 hour period.

If significant changes occur in the record during this time period, report additional epochs separately as needed.

C. Quantification and categorization of sporadic (non-rhythmic and non-periodic)

epileptiform discharges (includes sharp waves and spikes as previously defined [Noachtar et al 1999]).

- $\geq 1/10s$, but not periodic (“Abundant”)
 - $\geq 1/min$ but less than $1/10s$ (“Frequent”)
 - $\geq 1/h$ but less than $1/min$ (“Occasional”)
 - $< 1/h$ (“Rare”)
-

D. Background EEG:

Symmetry: 1. Symmetric; 2. Mild asymmetry (consistent asymmetry in amplitude on referential recording of $< 50\%$, or consistent asymmetry in frequency of 0.5 - 1 Hz); 3. Marked asymmetry ($\geq 50\%$ amplitude or > 1 Hz frequency asymmetry).

- Breach effect (note presence, absence, or unclear)
- When any of the following features are asymmetric, they should be described separately for each hemisphere.

Posterior dominant “alpha” rhythm: Must be demonstrated to attenuate with eye opening. Specify frequency (to the nearest 0.5 Hz) or absence.

Predominant background EEG frequency: Delta, Theta, and/or \geq Alpha (including beta). If 2 or 3 frequency bands are equally prominent, record each one.

Anterior-posterior (AP) gradient: Present, absent or reverse. An AP gradient is present if at any point in the epoch, there is a clear and persistent (at least 1 continuous minute) anterior to posterior gradient of voltages and frequencies such that lower amplitude, faster frequencies are seen in anterior derivations, and higher amplitude, slower frequencies are seen in posterior derivations. A reverse AP gradient is defined identically but with a posterior to anterior gradient of voltages and frequencies.”

Variability: Yes, No, or Unknown/unclear/not applicable. The last choice might apply, for example, in a 30 minute wake record.

Reactivity: Change in cerebral EEG activity to stimulation: Yes, No, or Unclear/unknown/not applicable. This may include change in amplitude or frequency, including attenuation of activity. Strength and/or nature of stimulus should be noted. Appearance of muscle activity or eye blink artifacts does not qualify as reactive.

If the only form of reactivity is SI-RDA, SI-PDs or SI-seizures, categorize as “Reactive, SIRPIDs only”)

Voltage: 1. Normal; 2. Low (most or all activity $<20 \mu\text{V}$ in longitudinal bipolar with standard 10-20 electrodes, [measured from peak to trough]); or 3. Suppressed (all activity $<10 \mu\text{V}$). If the background is discontinuous, this refers to the higher amplitude portion.

Stage II sleep transients (K-complexes and spindles): 1. Normal (K-complexes and spindles both present and normal); 2. Present (at least one) but abnormal; or 3. Absent (both absent).

Continuity:

1. Continuous.
2. Nearly Continuous: continuous, but with occasional ($\leq 10\%$ of the record) periods of attenuation or suppression. Describe typical duration of attenuation/suppression as above.
 - a. Nearly continuous with attenuation: periods of lower voltage are $\geq 10\mu\text{V}$ but $<50\%$ of the background voltage.
 - b. Nearly continuous with suppression: periods of lower voltage are $<10 \mu\text{V}$;
 - c. If suppressions/attenuations are stimulus-induced, code as “nearly continuous with SI-attenuation” or “...with SI-suppression”;
3. Discontinuous: 10-49% of the record consisting of attenuation or suppression, as defined above.

4. Burst-attenuation/Burst-suppression: more than 50% of the record consisting of attenuation or suppression, as defined above, with bursts alternating with attenuation or suppression; specify the following:
 - a. Typical duration of bursts and interburst intervals;
 - b. Sharpest component of a typical burst using the sharpness categories defined above under modifiers;
 - c. Presence or absence of Highly Epileptiform Bursts: Present if multiple epileptiform discharges (traditional definition) are seen within the majority (>50%) of bursts and occur at an average of 1/s or faster; record typical frequency (using categories above) and location (G, L, BI or Mf). Also present if a rhythmic, potentially ictal-appearing pattern occurs at 1/s or faster within the majority (>50%) of bursts; record frequency and location as well.
5. Suppression: entirety of the record consisting of suppression (<10 μ V, as defined above).

NOTE 5: Bursts must average more than 0.5 seconds; if shorter, they should be considered single discharges (as defined above under main term 2). Bursts within burst-suppression or burst-attenuation can last up to 30 seconds.

E. Other Terms for Research Use:

“Daily Pattern Duration” is defined as total duration of a pattern per 24 hours. e.g. if GPDs were present for 33% of the record for 12 hours, then 10% of the record for 12 hours, the Daily GPD Duration would be 4 hours + 1.2 hours = 5.2 hours. Daily Seizure Duration can be calculated similarly: e.g. six 30-second seizures in one day would have a Daily Seizure Duration of 3minutes.

“Daily Pattern Index” is defined as Daily Duration X Mean Frequency (Hz). In the above example, if GPDs were at 1.5 Hz, the Daily GPD Index would be 5.2 h x 1.5 Hz = 7.8 Hz-hours.

Examples of appropriate terms:

Continuous 1-2/s fluctuating GPDs
Occasional 30-60 second periods of 1.5/s SI-LRDA
Abundant 1-3 minute periods of 0.5-1.5/s LPDs+F
Occasional 10-second periods of 1/s BIPDs

Other examples of corresponding new terms for older terms (some could have alternative new terms depending on exact pattern):

<u>OLD term</u>		<u>NEW term</u>
Triphasic waves, most of record	=	continuous 2/s GPDs (with triphasic morphology)
PLEDs	=	LPDs
BIPLEDs	=	BIPDs
GPEDs/PEDs	=	GPDs
FIRDA	=	Occasional frontally predominant brief 2/s GRDA (if 1-10% of record)
PLEDs+	=	LPDs+
SIRPIDs* w/ focal evolving RDA	=	SI-Evolving LRDA
Lateralized seizure, delta frequency	=	Evolving LRDA
Semirhythmic delta	=	Quasi-RDA

*SIRPIDs = stimulus-induced rhythmic, periodic or ictal discharges.

References:

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3. Gerber PA, Chapman KE, Chung SS, Drees C, Maganti RK, Ng Y-T, et al. Interobserver agreement in the interpretation of EEG patterns in critically ill adults. *J Clin Neurophysiol*. 2008 Oct.;25(5):241–9.
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Figure Legends:

1. **LPDs:** Sharply contoured lateralized periodic discharges. In this case, LPDs are unilateral.
2. **LPDs:** Sharply contoured lateralized periodic discharges. In this case, PDs are bilateral asymmetric.
3. **LPDs:** Sharply contoured lateralized periodic discharges. In this case, PDs are bilateral asymmetric. Although some discharges are on the border of sharp, most are sharply contoured.
4. **LPDs:** 0.5 per second spiky lateralized periodic discharges.
5. **LPDs:** 0.5-1 per second spiky lateralized periodic discharges. Despite their spike-and-wave morphology, the discharges are periodic (as there is a quantifiable inter-discharge interval between consecutive waveforms and recurrence of the waveform at nearly regular intervals).

6. **LPDs+F**: 0.5 to 1 per second spiky LPDs with superimposed burst of low amplitude fast activity (highlighted in boxes).
7. **LPDs+R**: Irregular (in morphology and repetition rate) 0.5-1 per second quasi-periodic discharges with superimposed quasi-rhythmic delta activity in the right hemisphere with occasional spread to the left. Less “stable” pattern and more ictal-appearing than LPDs alone; compare with Figure 1.
8. **Fluctuating LPDs**: Lateralized periodic discharges that fluctuate in frequency between 0.5 and 1 per second.
9. **GPDs**: One per second sharp generalized periodic discharges.
10. **GPDs with triphasic morphology and A-P lag**: Generalized periodic discharges at just under 1.5 per second. In this case there is also a triphasic morphology and an anterior-posterior lag, highlighted with the diagonal line in the upper right of the figure.
11. **GPDs+F**: 1-1.25 per second sharp GPDs with superimposed low amplitude quasi-rhythmic sharp activity (highlighted in boxes).
12. **GPDs**: One per second generalized periodic discharges, characterized by a marked frontal predominance and a sharp morphology. Despite background attenuation, the discharges last less than 500ms and thus do not qualify as bursts.
13. **BIPDs+F**: Bilateral independent periodic discharges at 0.5-1 per second, most prominent centroparietally on both sides. The periodic discharges have a sharp morphology and are associated with low amplitude sharply contoured quasi-rhythmic fast activity, especially posteriorly, and more prominent on the right where the fast activity is nearly continuous.
14. **GRDA**: Generalized rhythmic delta activity, frontally predominant.
15. **SI-GRDA**: Stimulus-induced generalized rhythmic delta activity. In this case, the pattern was elicited by suctioning the patient.
16. **Evolving LRDA**: Lateralized rhythmic delta activity that evolves in morphology and frequency. It begins as low voltage sharply contoured 1.5 Hz delta in the left parasagittal region, evolves to 3 Hz rhythmic delta, then again slows.
17. **Evolving LRDA**: Lateralized rhythmic delta activity that evolves in frequency and morphology from a 4 per second blunt RDA to a 2.5 per second sharply contoured RDA.
18. **LRDA+S**: Two per second lateralized rhythmic delta activity with superimposed repetitive sharp waves (several marked with asterisks). The superimposed low amplitude fast activity is also present on the right hemisphere and should not be recorded as +F.
19. **LRDA+S**: Two per second lateralized rhythmic delta activity with superimposed sharp waves most prominent in the left parasagittal region. The superimposed low amplitude fast activity is also present on the right hemisphere and could be recorded as +F if not present in the background (i.e., in the absence of the rhythmic delta activity).
20. **GSW**: 1.5 per second generalized polyspike-and-wave, frontally predominant. A polyspike precedes every slow wave and there is no inter-discharge interval; thus this pattern does not qualify for GRDA+S or GPDs+R.
21. **GSW**: 1.5 per second generalized spike-and-wave.
22. **Burst-suppression pattern**: Bursts (>500ms AND >3phases) of generalized activity on a suppressed background.
23. **Burst-attenuation pattern**: In between bursts of generalized activity, there is low amplitude background activity.

Abbreviation list:

BI = Bilateral Independent

EDs = Epileptiform Discharges

G = Generalized

L = Lateralized

Mf = Multifocal

PDs = Periodic Discharges

RDA = Rhythmic Delta Activity

SI = Stimulus-Induced.

SW = Spike-and-wave or sharp-and-wave

+ = Plus = Additional feature which renders the pattern more ictal-appearing than the usual term without the plus

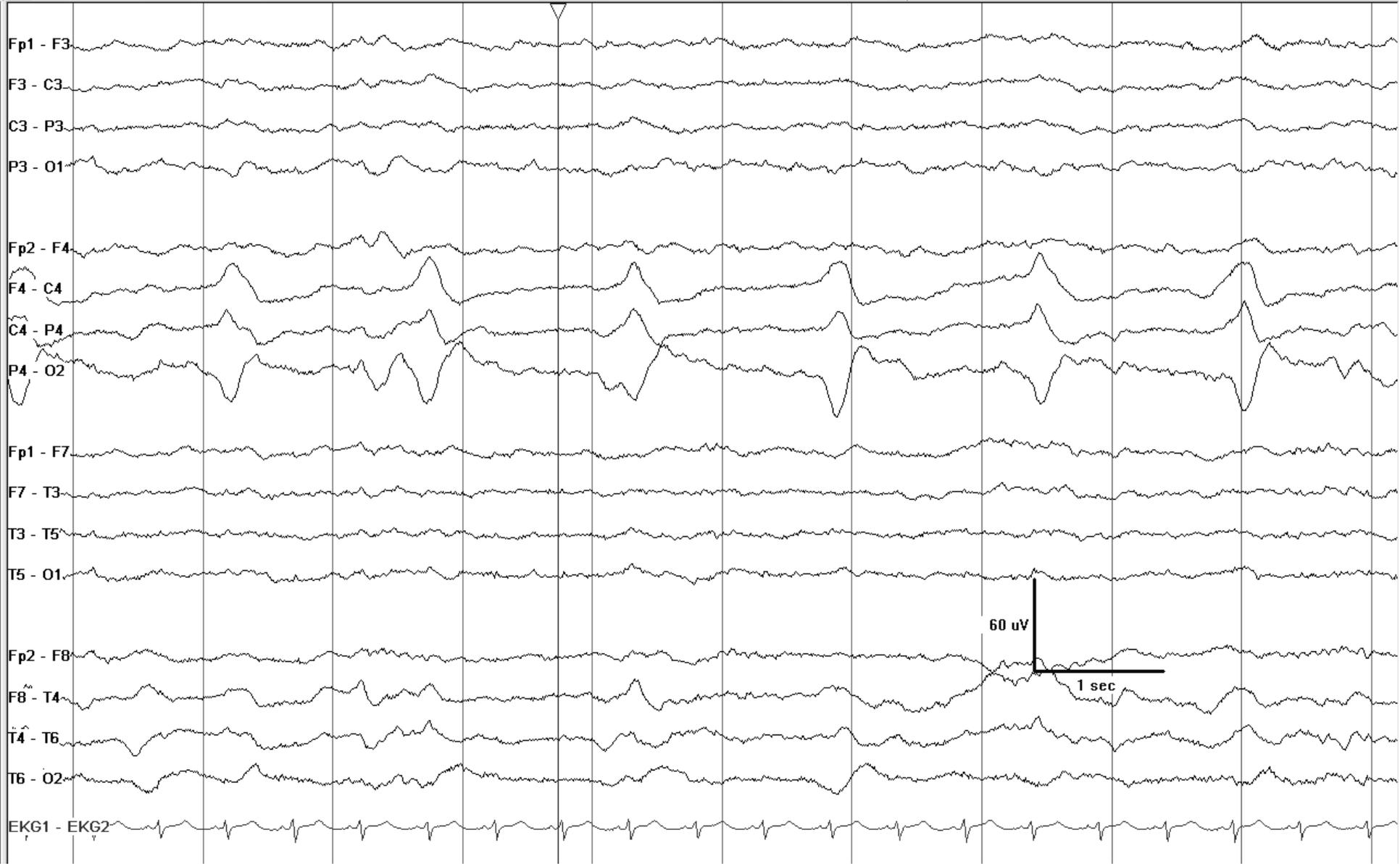
+F = Superimposed fast activity

+R = Superimposed rhythmic activity

+S = Superimposed sharp waves or spikes, or sharply contoured

Acknowledgments

We would like to acknowledge the prior contribution of the following people to this terminology: Thomas P. Bleck, Richard Brenner, Ronald G. Emerson, Paula Gerber-Gore, Kenneth G. Jordan, Mark L. Scheuer.



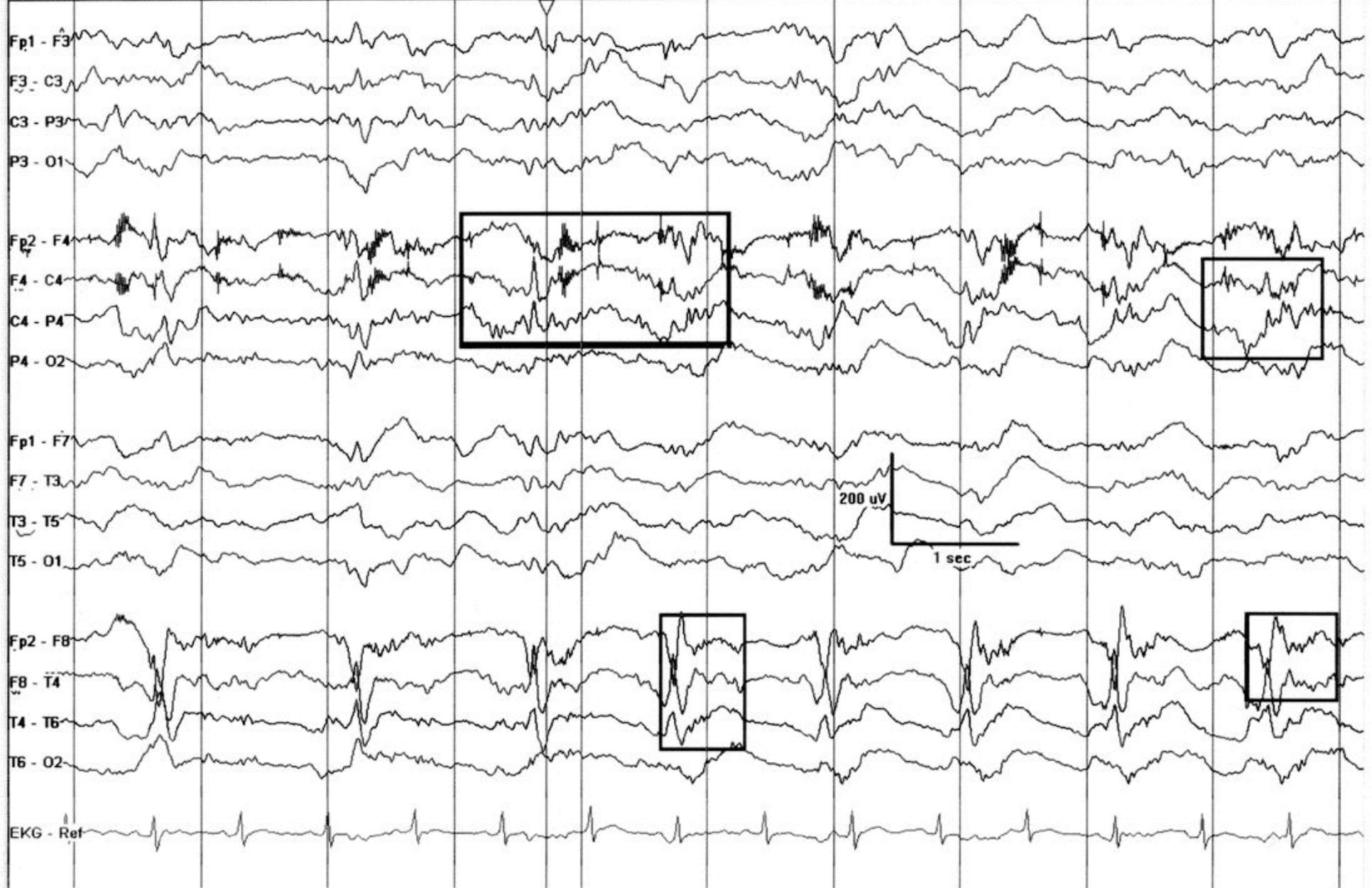




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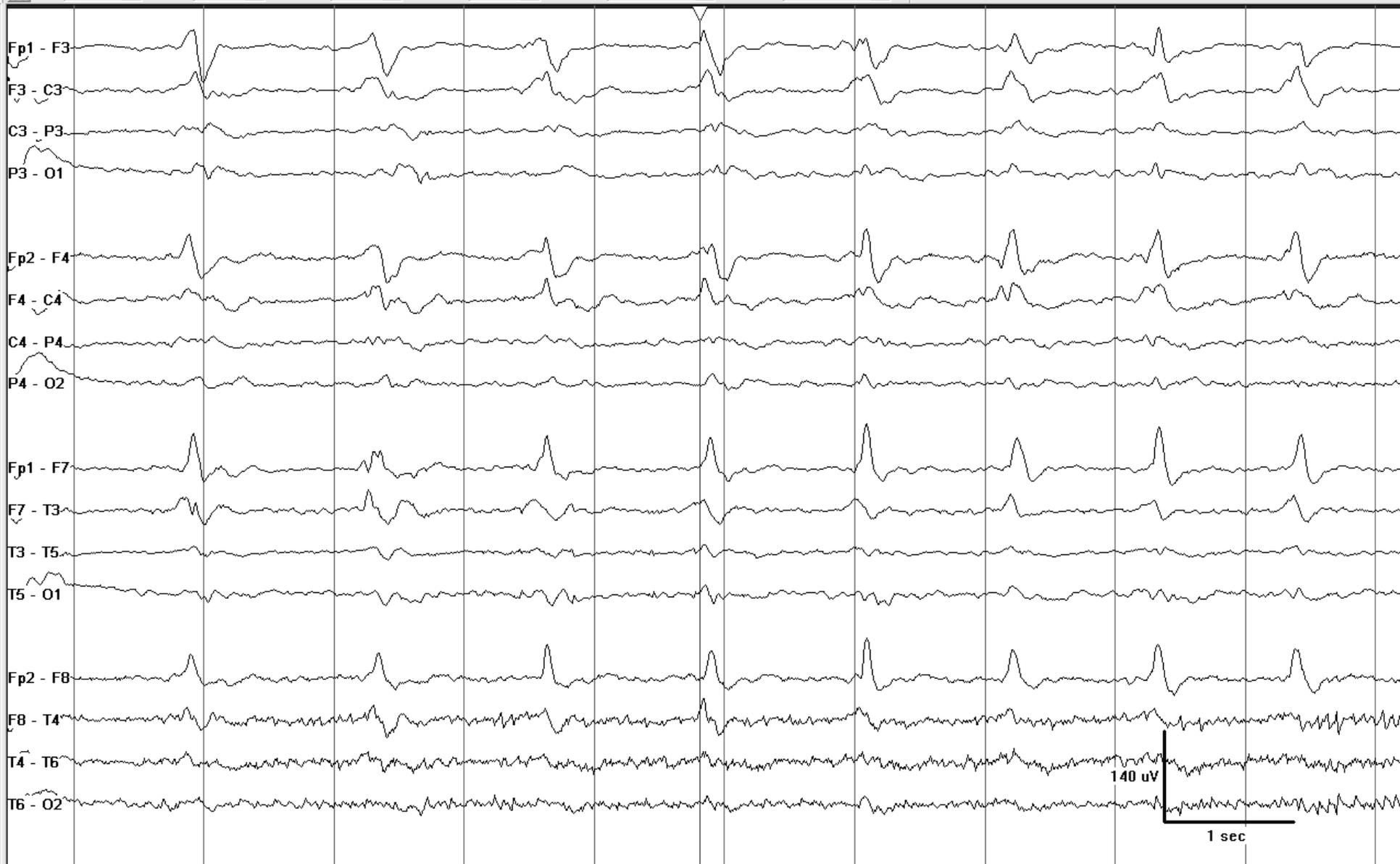




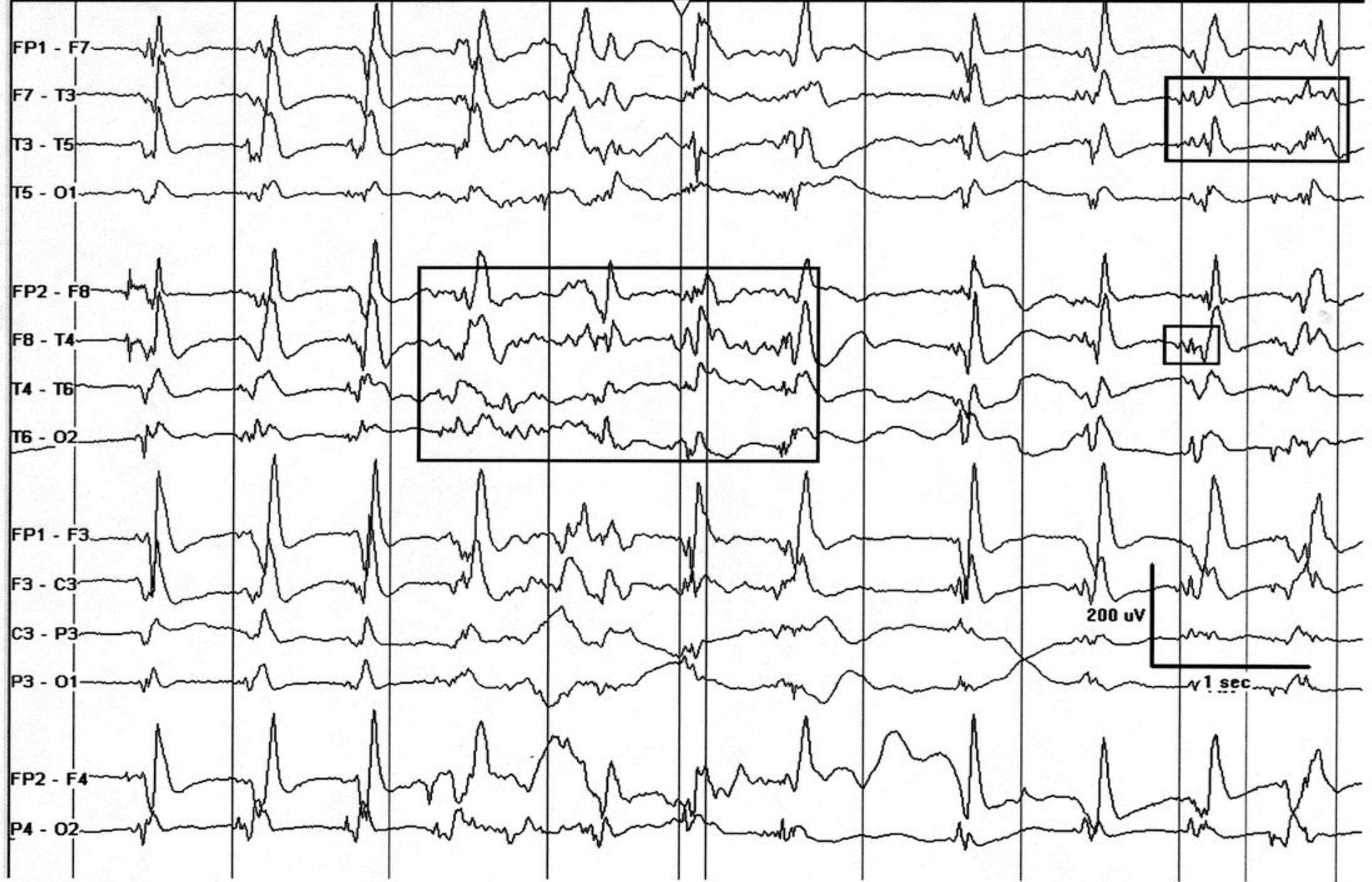


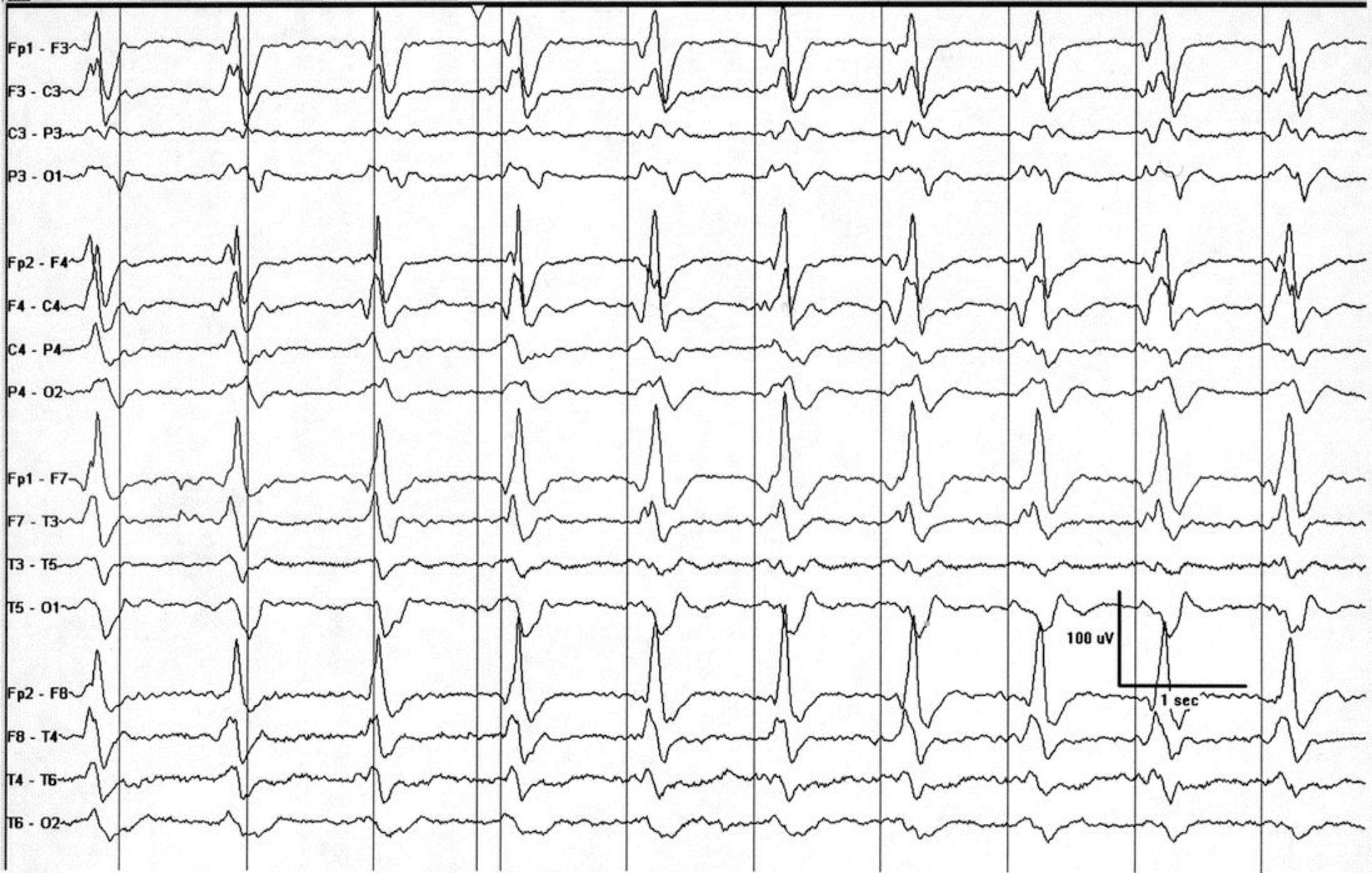




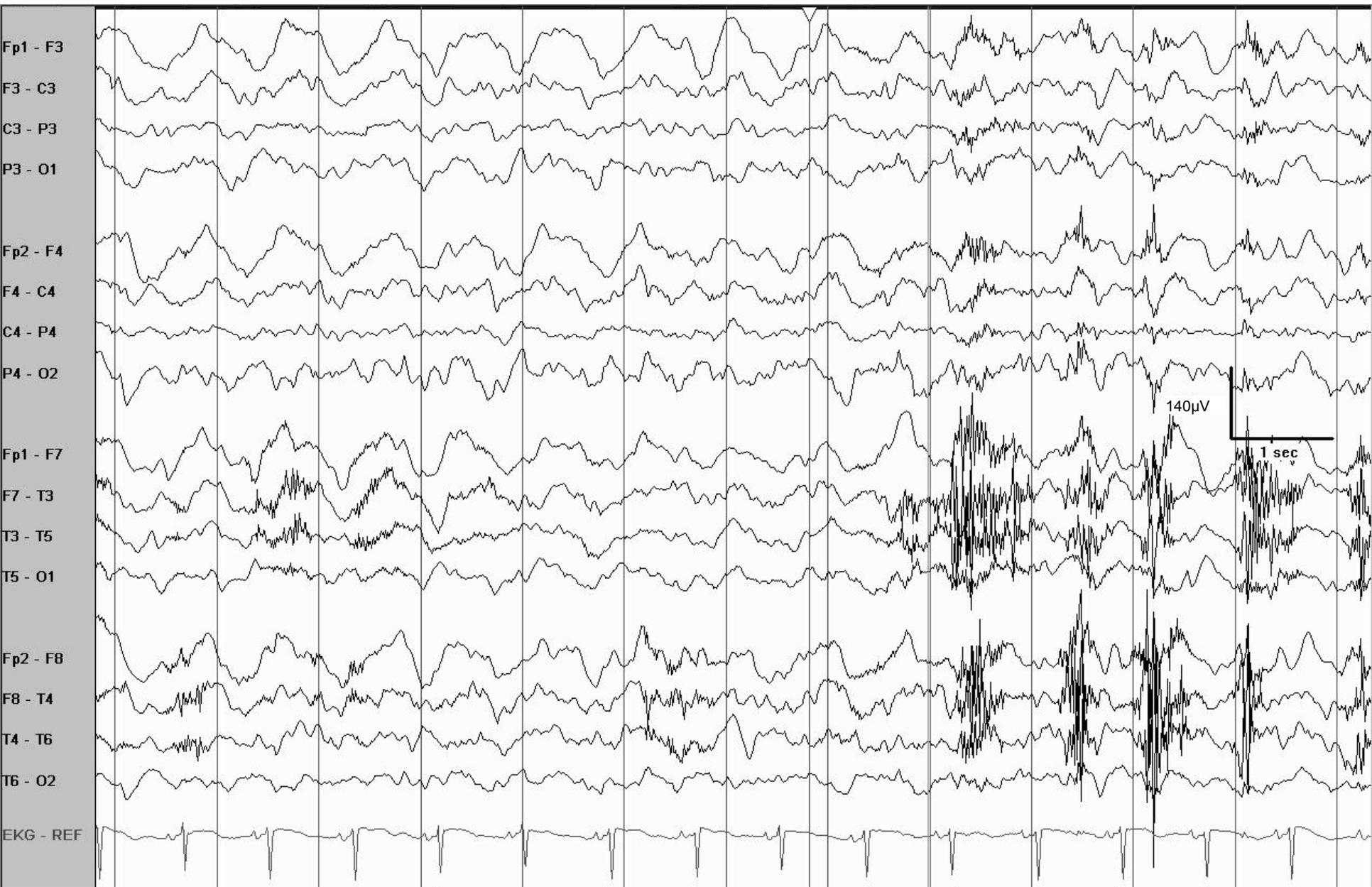


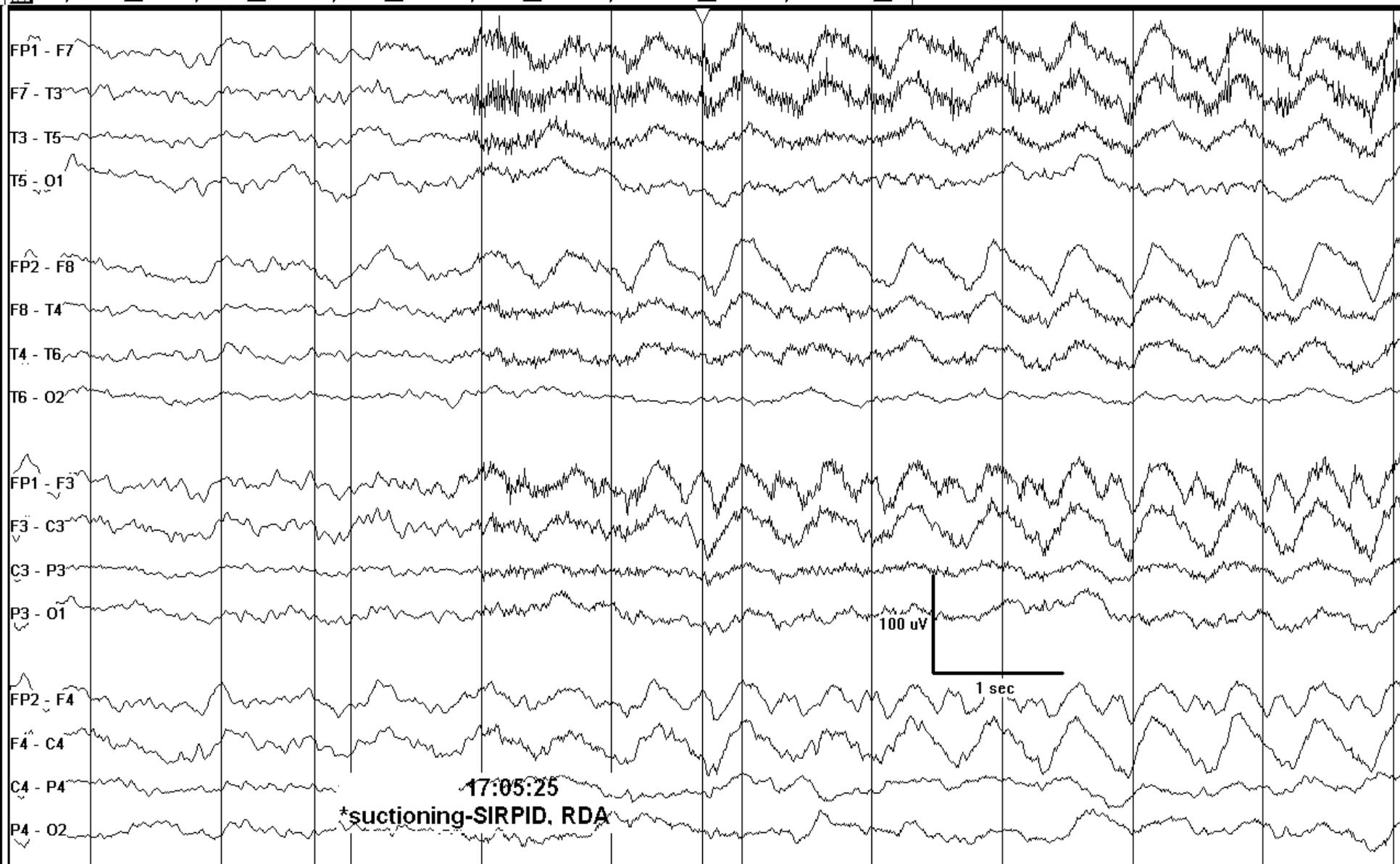




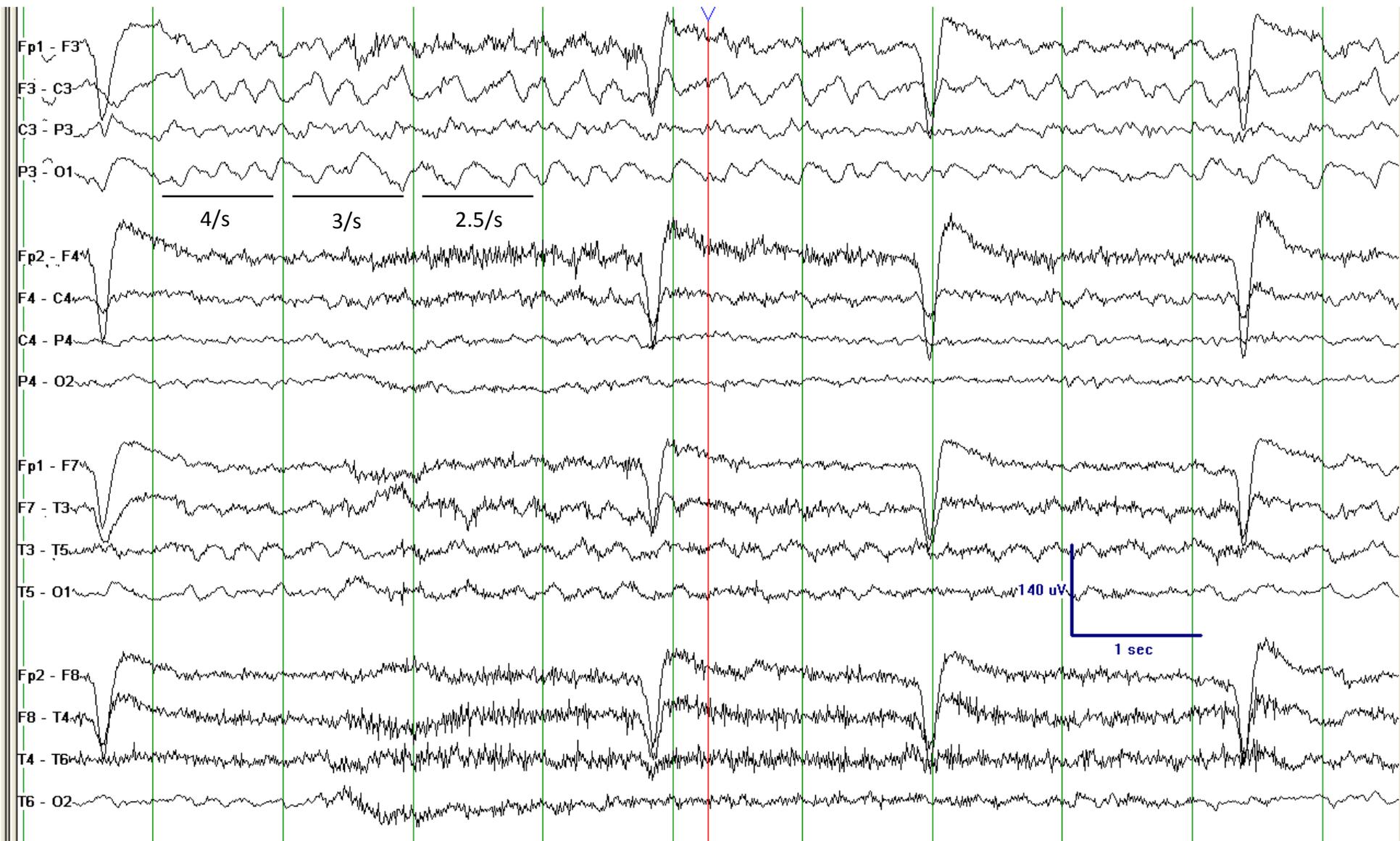


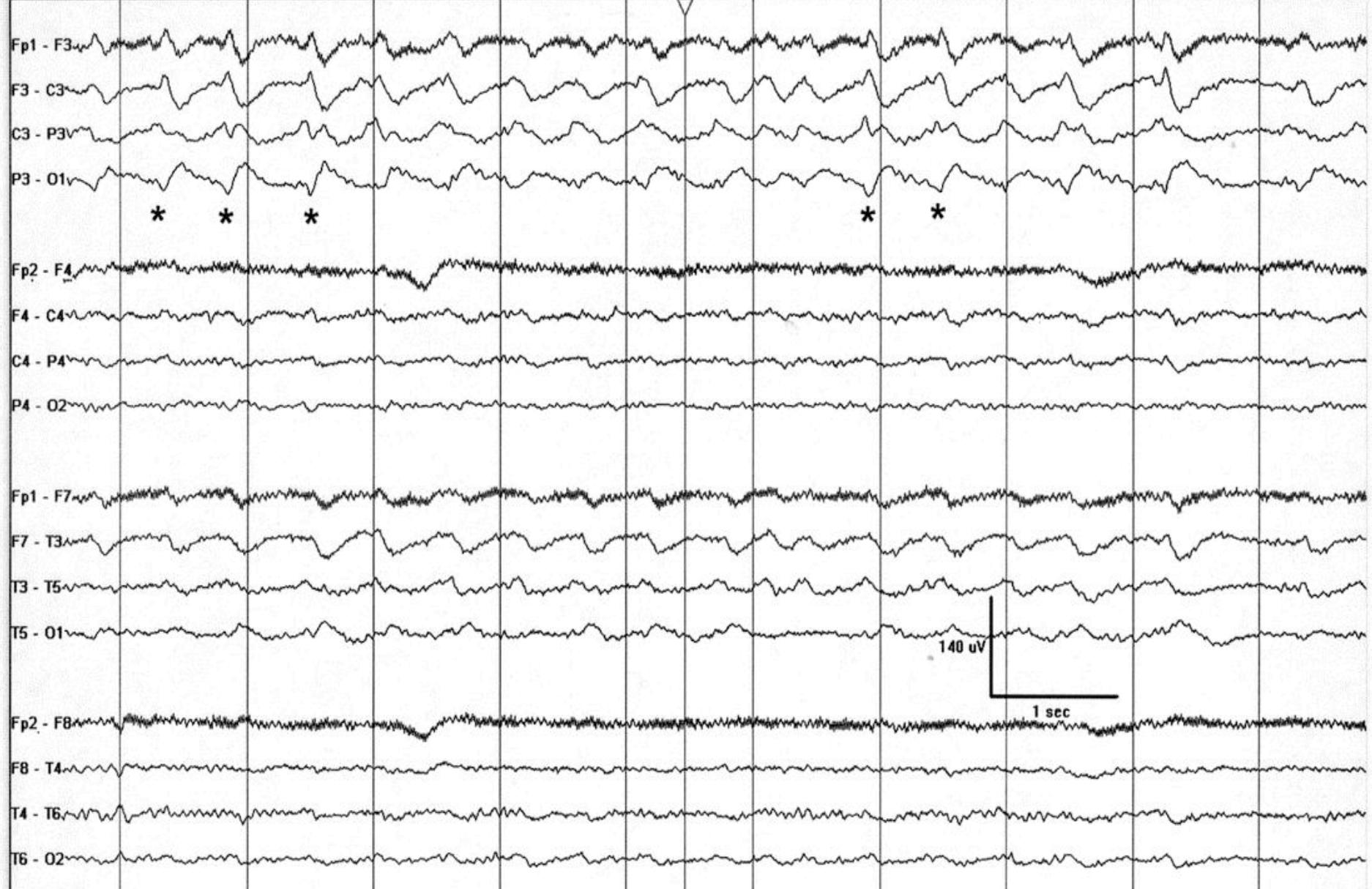


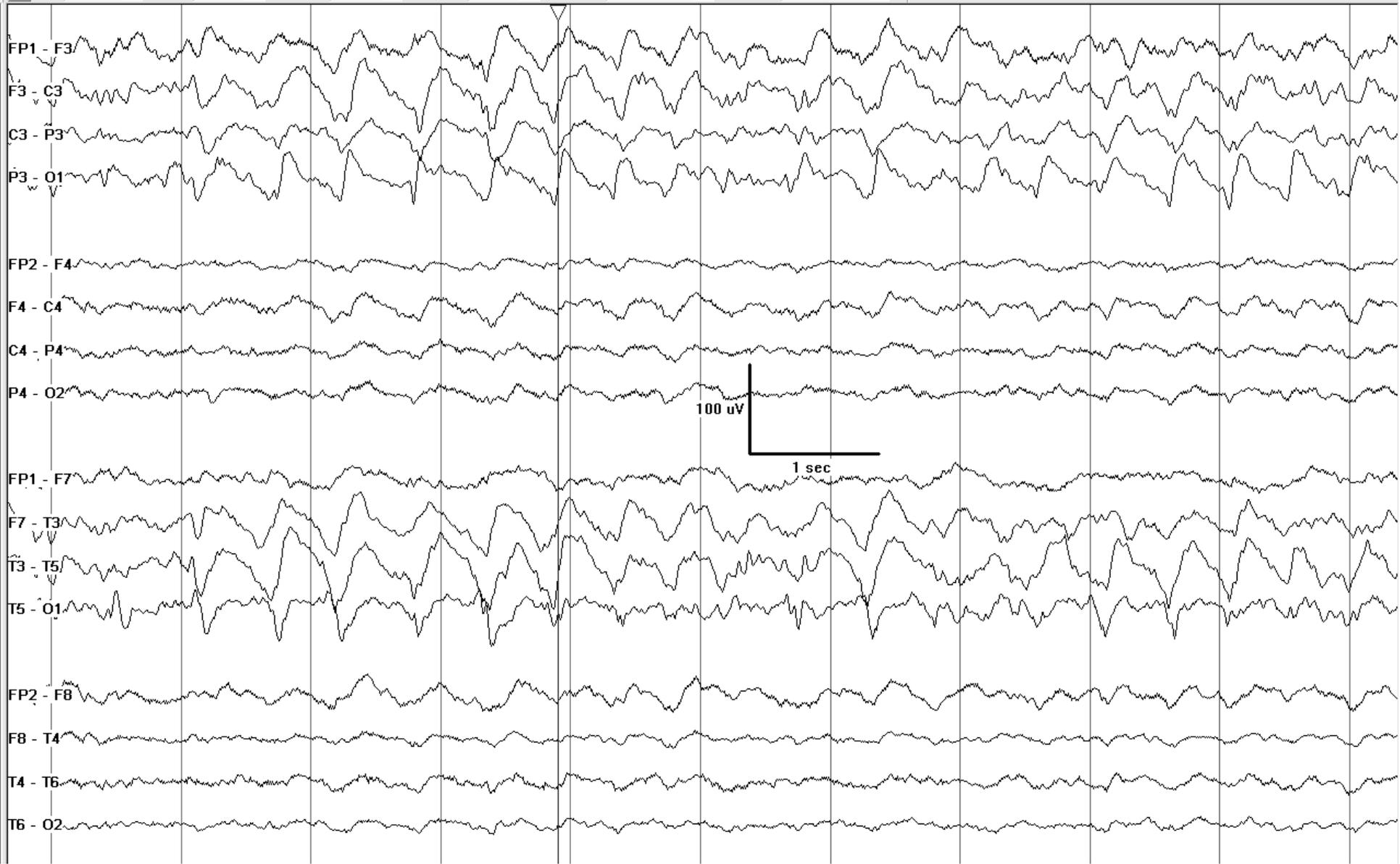


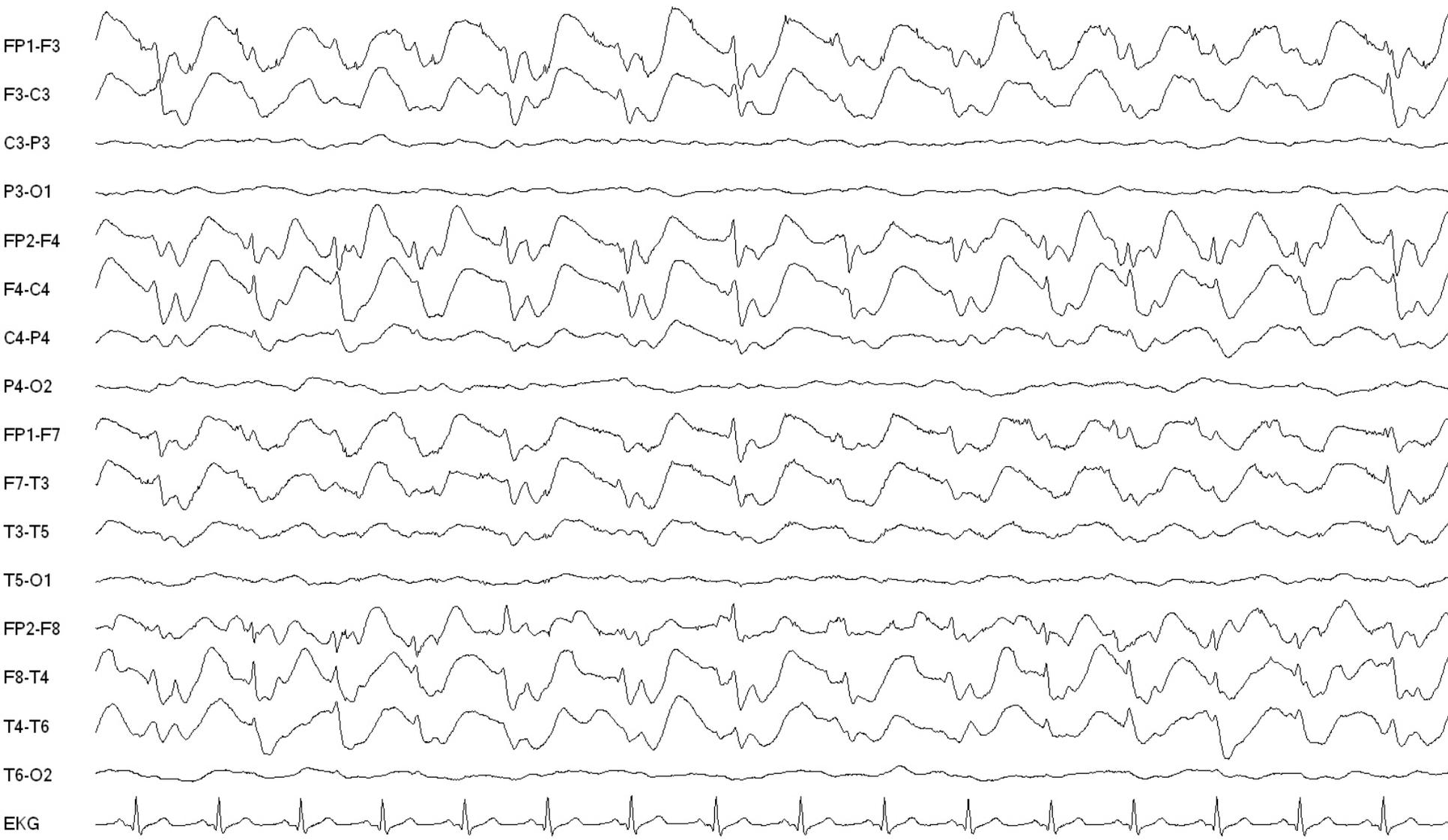






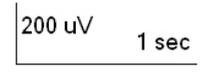


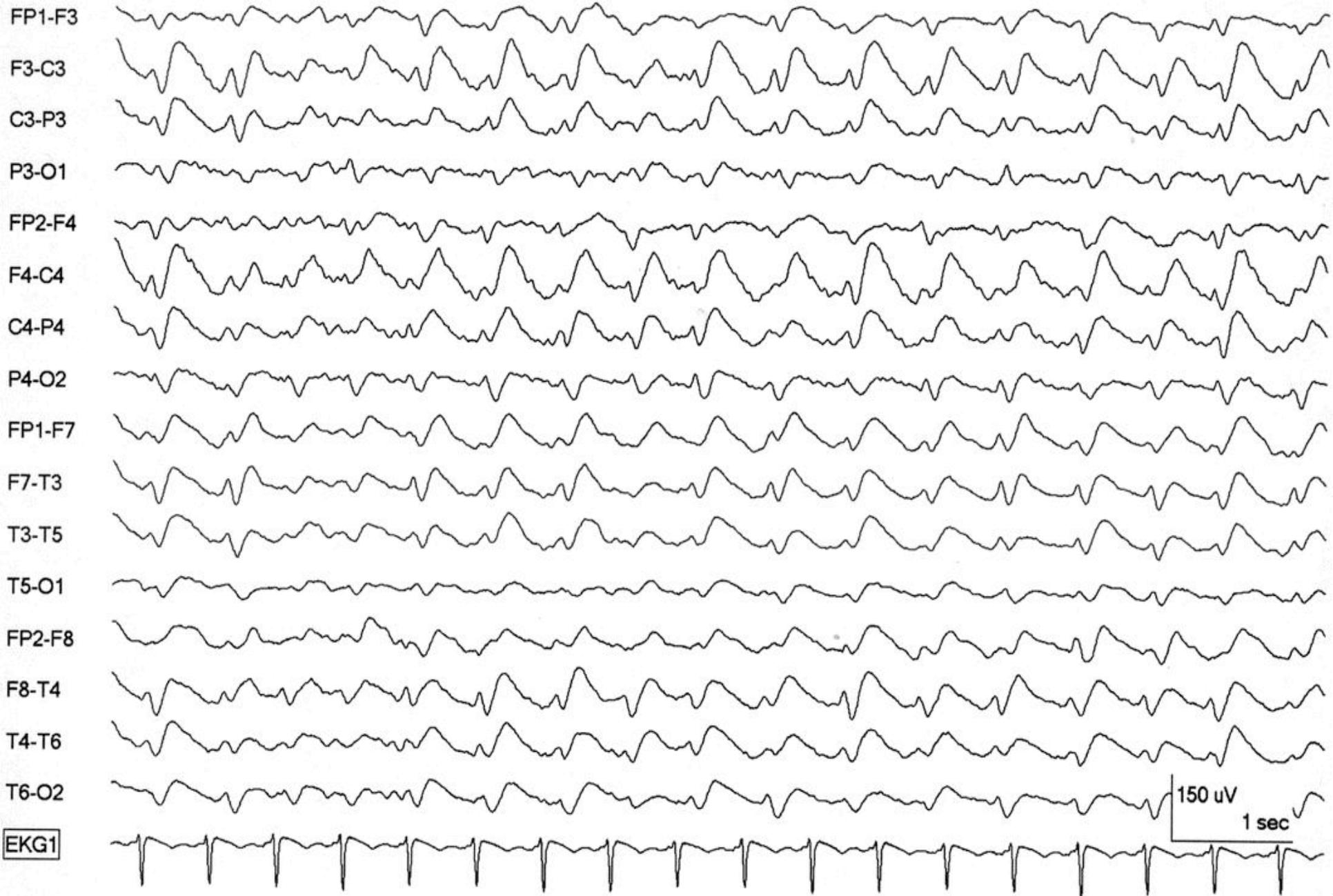


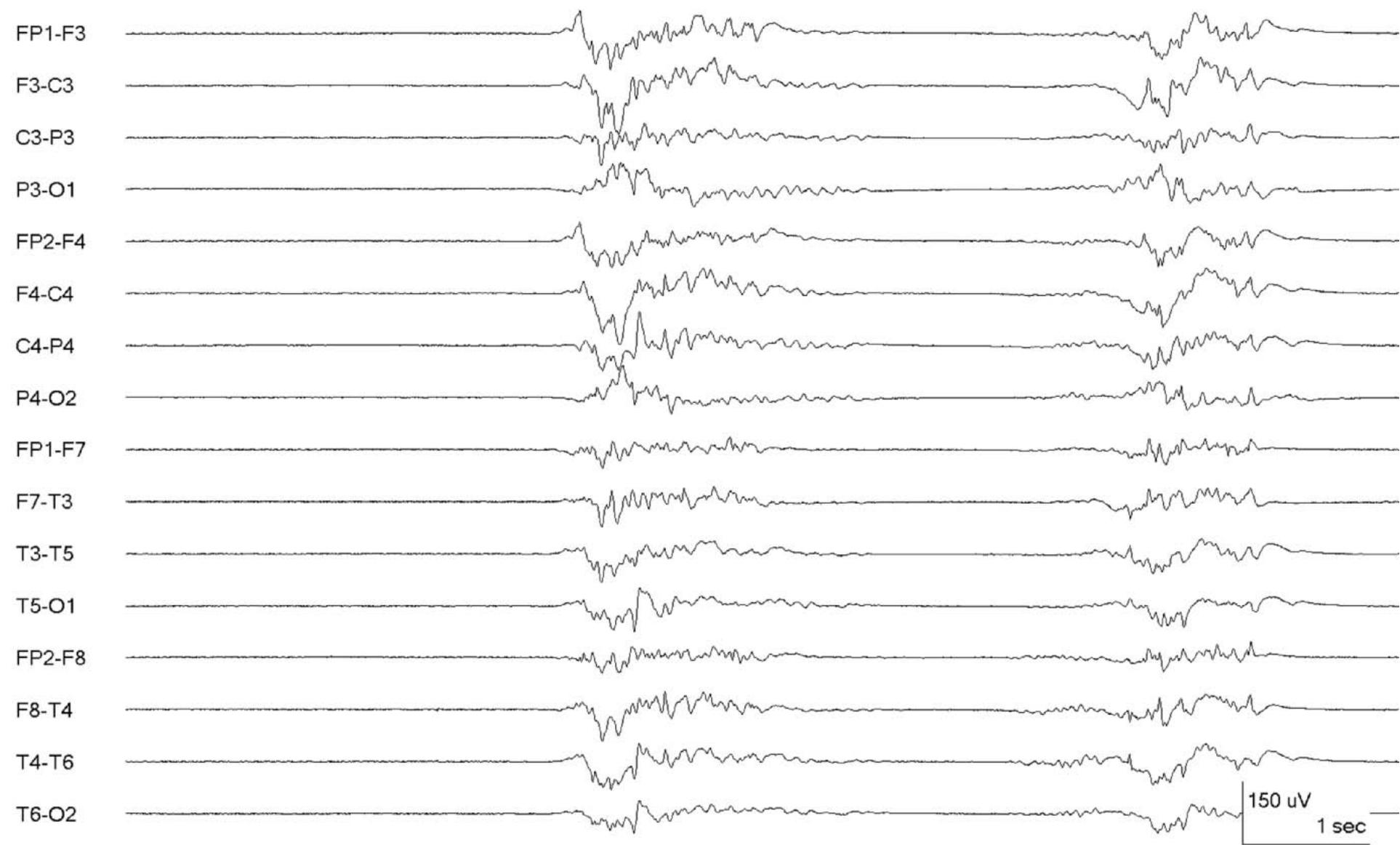


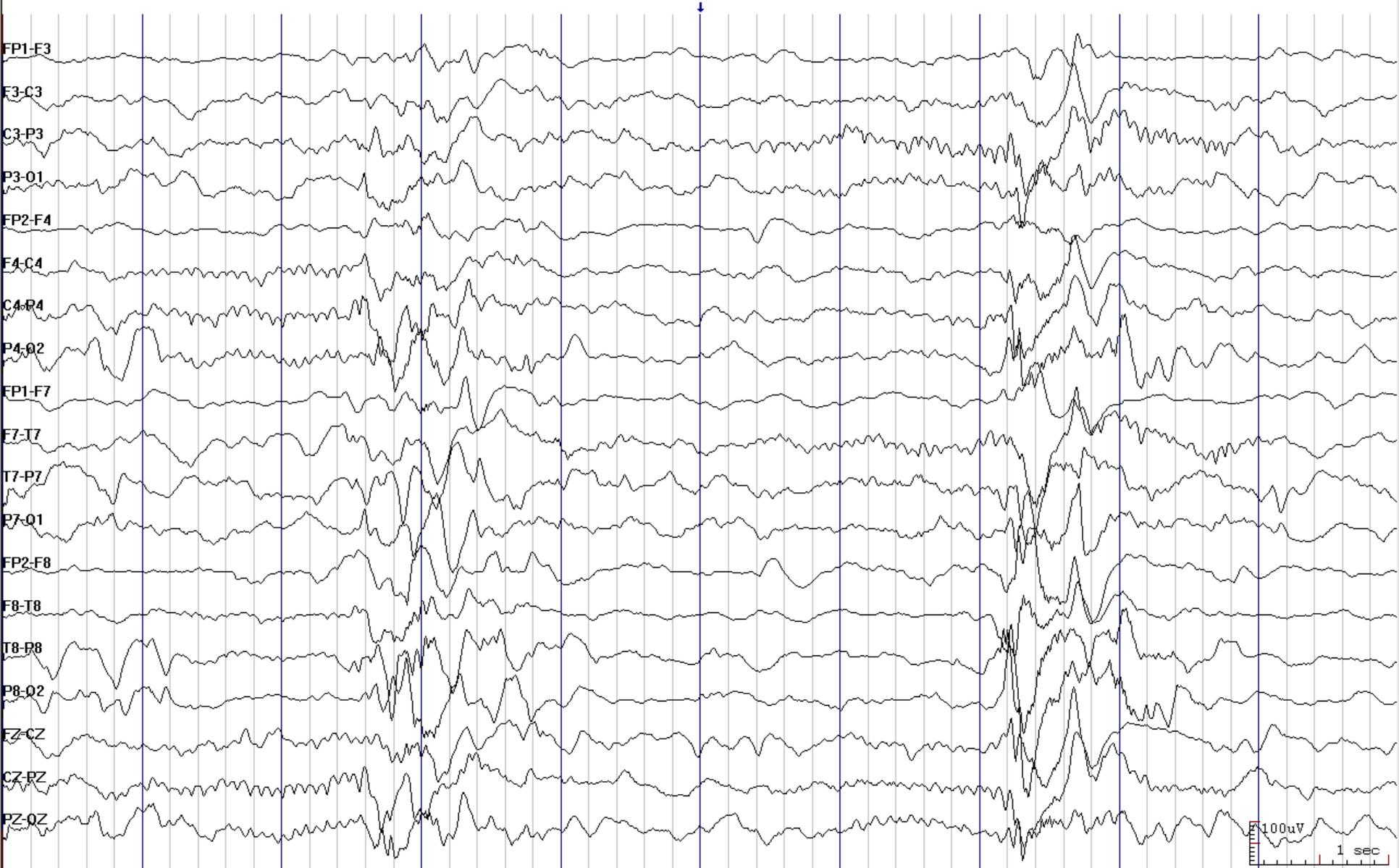
Comment

no clinical change









Response to public comments on

American Clinical Neurophysiology Society's Standardized Critical Care EEG Terminology: 2012 version

June 3, 2012

Hirsch LJ, Gaspard N, Laroche SM

Public Reviewer Comments are in standard font, and our responses are in italics. The revised manuscript has the major changes highlighted in yellow.

Comment #1: From my standpoint there are numerous problems with this classification scheme. The main issue is that since we do not know which patterns are associated with what structural lesions, there is no reason to change our language for describing these patterns at the present time. If we want to do research it is better to say that a record has generalized periodic complexes of 20uV in amplitude with a duration of 200-300msec occurring at a rate of 1/second than to use the new proposed descriptive terms such as "abundant", "long", "very long", etc. Because this scheme is very complex and has no clinical correlate, it will be largely ignored even if the ACNS endorses it. We should wait until we know which waveforms are correlated with specific pathologies as we know what that pathologic correlate of a PLED is.

Comment #2: Sounds reasonable but there is replacement of ingrained traditional terms (e.g. PLEDs, triphasic waves, GPEDs) and there is a significant risk of miscommunication (not that those terms are not open to misinterpretation also) when using the new terms. Before switching to the new terms I would suggest mentioning in parentheses (previously called -----) for a few years until there is general understanding of the new terminology.

>>Response to comments #1 and #2: This lack of knowledge of the meaning of these patterns is the exact reason we have created an objective, logical nomenclature with input from as many people as possible throughout the world over many years. The descriptive terms ("abundant", "long", etc) are only provided for those who prefer them, but the actual numbers/categories can be used instead. However, for those who use descriptive terms, we think it is important that they are standardized. Hence, they are included and defined, albeit somewhat arbitrarily. We understand that this nomenclature represents a change from classic terminology; thus, we have provided a table of the equivalent "old" and "new" terms. We believe the changes are all improvements, or at least more accurate descriptions, and that they are more amenable to consistent use and research (including dropping the E from "PLEDs").

Comment #3: SECTION "MODIFIERS"- #5 Sharpness- What is the difference between c "sharply contoured" and d. Blunt? If none then d should be included in the c description -OR- d should be defined.

>> Response to comment 3: We have revised this definition as follows: Sharply contoured: having sharp morphology (sharp inflection at its peak or trough, or steep upslope or downslope (such as saw-tooth

morphology), but the duration of the wave at the baseline is >200 msec and thus does not qualify as "sharp". Blunt: having smooth or sinusoidal morphology. We have also included examples of both sharply contoured and blunt waves in the figures.

Comment #4: My question is about the requirement for ictal events to exceed 4 Hz. We often see events in ICU recordings that look ictal when slowed down to 30 sec per page, either by virtue of rudimentary spike-wave runs or by evolution. Sometimes we see clinical correlations suggestive of seizures. I am coming to think of these as "slow seizures" in sick brains. I am early in the process of gathering a series for publication. These events are distinct from intermittent rhythmic non-evolving delta without spikes. Is there a way to encompass such events in the terminology and is there any consensus on such slow events (sometimes) being ictal? I can attach a figure with an example, if you tell me which email.

>>Response to comment 4: *It is our opinion too that seizure activity might demonstrate slower frequency in the critically ill. This nomenclature aims to create a common language to be used in studies in the field and applies to all equivocal EEG patterns whose nature might or might not be ictal. Runs of rhythmic delta activity with evolution and with embedded spikes would be described in the nomenclature as evolving RDA+S. This would not exclude that they are ictal, simply that this pattern is included in this nomenclature and warrants investigation. We attempted to make it clear that patterns in this nomenclature may still be definite seizures based on evolution, clinical correlate, etc. The corollary in the background section in the current form of the nomenclature already states the following to address this point [bolding added]:*

*"Corollary: The following patterns are included in this nomenclature and would not be termed electrographic seizures for research purposes (**whether or not these patterns are determined to represent seizures clinically in a given patient**): Generalized spike and wave patterns slower than 3/s; and evolving discharges that remain slower than or equal to 4/s. **This does not imply that these patterns are not ictal, but simply that they may or may not be.** Clinical correlation, including response to treatment, may be necessary to make this determination."*

As this is indeed an important point, we have bolded these parts in the new version, and removed the parentheses.

Comment 5: Some minor comments: 1. For localizations in main term 1, would suggest including "central" and/or "vertex". I have seen adults with spikes/seizures there, and would make terminology extend to neonates more easily.

>> 1. *A similar point could be made about bifrontal and bioccipital discharges; they are actually focal, but are included them in the term "generalized" in this nomenclature for simplicity, with a defined*

subcategory for them. Based on this comment, we have added a subcategory under “generalized” entitled “Midline Predominant”, defined as “having an amplitude in midline derivations that is at least 50% greater than in parasagittal derivations on an average or non-cephalic referential recording”.

Comment #6: Number 6 (amplitude definitions): I would generally consider 20-49 uV as being moderate or medium, not low amplitude (and in fact you call it that when discussing background activity later on). I think terms should be consistent across types of activities.

*Response to comment #6: We think that the amplitude scale for the main terms such as periodic discharges has to be necessarily different than the scale for background as they have to stand out of the background. Indeed, 40µV LPDs over a 40µV background would not be noticeable. We agree that a background of 40 µV is not low amplitude, and it would be categorized as “normal” voltage background in this nomenclature (≥ 20 µV). However, for PDs, 40 µV is indeed in the low range for peak to trough amplitude based on the literature (usually closer to 100-150 µV; see Kalamangalam et al., *Epilepsia* 2007. We have added a comment in each location that this applies only to the one situation and not the other (either describes Main Term #2 or the background EEG, but different scales).*

Comment #7: Pocket guide is great, could have a copy hanging on the EEG machine in ICU. I would find it helpful to show an example of an actual clinical report built using these terms to help people set up their lab report formats. By the same token, figure legends could be not just the description, but actually the way you would state the finding in a report. 4. Don't be dismayed by those resistant to new terminology (if they aren't already exhausted over the ILAE classifications!). But would be helpful to offer some sample boilerplate that could be appended to reports to explain significance of findings to the clinicians. Also a teaching file/slide show that EEGers could use to educate their referring docs and trainees.

Response to comment #7: This is a good idea. We will try to incorporate something like this in the future, but not as part of the formal ACNS guideline.

Comment #8: The definitions of Generalized and Lateralized include serious contradictions: generalized is explicitly defined as possibly not generalized and similarly for lateralized. According to the definitions, I think the terms "symmetrical" and "asymmetrical" would appear to be more appropriate; they would not include contradictions.

Response to Comment 8: Generalized and lateralized are widely accepted terms in the EEG literature, including when referring to non-generalized patterns. GPEDs, as well as generalized epileptiform discharges are in fact rarely generalized; and PLEDs are often bilateral synchronous and asymmetric (rather than truly unilateral). In order to make the “generalized” term more accurate, one would have to say “bilateral; synchronous or time-locked; and symmetric”, and possibly widely distributed. We have

simplified this by referring to all as “generalized”, then having subcategories. We also included this explanation in the initial definition of “generalized”, as follows:

“for this purpose, the term “generalized” refers to any bilateral, bisynchronous and symmetric pattern, even if it has a restricted field [e.g. bifrontal]”

Simply stating “symmetrical” would not suffice, as bilateral independent patterns are often symmetrical.

Comment #9: On main term Rhythmic Delta Activity (RDA). In the second line: uniform morphology and duration, and no interval between, it could better say: uniform morphology and duration, but with no regular interval between.

Response to comment 9: We have fixed this as follows: “...uniform morphology and duration, and without an interval between...”.

Comment #10: On modifier # 8 Stimulus-Induced (SI): In the first line the word: reproducibly does not exist in the English language; also, the second part of the phrase: brought about by an alerting stimulus, could be changed to: brought about by a sensory stimulus....

Response to comment #10: The adverb “reproducibly” does appear in both the Oxford and Collins dictionaries. We thus believe it is correct to use it. Concerning the stimulus, its nature is not as relevant as the fact that it is able, or potentially able, to arouse the patients. All stimuli are by definition sensory but many of them may not be ‘alerting’ (odors, tastes, quiet sounds).

Comment #11: On modified # 9 Evolving: In line number six: sequentially out of at least two standard 10-20 electrode locations, it could better say: sequentially out of at least two standard 10-20 electrode locations, it could say better: sequentially out of at least two different standard 10-20 electrode locations.

Response to comment #11: We have rephrased this as suggested by the reviewer.

Comment #12: On minor modifier # 4: Anterior-posterior lag or posterior-anterior lag: The paragraph: applies if a consistent measurable delay of > 100 ms appears to be present from the most anterior derivation in which it is seen to the most posterior derivation in which is seen; specify typical delay in ms from anterior to posterior (negative = posterior to anterior) in both longitudinal bipolar and in a referential montage, preferably with an ipsilateral ear reference, could be more clear as: applies if a consistent measurable delay of > 100 ms exists from the most anterior to the most posterior derivation

in which is seen; specify typical delay in ms from anterior to posterior (negative = posterior to anterior) in both a longitudinal bipolar and a referential montage, preferably with an ipsilateral ear reference.

Response to comment #12: We have rephrased this as suggested by the reviewer.

Comment #13: On D. Background EEG, in the continuity characteristic, numeral 4. Burst-attenuation/Burst-suppression, in section c. Presence or absence of Highly Epileptiform Bursts: At the end of the second line the word "majority" is used, without specifying what that majority refers to: (>50%)?. Also, at the end of the fifth line the word "majority" is used, without specifying again what that majority refers to: (>50%)?. In line 3, bursts and occur an average of 1/s, could be more clear if it would say: bursts and occur at an average of 1/s.

Response to comment #13: We have now defined majority as >50% and rephrased as suggested by the reviewer.

Comment #14: On Figure Legend # 5. In the second line in parenthesis: (as there is an inter-discharge interval) would not it be better?: (as there is an approximately constant inter-discharge interval).

Response to comment #14: We have rephrased this as follows: "... as there is a quantifiable inter-discharge interval between consecutive waveforms and recurrence of the waveform at nearly regular intervals."

Comment #15: I think a discussion of the organization of the background, including the anterior to posterior gradient is actually the most important aspect of the background and should be added.

Response to comment #15: We have now added this to the background EEG description as "AP gradient: present or absent". We have defined it as follows: "AP gradient is present if there are clear and persistent lower amplitude, faster frequencies in anterior derivations compared to posterior derivations".

Comment #16: I think the term "spiky" does not sound right. It is kind of cute, and I think we need something more professional like "with admixed spikes".

Response to comment #16: We also are not enamored with the term "spiky". We have tried to find an alternative term ("apiculate", "pointy", etc.) without success, and another word would lose the well known correlation with "spike", an important advantage of this word. The cuteness of the word is subjective and relative; for instance, the example in Webster's dictionary of its use is in "spiky barbed wire". We believe that people will get accustomed to its use. "Spiky" has a different meaning from "with admixed spikes". The first term applies to periodic discharges and refers to the degree of sharpness of a

single discharge, whereas the latter, included in the "Plus S" modifiers, refers to the presence of spikes embedded within runs of rhythmic delta activity.

Comment #17: This is an excellent series of documents! The only major suggestion I would have is to consider including how artifact is defined both for practical use and research use (ie daily index). It is highly relevant to the interpretation of cEEG and perhaps including similar prevalence values as a major modifier this would make the paper more practical.

Response to comment #17: The purpose of this nomenclature was to address the need for an objective description of EEG patterns in the ICU. The description of artifacts is beyond its scope, and would be more appropriate in an educational publication rather than a guideline.

Comment #18: Minor suggestions would be to eliminate "blunt" from the "sharpness" category.

Response to comment #18: Blunt was included in the "sharpness" modifier to allow the description of the full spectrum of sharpness. In a sense it can be seen as the degree zero (or lack) of sharpness.

Comment #19: In the 1b category under EEG background change "or" to "and" to ensure that the minor asymmetries are an abnormality and therefore worthy of mention or eliminate the category in favor of symmetry v asymmetry.

Response to comment #19: Changing "or" to "and" would exclude asymmetries in frequency or amplitude alone.