



Ictal-interictal interpretation, & Pattern recognition

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ACNS GUIDELINE

American Clinical Neurophysiology Society's Standardized Critical Care EEG Terminology: 2021 Version

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RHYTHMIC AND PERIODIC PATTERN (RPP)



LPDS, GPDS, LRDA, GRDA

location

Main term 1
G <i>Generalized</i> - Optional : Specify frontally, midline or occipitally predominant
L <i>Lateralized</i> - Optional: Specify unilateral or bilateral asymmetric - Optional: Specify lobe(s) most involved or hemispheric
BI <i>Bilateral Independent</i> - Optional: Specify symmetric or asymmetric - Optional: Specify lobe(s) most involved or hemispheric
Mf <i>Multifocal</i> - Optional: Specify symmetric or asymmetric - Optional: Specify lobe(s) most involved or hemispheric
UI : unilateral independent

type of waveform

Main term 2
PD <i>Periodic Discharges</i>
RDA <i>Rhythmic Delta Activity</i>
SW <i>Rhythmic Spike and Wave</i> OR <i>Rhythmic Sharp and Slow Wave</i> OR <i>Rhythmic Polyspike and Wave</i>

plus modifiers

Plus (+) Modifier
No +
+F <i>Superimposed fast activity – applies to PD or RDA only</i>
+R <i>Superimposed rhythmic activity – applies to PD only</i>
+S <i>Superimposed sharp waves or spikes, or sharply contoured - applies to RDA only</i>
+FR <i>If both subtypes apply – applies to PD only</i>
+FS <i>If both subtypes apply – applies to RDA only</i>

+EDB: extreme delta brush (specific type of +F) applies to blunt delta wave

Main term 1: **G**, L, BI, UI or MF

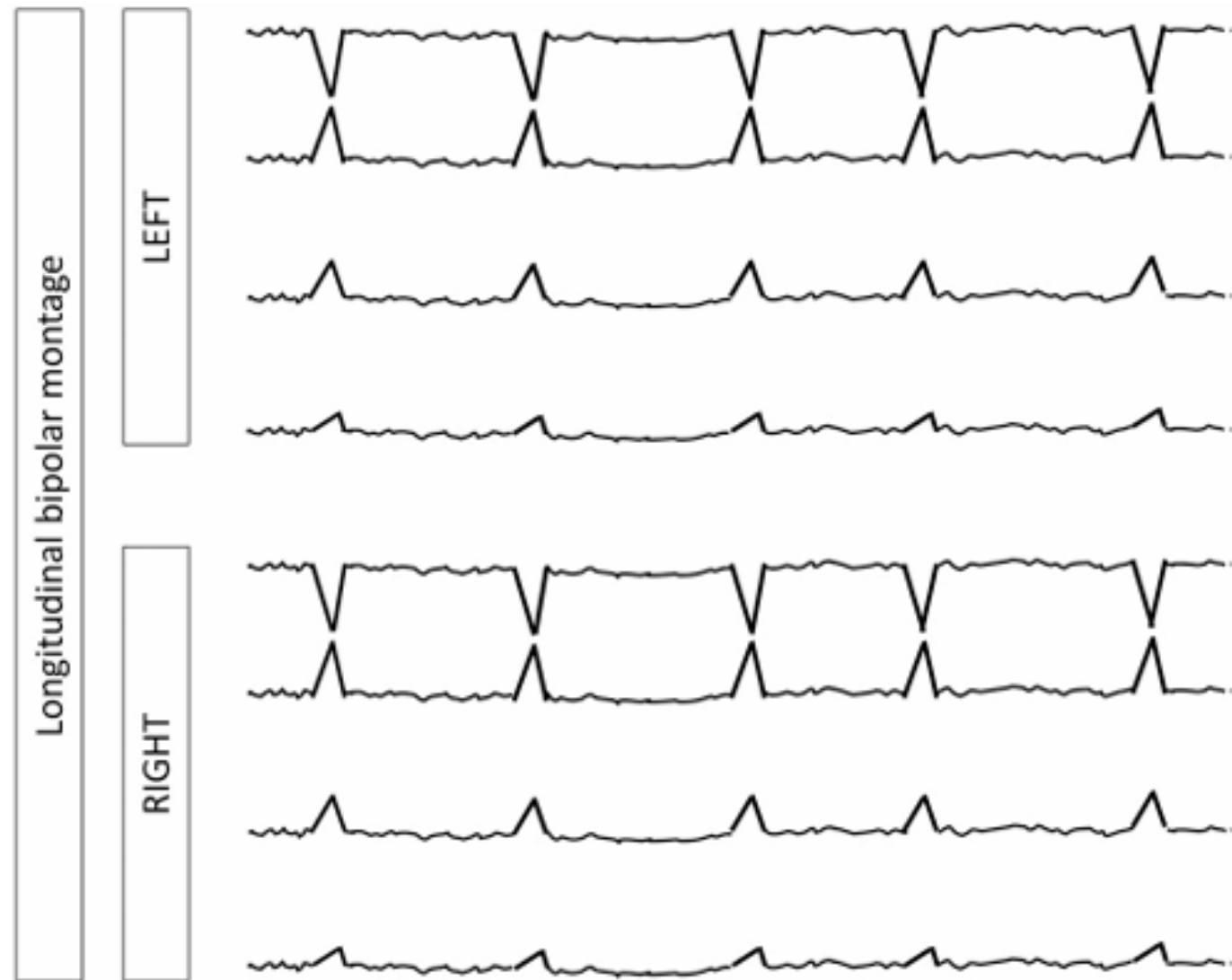


FIG. 13. Generalized Periodic Discharges (GPDs). Generalized: Bilateral synchronous and symmetric periodic discharges. In this case, the pattern is "frontally predominant."

- **Generalized (G):** any bilaterally synchronous and symmetric pattern
 - "Frontally predominant": Voltage in anterior derivations is at least 50% greater than that in posterior derivations
 - "Occipitally predominant": Voltage in posterior derivations is at least 50% greater than in anterior derivations
 - "Midline predominant": Voltage in midline derivations is at least 50% greater than in parasagittal derivations
 - "Generalized, not otherwise specified": Similar voltage in all regions and not qualifying as any one of the above three categories.

Generalized Periodic Discharges (GPDs)

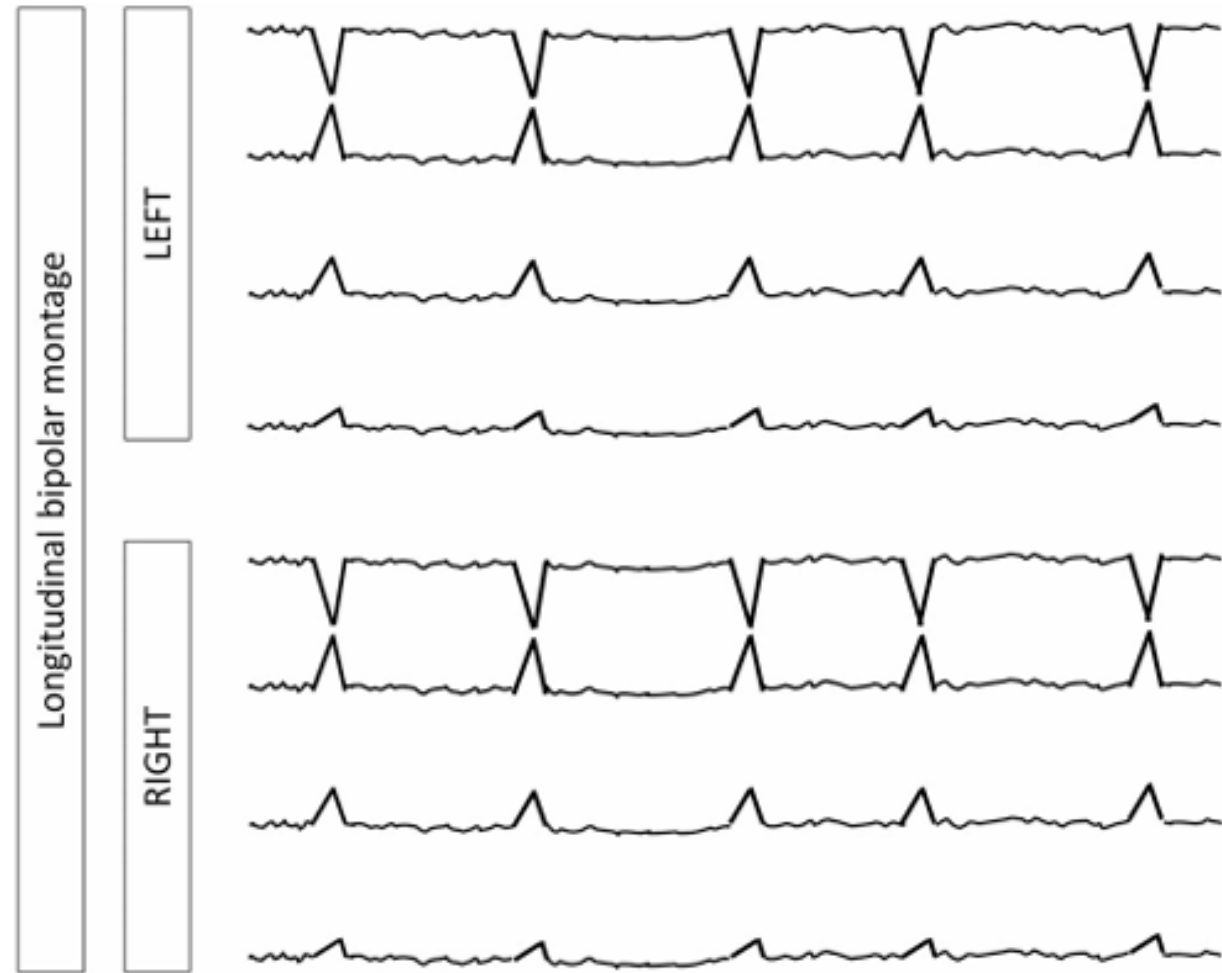
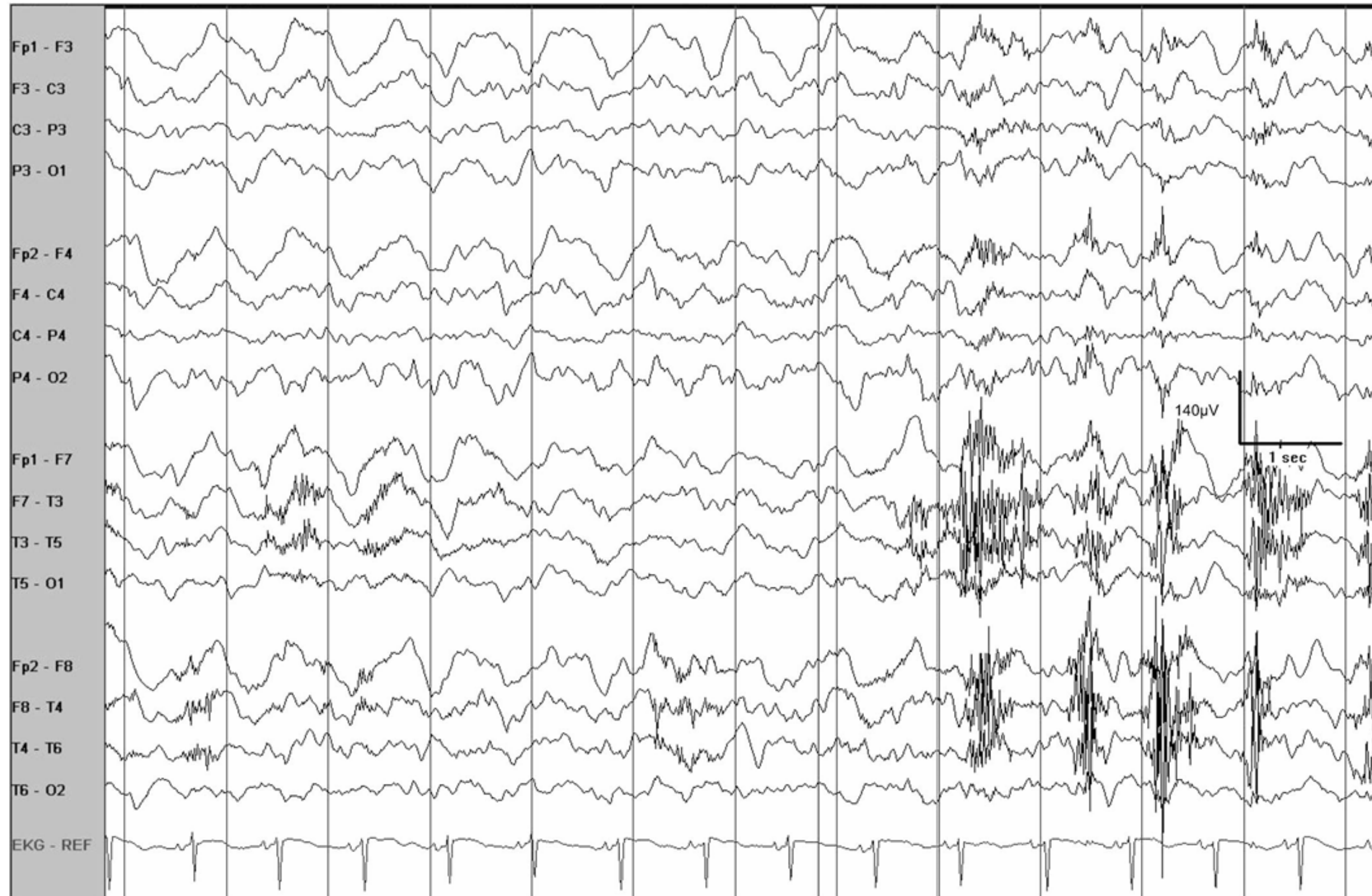


FIG. 13. Generalized Periodic Discharges (GPDs). Generalized: Bilateral synchronous and symmetric periodic discharges. In this case, the pattern is “frontally predominant.”



Generalized Rhythmic Delta Activity (GRDA): 1.5 Hz

frontally predominant GRDA



Main term 1: G, **L**, BI, UI or MF

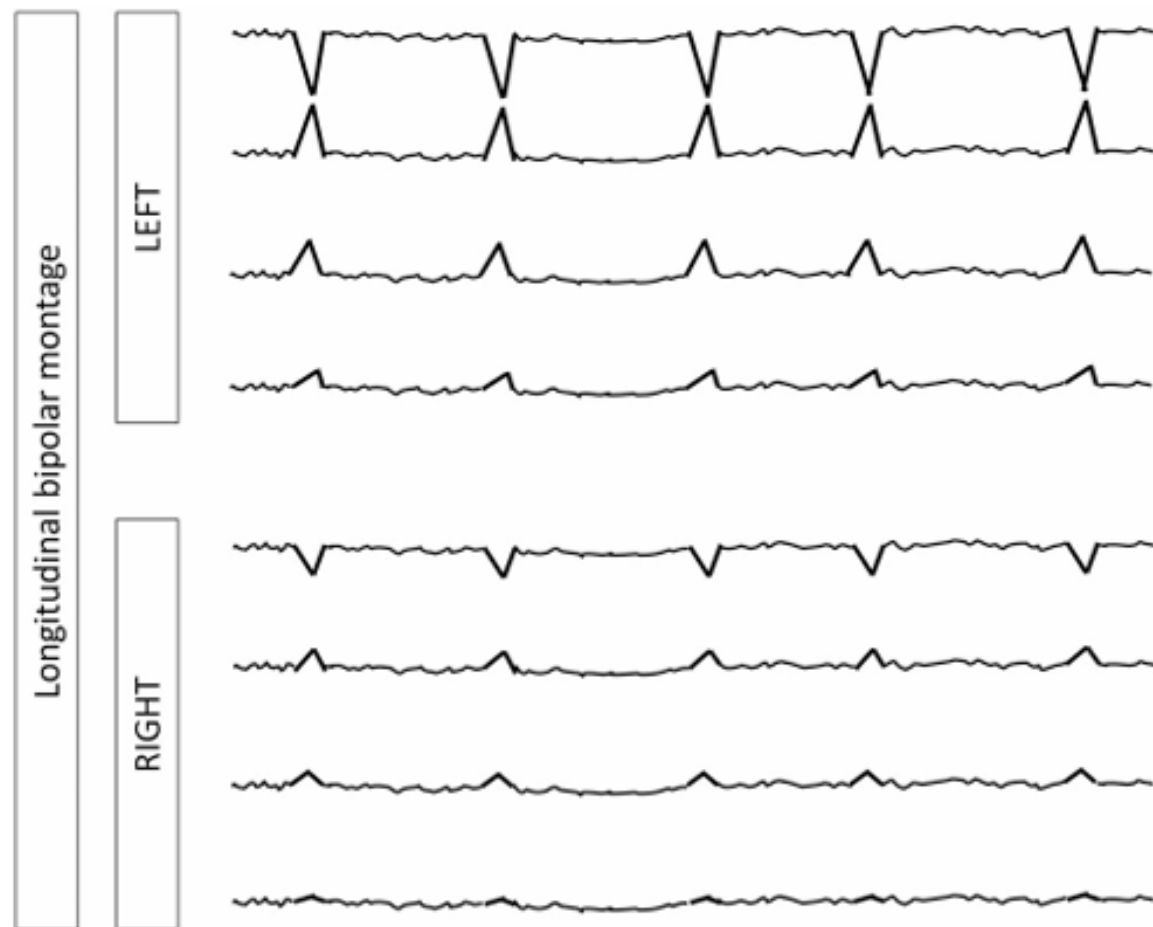
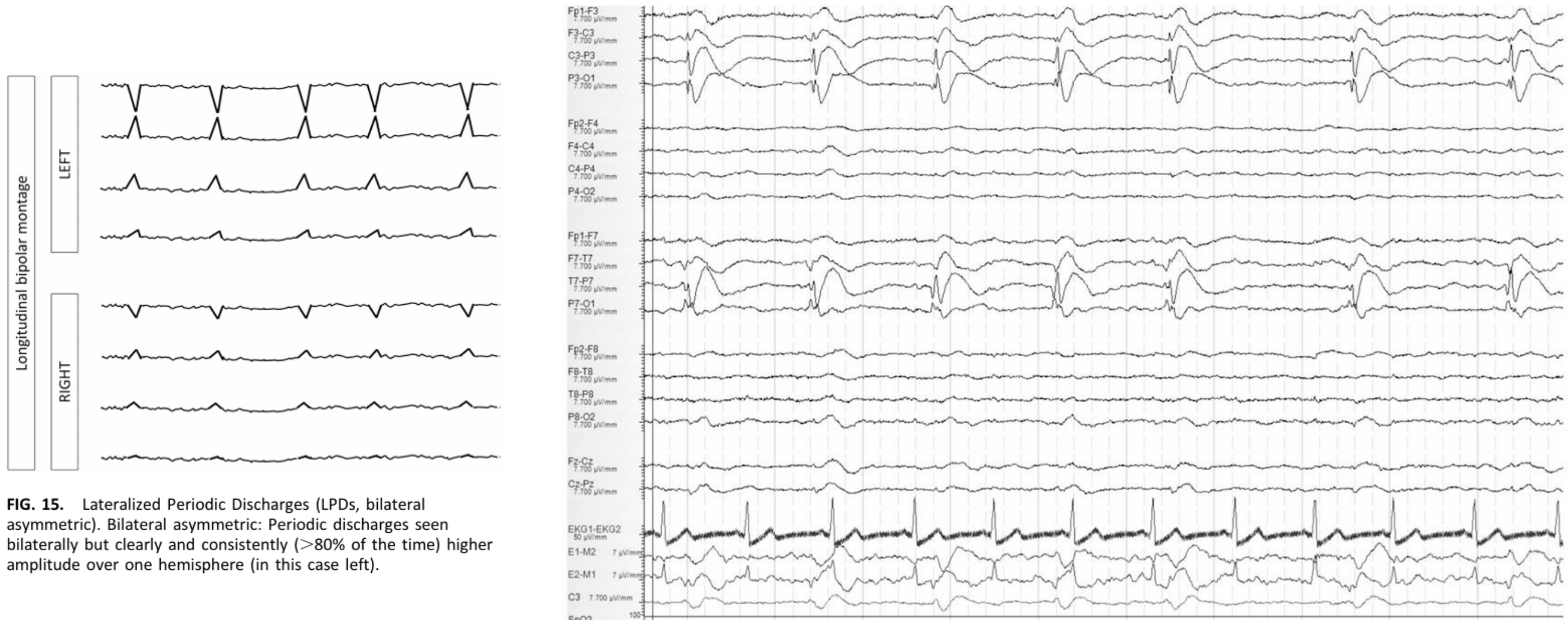


FIG. 15. Lateralized Periodic Discharges (LPDs, bilateral asymmetric). Bilateral asymmetric: Periodic discharges seen bilaterally but clearly and consistently (>80% of the time) higher amplitude over one hemisphere (in this case left).

- **Lateralized (L):** unilateral OR bilateral but clearly and consistently higher amplitude in one hemisphere (bilateral asymmetric)
 - OR bilateral but with a consistent lead-in from the same side (bilateral asynchronous)

Lateralized Periodic Discharges (LPDs)



Main term 1: G, L, **BI**, UI or MF

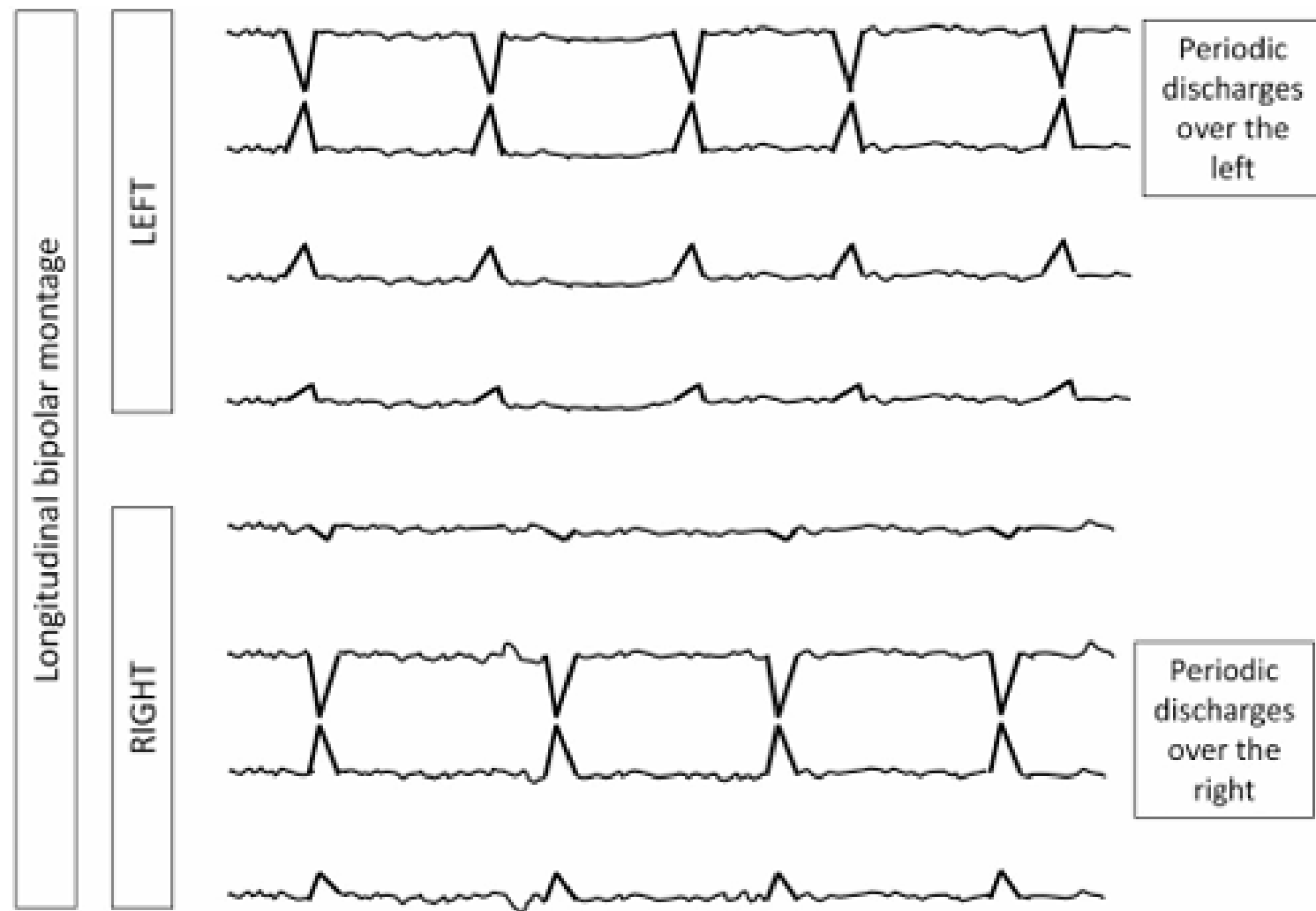


FIG. 17. Bilateral Independent Periodic Discharges (BIPDs). In BIPDs, lateralized patterns occur in each hemisphere asynchronously and at different frequencies.

- **Bilateral Independent (BI):** two independent (and therefore asynchronous) lateralized patterns with one in each hemisphere, with both patterns occurring simultaneously

Bilateral Independent Periodic Discharges (BIPDs)



FIG. 17. Bilateral Independent Periodic Discharges (BIPDs). In BIPDs, lateralized patterns occur in each hemisphere asynchronously and at different frequencies.



Periodic spike wave occurring at 0.3-0.5 Hz in the left posterior quadrant (arrows). At the same time, there is another periodic spike wave population occurring at 0.5-1 Hz in the right posterior quadrant (asterisks).

Bilateral Independent Periodic Discharges (BIPDs)



Main term 1: G, L, BI, **UI** or MF



- **Unilateral Independent (UI):** two independent (and therefore asynchronous) periodic

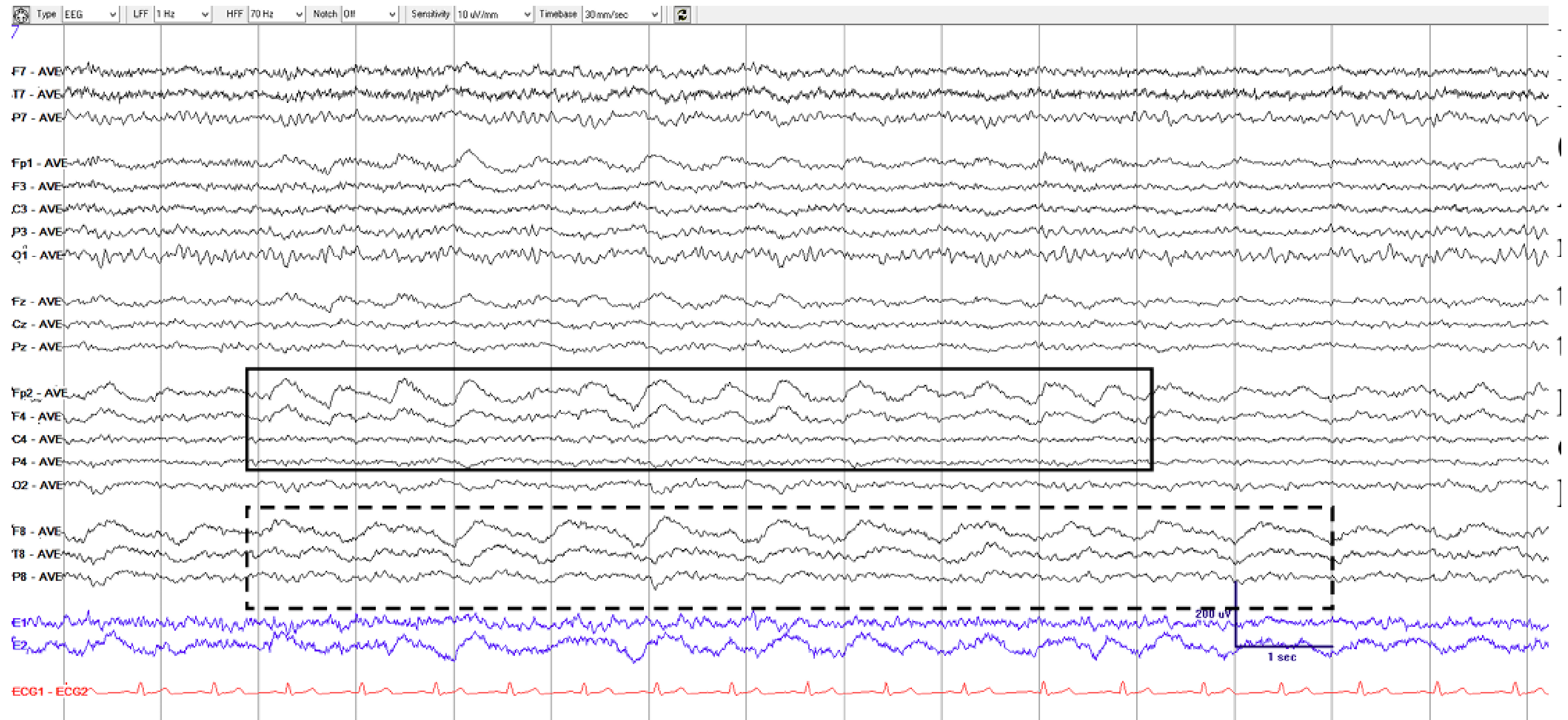
FIG. 18. Unilateral Independent Periodic Discharges (UIPDs). In UIPDs, periodic discharges occur in two independent locations simultaneously with both populations within a single hemisphere (in this case left).

Unilateral Independent Periodic Discharges (UIPDs)



1-1.5 Hz Periodic Discharges (PDs) maximal at F3. At the same time there are independent 0.5-Hz PDs in the central region. The two PD patterns in the same hemisphere qualify as UIPDs. NOTE a focal midline pattern may still be classified in the same hemisphere (unilateral) as an independent pattern in either the right or left hemisphere.

Unilateral Independent Rhythmic Delta Activity (UIRDA)



1.5-Hz Rhythmic Delta Activity (RDA) in the right frontal region (solid box). At the same time, there is 1-Hz RDA in the right temporal region (dashed box). The patterns are independent from each other but are both in the same hemisphere (so unilateral).

Main term 1: G, L, BI, UI or **MF**



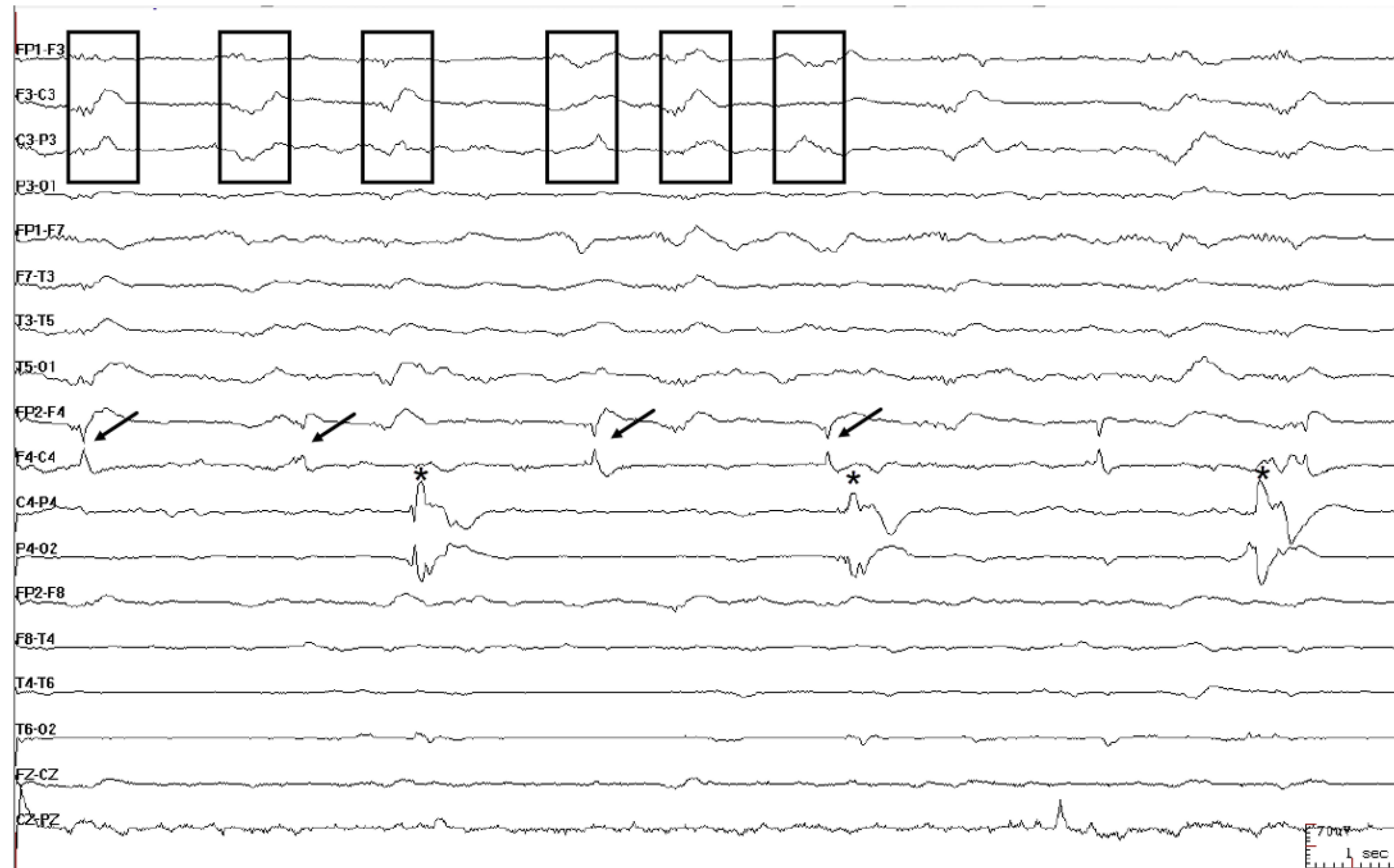
- **Multifocal (Mf):** at least three independent lateralized patterns, with at least one in each hemisphere, with all three or more patterns occurring simultaneously unilateral

FIG. 19. Multifocal Periodic Discharges (MfPDs). In MfPDs, periodic discharges occur in three independent locations simultaneously with at least one in each hemisphere. If all three populations occurred within a single hemisphere this would remain UIPDs.

Multifocal Periodic Discharges (MfPDs)



FIG. 19. Multifocal Periodic Discharges (MfPDs). In MfPDs, periodic discharges occur in three independent locations simultaneously with at least one in each hemisphere. If all three populations occurred within a single hemisphere this would remain UIPDs.



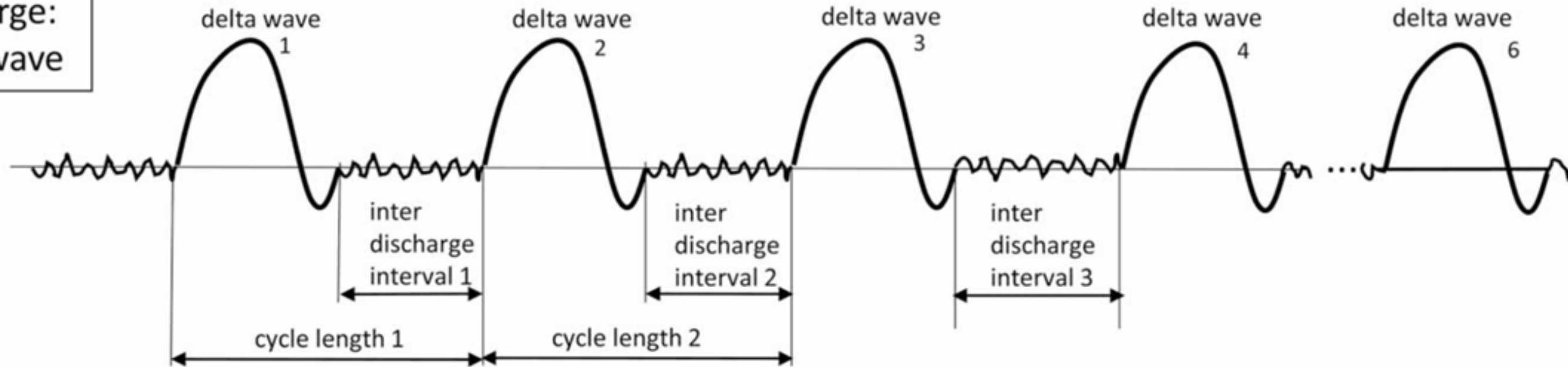
Three independent lateralized periodic patterns occurring at the same time, with at least one in each hemisphere (2 on the right and 1 on the left). Blunt PDs left fronto-central at 0.75 Hz (boxes), sharp PDs at F4 at 0.33 Hz (arrows) and spiky PDs at P4 at 0.2-0.25 Hz (asterisks)

Main term 2: **PDs**, RDA or SW

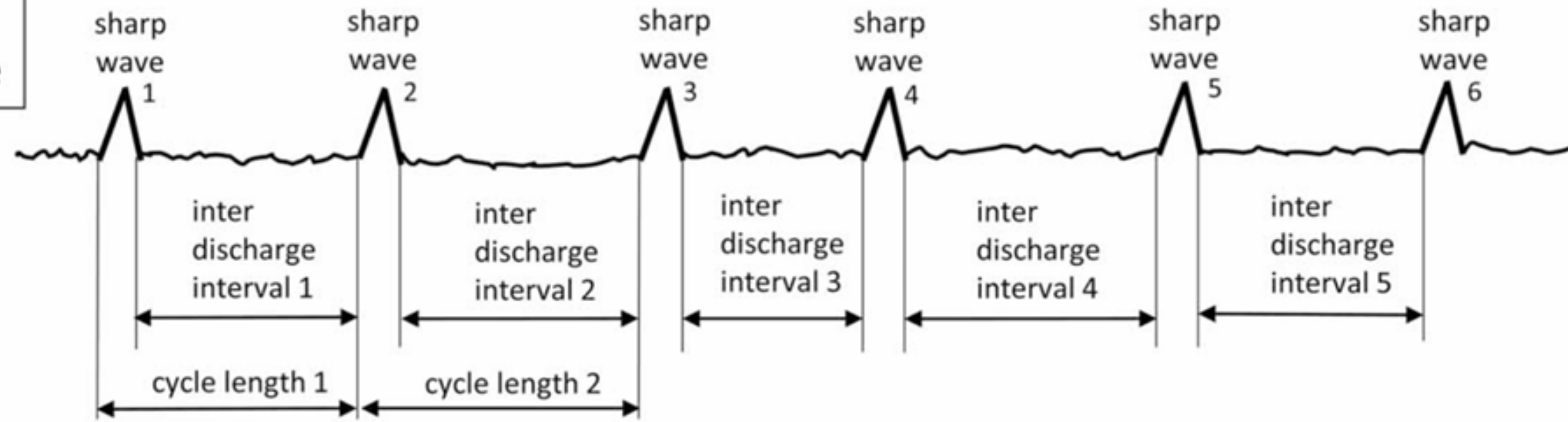
- **Periodic Discharges (PDs):**
 - Periodic: Repetition of a waveform with relatively uniform morphology and duration with a clearly discernible inter discharge interval between consecutive waveforms and recurrence of the waveform at nearly regular intervals. “Nearly regular intervals” is defined as having a cycle length (i.e., period) varying by $< 50\%$ from one cycle to the next in most ($>50\%$) cycle pairs.
 - Discharges: Waveforms lasting < 0.5 seconds, regardless of number of phases, or waveforms ≥ 0.5 seconds with no more than 3 phases. This is as opposed to Bursts, defined as waveforms lasting ≥ 0.5 seconds and having at least 4 phases. Discharges and bursts must clearly stand out from the background activity.

Main term 2: **PDs**, RDA or SW

Discharge:
delta wave



Discharge:
sharp wave



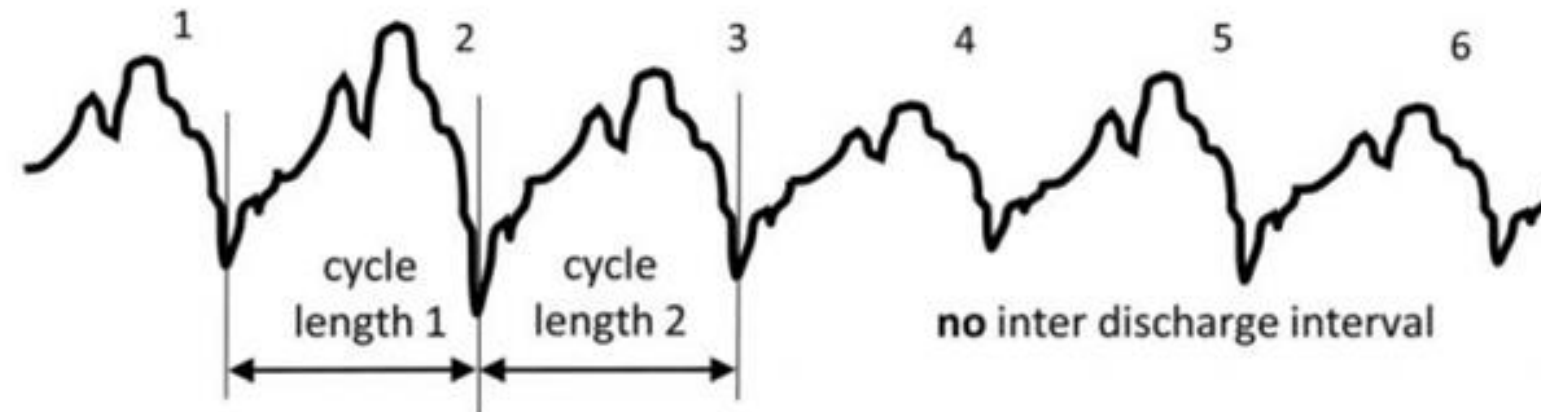
Main term 2: PDs, **RDA** or SW

- **Rhythmic Delta Activity (RDA):**

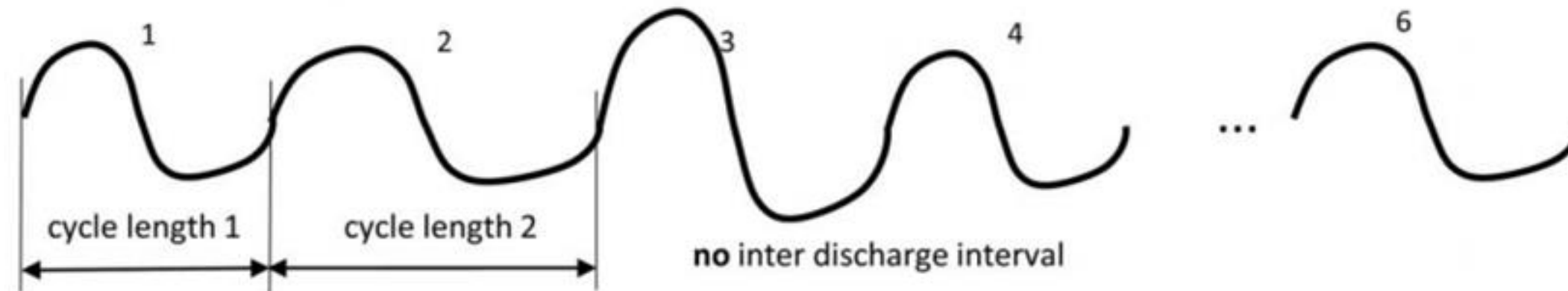
- Rhythmic: Repetition of a waveform with relatively uniform morphology and duration and without an interval between consecutive waveforms. The duration of one cycle (i.e., the period) of the rhythmic pattern should vary by <50% from the duration of the subsequent cycle for most (>50%) cycle pairs to qualify as rhythmic.
- Irregular or polymorphic delta should not be reported as RDA.
- RDA: Rhythmic activity 0.5 to $\leq$ 4.0 Hz.

Main term 2: PDs, **RDA** or SW

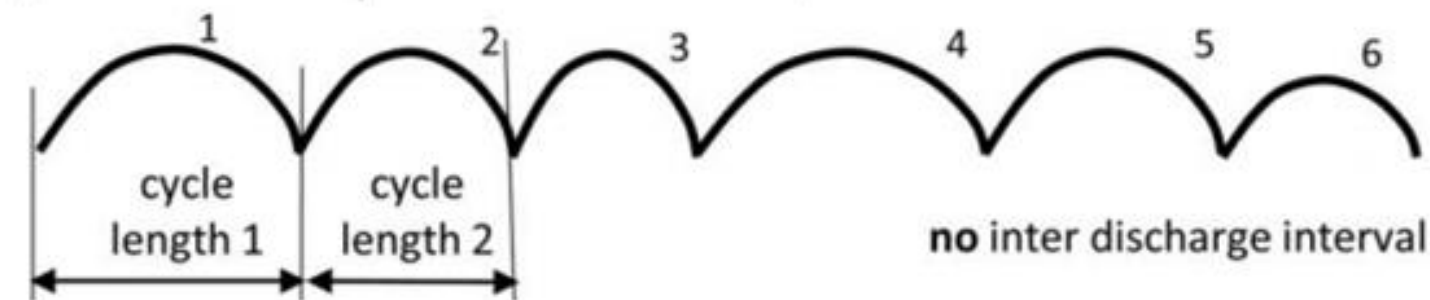
complex
delta wave



sinusoidal
delta wave



arciform
delta wave

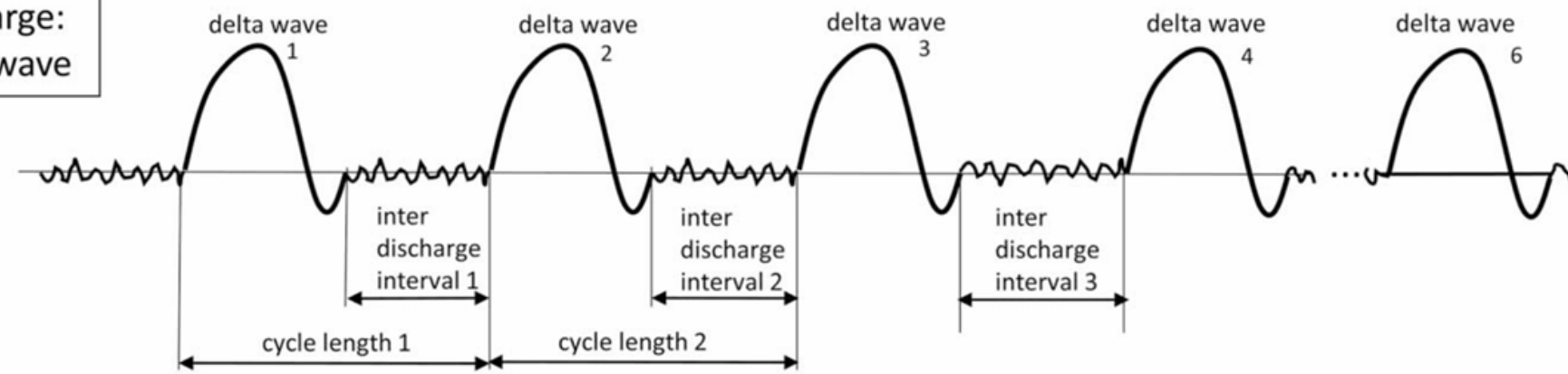


NOT
RHYTHMIC

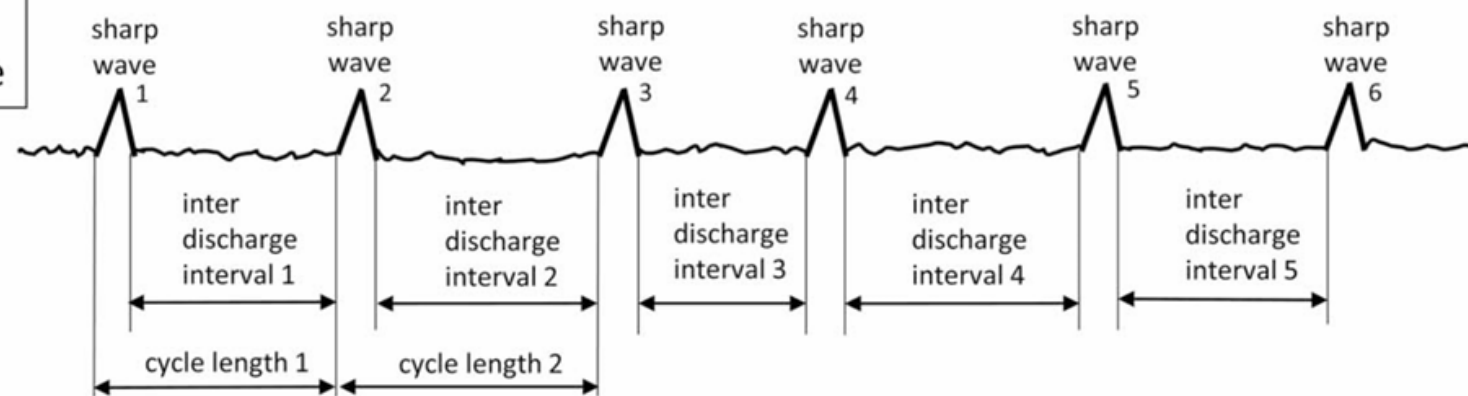


PD

Discharge:
delta wave



Discharge:
sharp wave



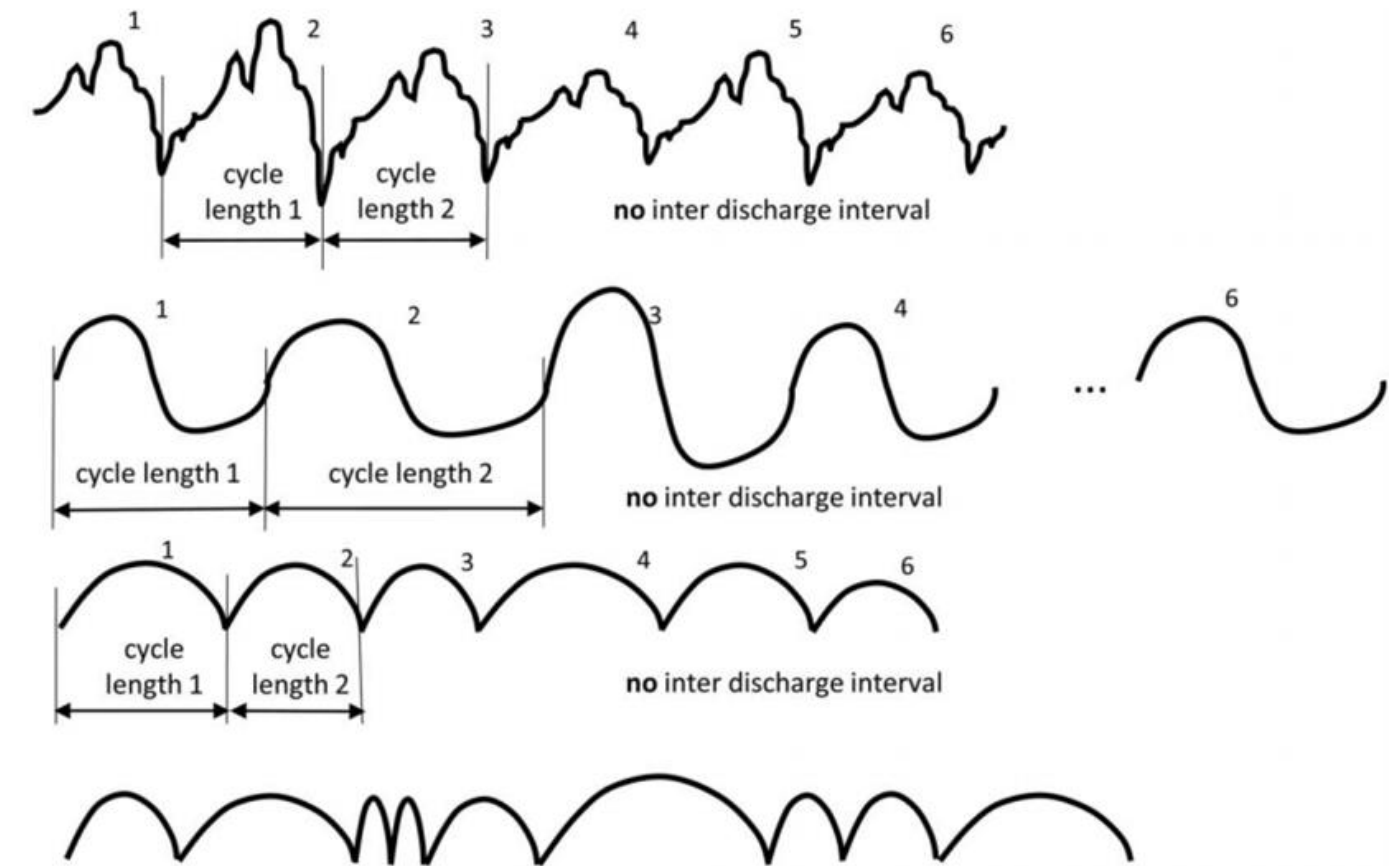
complex
delta wave

sinusoidal
delta wave

arciform
delta wave

NOT
RHYTHMIC

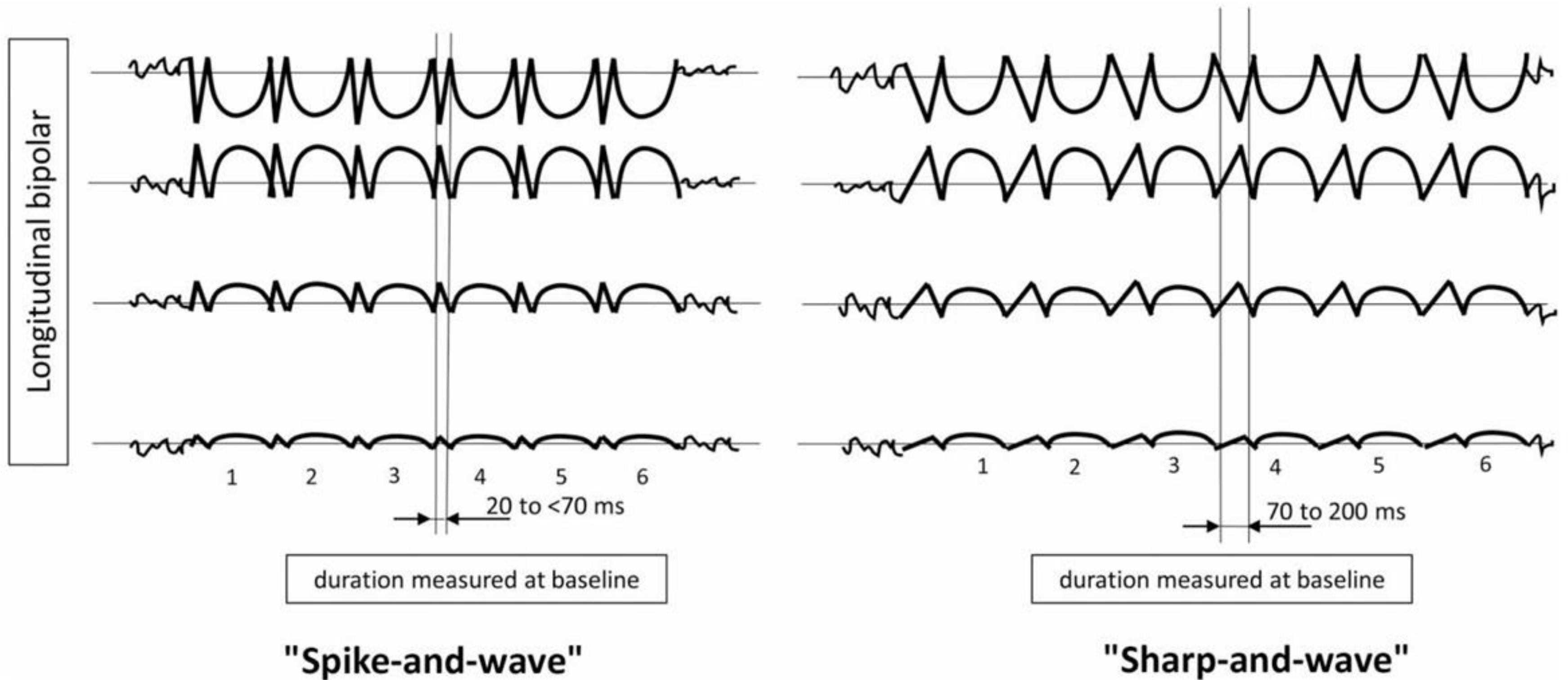
RDA



Main term 2: PDs, RDA or **SW**

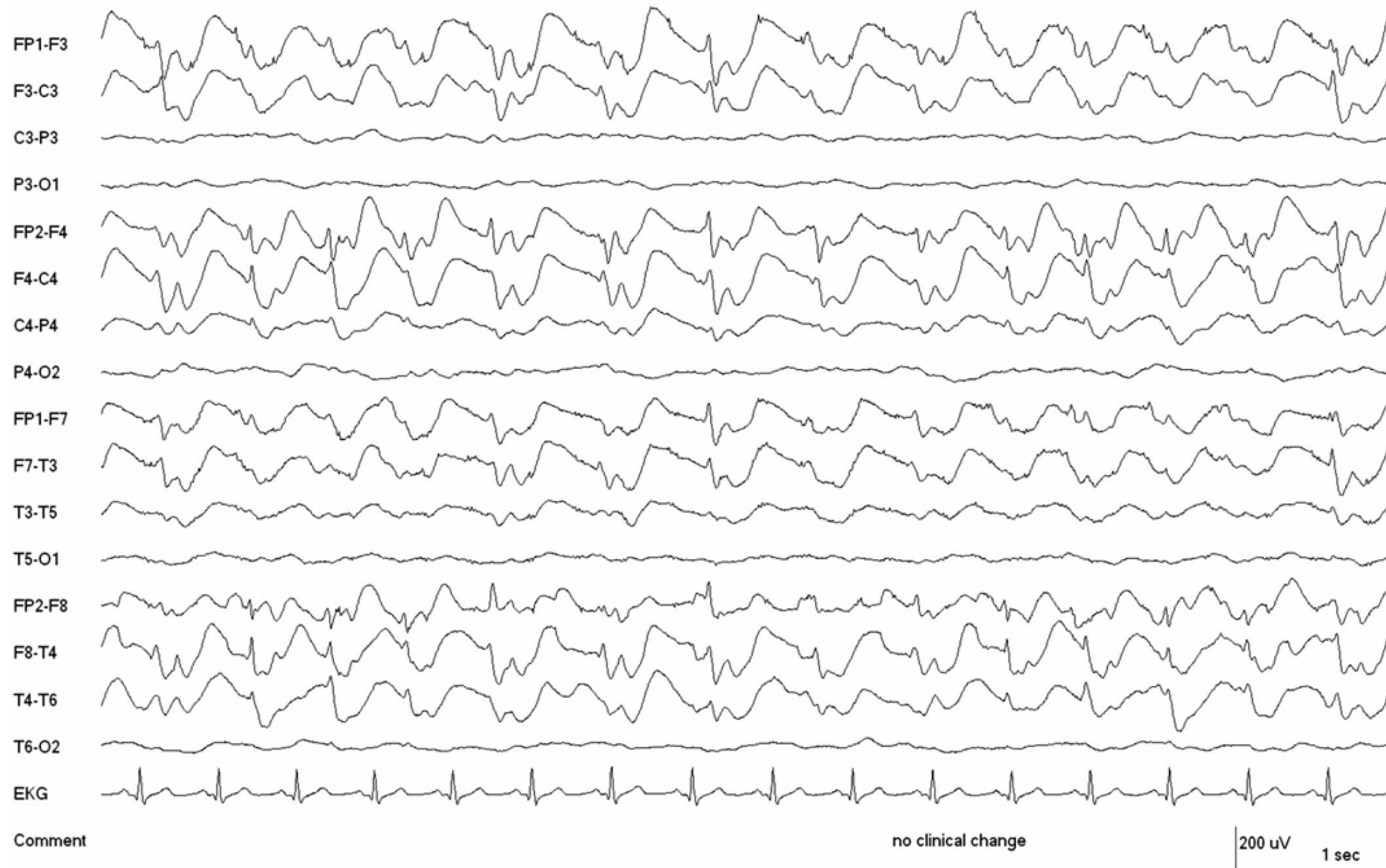
- **Spike-and-wave or Sharp-and-wave (SW):**
 - Spike, polyspike, or sharp wave consistently followed by a slow wave in a regularly repeating and alternating pattern (spike-wave spike-wave-spike-wave), with a consistent relationship between the spike (or polyspike or sharp wave) component and the slow wave for at least six consecutive cycles and with no interval between one spike-wave complex and the next

Main term 2: PDs, RDA or **SW**



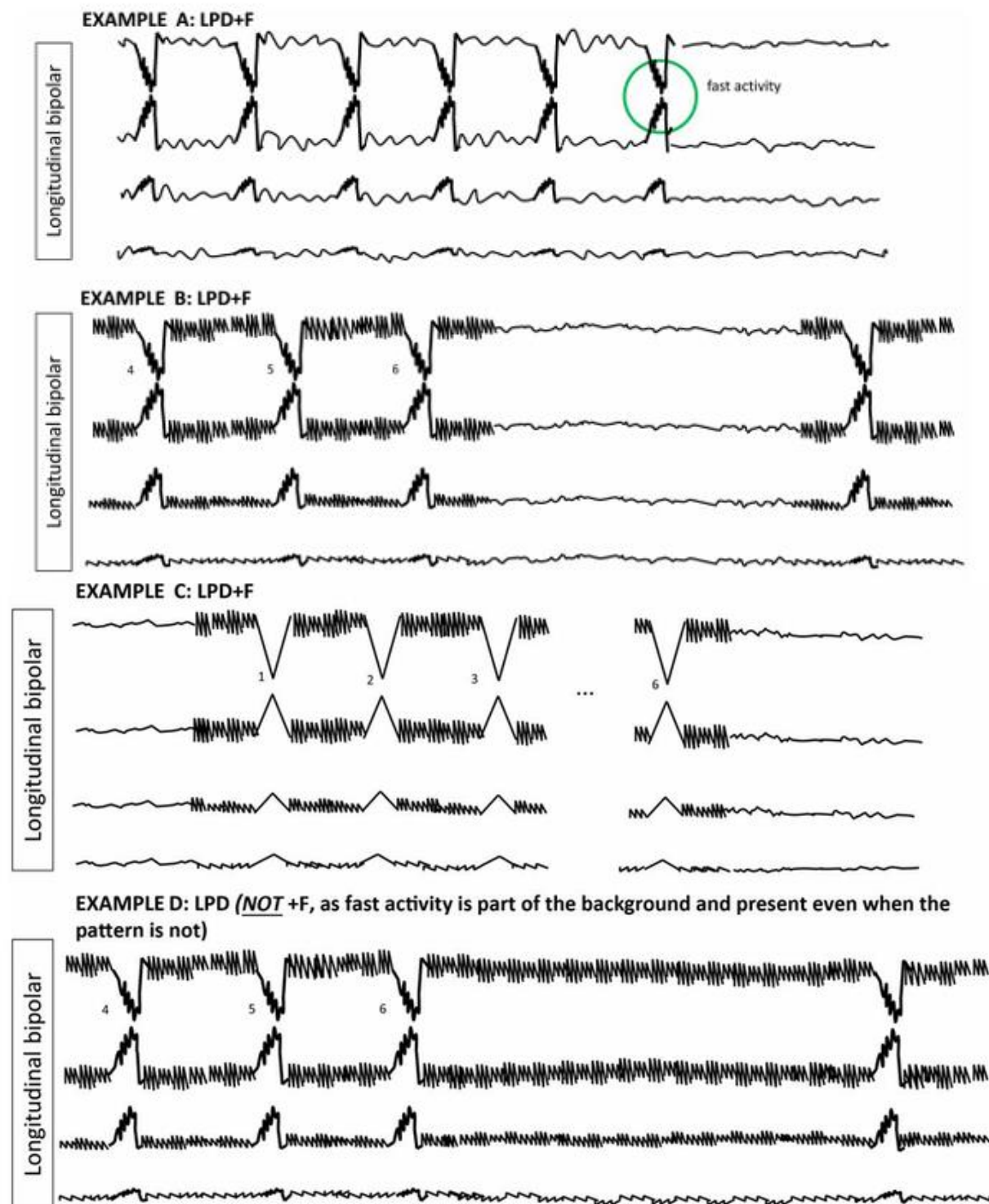
no interval between one spike-wave complex and the next (if there is an interval, this would qualify as PDs, where each discharge is a spike-and-wave).

Generalized Spike-and Wave (GSW)



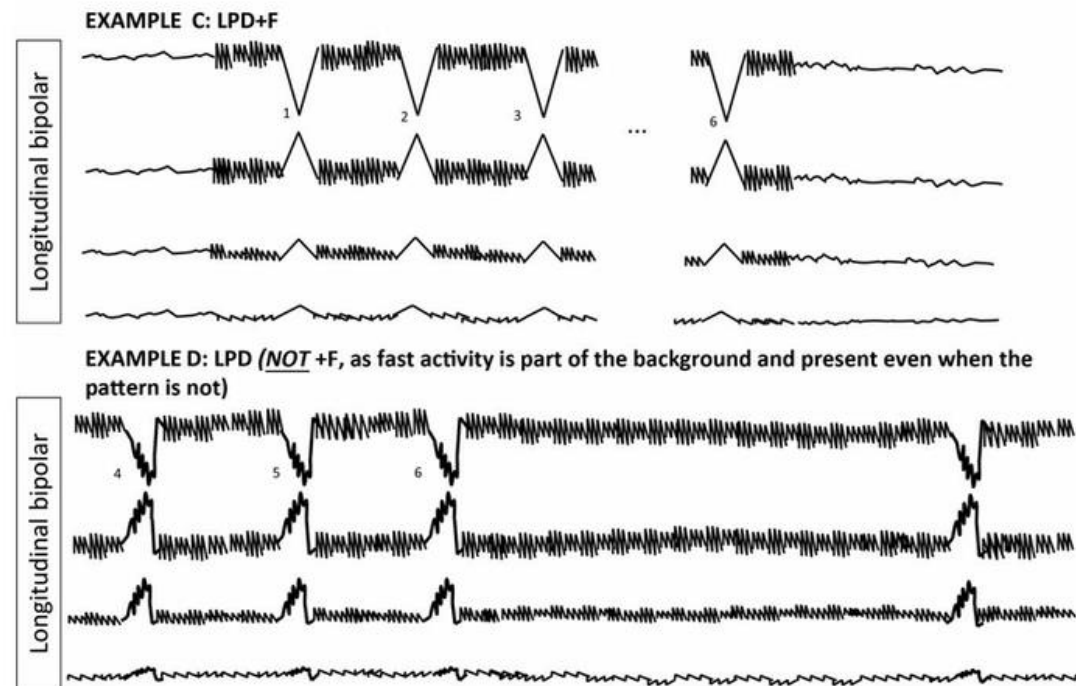
Main term 3: **+F**, +R, +S, +FS, or +FR

additional feature which renders the pattern more ictal-appearing (i.e., more closely resembling an EEG pattern seen during seizures) than the usual term without the plus. This modifier applies only to PDs and RDA, **not SW**

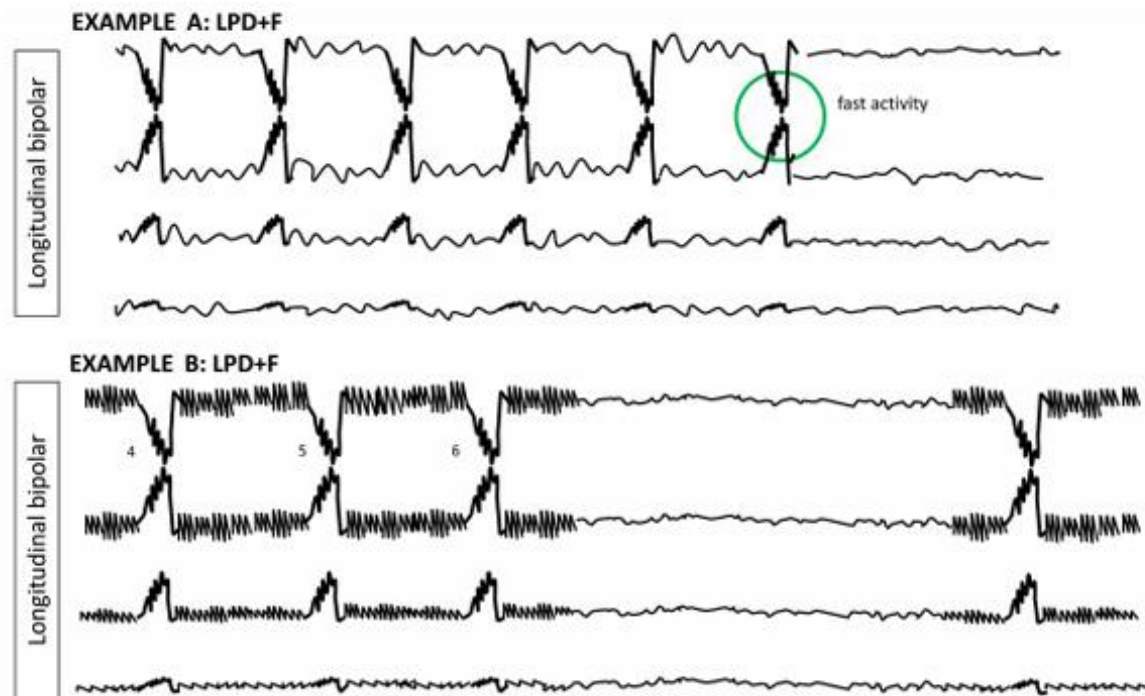


- “**+F**”
 - with superimposed (some prefer the synonyms of admixed or associated) fast activity, defined as theta or faster, whether rhythmic or not. “+F” can be applied to PDs

GPDs+F

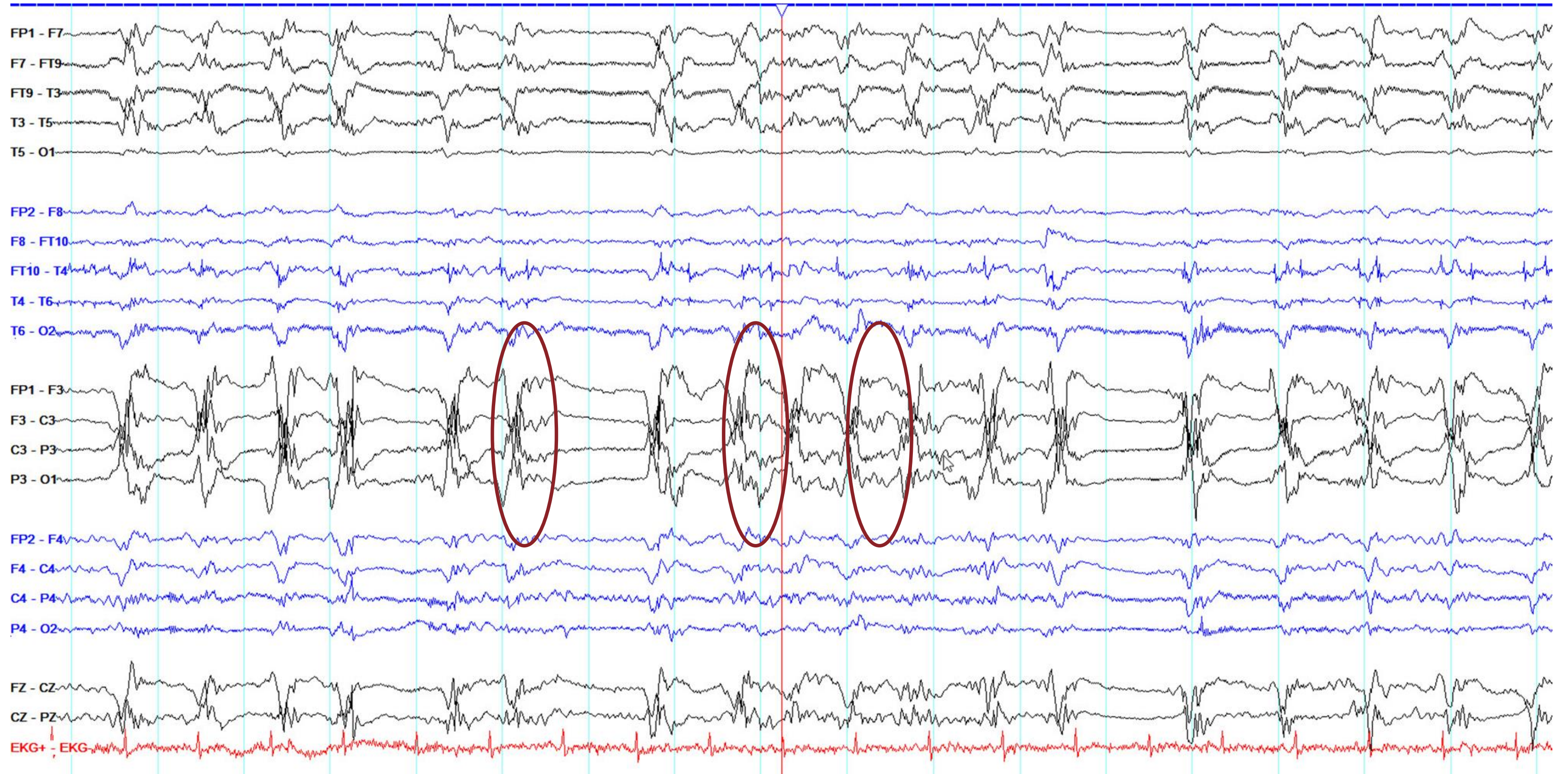


LPDs+F



1-Hz spiky LPDs in the right hemisphere, each associated with a short run of fast activity (ellipses)

Lateralized Periodic Discharges (LPDs) + F



Bilateral Independent Periodic Discharges (BIPDs) + F



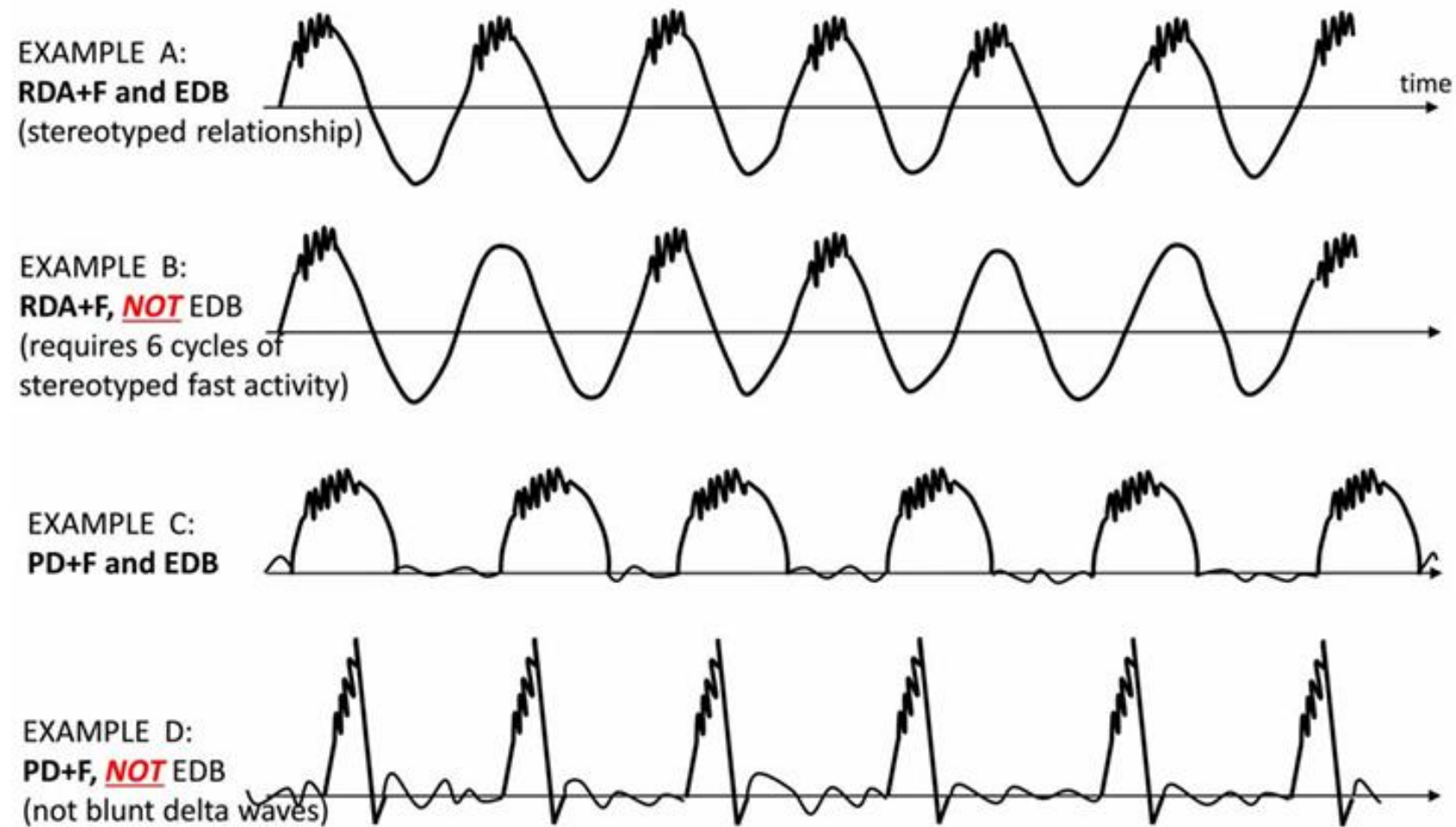
Main term 3: +F, +R, +FS, or +FR

TABLE 2. Relationship between RDA+F, PDs+F and Extreme Delta Brush (EDB)

	RDA+F; or PDs+F if (and only if) the PDs are blunt delta waves	
	Continuous/ Abundant (≥50% of record/epoch)	Frequent/ Occasional (≥1 to 49% of record/epoch)
Fast activity WITH stereotyped relationship to delta wave	Definite EDB	Possible EDB
Fast activity WITHOUT stereotyped relationship to delta wave	Possible EDB	RDA+F or PDs+F, but NOT EDB

- “Extreme delta brush (EDB)”
 - A specific subtype of +F

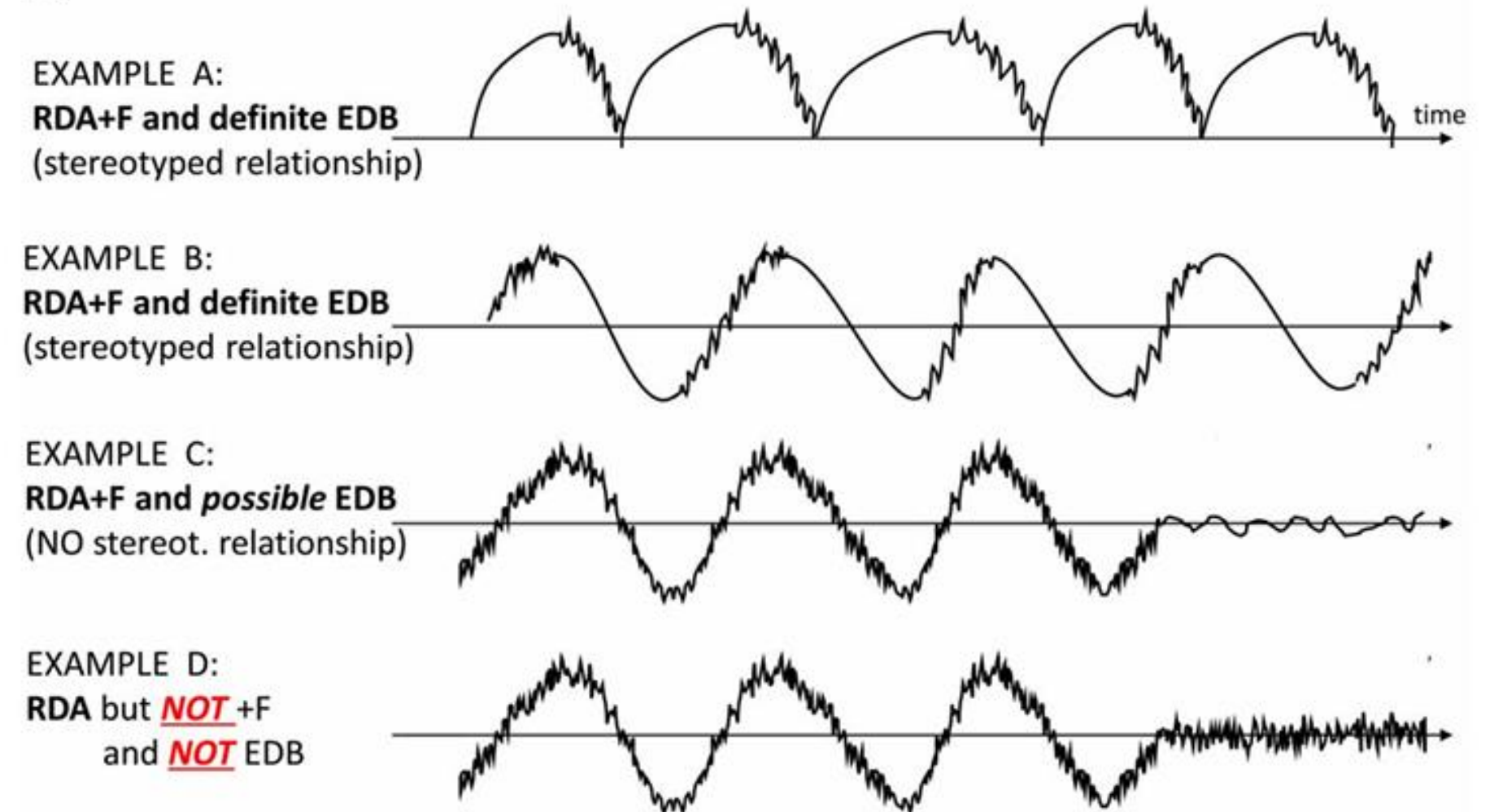
A



A. This is a subset of 1F, with abundant or continuous RDA+F or PDs+F (only if the PDs are blunt delta waves), where the fast activity has a stereotyped relationship to each delta wave.

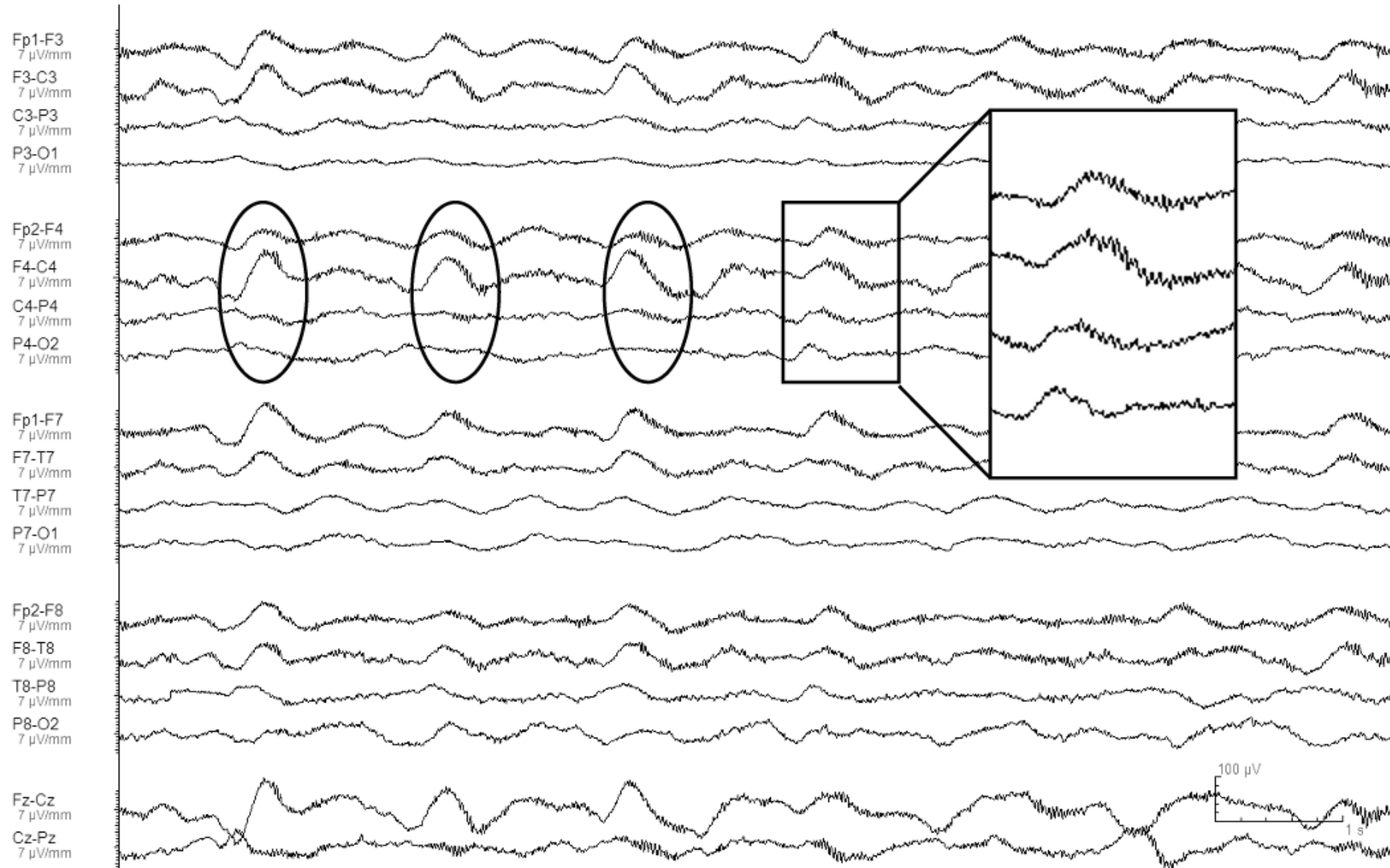
Extreme Delta Brush (EDB)

B

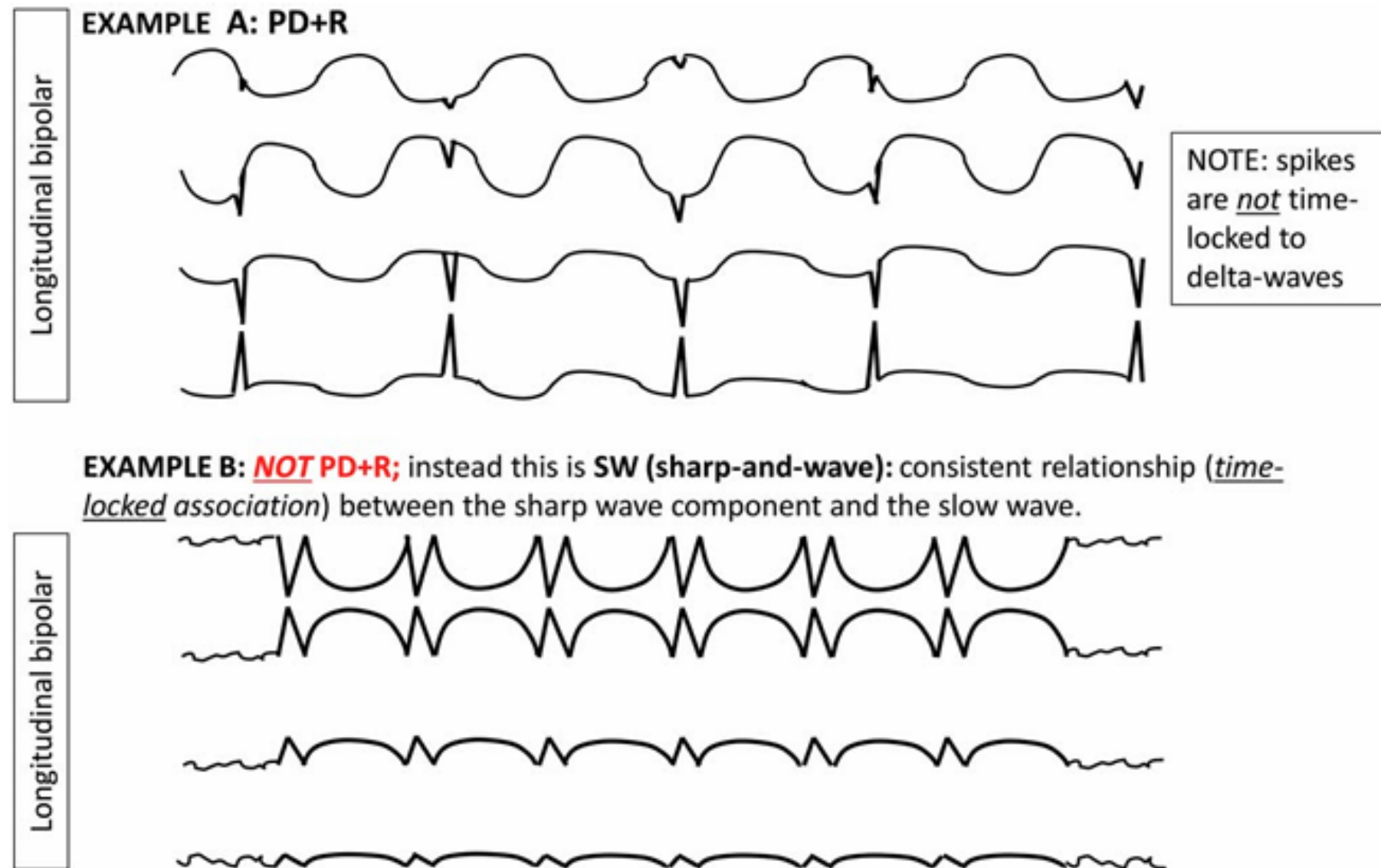


B. Extreme delta brush (EDB): RDA subtype. Examples of RDA that meet criteria for definite and possible EDB (A-C); with an example that does not (D), as the fast activity is part of the background (therefore this pattern does not count as RDA1F).

Extreme Delta Brush (EDB)



Main term 3: +F, **+R**, +S, +FS, or +FR



- “+R”
 - with superimposed rhythmic or quasi-rhythmic delta activity;
 - can be applied to **PDs only**

FIG. 32. Periodic Discharges PLUS RDA (PDs+R). RDA occurring at the same time as PDs but *without* time-locked association with the PDs would qualify as PDs+R.

Main term 3: +F, +R, **+S**, +FS, or +FR

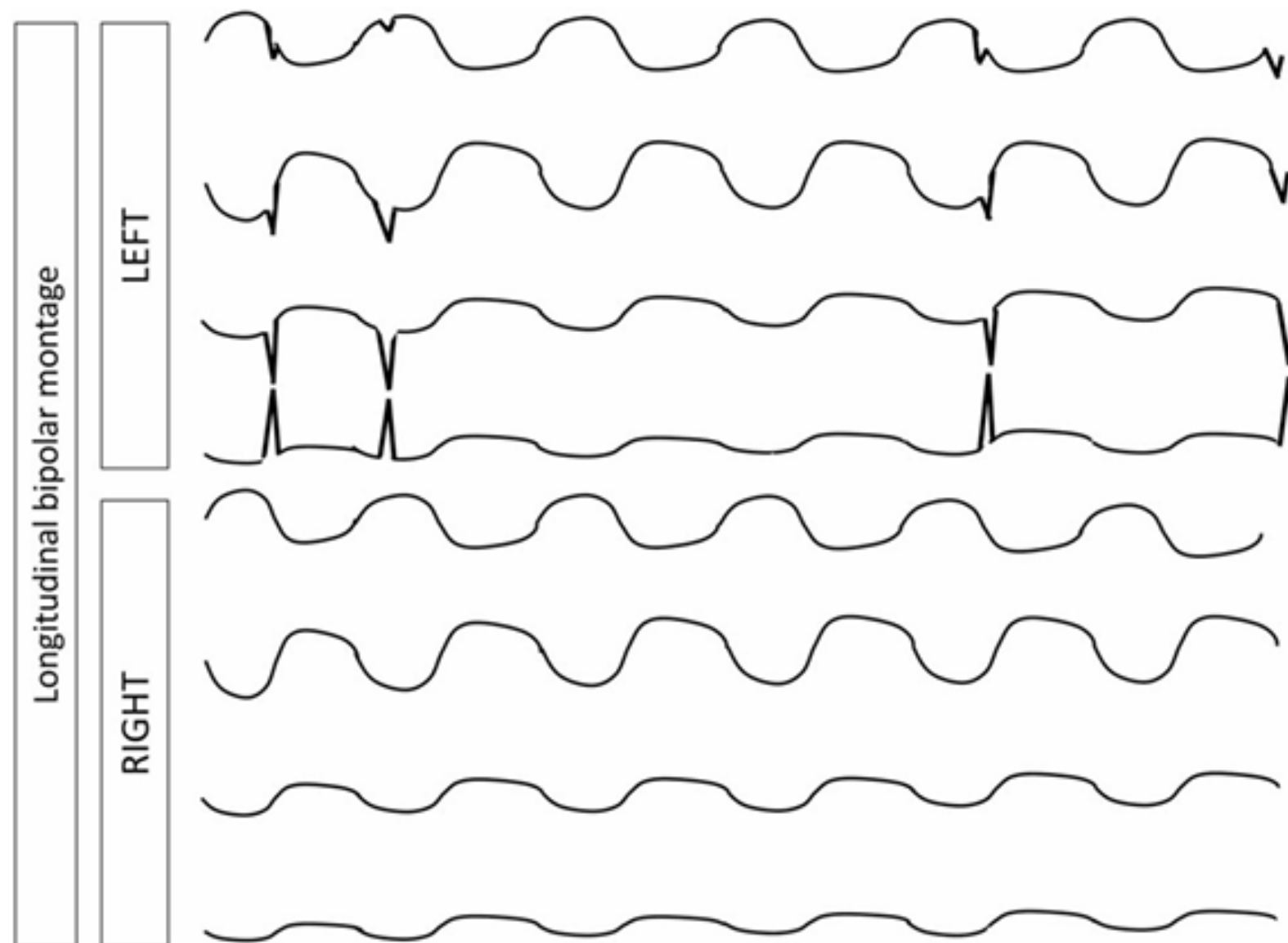
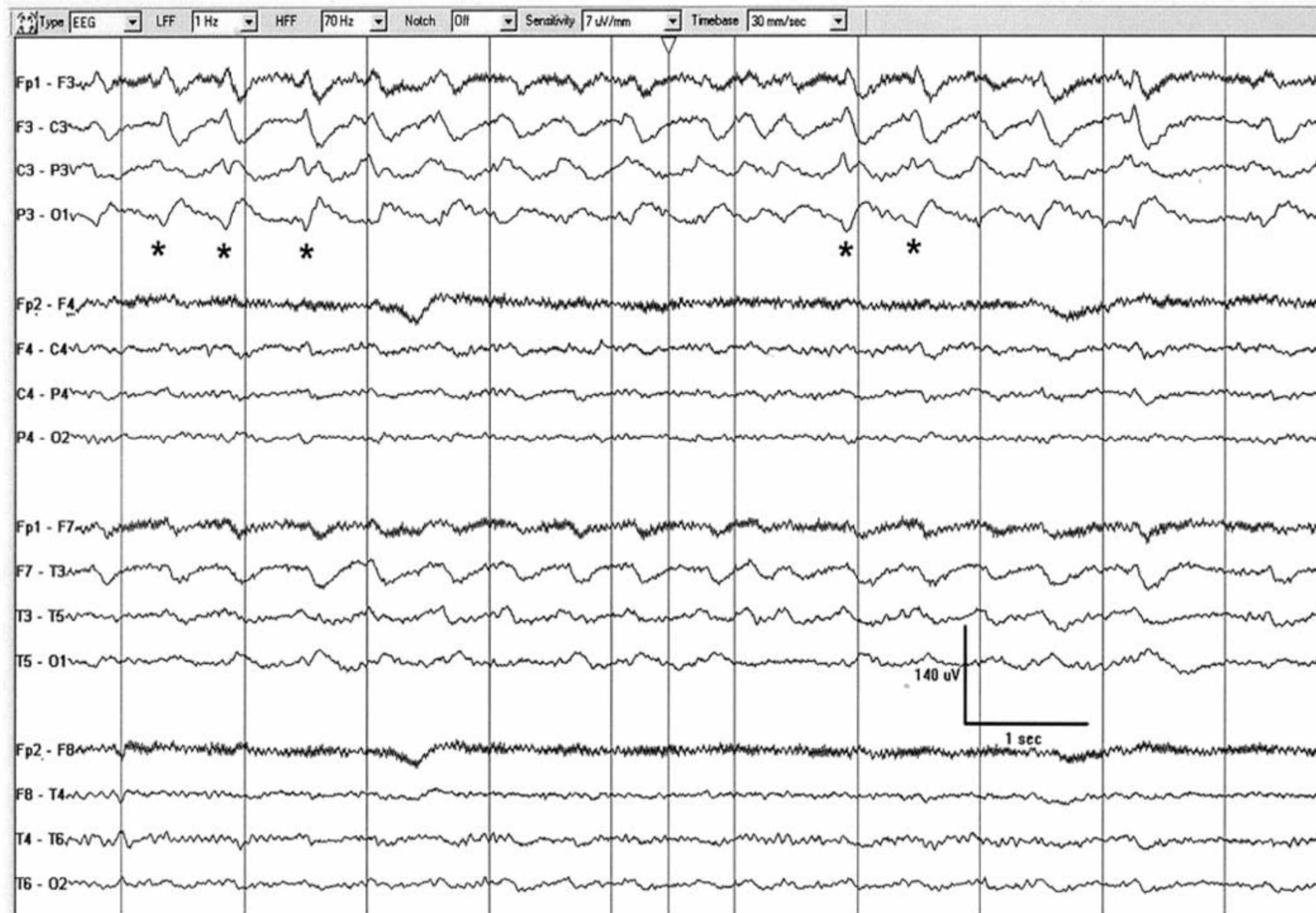


FIG. 33. Generalized Rhythmic Delta Activity PLUS Spikes (GRDA+S). Generalized rhythmic delta activity with associated spikes in one hemisphere only (RDA on one side and synchronous RDA +S on the other) would still qualify as GRDA+S.

- “+S”
 - with associated sharp waves or spikes, or sharply contoured;
 - can be applied to **RDA only**
 - The sharp contour, sharp waves, or spikes need to occur at least once every 10 seconds but not as part of an SW pattern

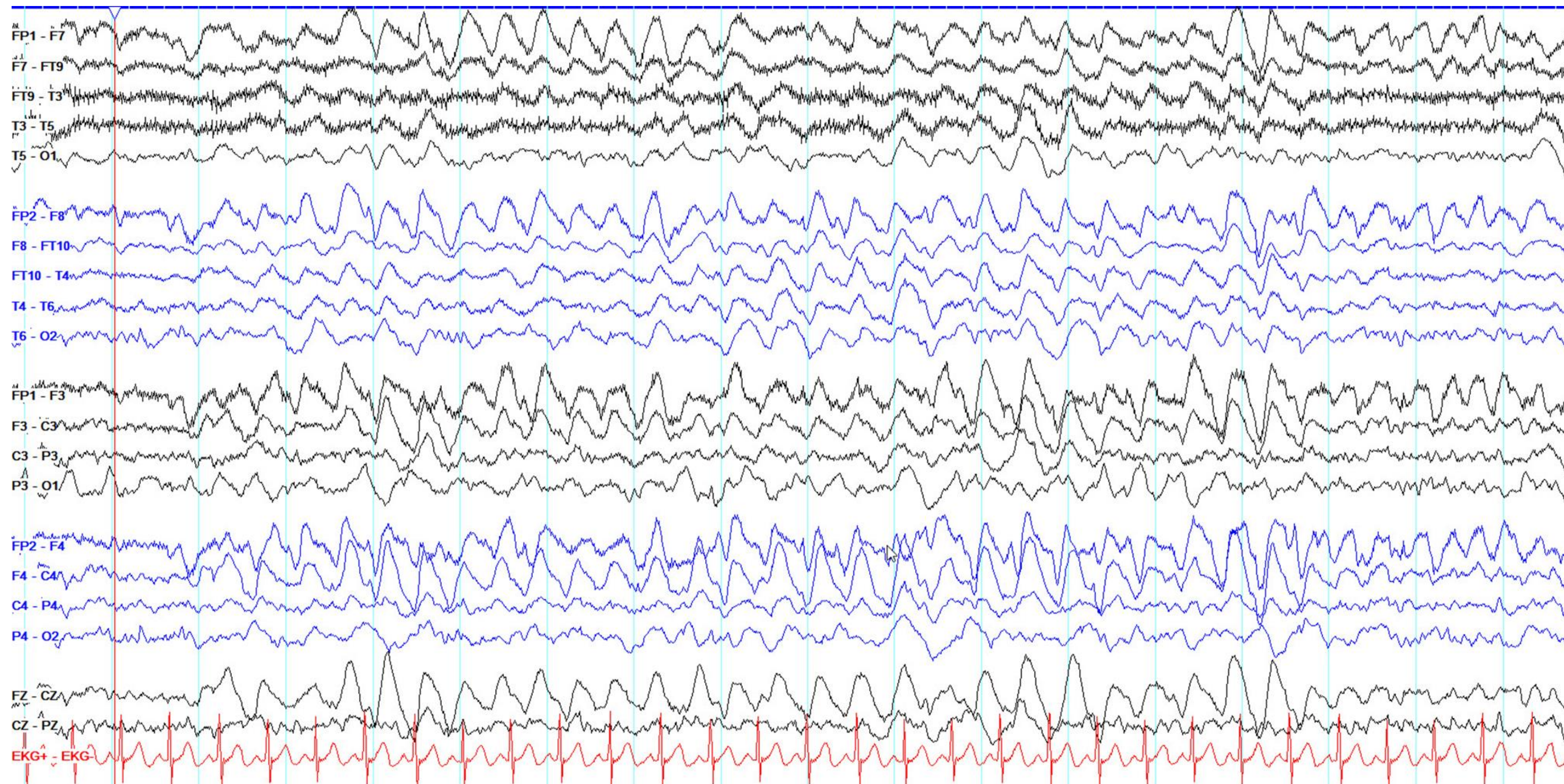
It is possible to have “+FR” for PDs or “+FS” for RDA.

LRDA+S



2-Hz LRDA with superimposed repetitive sharp waves (several marked with asterisks) (LRDA+S). The superimposed low amplitude fast activity is also present on the right hemisphere and should not be recorded as +F.

LRDA+S



LRDA+S





THE ICTAL-INTERICTAL CONTINUUM (IIC)

This term is synonymous with “possible ESz” or “possible electrographic SE.”

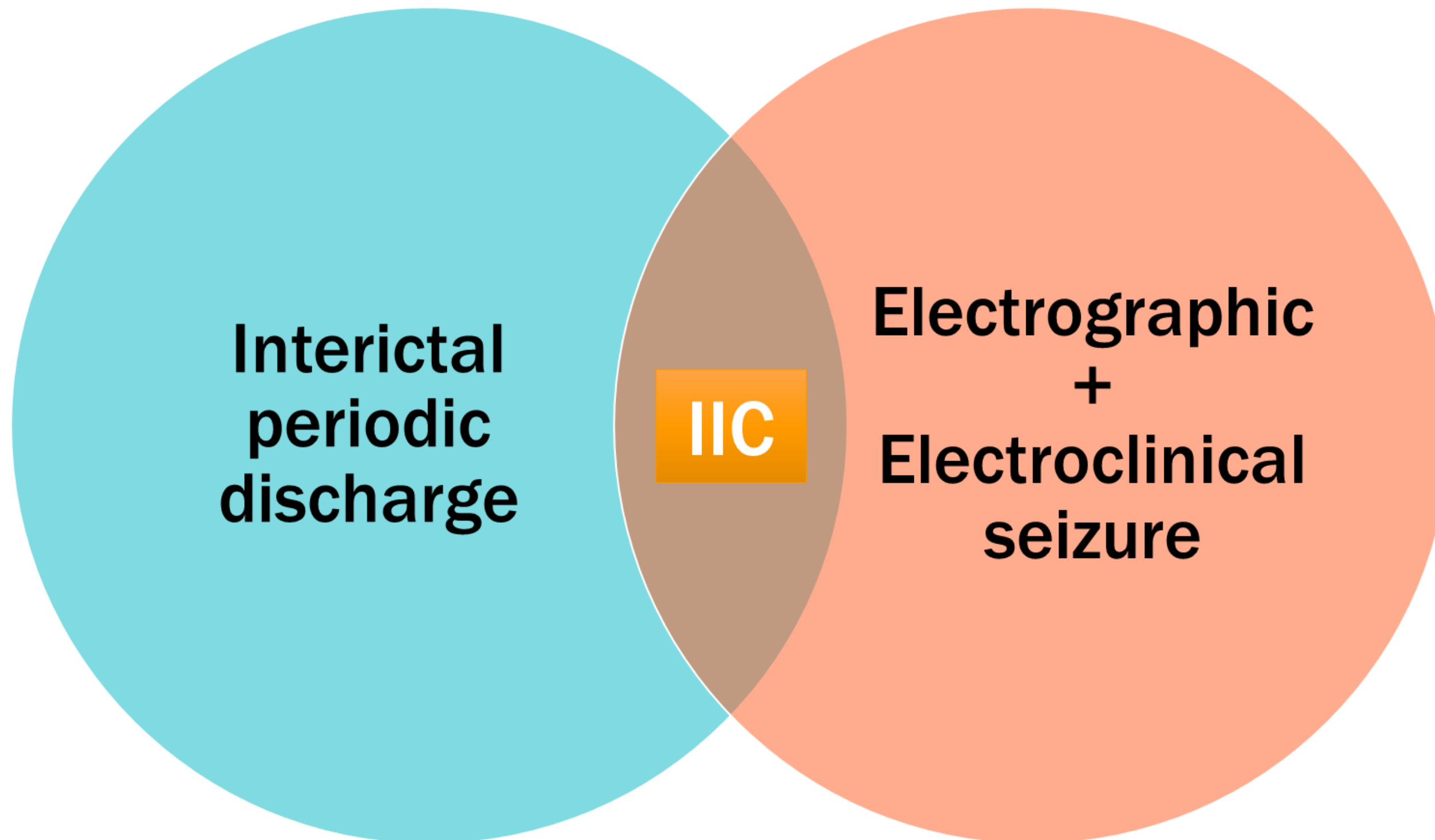
The IIC is a purely electrographic term that is not a diagnosis

It requires careful interpretation in the full clinical context



ICTAL-INTERICTAL CONTINUUM: IIC

The borderland between ictal and interictal



ICTAL-INTERICTAL CONTINUUM: IIC

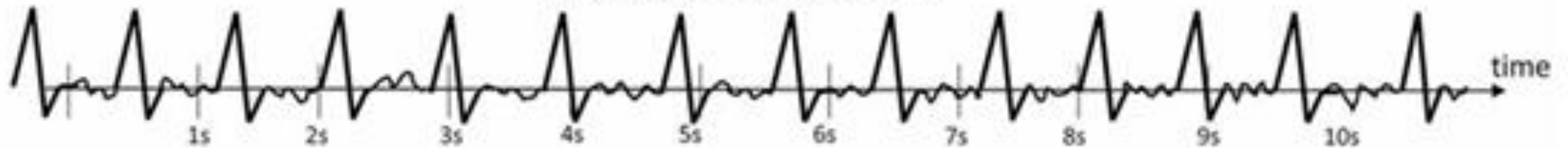
- Any PD or SW pattern that averages > 1.0 and ≤ 2.5 Hz over 10 seconds (>10 and ≤ 25 discharges in 10 seconds)

A

Epileptiform discharges > 1.0 Hz and ≤ 2.5 Hz over 10 s (>10 and ≤ 25 ED in 10 s)

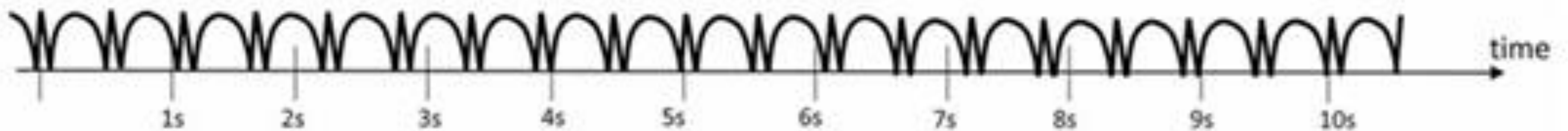
PD

Example: 12 EDs per 10 s



SW

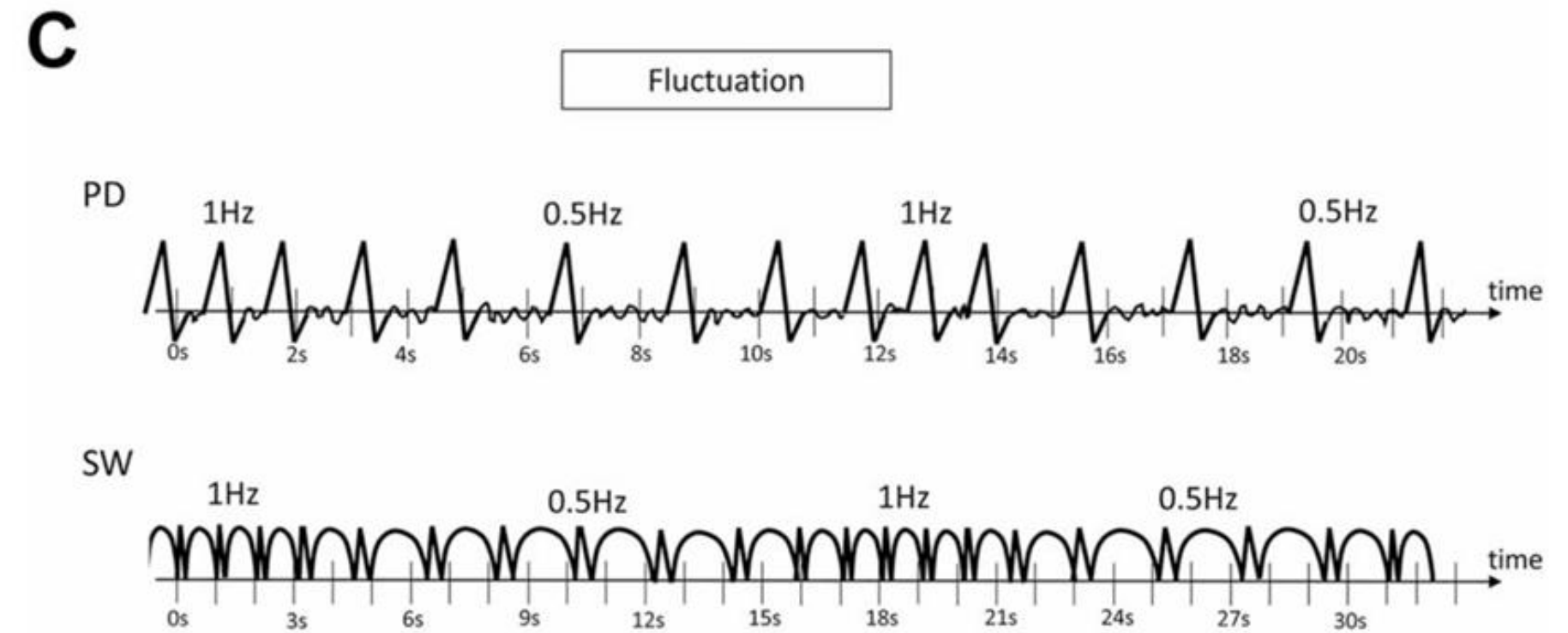
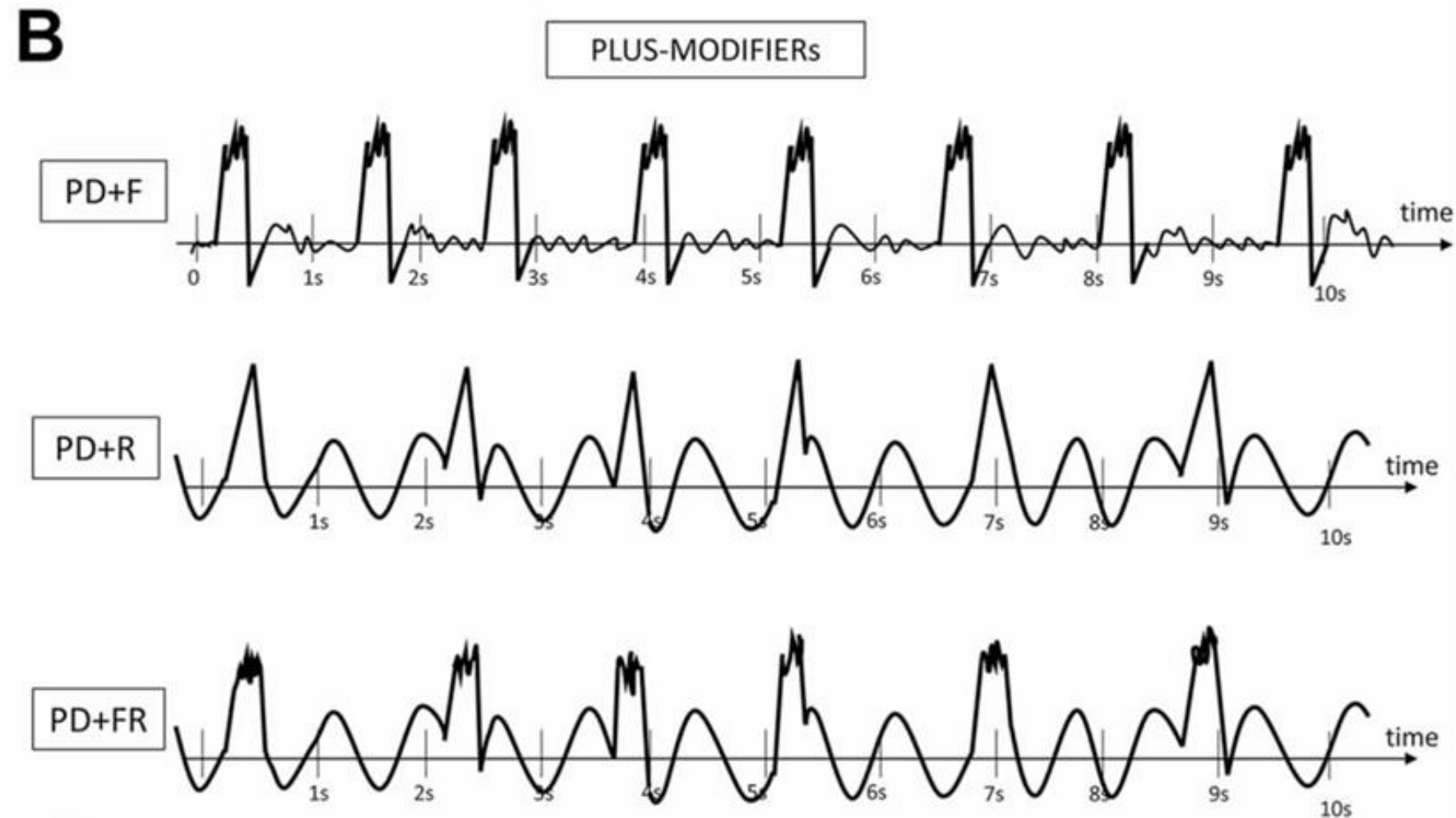
Example: 18 EDs per 10 s



OR

ICTAL-INTERICTAL CONTINUUM: IIC

- Any PD or SW pattern that averages ≥ 0.5 Hz and ≤ 1.0 Hz over 10 seconds (≥ 5 and ≤ 10 discharges in 10 seconds) and has a plus modifier or fluctuation



ICTAL-INTERICTAL CONTINUUM: IIC

“Possible seizure”

Pattern type	Frequency	Other features
Any periodic discharge (PD) or spike and wave (SW)	1.0-2.5 Hz	
Any periodic discharge (PD) or spike and wave (SW)	0.5-1.0 Hz	Plus features (sharp, fast) or fluctuation
Lateralized rhythmic delta activity (LRDA)	>/= 1 Hz	Plus features (sharp, fast) or fluctuation

“Duration at least 10 seconds”

ICTAL-INTERICTAL CONTINUUM (IIC) – FOCAL



Continuous fluctuating 1.5-2 Hz LPDs+R over the right temporal region. Not >2.5 Hz and therefore not an electrographic seizure, but with a reasonable chance it may be contributing to impaired alertness, causing other clinical symptoms, and/or contributing to neuronal injury.

ICTAL-INTERICTAL CONTINUUM (IIC) – GENERALIZES



The record begins with 1-Hz GPDs. Not qualifying as IIC.

ICTAL-INTERICTAL CONTINUUM (IIC) – GENERALIZES



As the recording continues the EEG begins to change, with GPDs fluctuating between 1 Hz and very briefly up to 1.5 Hz. Now qualifying as a pattern on the IIC

ICTAL-INTERICTAL CONTINUUM (IIC) – GENERALIZES

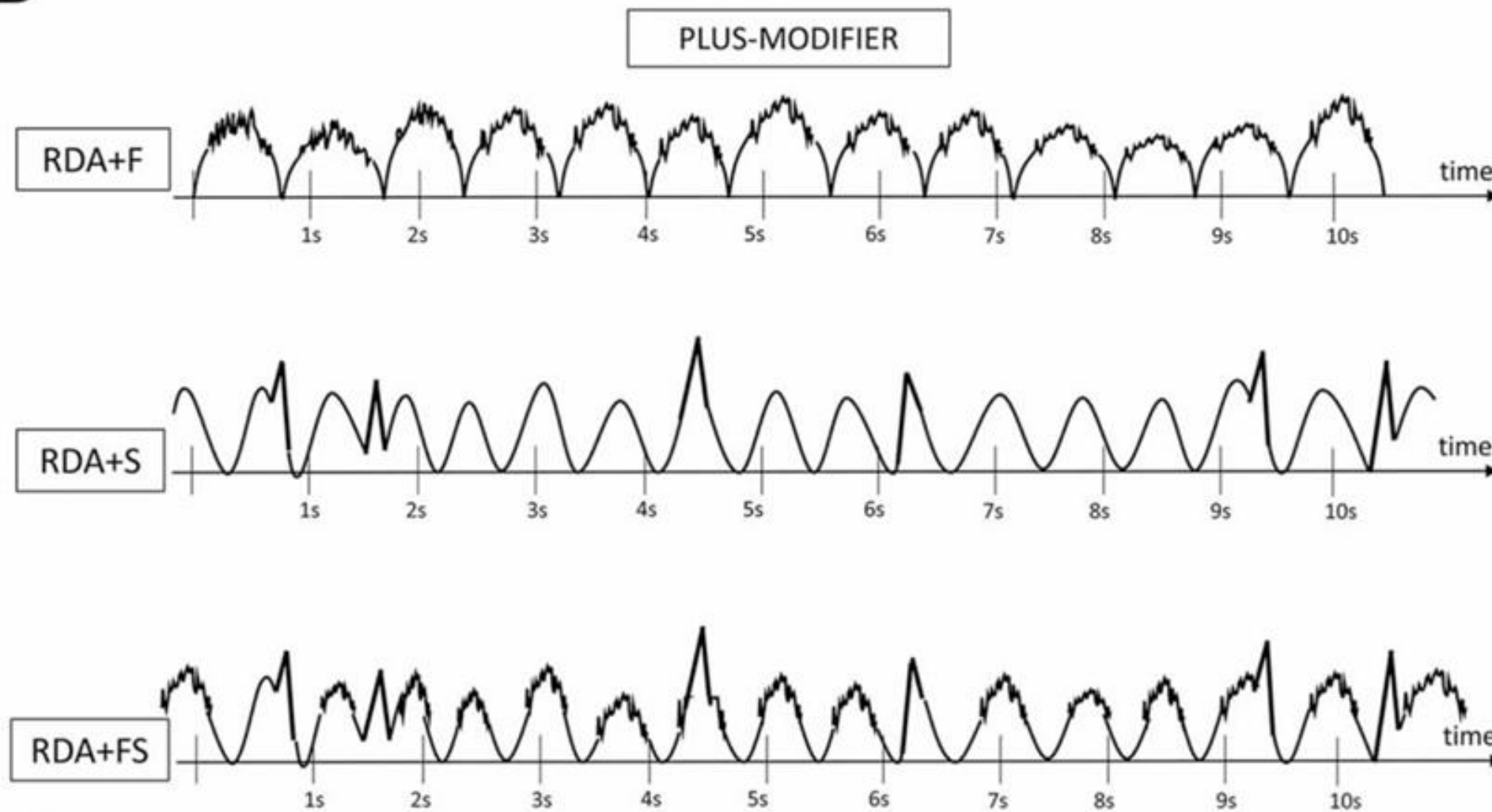


Later in the same record, the GPDs are now occurring between 1.5-2 Hz, and the background EEG has gained intermittent low amplitude fast activity and intermittent rhythmic delta activity (GPD+FR)

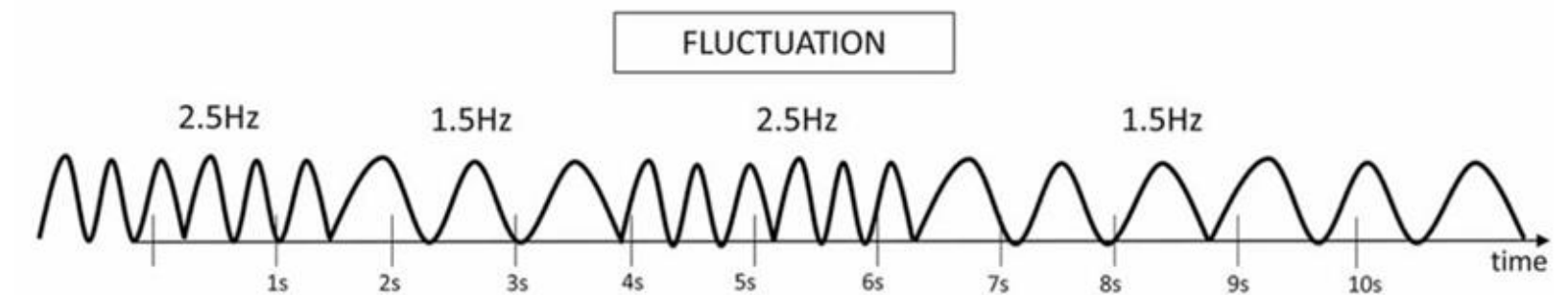
ICTAL-INTERICTAL CONTINUUM: IIC

- Any lateralized RDA averaging >1 Hz for at least 10 seconds (at least 10 waves in 10 seconds) with a plus modifier or fluctuation. This includes any LRDA, BIRDA, UIRDA, and MfRDA, but not GRDA

D



E





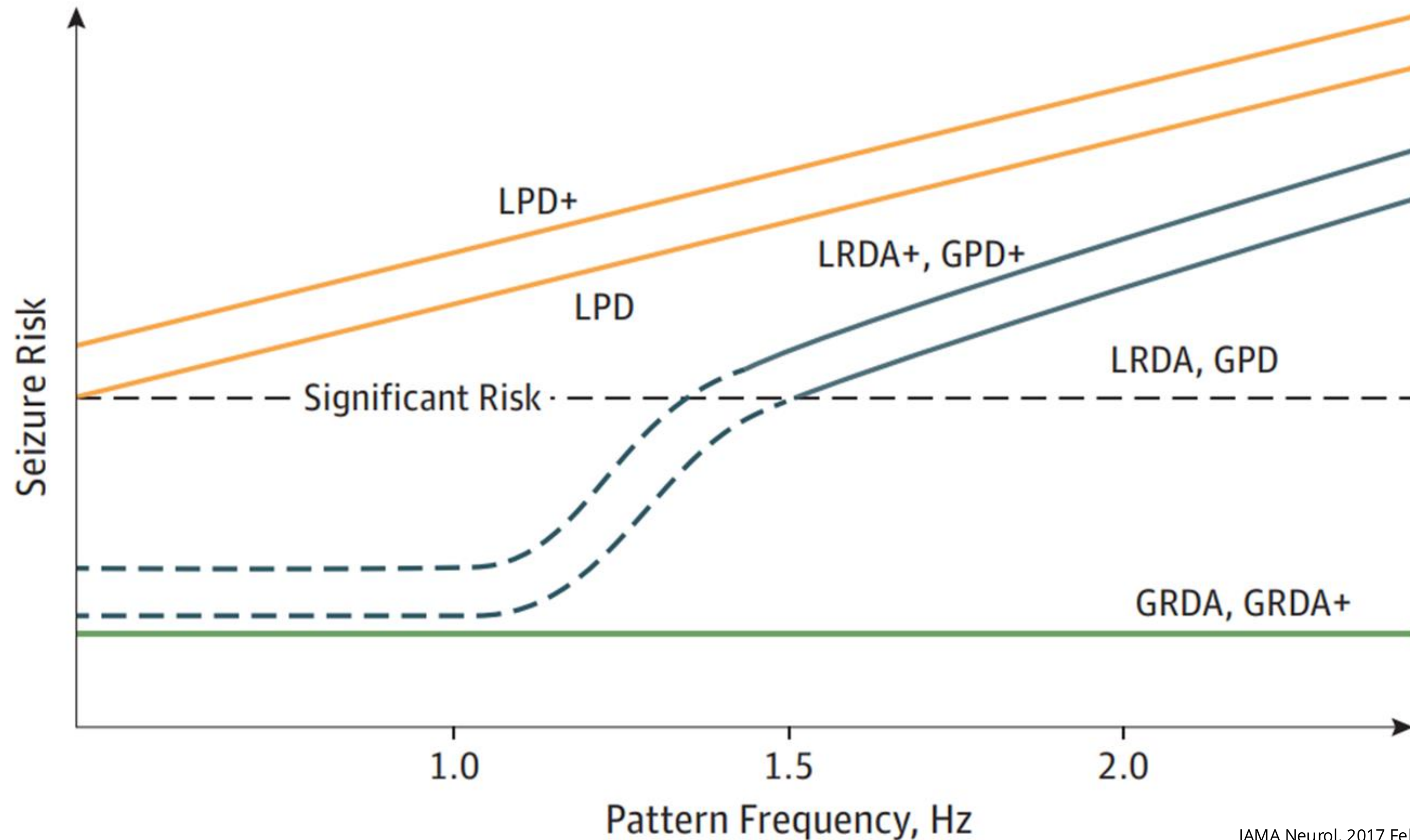
TREATMENT THRESHOLD



TREATMENT THRESHOLD

- Management of IIC patterns involves 2 primary considerations. The first centers on determining whether the pattern reflects an ictal process consistent with nonconvulsive status epilepticus, while the second focuses on identifying treatable or reversible causes of rhythmic or periodic discharges
- Decisions regarding antiseizure therapy must be made within the broader context of the patient's clinical trajectory and comorbidities.
- Confirmation of a positive therapeutic response requires both improvement in the EEG background **and** parallel clinical recovery.
- EEG changes alone cannot establish this determination, since some antiseizure medications can suppress epileptiform activity even in the absence of ongoing seizures.

ASSOCIATION OF RPP WITH RISK OF SEIZURE



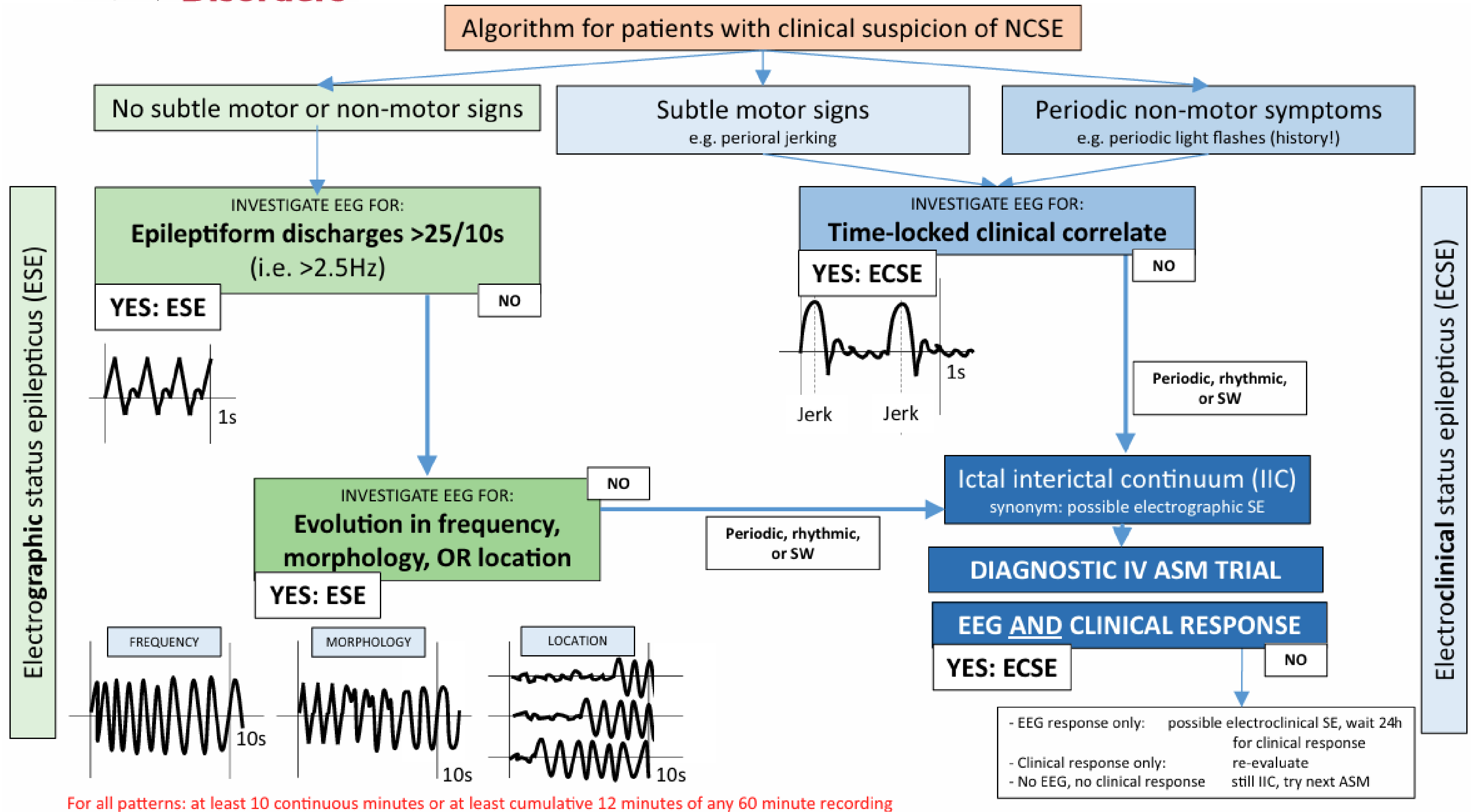


FIGURE 1 Overview over the diagnostic criteria of NCSE for patients without pre-existing epileptic encephalopathy. Modified with permission from Hirsch et al. 2021.⁵⁵



THANK YOU