

Cartoons describing graphoelements and patterns

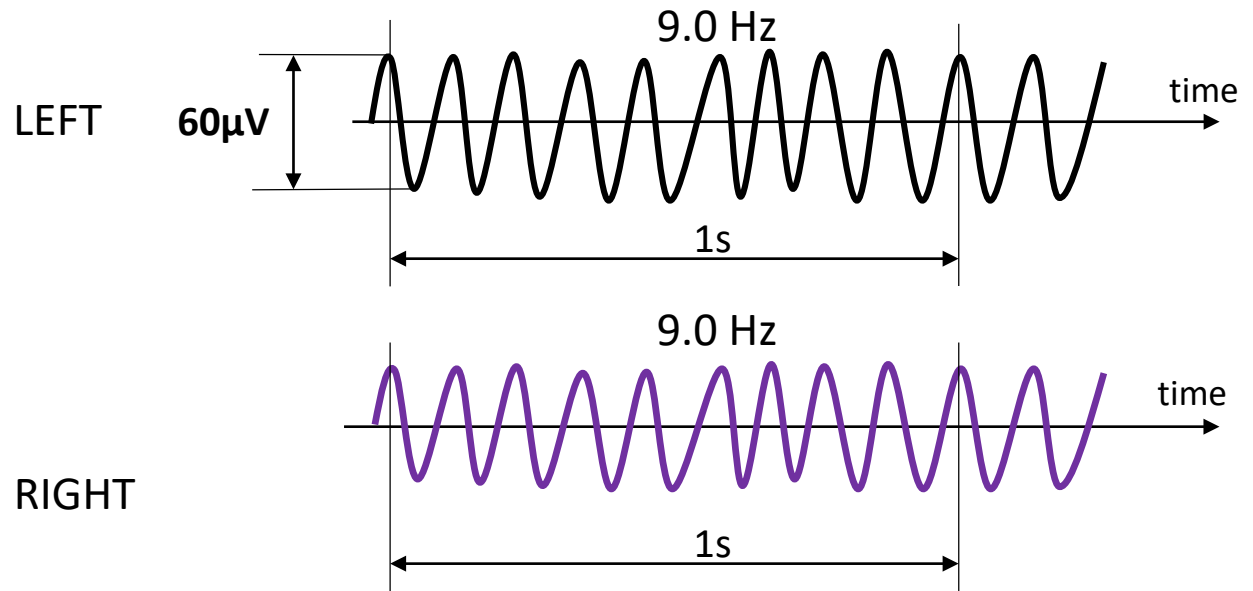
Leitinger M, Fong MWK, Hirsch LJ.

Version 2020-JULY-25



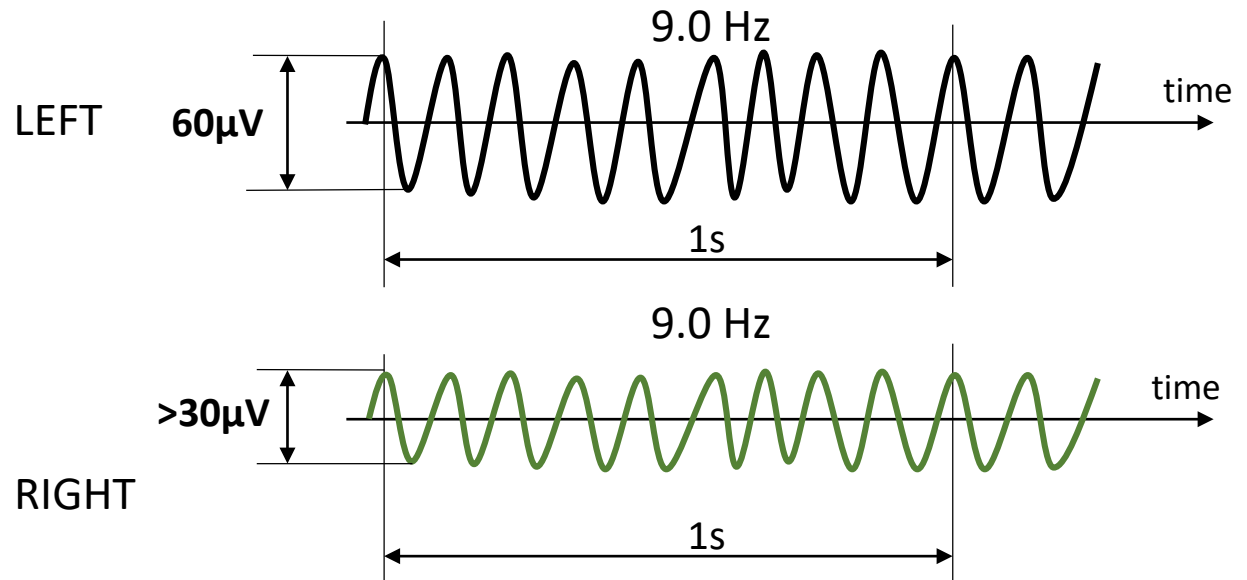
Symmetry – voltage:

Symmetric



Mild asymmetry

Consistent but $<50\%$ voltage difference between sides (on appropriate referential recording).

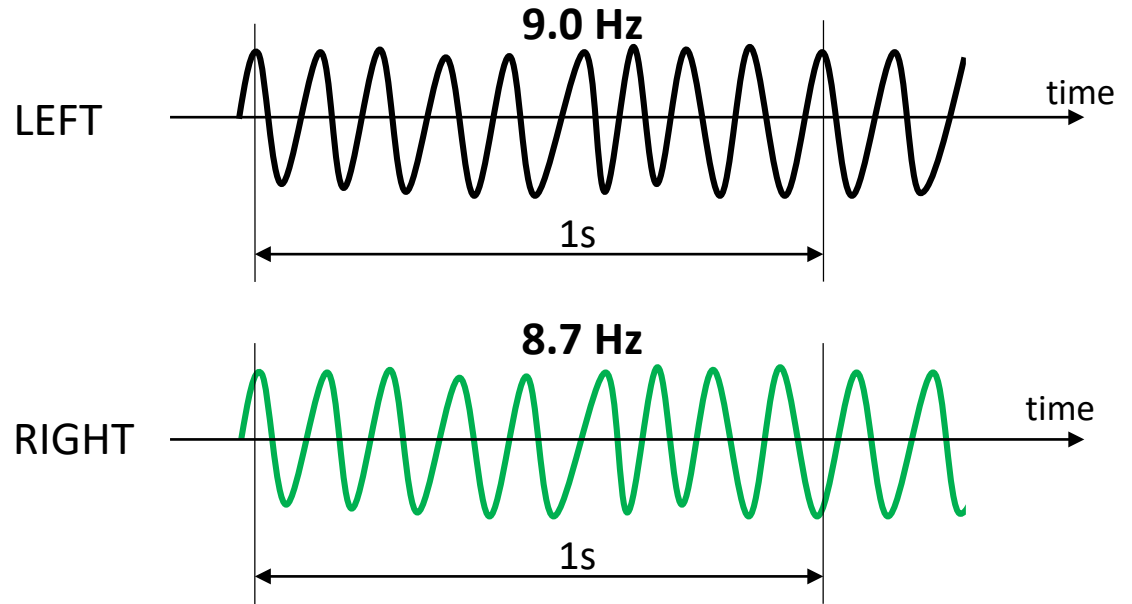




Symmetry – frequency:

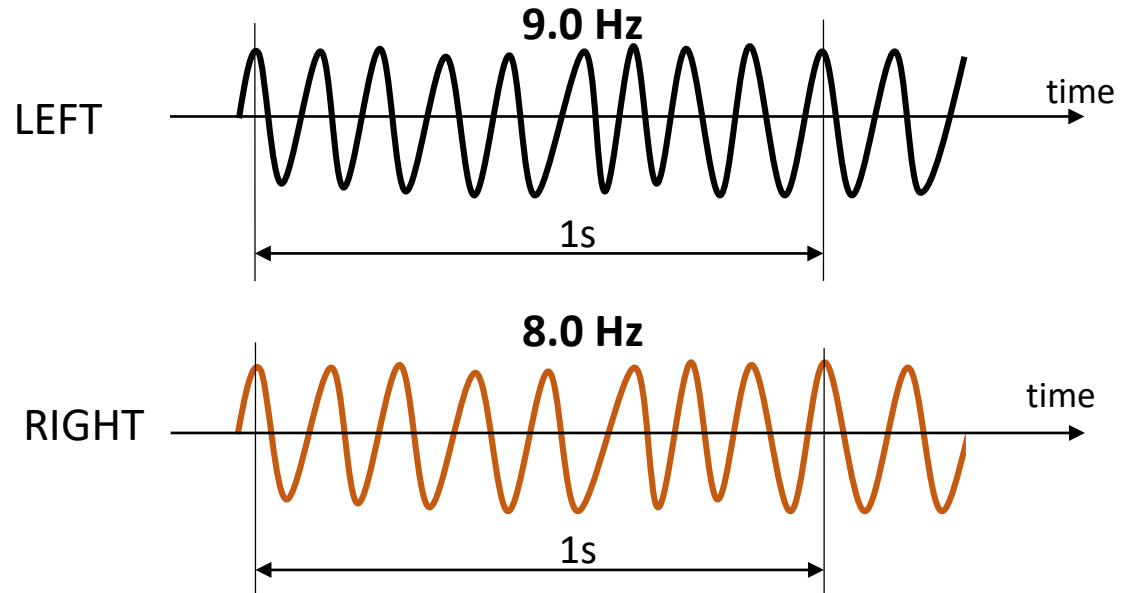
Symmetric

<0.5 Hz difference between sides



Mild asymmetry

0.5–1 Hz difference between sides

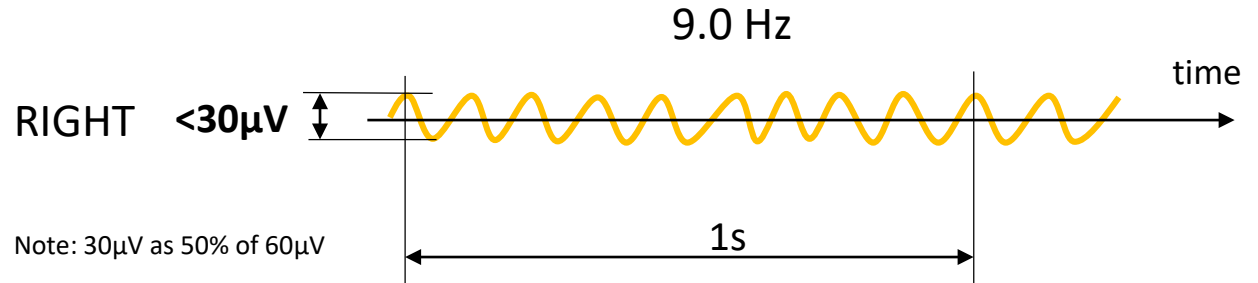
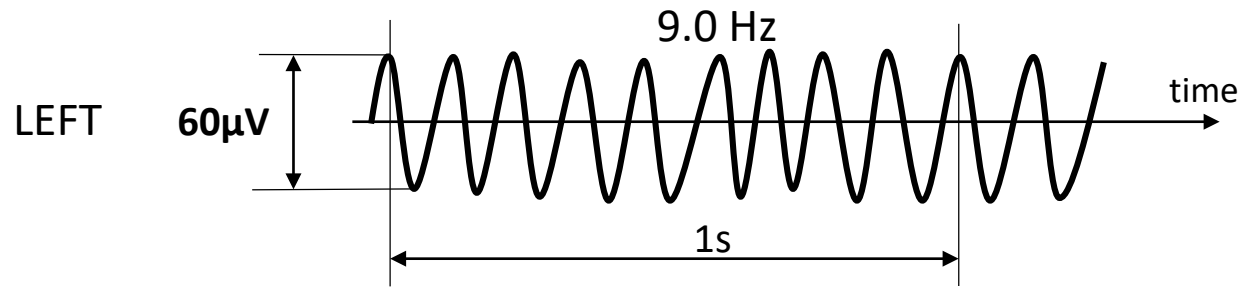




Symmetry – voltage:

Marked asymmetry:

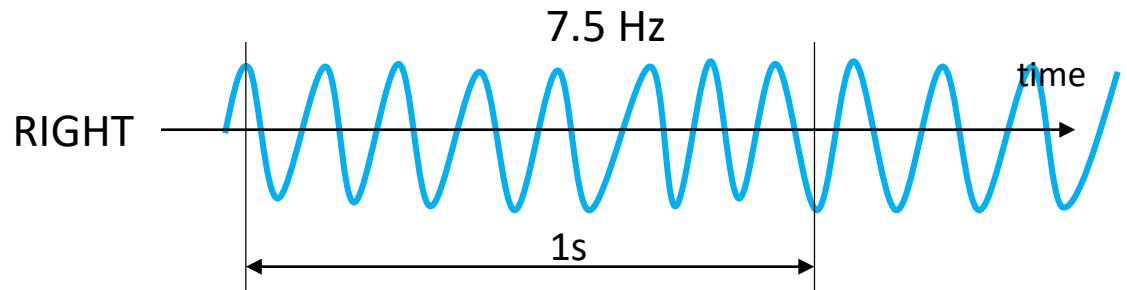
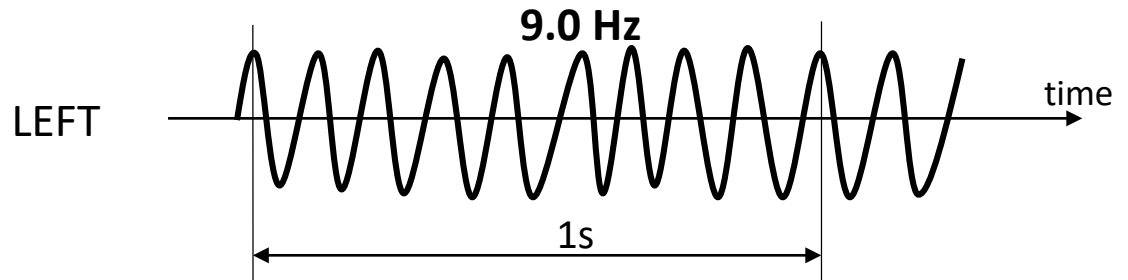
≥50% voltage difference between sides (on appropriate referential recording).



Symmetry – frequency:

Marked asymmetry:

>1 Hz difference between sides





Continuity:

Attenuation or suppression, % of recording (≥ 1 s)

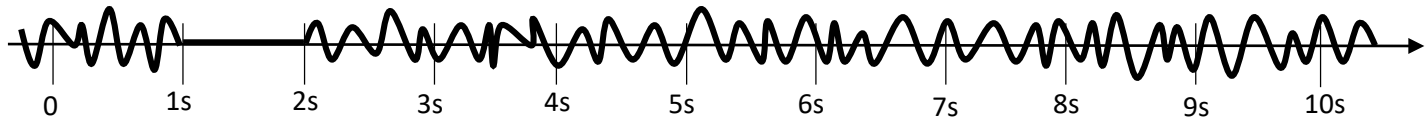
Continuous

$<1\%$



Nearly continuous

1 to 9%



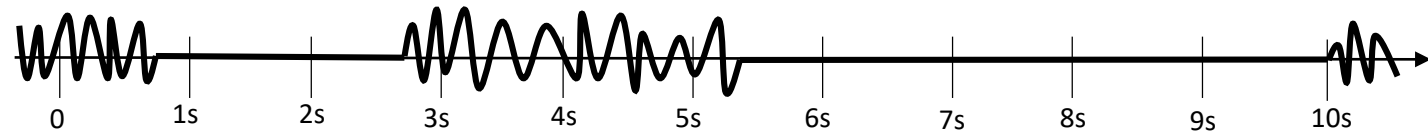
Discontinuous

10 to 49%



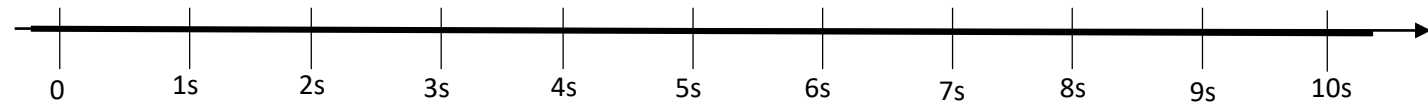
Burst-attenuation/
Burst-suppression

50 to 99%



Attenuation/
Suppression

$>99\%$

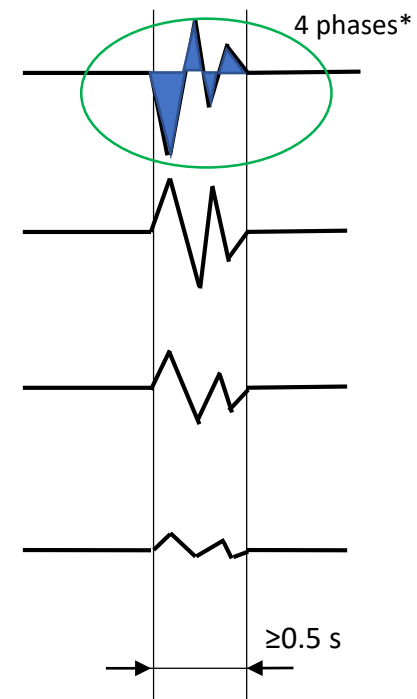
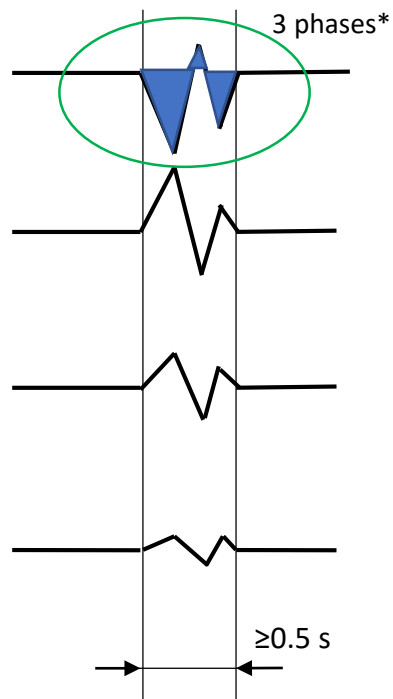
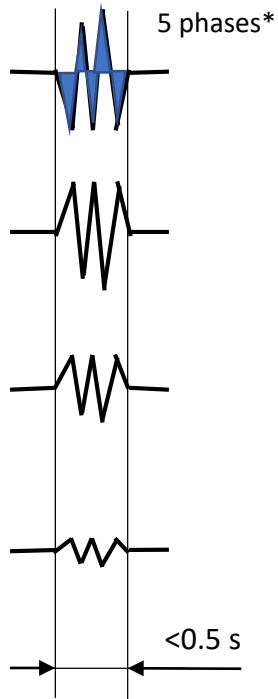
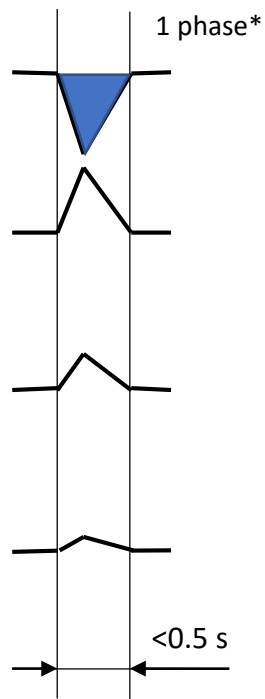


Attenuation: $\geq 10 \mu\text{V}$, $< 50\%$ of higher voltage background
Suppression: $< 10 \mu\text{V}$



“Discharge” versus “Burst”:

Longitudinal bipolar



Discharge

Burst

“<0.5 s regardless
of phases”

OR

“≥0.5 s and ≤3 phases”

“≥0.5 s and ≥4 phases”

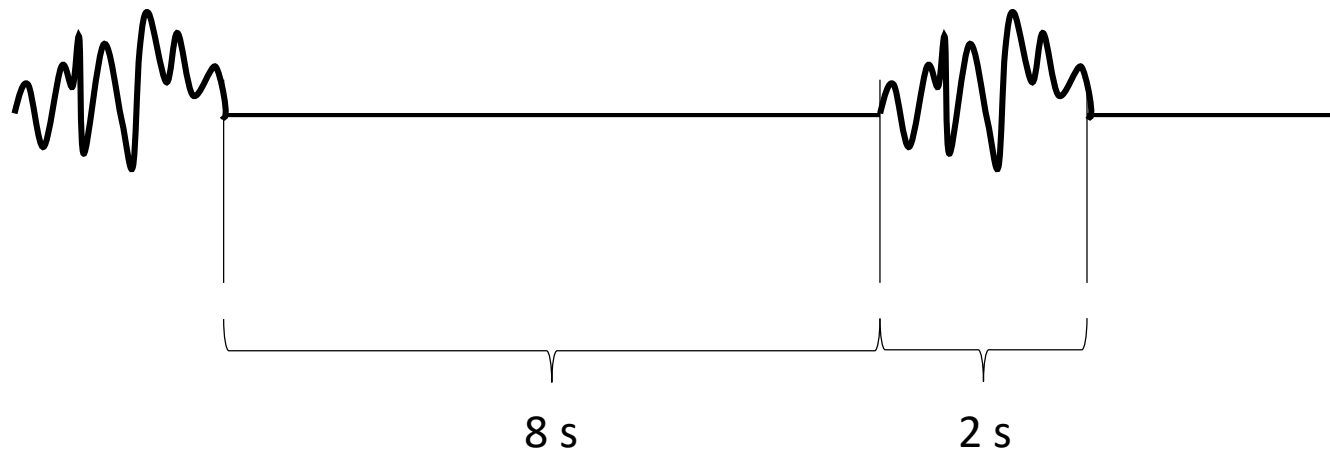
“Bursts must be ≤30 s”

***phase**: an area under the curve on one side of the baseline. See Main modifier (d) below.



Attenuation Percent or Suppression Percent:

Attenuation Percent or *Suppression Percent*: the percent of the record/epoch that is attenuated or suppressed. This can range from 1% to 99%. If $<1\%$, it is considered continuous. If $>99\%$, it is considered either suppressed or attenuated, but not discontinuous. **For example, a record with 2 second bursts alternating with 8 seconds of suppression would be Burst-Suppression with a suppression percent of 80%.**



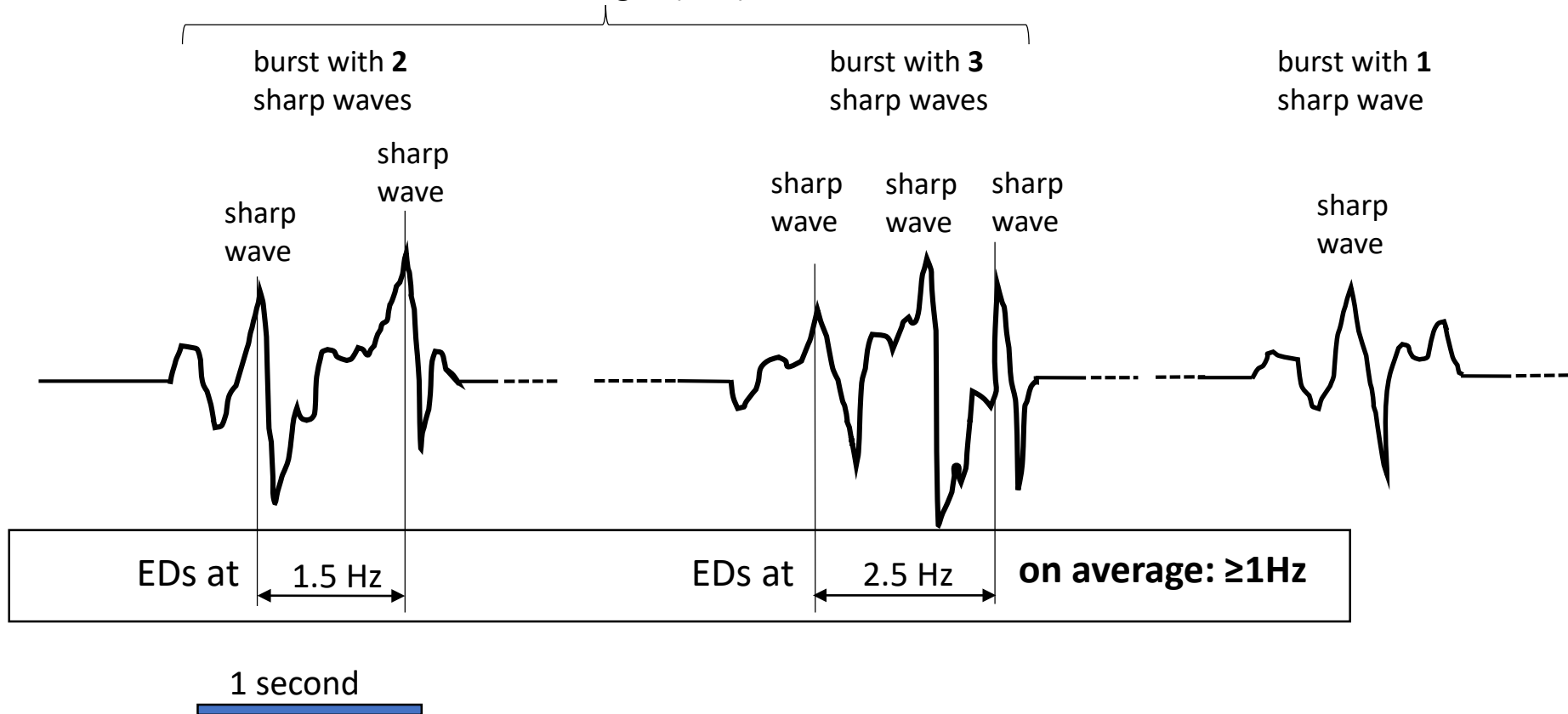
Suppression percent of 80%.



Highly Epileptiform Bursts

1. Two or more epileptiform discharges (spikes or sharp waves),
2. within the majority (>50%) of bursts, and
3. occur at an average of 1 Hz or faster within a single burst

majority (>50%) of bursts with 2 or more epileptiform discharges (EDs)

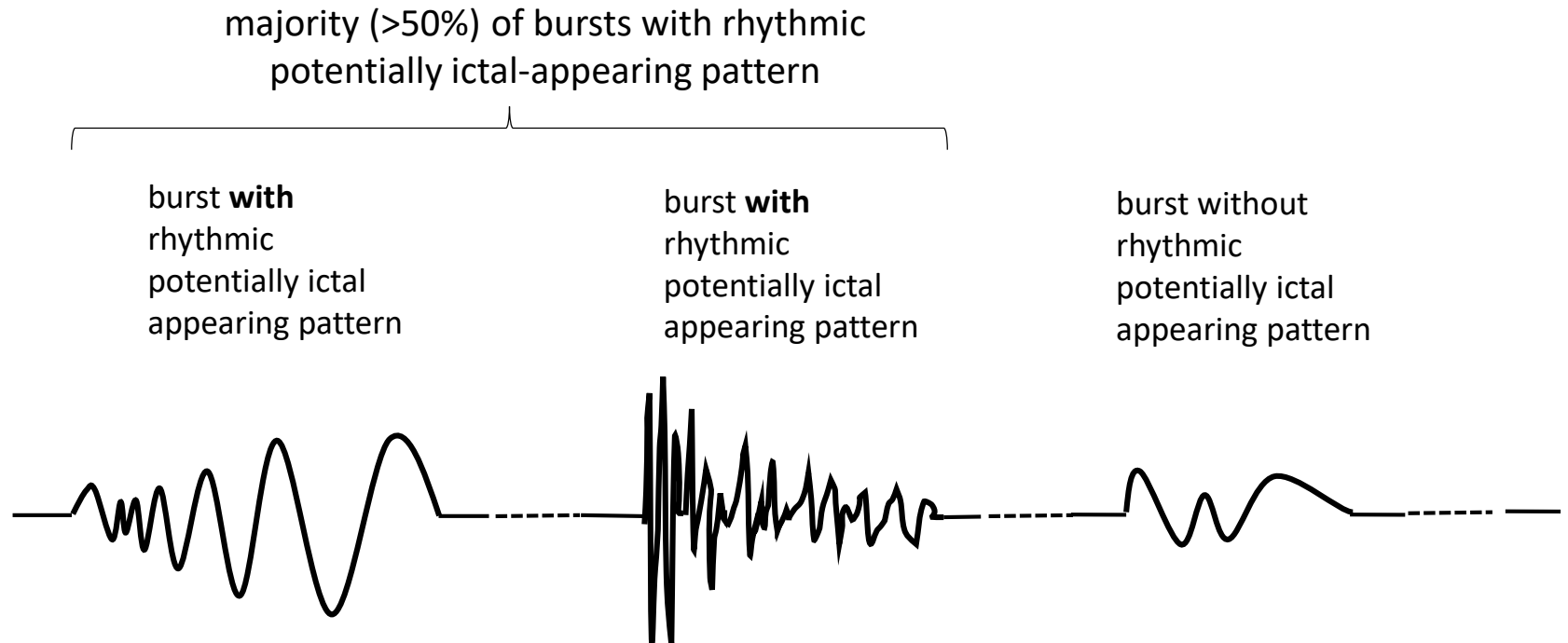


..... dotted lines represent longer duration of suppression for reasons of presentation; ED epileptiform discharge



Highly Epileptiform Bursts

1. A rhythmic, potentially ictal –appearing pattern,
2. within the majority (>50%) of bursts

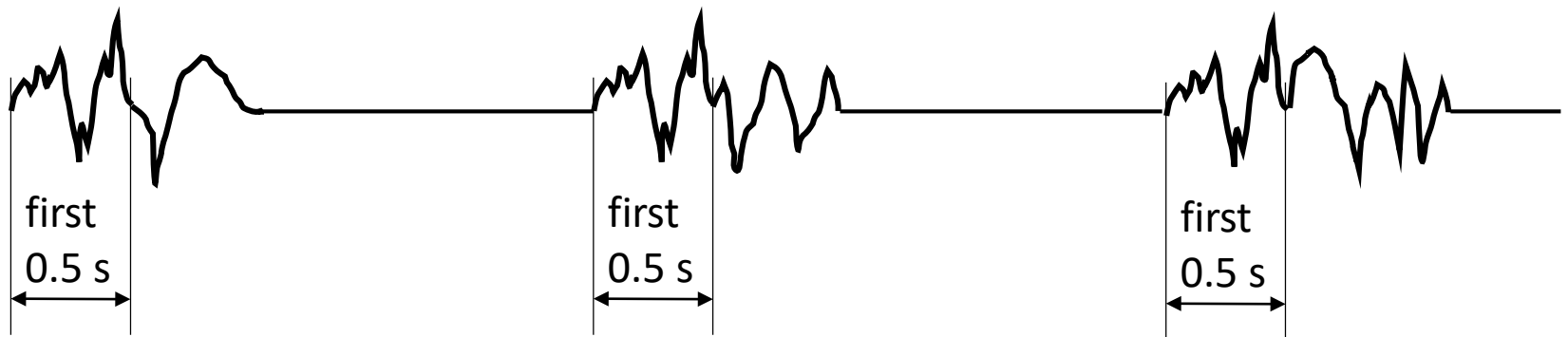


..... dotted lines represents longer duration of suppression for reasons of presentation;



Identical Bursts

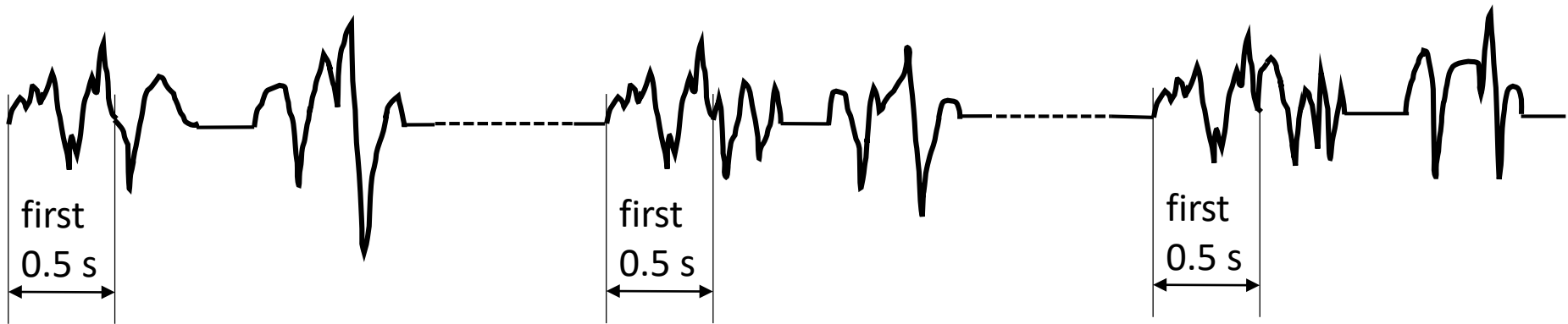
The first 0.5 s or longer of each burst is visually similar in all channels in the vast majority (>90%) of bursts





Identical Bursts in a Stereotyped Cluster

The first 0.5 s or longer of each of **two or more** bursts in a stereotyped cluster are visually similar in all channels in the vast majority (>90%) of bursts

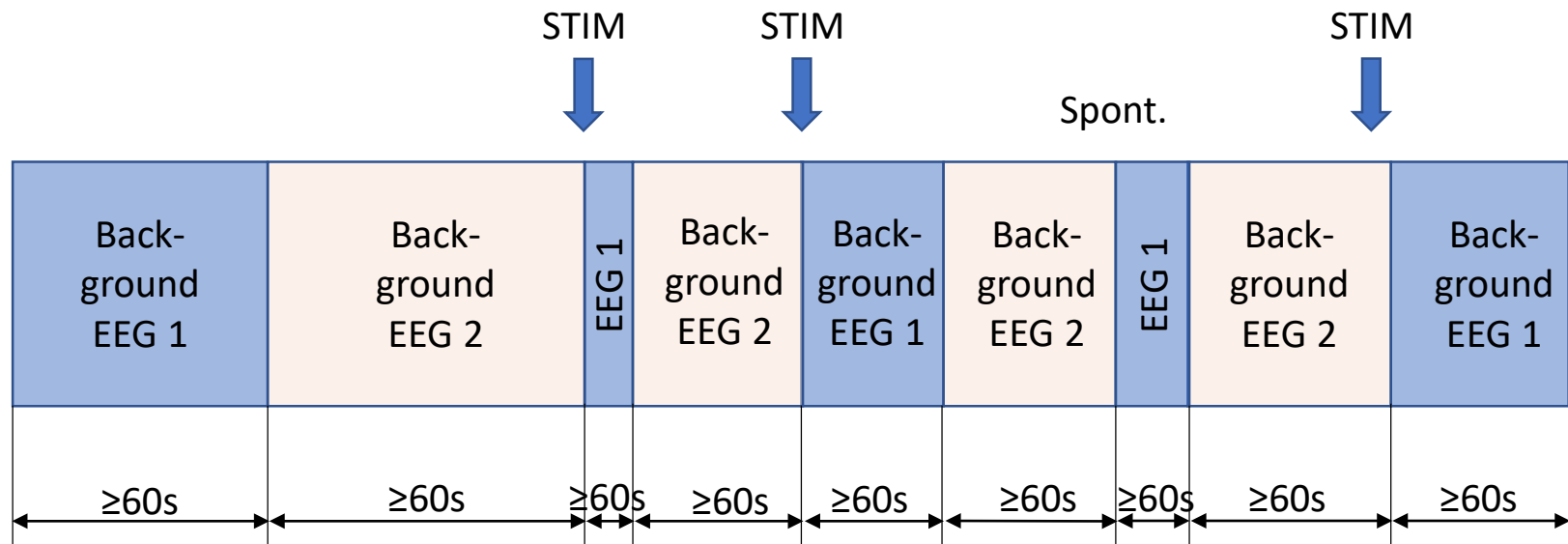




State changes:

At least 2 sustained types of background EEG:

1. Related to level of alertness or stimulation.
2. Each must persist at ≥ 60 s to qualify as a “state”.
3. Stimulation should be able to transition the patient from the less alert to more alert/more stimulated state.
4. The more alert/more stimulated state is considered the “reported background” EEG.
5. State changes can also occur spontaneously.



EEG background 1: stimulated/more awake: used for background feature description (“reported background”)
EEG background 2: unstimulated/less awake state; commonly lasts minutes to hours (minimum: 60 s)

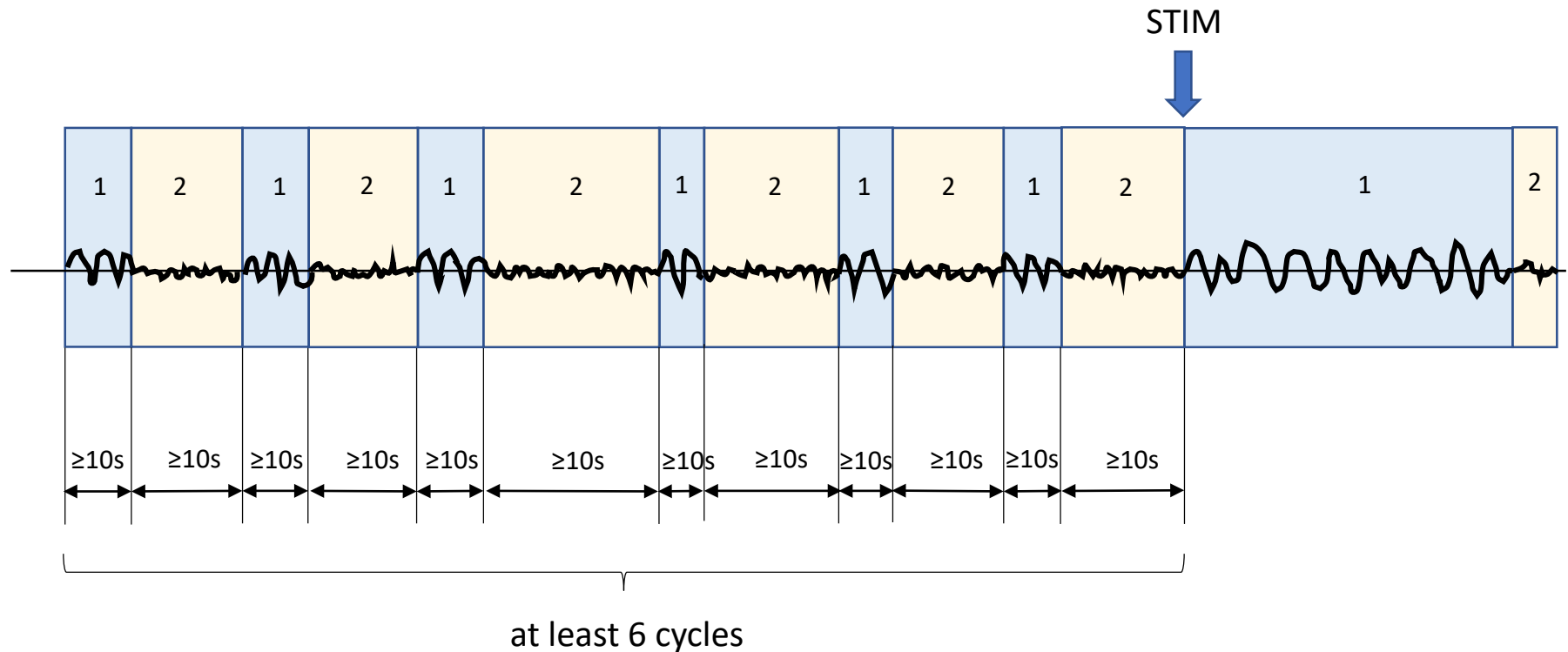
STIM = stimulation, Spont. = spontaneous



Cyclic Alternating Pattern of Encephalopathy (CAPE):

Changes in EEG background patterns 1 and 2:

1. each lasting at least 10 s,
2. **spontaneously** alternating between the two patterns in a regular manner,
3. for at least 6 cycles.

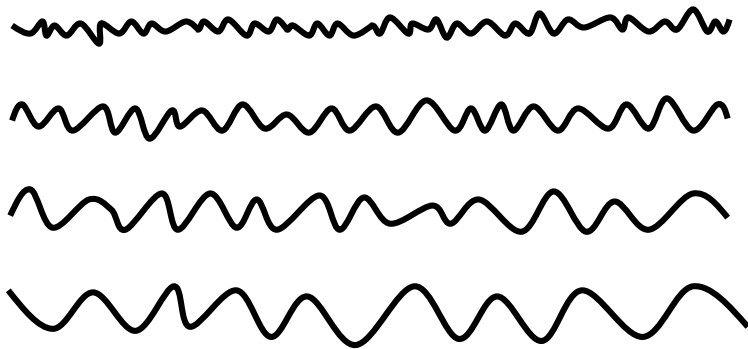


NOTE: If each pattern of CAPE lasts >60 seconds, this would qualify as presence of state changes. If CAPE is always present, cannot be interrupted with stimulation, and at least one of the states lasts <60 seconds, it remains possible for a patient to have CAPE and no state changes.



Anterior-posterior (AP) gradient:

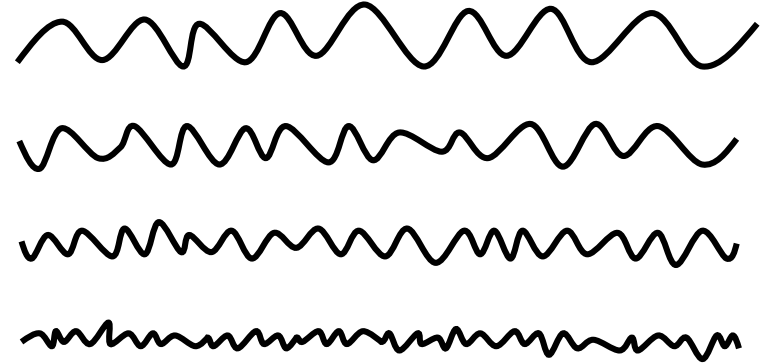
anterior-posterior (AP) gradient



at least 1 continuous minute

reversed AP gradient

anterior

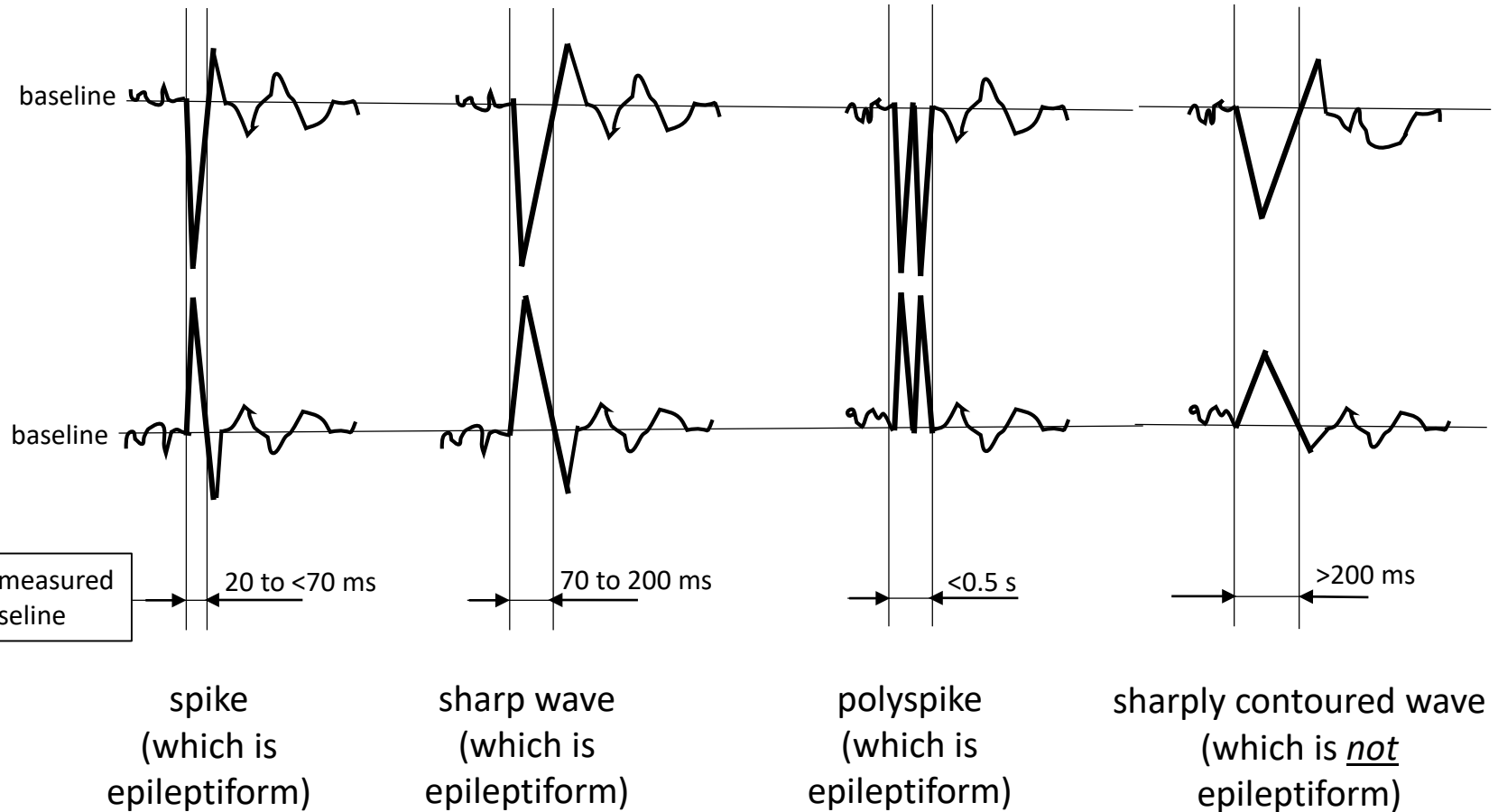


posterior

at least 1 continuous minute



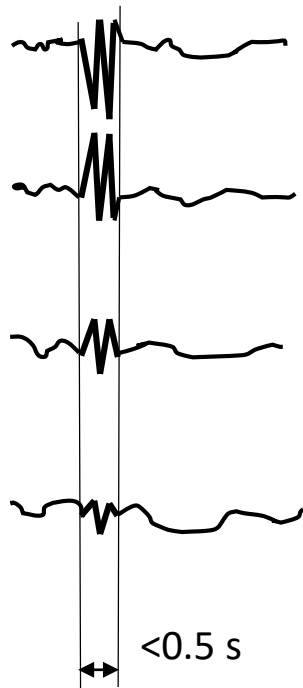
Sporadic Epileptiform Discharges:



Blunt: having smooth or sinusoidal morphology.



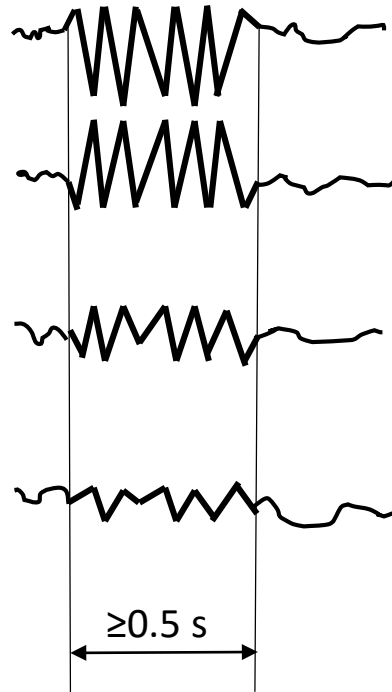
Polyspike versus BIRD versus Highly Epileptiform Burst:



Polyspike

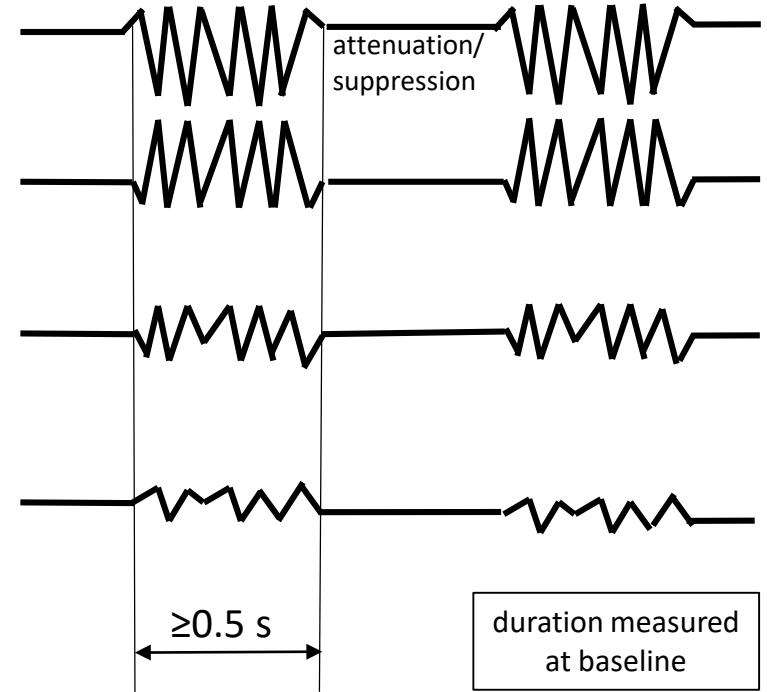
duration <0.5 s:

1. Two or more spikes,
2. occurring in a row with no interdischarge interval,
3. lasting <0.5 s.



BIRD

Brief **P**otentially **I**ctal
Rhythmic **D**ischarge



**Highly Epileptiform
Burst**

duration ≥0.5 s:

or, if alternating with suppression or
attenuation, a highly epileptiform burst
within burst suppression/attenuation



Lateralized Periodic Discharges (LPDs)

Longitudinal bipolar montage

LEFT

RIGHT



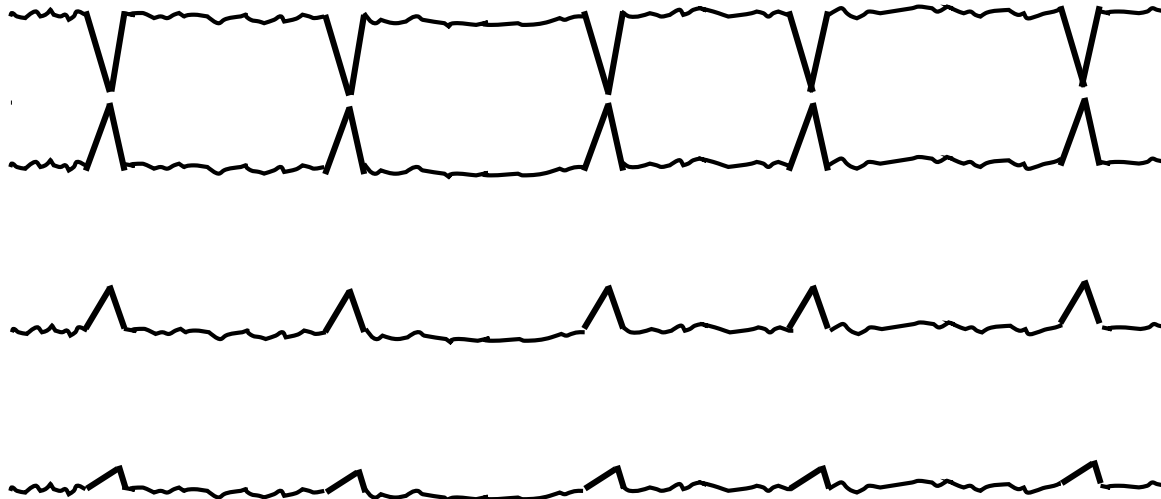
Periodic
discharges over
the left



Bilateral Independent Periodic Discharges (BIPDs)

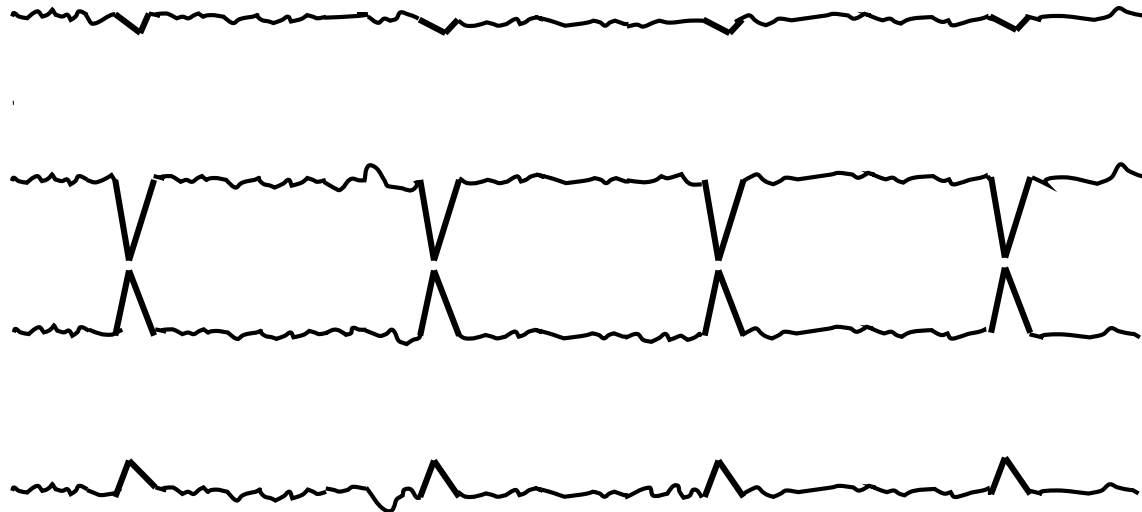
Longitudinal bipolar montage

LEFT



Periodic discharges over the left

RIGHT



Periodic discharges over the right

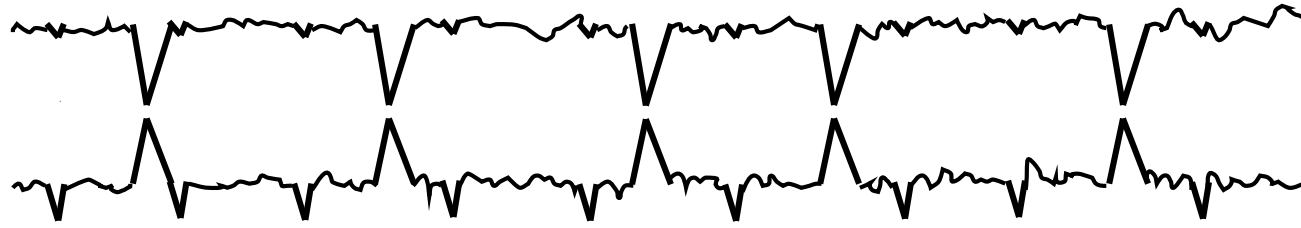
Note: In BIPDs, lateralized patterns occur on each hemisphere asynchronously and at different frequencies. It does not matter that they occur with a maximum over different regions.



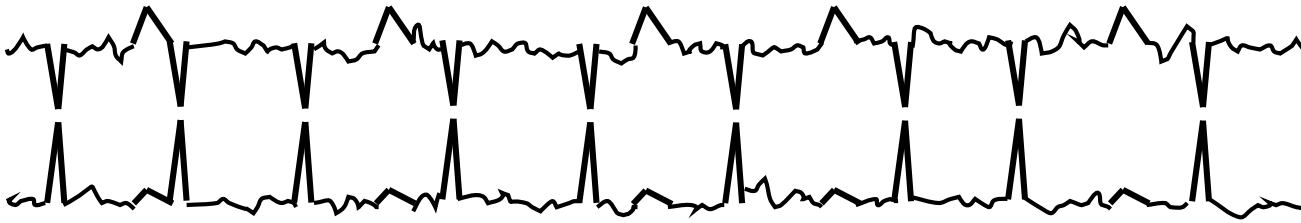
Unilateral Independent Periodic Discharges (UIPDs):

Longitudinal bipolar montage

LEFT

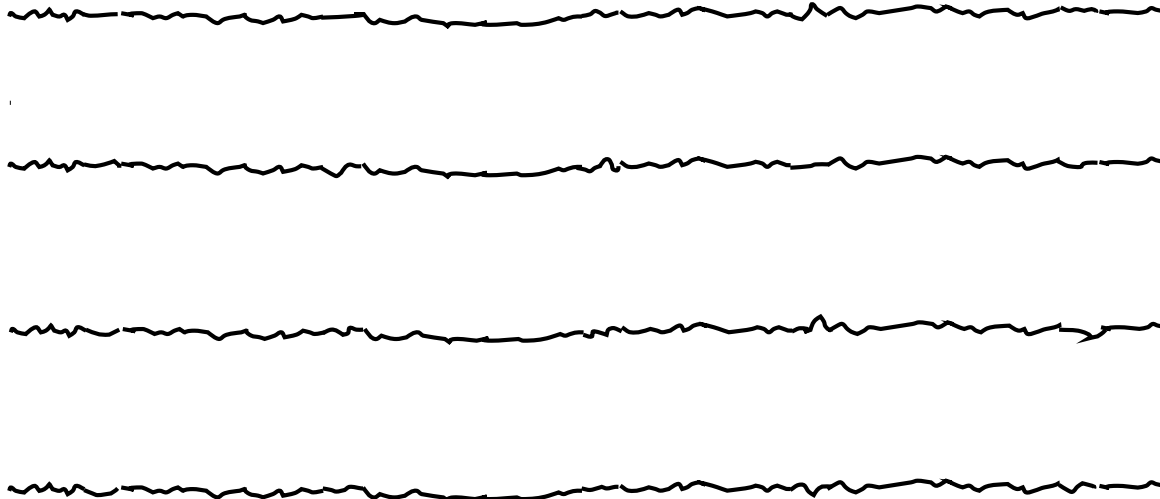


Periodic discharges over left **anterior**



Periodic discharges over left **posterior**

RIGHT

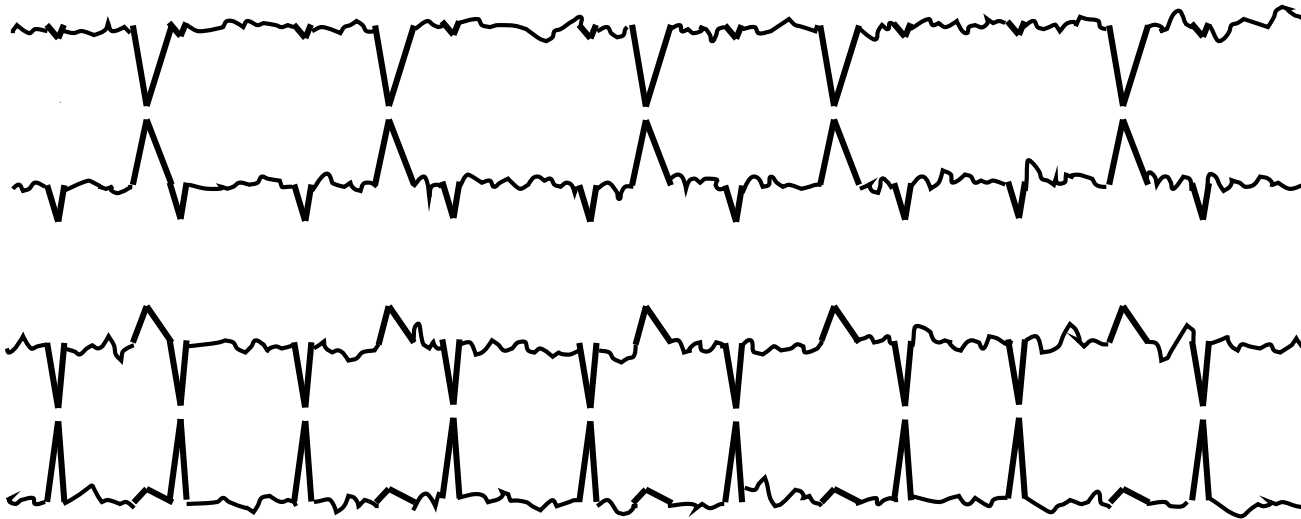




Multifocal Periodic Discharges (MfPD):

Longitudinal bipolar montage

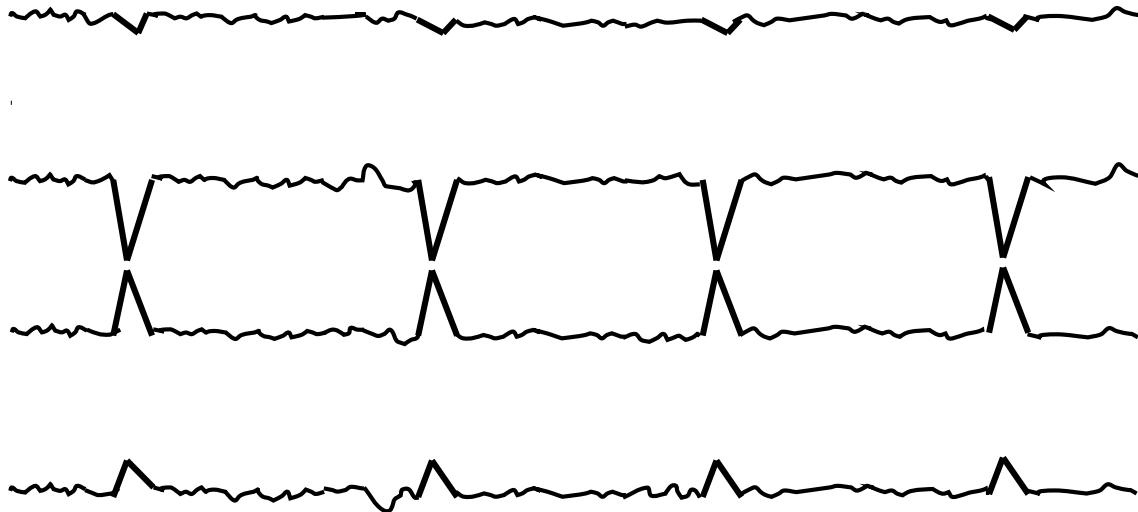
LEFT



Periodic discharges over left **anterior**

Periodic discharges over left **posterior**

RIGHT



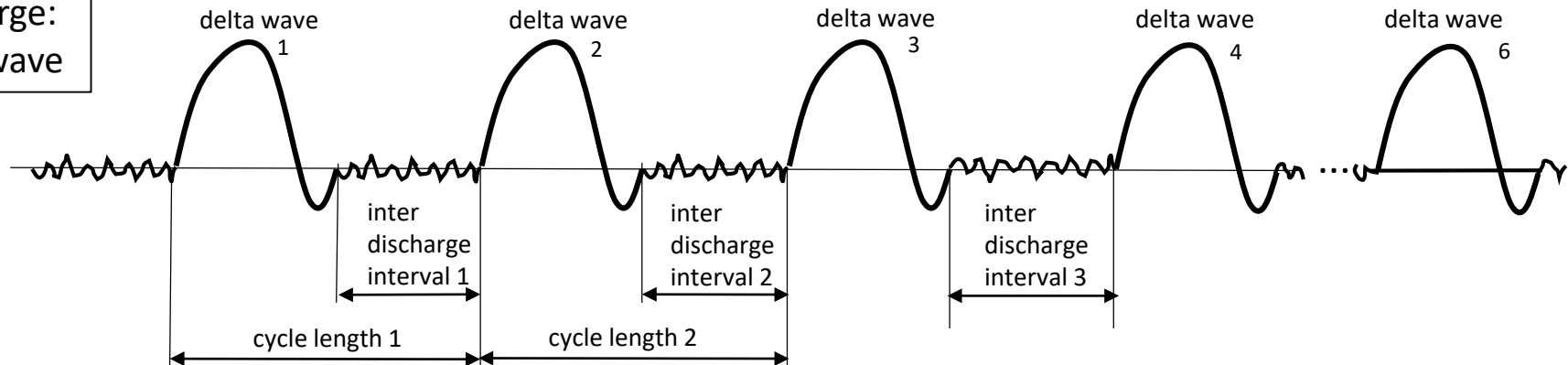
Periodic discharges over the right

Note: In MfPD, periodic discharges occur in three independent locations simultaneously with at least one in each hemisphere.

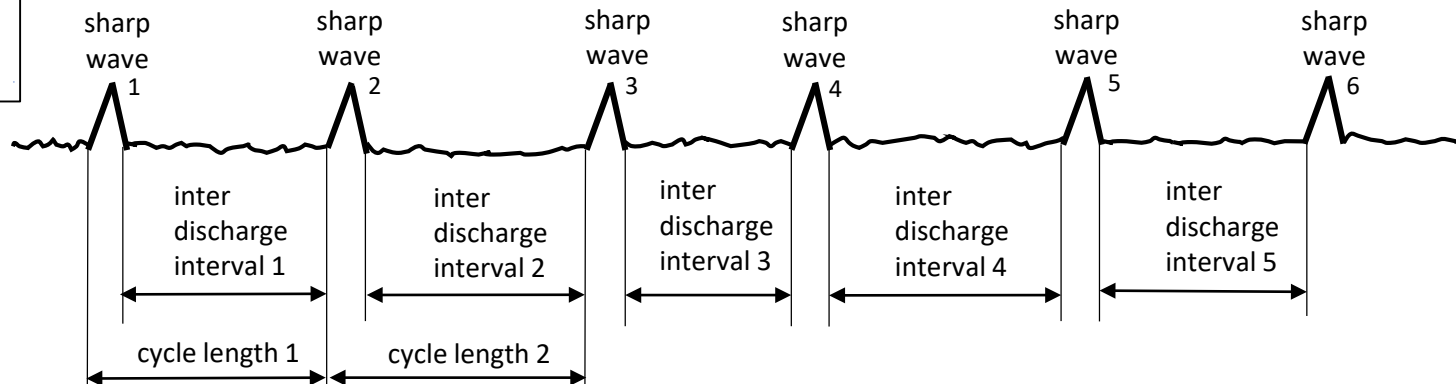
Periodic Discharges (PDs):

1. Repetition of a waveform with relatively uniform morphology and duration,
2. with a **clearly discernable inter-discharge interval** between consecutive waveforms, and
3. recurrence of the waveform at nearly regular intervals: having a cycle length (i.e., period) varying by <50% from one cycle to the next in the majority (>50%) of cycle pairs.

Discharge:
delta wave



Discharge:
sharp wave

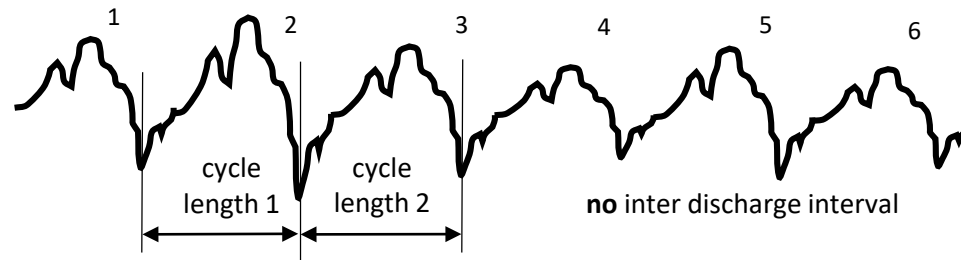


A pattern can qualify as rhythmic or periodic if and only if it continues for **at least 6 cycles** (e.g. 1 Hz for 6 seconds, or 3 Hz for 2 seconds).

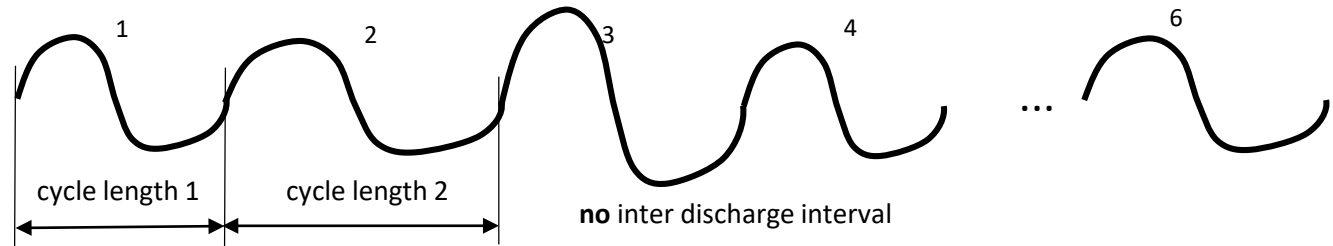
Rhythmic Delta Activity (RDA):

1. Repetition of a waveform with relatively uniform morphology and duration, and
2. without an interval between consecutive waveforms.
3. 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.

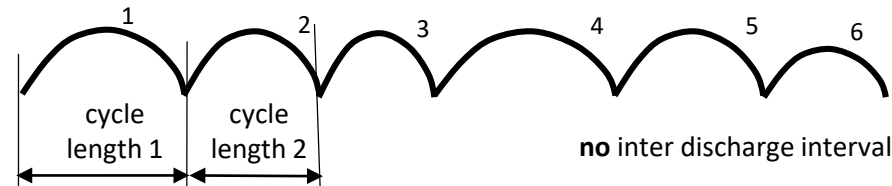
complex
delta wave



sinusoidal
delta wave



arciform
delta wave

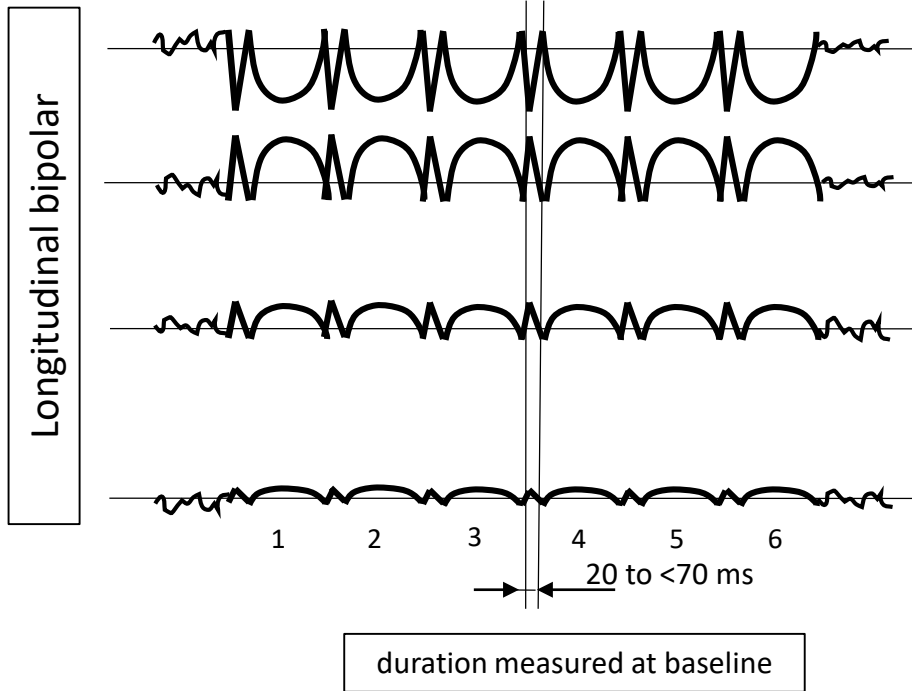


NOT
RHYTHMIC

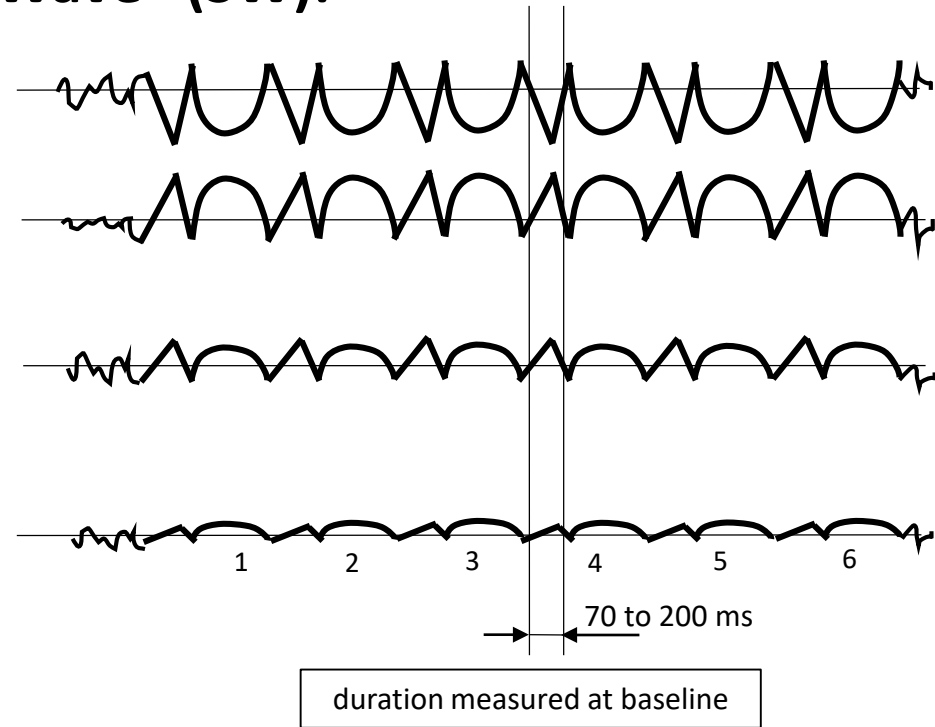


A pattern can qualify as rhythmic or periodic if and only if it continues for **at least 6 cycles** (e.g. 1 Hz for 6 seconds, or 3 Hz for 2 seconds).

“Spike and Wave” or “Sharp and Wave” (SW):



Spike and wave

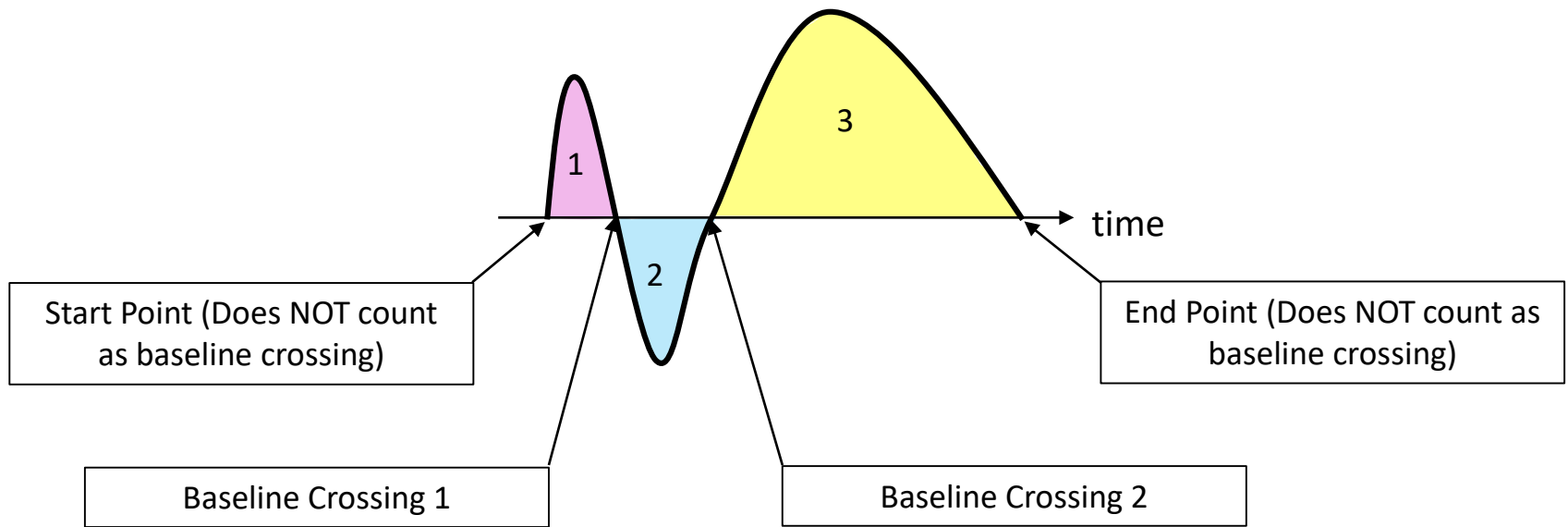


“Sharp and wave”

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 for at least 6 cycles; 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).



Number of Phases



Number of Phases = 1 + number of baseline crossings of the typical discharge. In this case there are a total of 2 baseline crossings, therefore the number of phases is $1 + 2 = 3$ phases. A phase is the part of the signal above or below the imaginary baseline. In this case phase 1 (pink) is above, phase 2 (blue) is below and phase 3 (yellow) is above again.

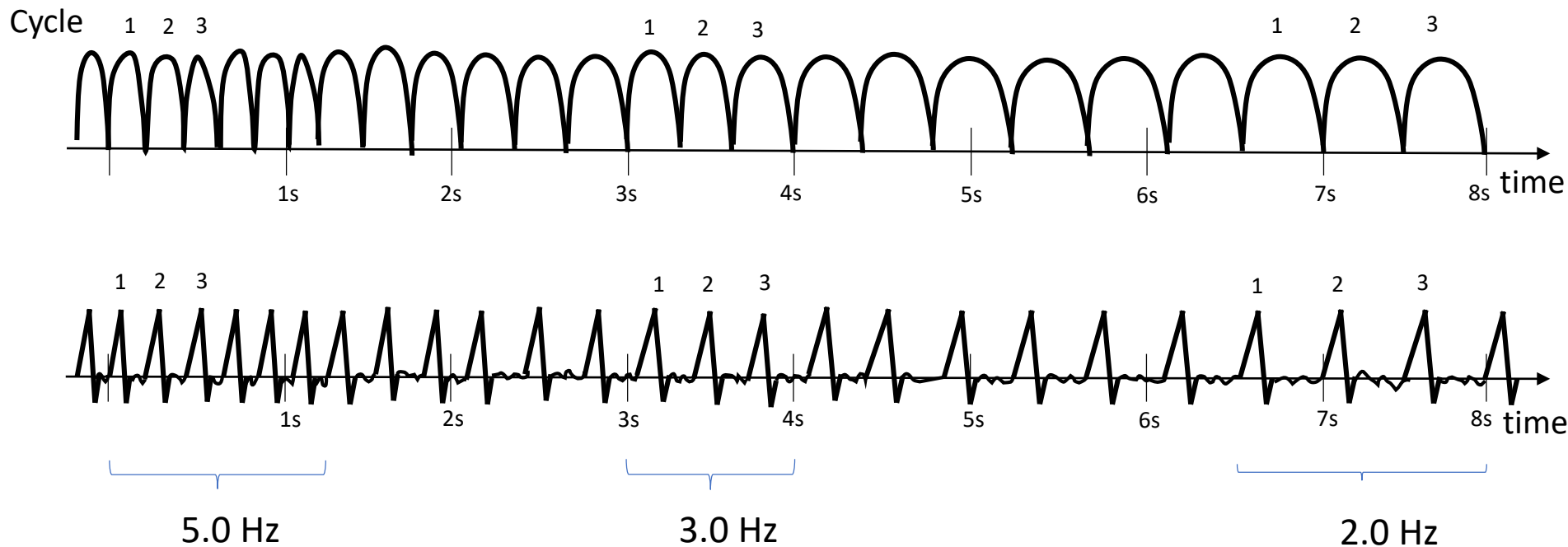


Evolution of frequency

At least 2 unequivocal, sequential changes in frequency defined as follows: Evolution in *frequency* is defined as at least 2 consecutive changes in the same direction by at least 0.5 Hz. In order to qualify as present, a single frequency must persist for at least 3 cycles. The criteria for evolution must be reached without the evolving feature (frequency) remaining unchanged for 5 or more continuous minutes.

1st change: 5 Hz to 3 Hz

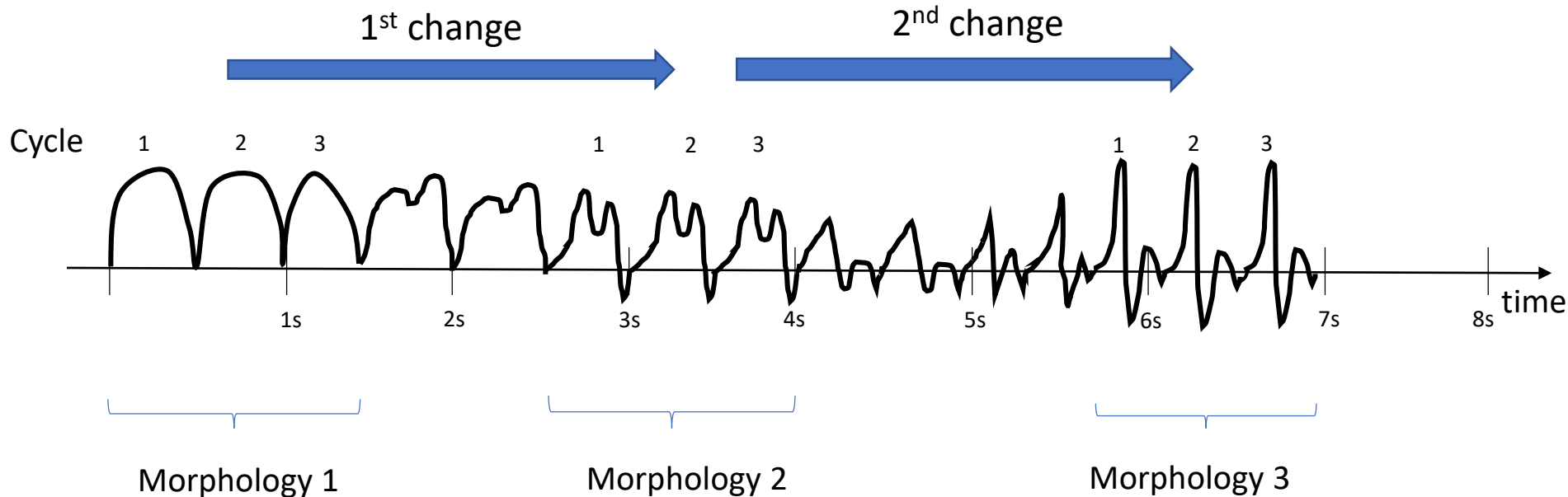
2nd change: 3.0 Hz to 2.0 Hz





Evolution of morphology

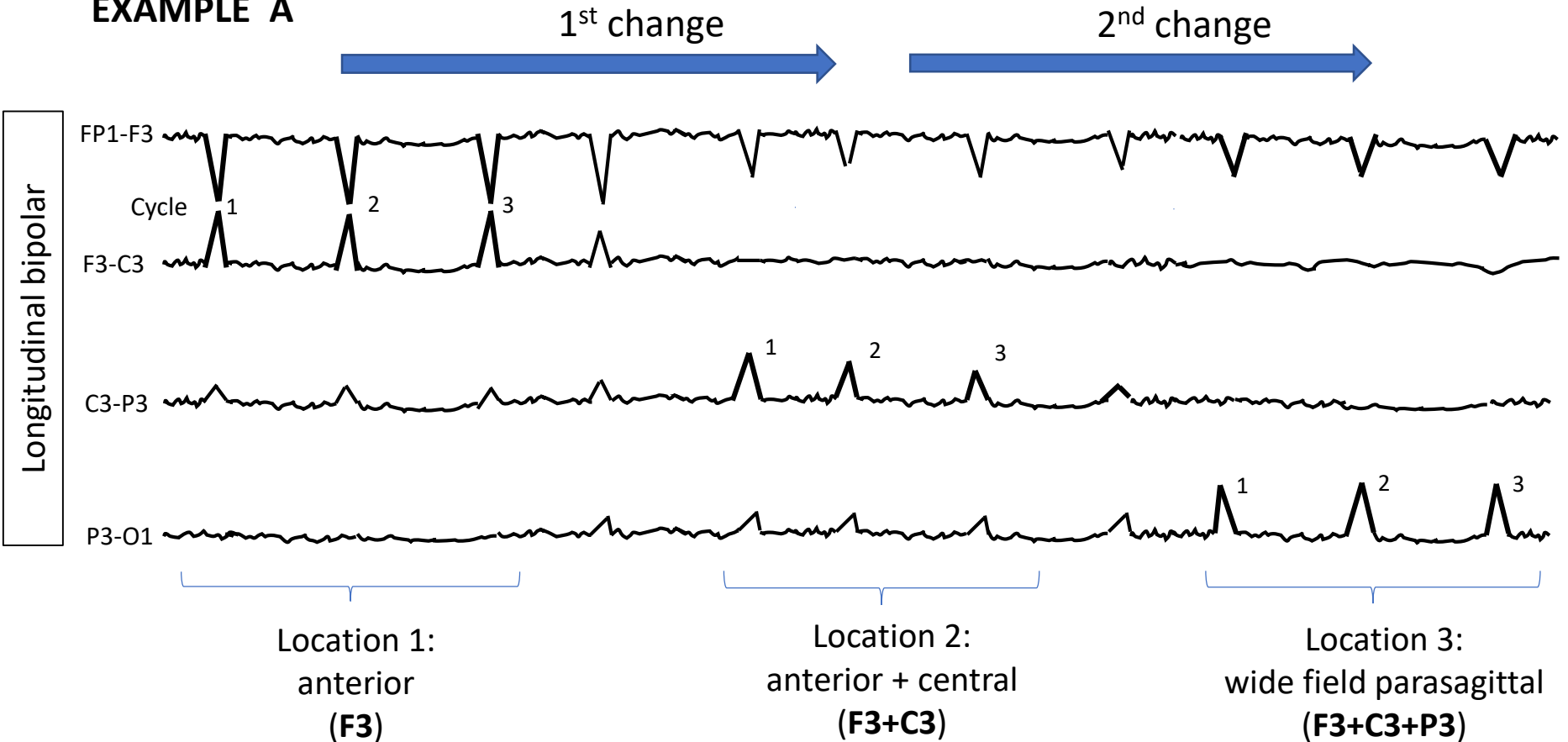
Evolution in *morphology* is defined as at least 2 consecutive changes to a novel morphology. The two consecutive changes must be in the same category (morphology) to qualify. To qualify as evolution in morphology, each different morphology or each morphology plus its transitional forms must last at least 3 cycles.



Evolution of location

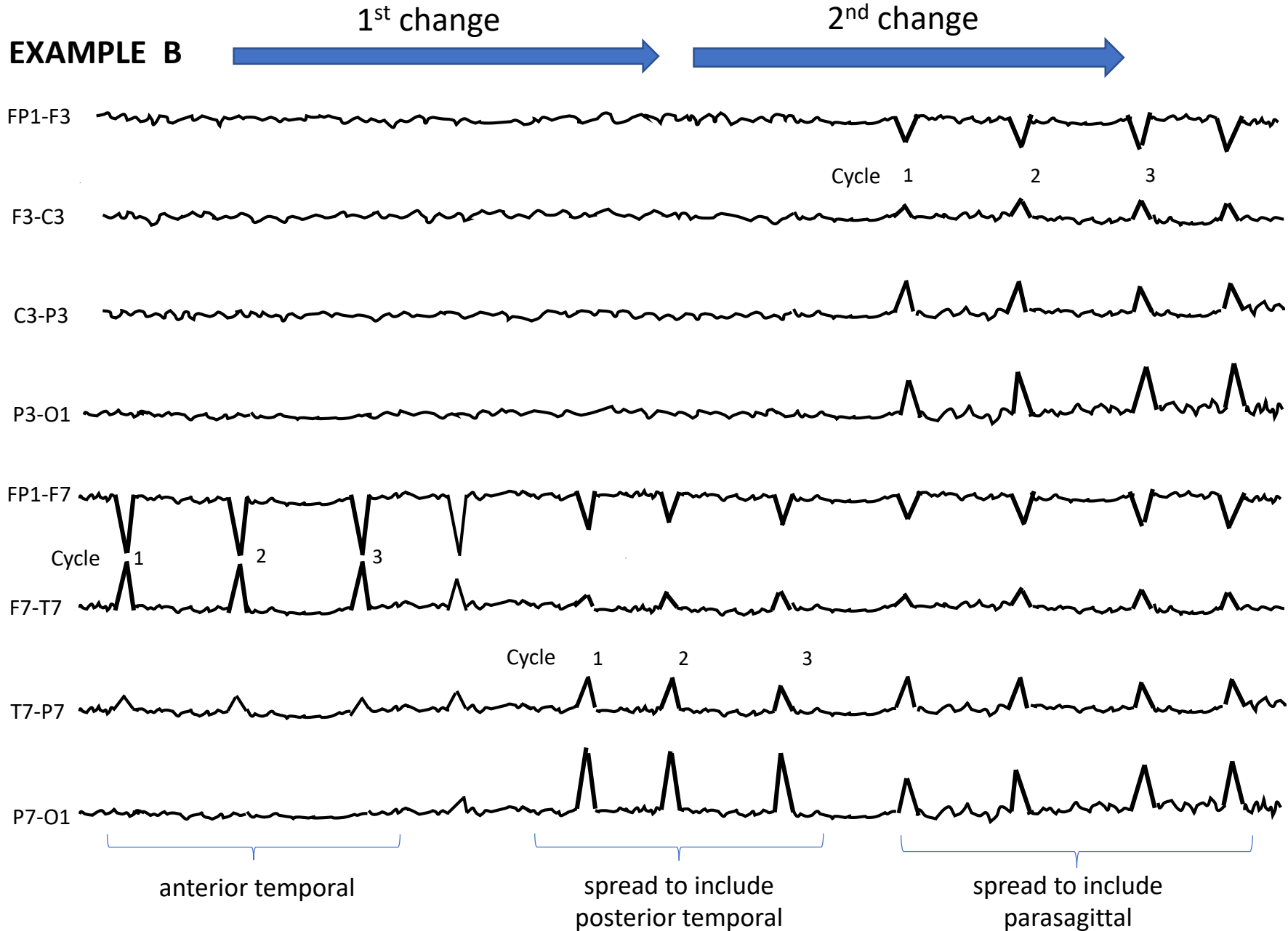
Evolution in *location* is defined as sequentially spreading into or sequentially out of at least two different standard 10-20 electrode locations. The two consecutive changes must be in the same category (location) to qualify. In order to qualify as present, a single location must persist for at least 3 cycles.

EXAMPLE A





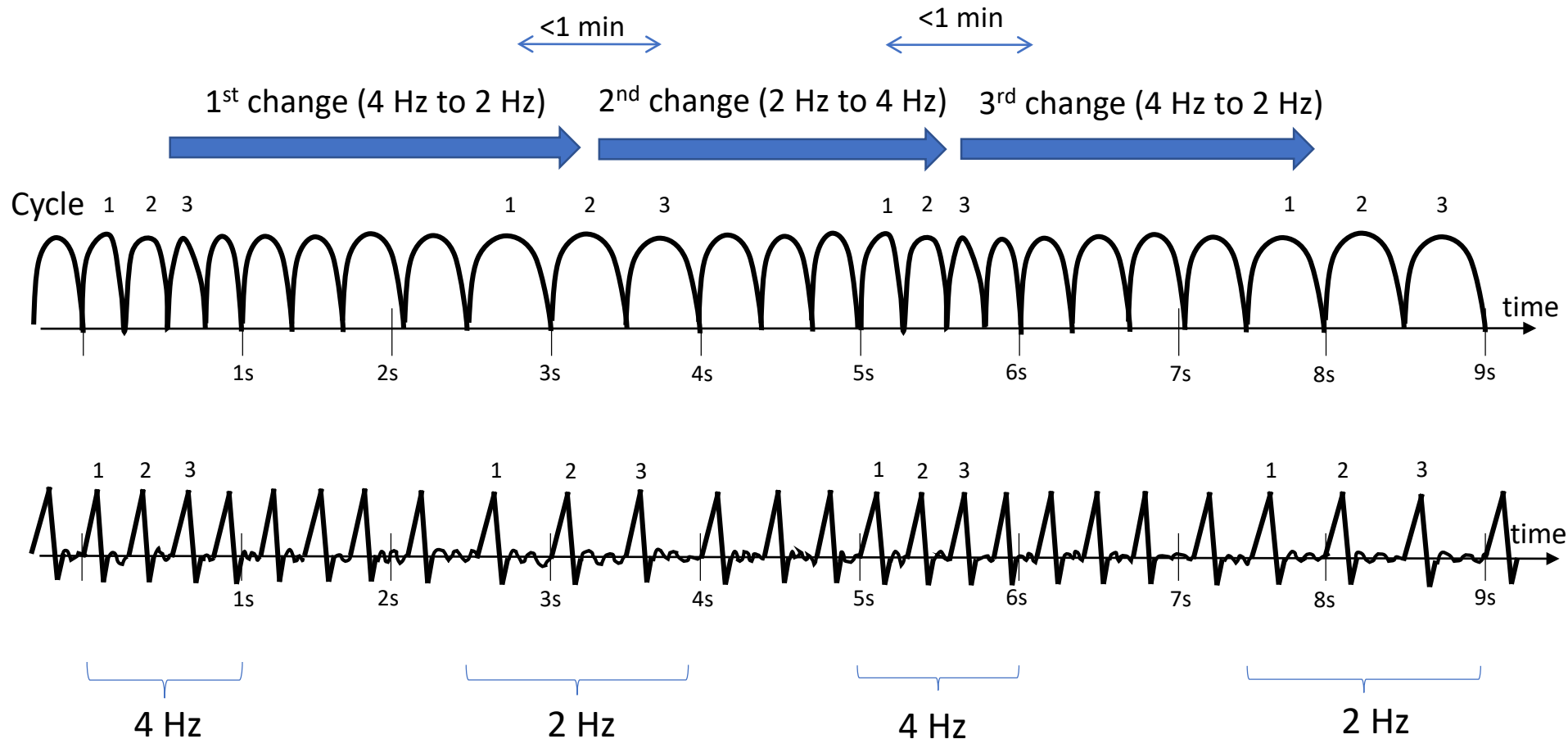
Evolution of location





Fluctuating frequency

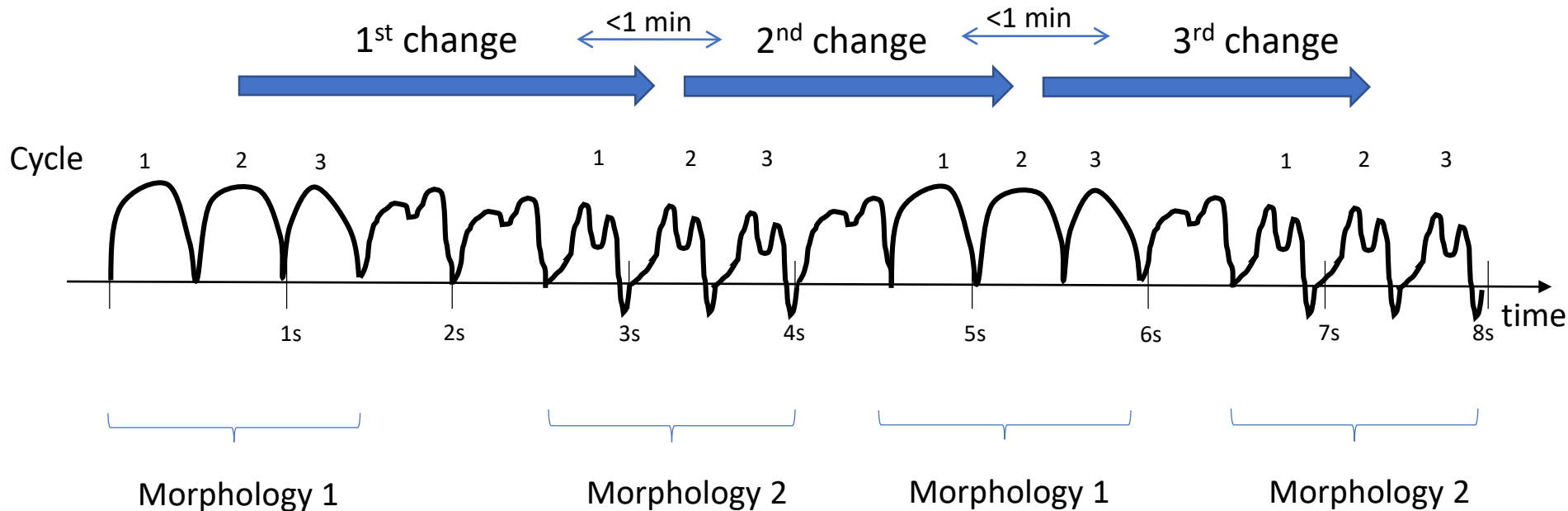
≥ 3 changes, not more than one minute apart, in frequency (by at least 0.5 Hz), but *not qualifying as evolving*. This includes patterns fluctuating from 1 to 1.5 to 1 to 1.5 Hz. In order to qualify as present, a single frequency must persist at least 3 cycles (e.g. 1 Hz for 3 s, or 3 Hz for 1 s).





Fluctuating morphology

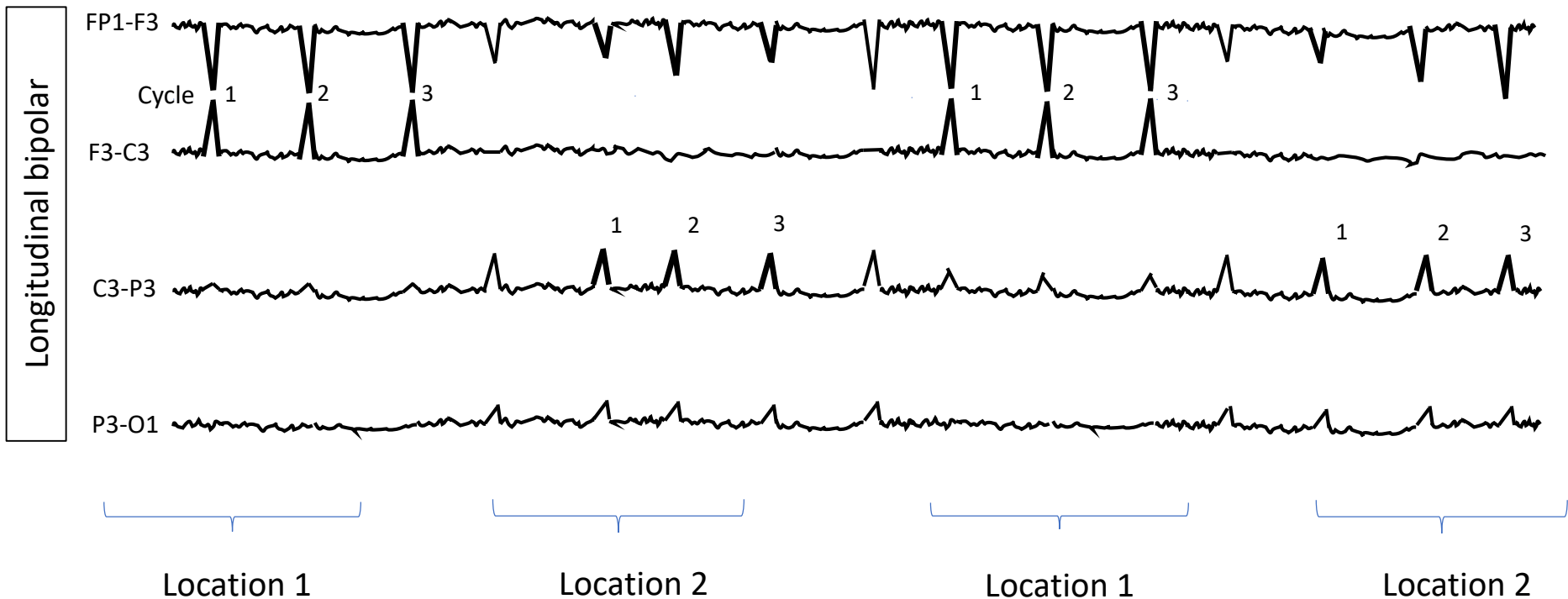
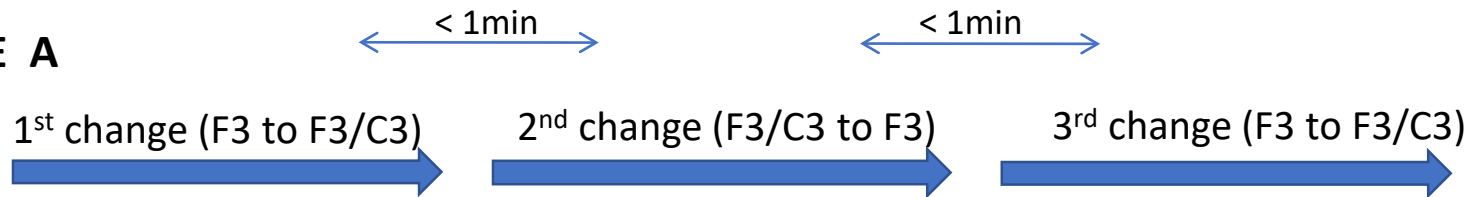
≥ 3 changes, not more than one minute apart, in morphology, but *not qualifying as evolving*. This includes patterns alternating between 2 morphologies repeatedly. In order to qualify as present, a single morphology must persist at least 3 cycles.



Fluctuating location

≥ 3 changes, not more than one minute apart, in location (by at least 1 standard inter-electrode distance), but *not qualifying as evolving*. This includes patterns spreading in and out of a single electrode repeatedly. In order to qualify as present, a single location must persist at least 3 cycles.

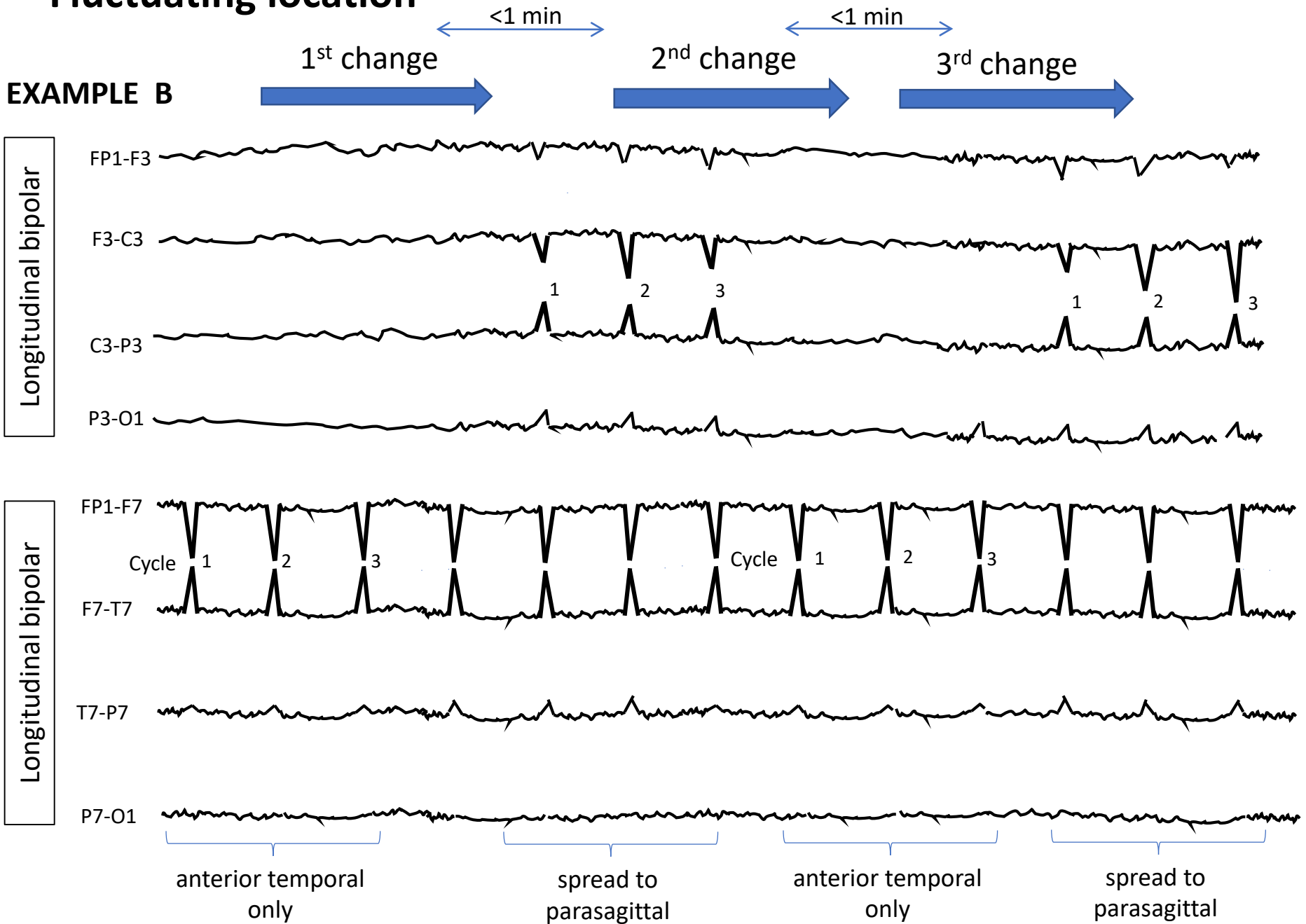
EXAMPLE A





Fluctuating location

EXAMPLE B



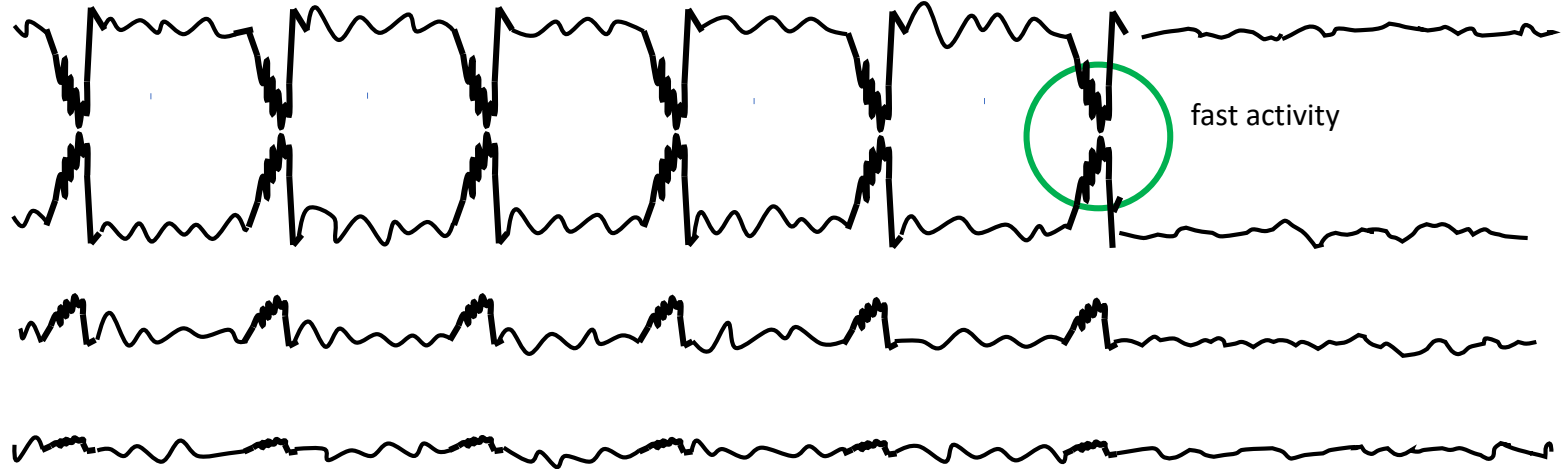


Lateralized Periodic Discharges PLUS *fast* activity (LPDs+F)

code as +F if the fast activity is part of the RDA or PD pattern and not simply part of the background activity

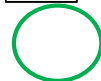
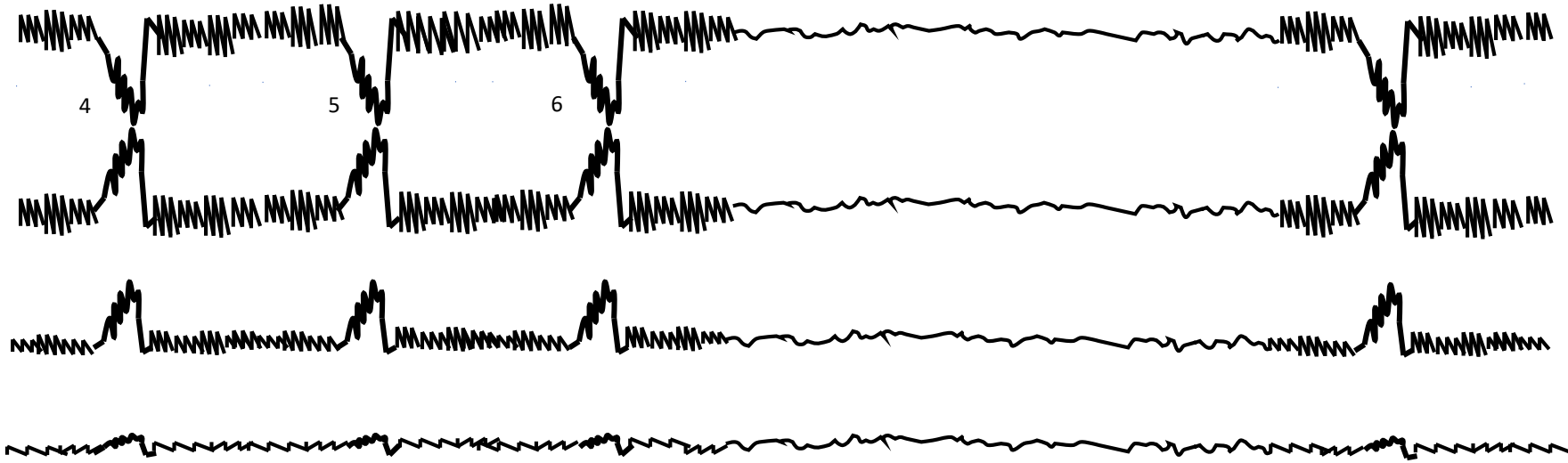
EXAMPLE A: LPD+F

Longitudinal bipolar



EXAMPLE B: LPD+F

Longitudinal bipolar



NOTE: fast activity cycling with the periodic discharge

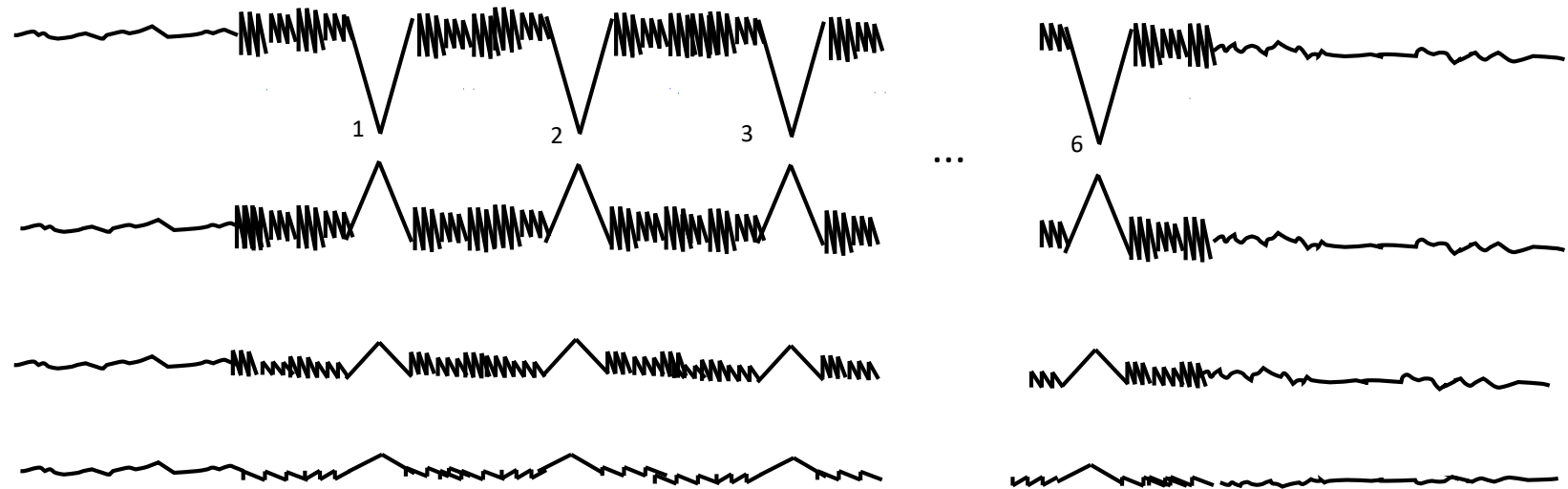


Lateralized Periodic Discharges PLUS *fast* activity (LPDs+F)

code as +F if the fast activity is part of the RDA or PD pattern and not simply part of the background activity

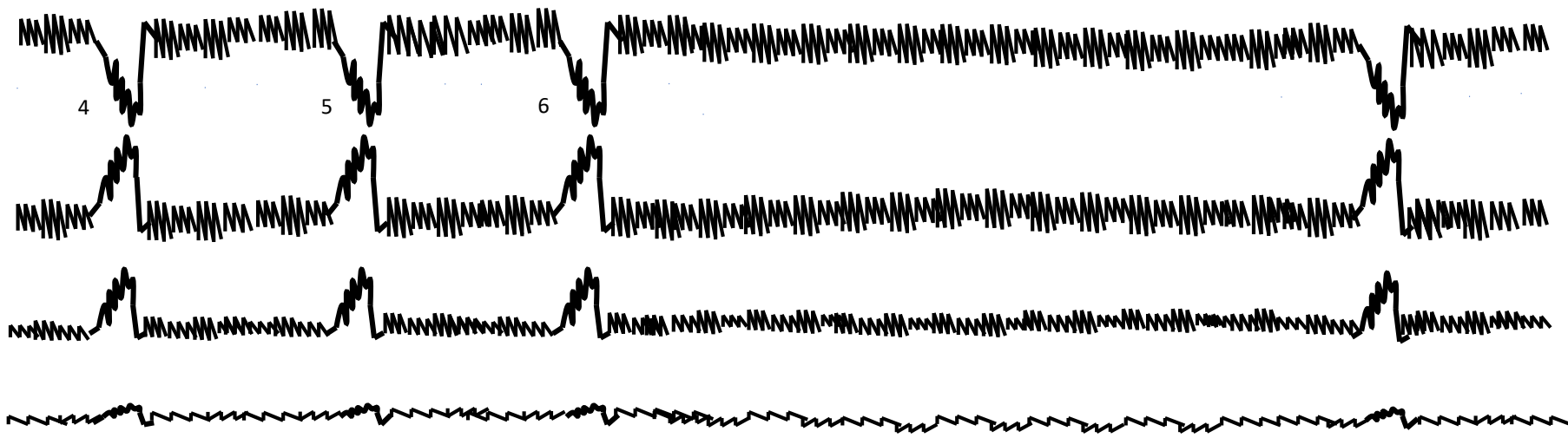
Longitudinal bipolar

EXAMPLE C: LPD+F



EXAMPLE D: LPD (NOT +F, as fast activity is part of the background and present even when the pattern is not)

Longitudinal bipolar



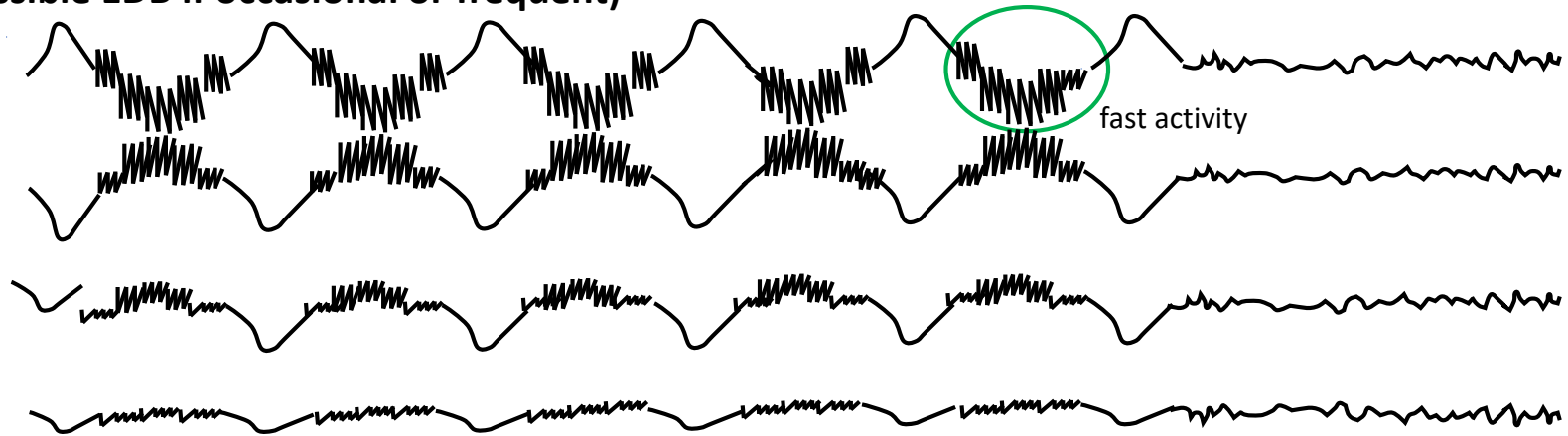


Rhythmic Delta Activity PLUS *fast* activity (RDA+F)

If a pattern qualifying as RDA or PDs has associated 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.

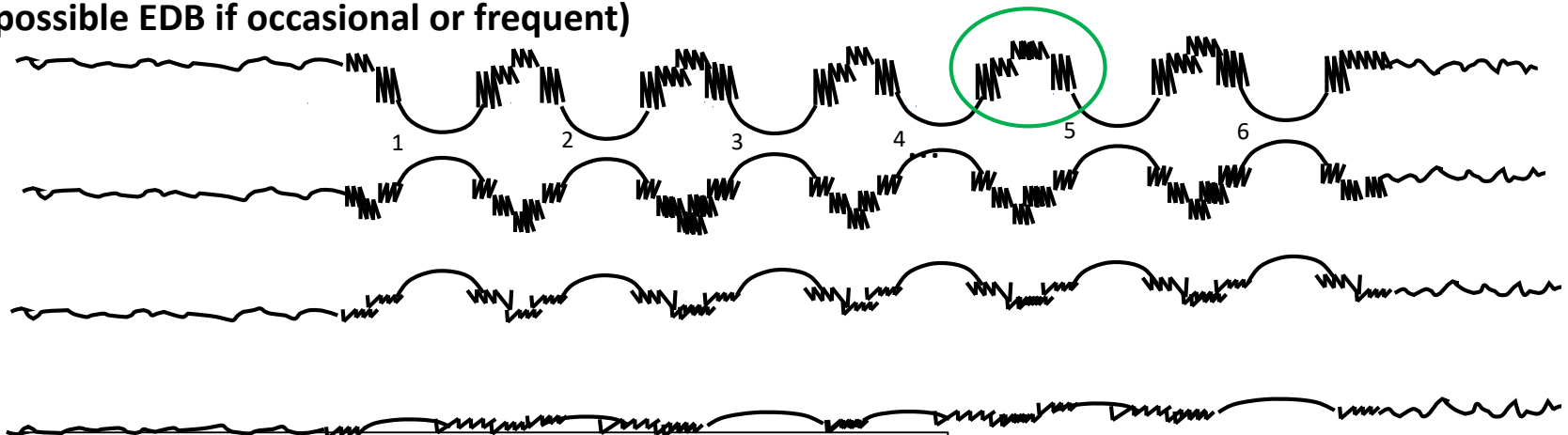
Longitudinal bipolar

EXAMPLE A: RDA+F (also qualifies as definite EDB if the RDA is abundant or continuous, or possible EDB if occasional or frequent)



Longitudinal bipolar

EXAMPLE B: RDA+F (also qualifies as definite EDB if the RDA is abundant or continuous, or possible EDB if occasional or frequent)



NOTE: fast activity cycling with the rhythmic delta and having a stereotyped relationship to the delta wave

EDB = Extreme Delta Brush

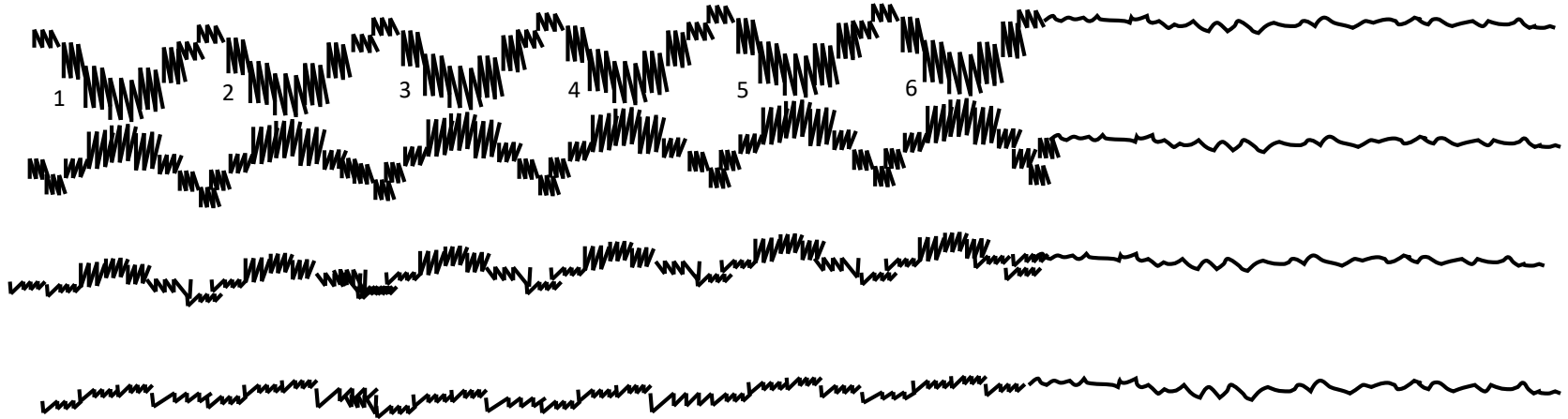


Rhythmic Delta Activity PLUS *fast* activity (RDA+F)

If a pattern qualifying as RDA or PDs has associated 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.

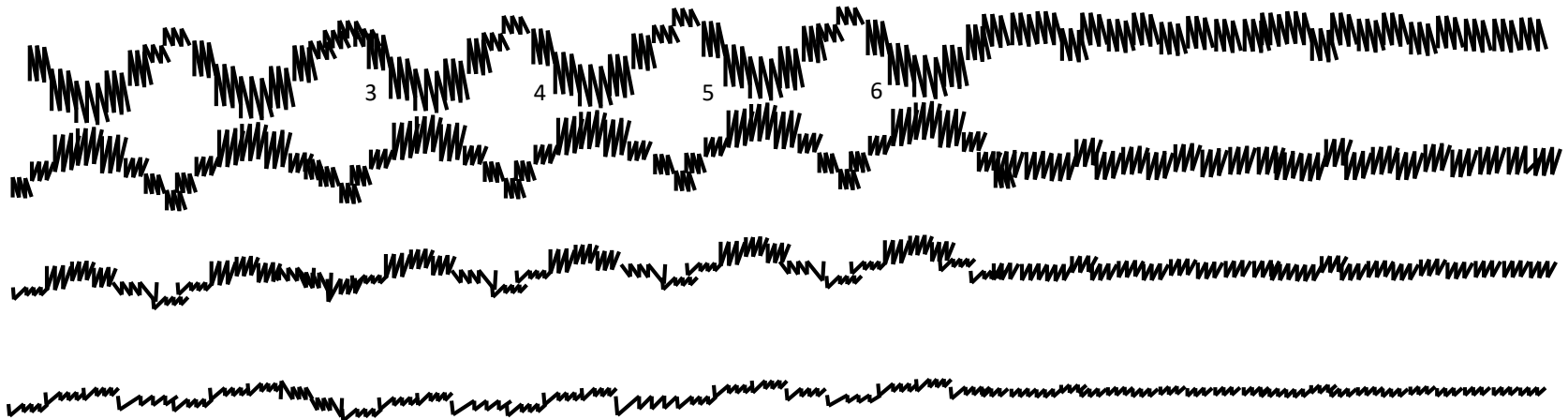
EXAMPLE C: RDA+F (also qualifies as possible EDB if the RDA is abundant or continuous)

Longitudinal bipolar



EXAMPLE D: RDA (NOT +F, as fast activity is part of the background and present even when the pattern is not; NOT EDB since not RDA+F or periodic delta bushes)

Longitudinal bipolar



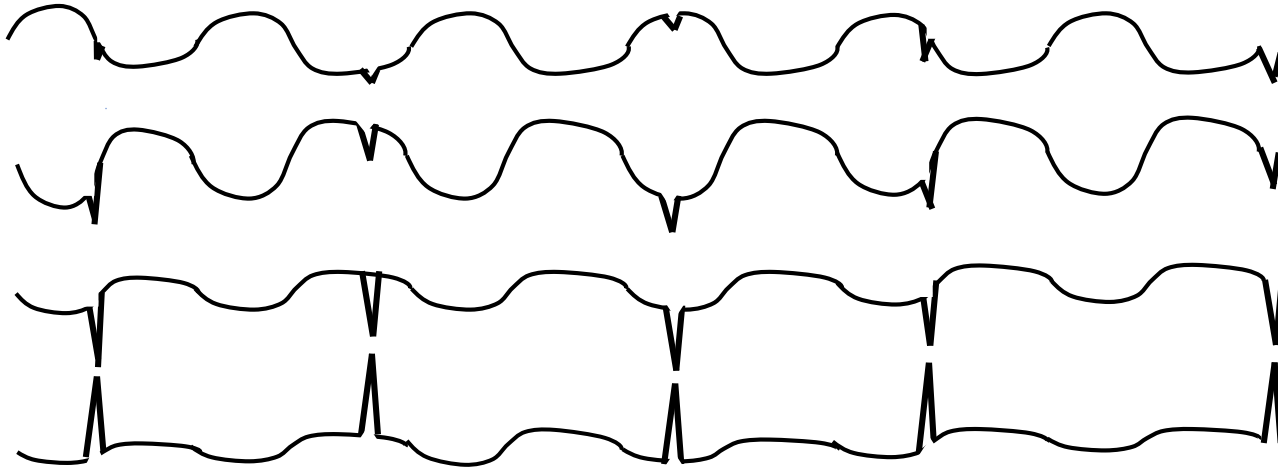


Periodic Discharges PLUS RDA (PD+R)

RDA occurring at the same time as PDs but without time-locked association with the PDs would qualify as PD+R.

EXAMPLE A: PD+R

Longitudinal bipolar



NOTE: spikes are not time-locked to delta-waves

EXAMPLE B: NOT PD+R; instead this is **SW (sharp-and-wave)**: consistent relationship (time-locked association) between the sharp wave component and the slow wave.

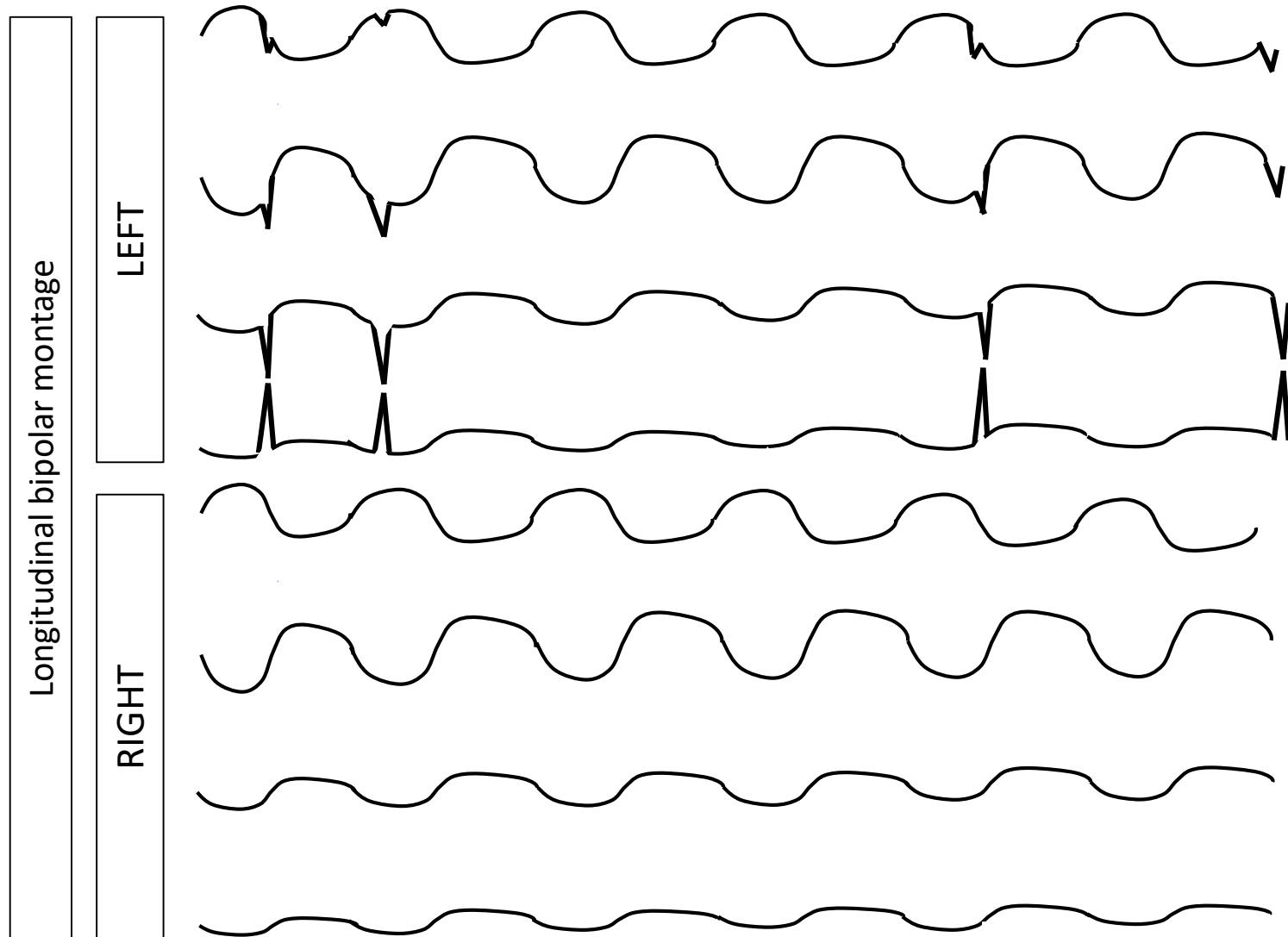
Longitudinal bipolar



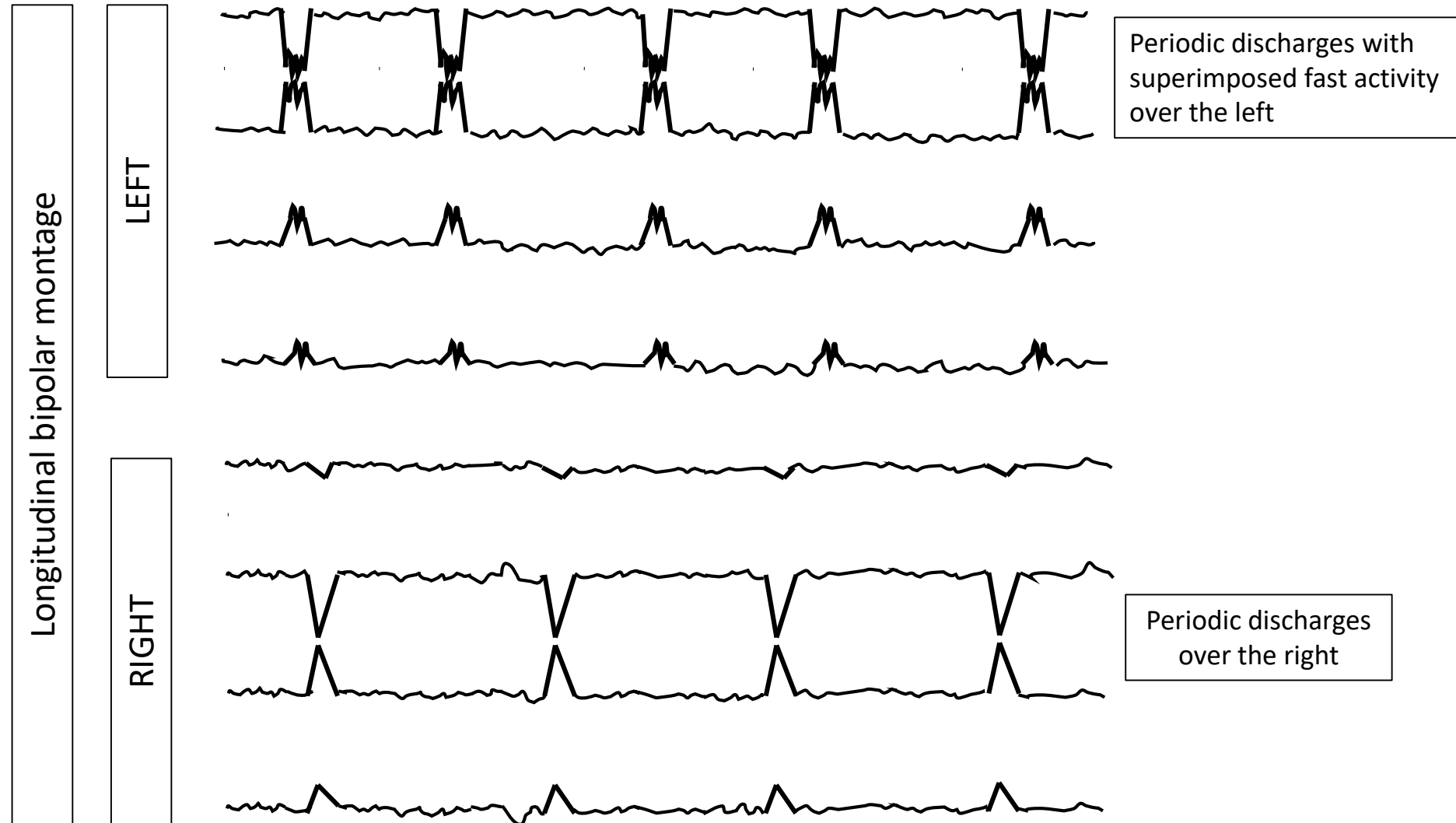


Generalized Rhythmic Delta Activity PLUS *Spikes* (GRDA+S)

Generalized rhythmic delta activity with associated spikes in one hemisphere only (RDA on one side and synchronous RDA+S on the other) would qualify for GRDA+S.



Bilateral Independent Periodic Discharges PLUS *fast* activity (BIPDs+F)



Note: bilateral independent periodic discharges with fast activity in one hemisphere only (PD on one side, and PD+F on the other) would qualify for BIPDs+F.



Relationship between RDA+F, PD+F and Extreme Delta Brush (EDB)

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

3. Main Modifiers:

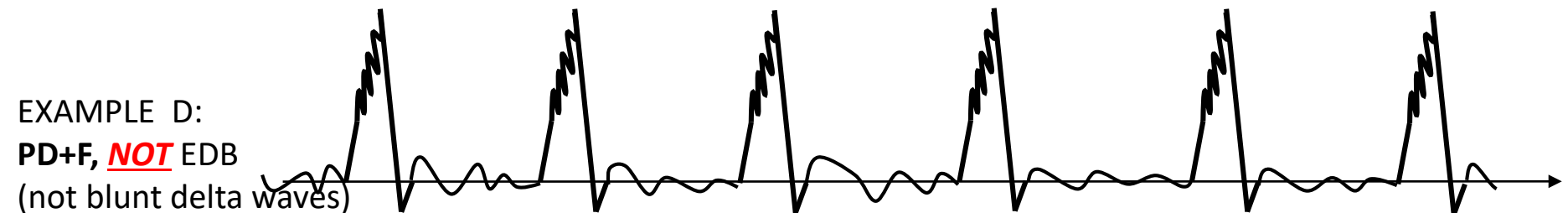
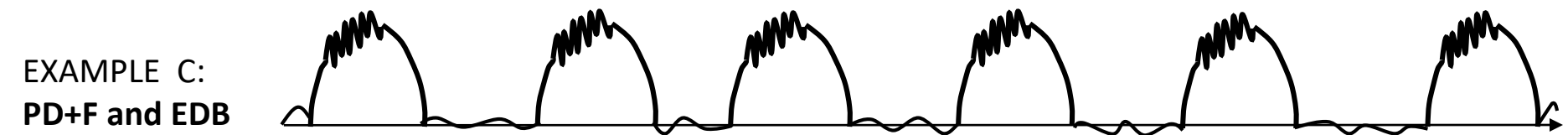
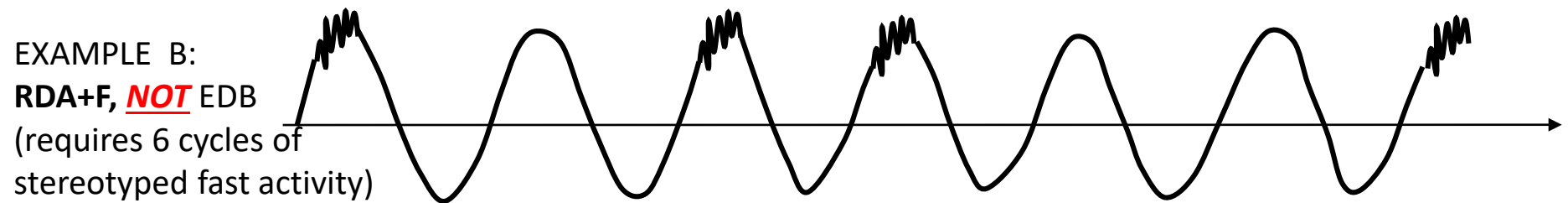
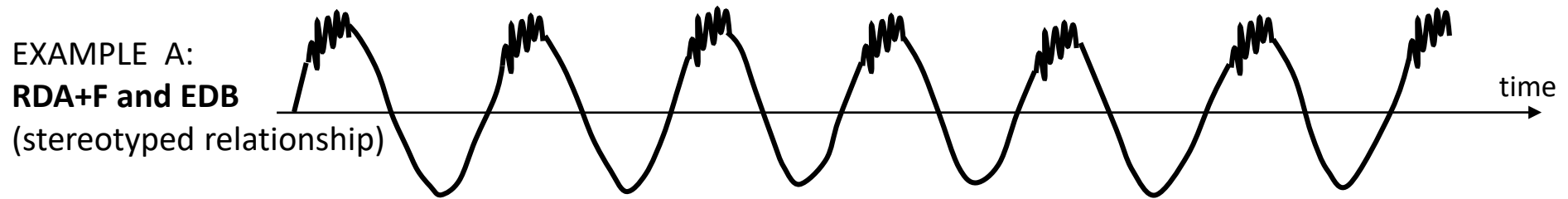
a. Prevalence:

- i. Continuous: ≥90% of record/epoch.
- ii. Abundant: 50-89% of record/epoch.
- iii. Frequent: 10-49% of record/epoch.
- iv. Occasional: 1-9% of record/epoch.
- v. Rare: <1% of record/epoch.



Extreme Delta Brush (EDB):

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



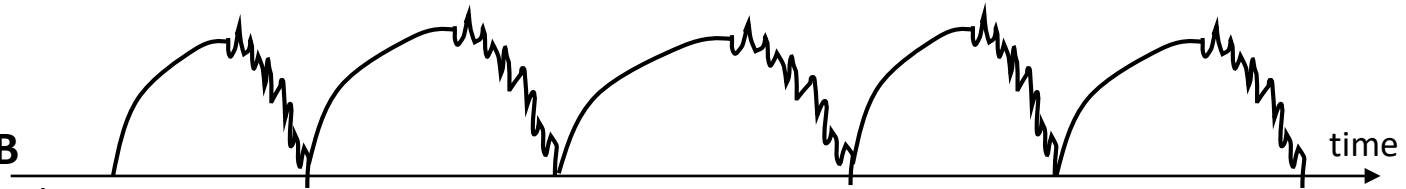


Extreme Delta Brush (EDB): RDA subtype

This is a subset of RDA+F, with **abundant or continuous RDA**, with superimposed fast on each delta wave, in which the **fast** has a stereotyped relationship to the **delta** wave.

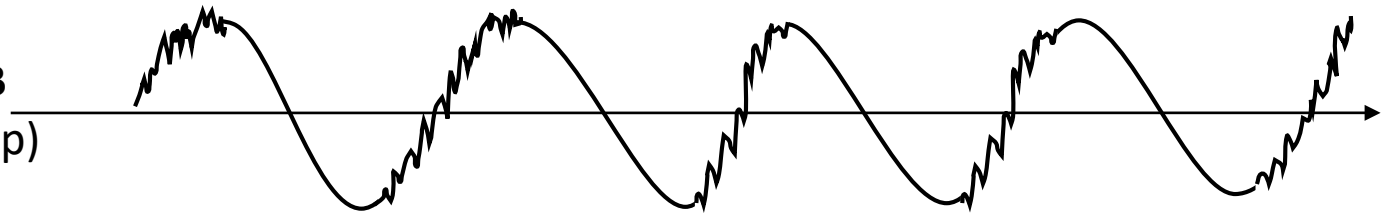
EXAMPLE A:

RDA+F and definite EDB
(stereotyped relationship)



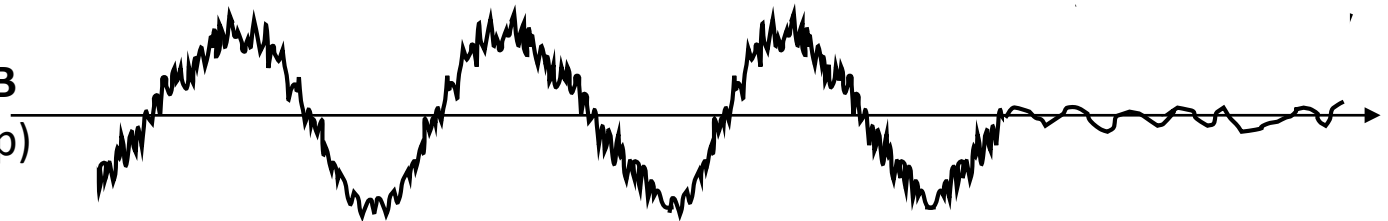
EXAMPLE B:

RDA+F and definite EDB
(stereotyped relationship)



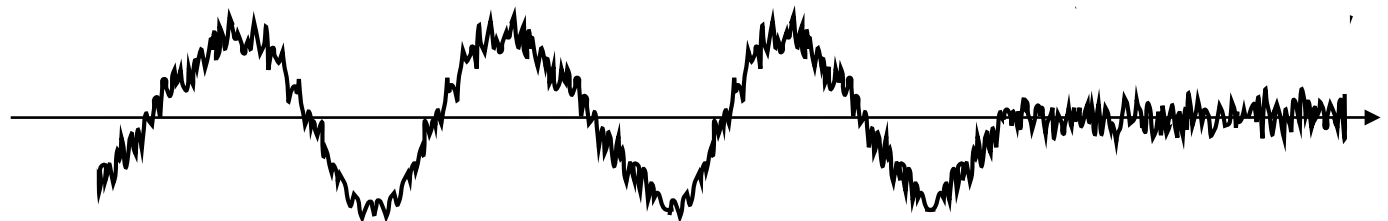
EXAMPLE C:

RDA+F and *possible* EDB
(NO stereot. relationship)



EXAMPLE D:

RDA but NOT +F
and **NOT EDB**



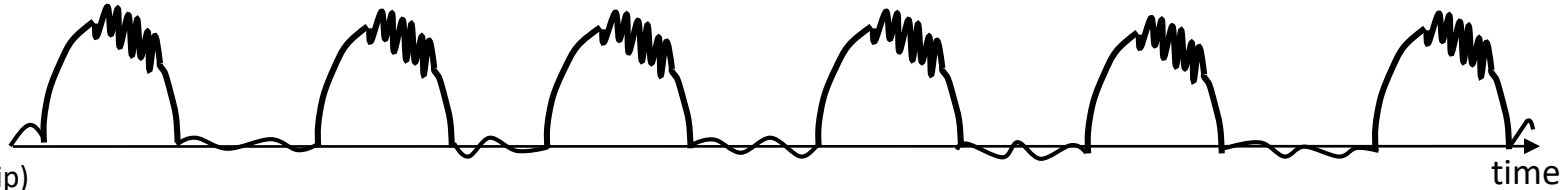
Extreme Delta Brush (EDB): PD subtype

This is a subset of PD+F, with **abundant or continuous PD**, with superimposed fast on each delta wave, in which the **fast** has a stereotyped relationship to the **periodic discharge**.

EXAMPLE A:

**PD+F and
definite EDB**

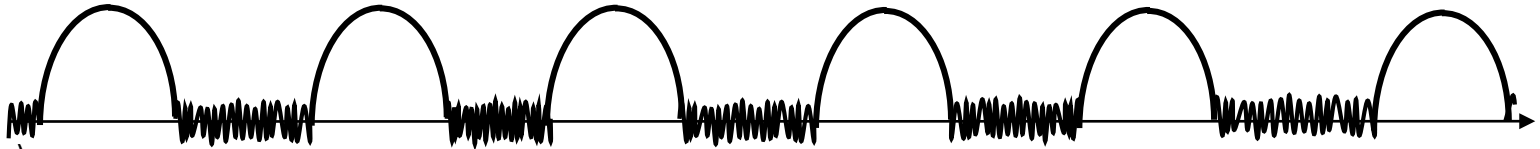
(stereotyped relationship)



EXAMPLE B:

PD+F, NOT EDB

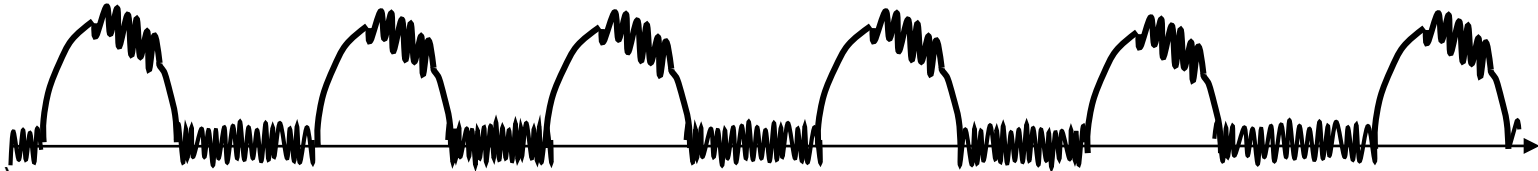
(no fast on the waveform)



EXAMPLE C:

**PD+F and
definite EDB**

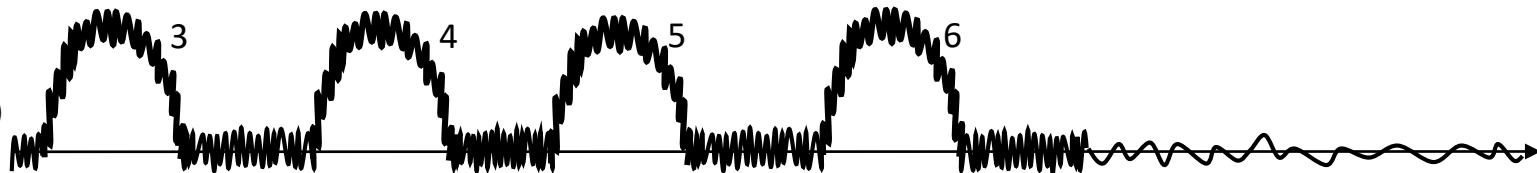
(stereotyped relationship)



EXAMPLE D:

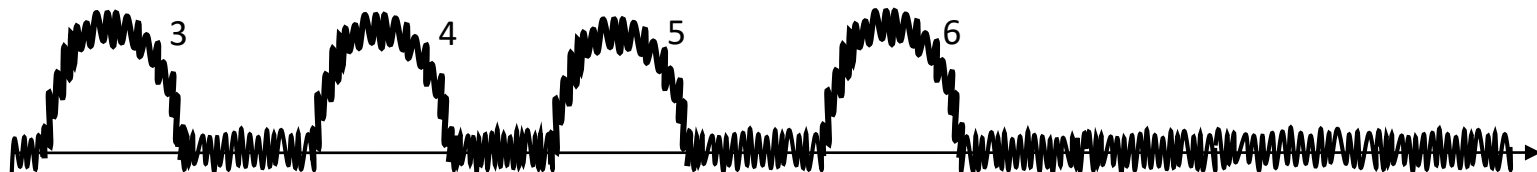
PD+F, possible EDB

(NO stereot. relationship)



EXAMPLE E:

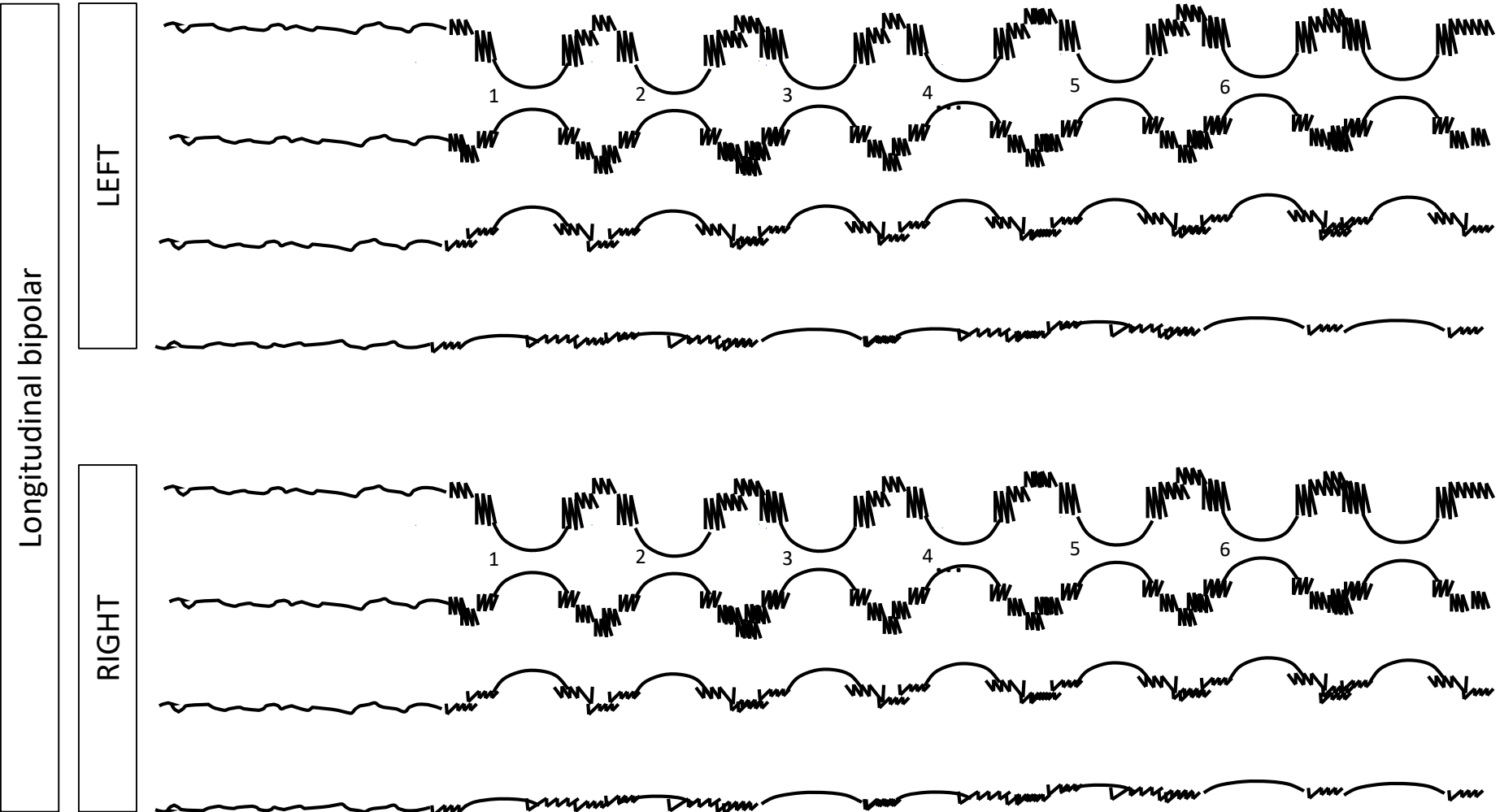
**PD but NOT +F
and NOT EDB**





Extreme Delta Brush (EDB):

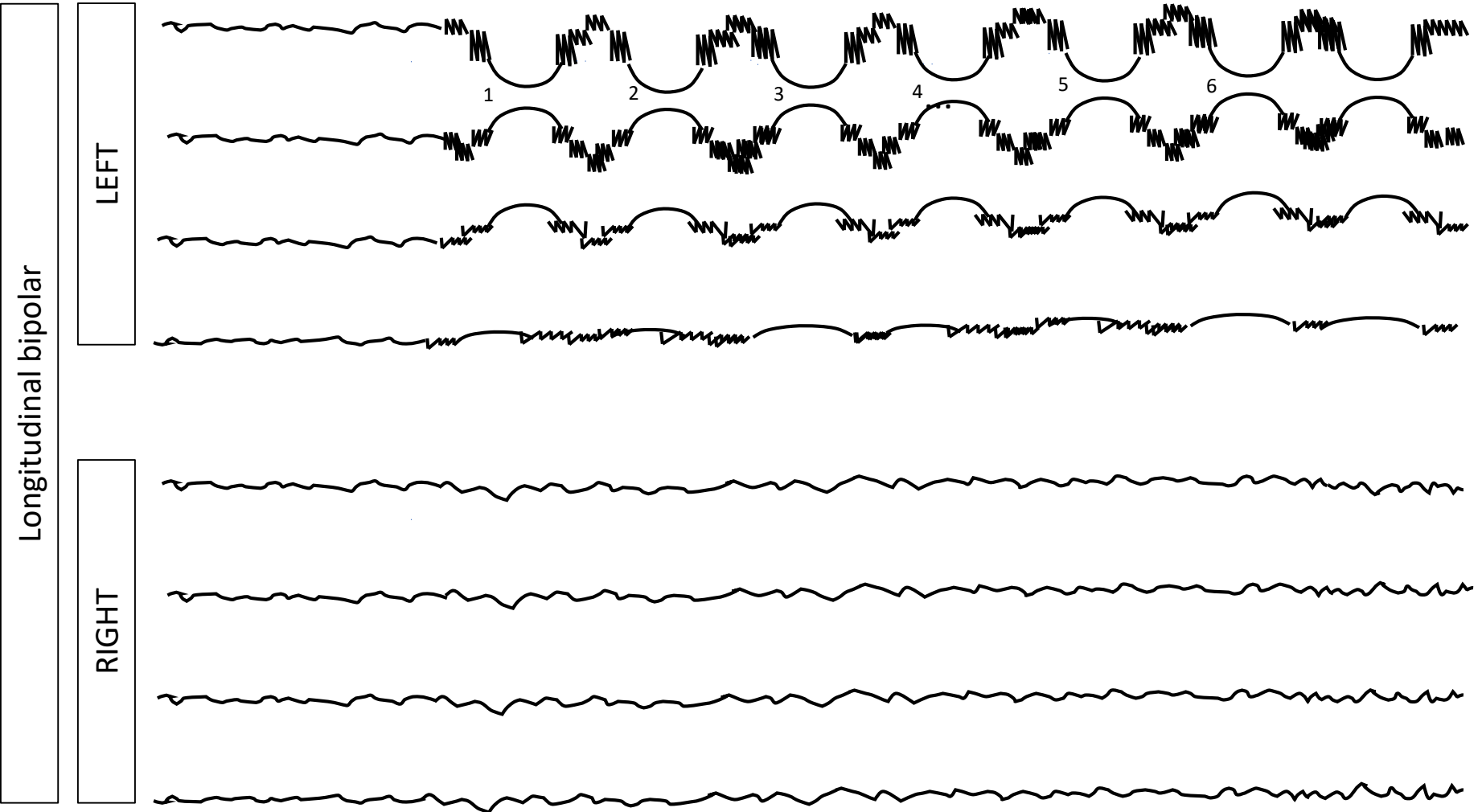
EXAMPLE A: GRDA+F (also qualifies as generalized EDB: definite EDB if the RDA+F is abundant or continuous; possible EDB if the RDA+F is occasional or frequent)





Extreme Delta Brush (EDB):

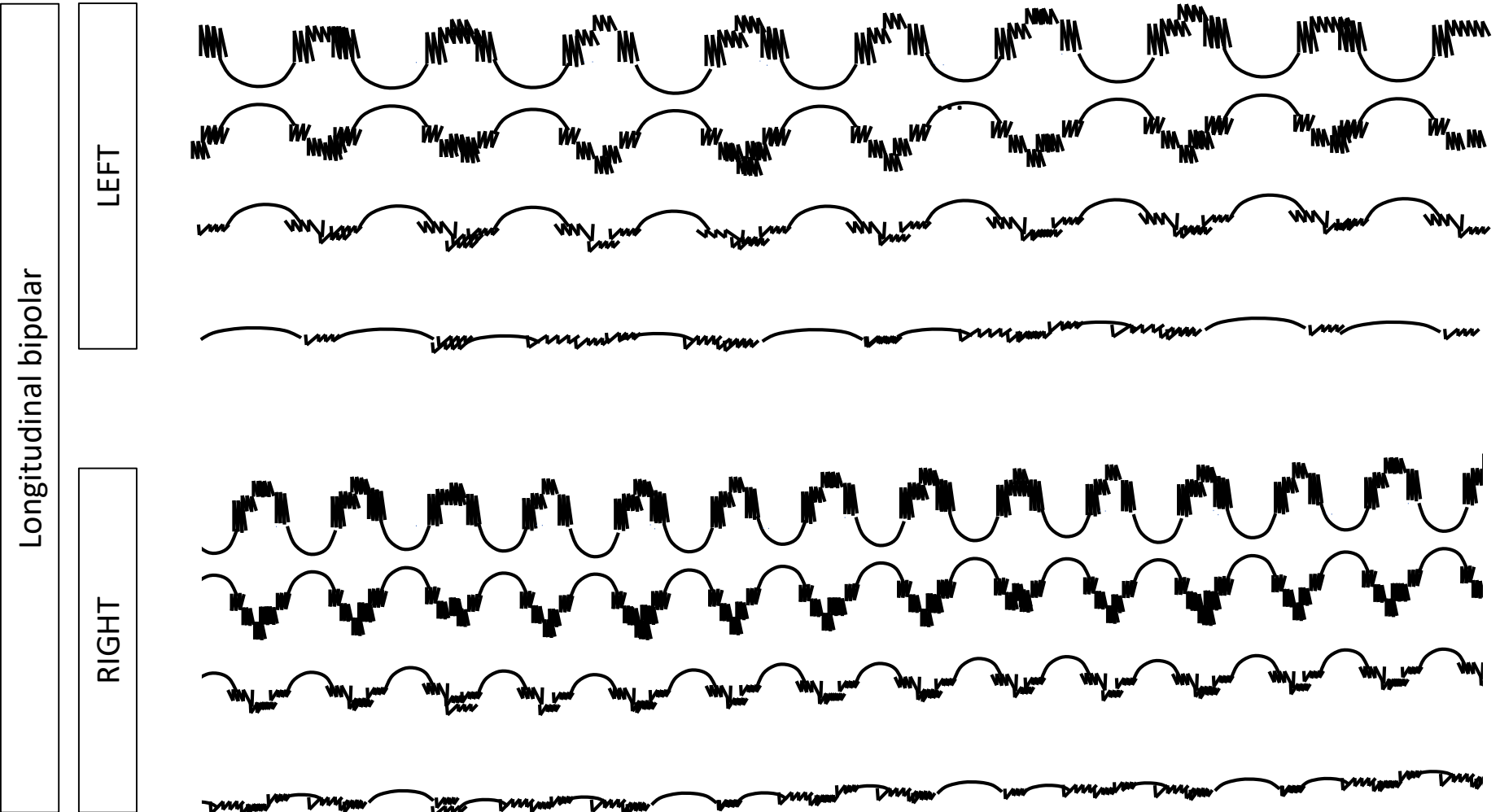
EXAMPLE B: LRDA+F (also qualifies as lateralized EDB: definite EDB if the LRDA+F is abundant or continuous; possible EDB if the LRDA+F is occasional or frequent)





Extreme Delta Brush (EDB):

EXAMPLE C: BIRDA+F (also qualifies as bilateral independent EDB: definite EDB if the BIRDA+F is abundant or continuous; possible EDB if the BIRDA+F is occasional or frequent)

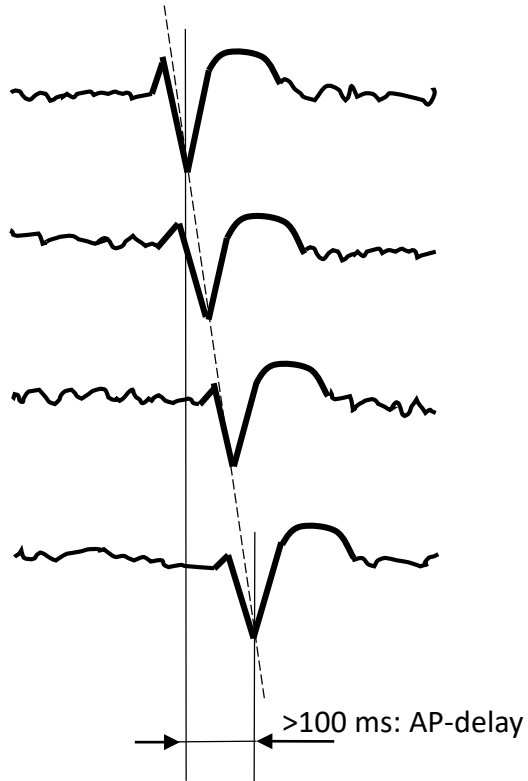




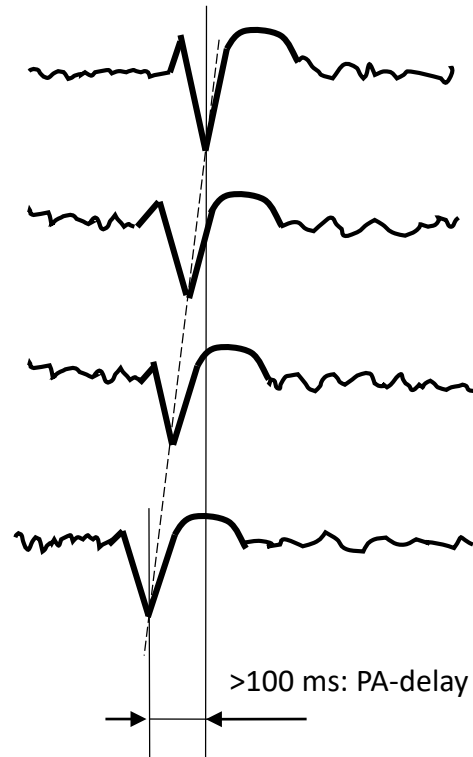
Anterior-posterior (AP) lag:

Longitudinal bipolar

Anterior-posterior lag:



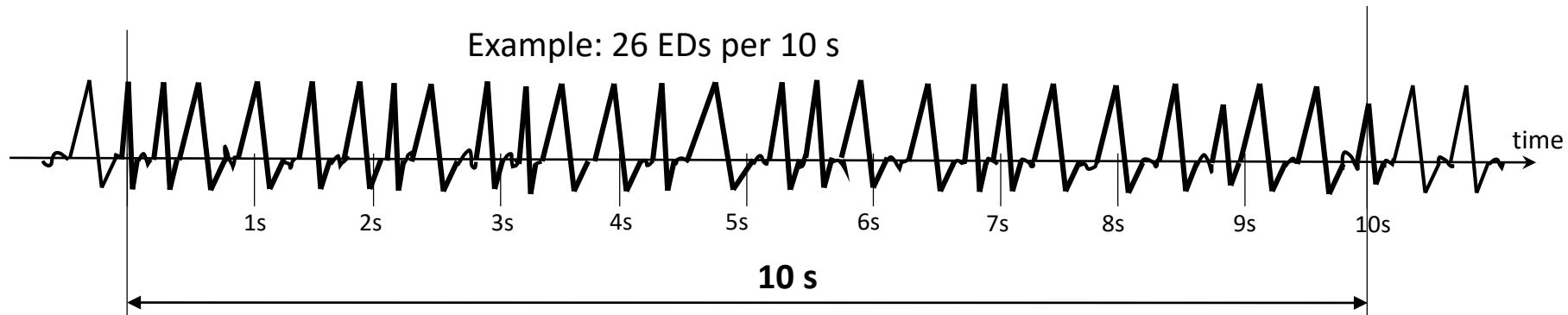
Posterior-anterior lag:





Electrographic seizure (ESz):

Epileptiform discharges **>2.5 Hz** for **≥ 10 s** (**>25 ED** in 10s)



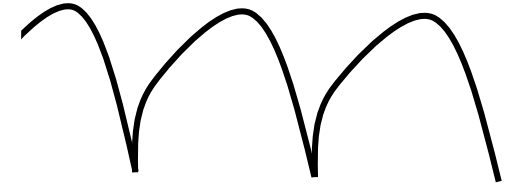
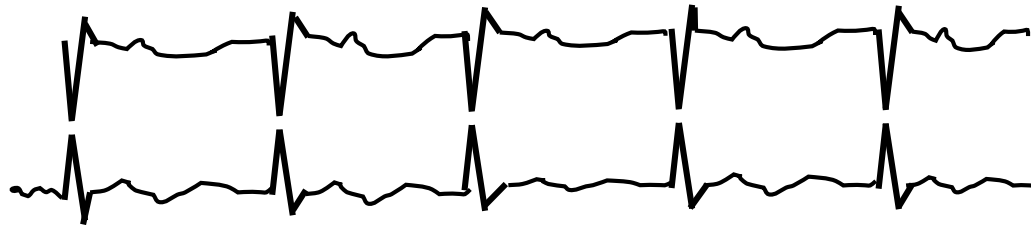
OR

Any pattern with definite evolution lasting ≥ 10 s



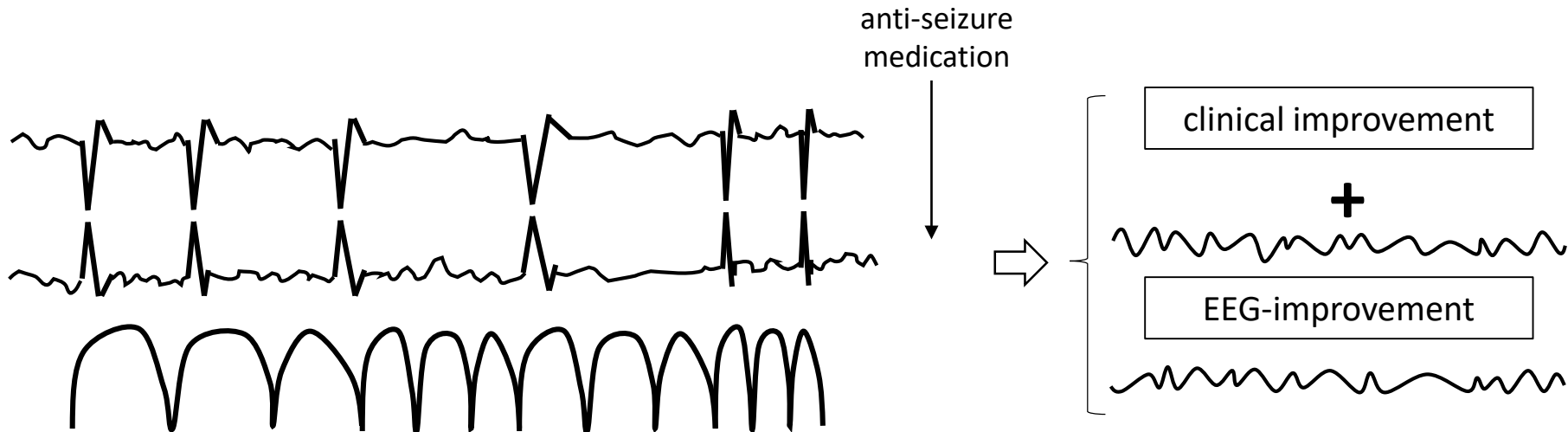
Electroclinical seizure (ECSz): Any EEG pattern with either:

Definite clinical correlate time-locked to the pattern (of any duration)



OR

EEG **AND** clinical improvement with a parenteral (typically IV) anti-seizure medication

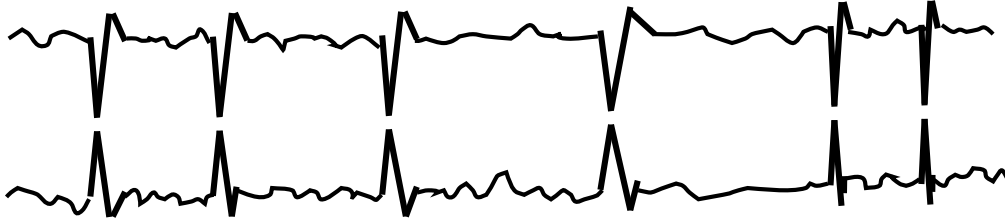




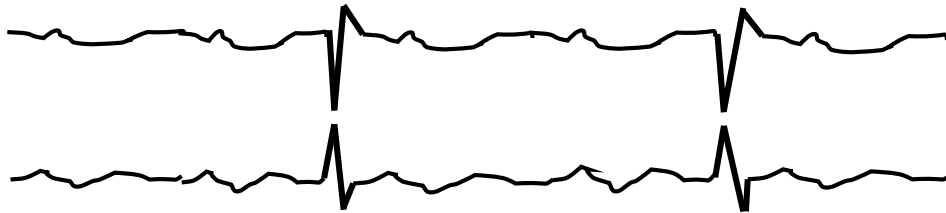
Electroclinical seizure (ECSz):

For patients with prior known epileptic encephalopathy

Current EEG



Baseline EEG



an increase in prominence or frequency of epileptiform discharges compared to baseline,

+

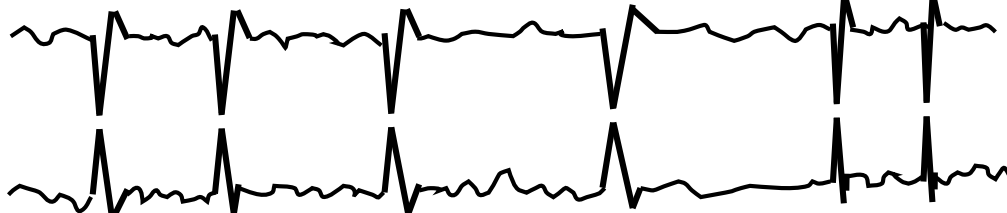
an observable decline in clinical state



OR

Any EEG pattern with EEG **AND** clinical improvement after a parenteral (typically IV) anti-seizure medication

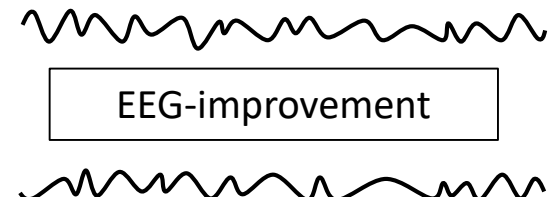
anti-seizure medication



clinical improvement

+

EEG-improvement

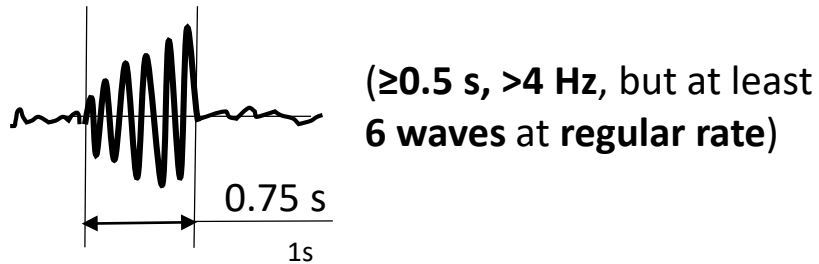


Brief Potentially Ictal Rhythmic Discharges (BIRDs):

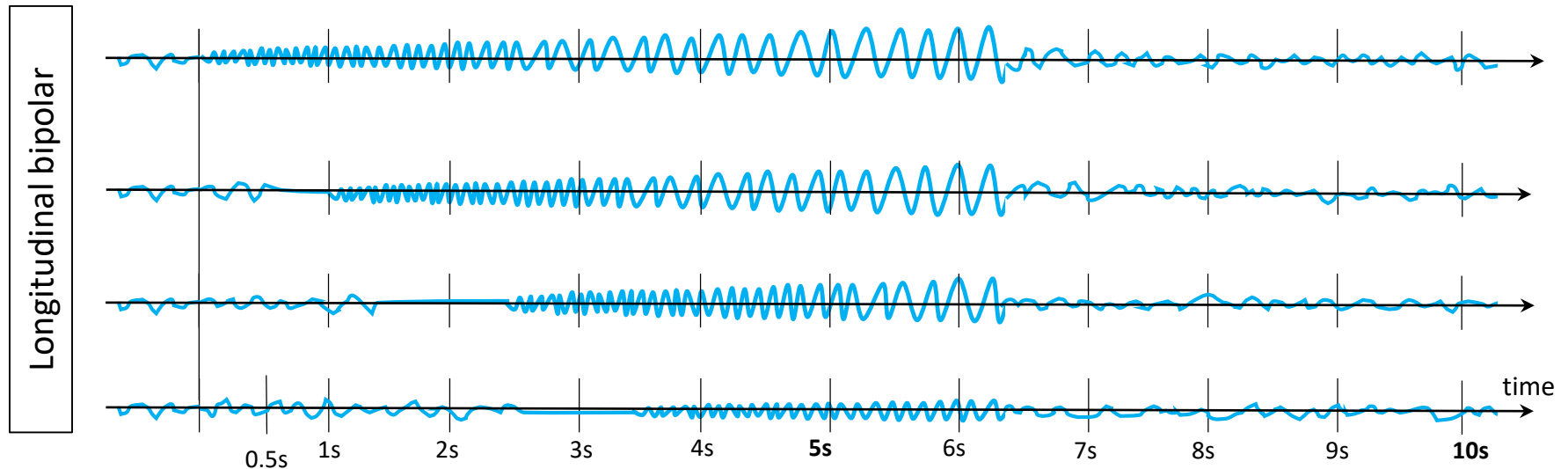
Focal (including L, BI, UI or Mf) or generalized rhythmic activity >4 Hz (at least 6 waves at a regular rate) lasting ≥ 0.5 to <10 s

1. not consistent with a known normal pattern or benign variant,
2. not part of burst-suppression or burst-attenuation,
3. without definite clinical correlate, and
4. that has at least one of the following features:

a. Evolving BIRDs (a form of definite BIRDs)



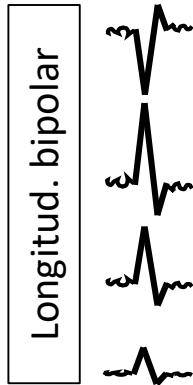
BIRD:



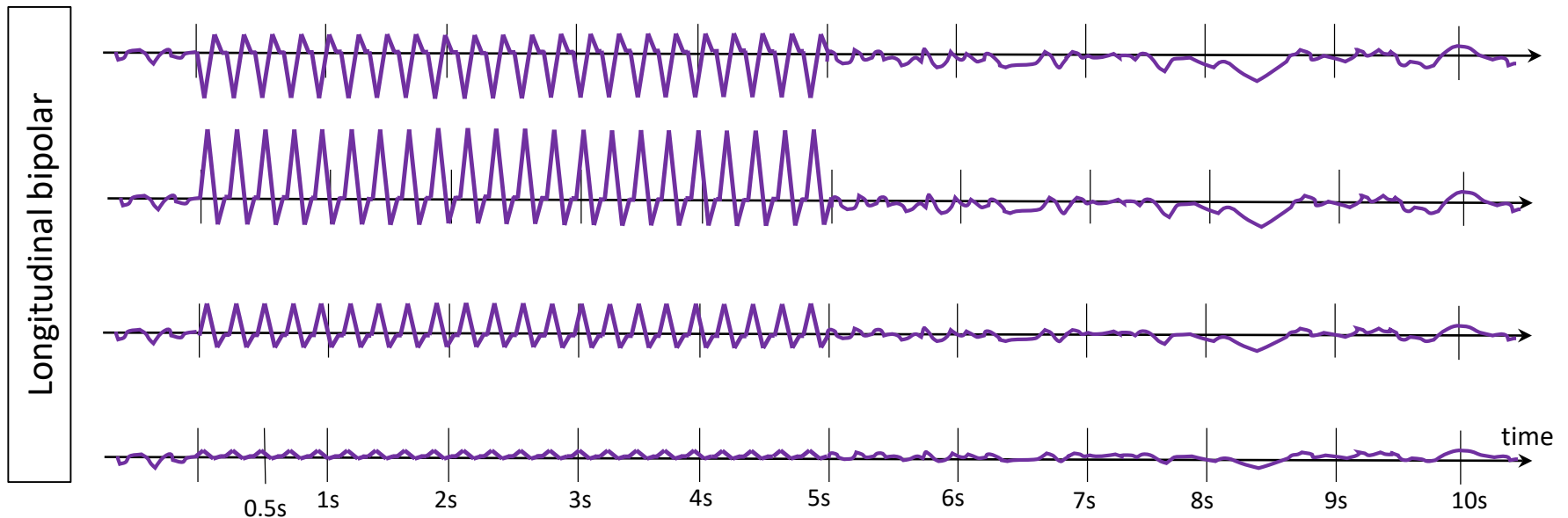
Brief Potentially Ictal Rhythmic Discharges (BIRDs):

b. Similar morphology and location as interictal epileptiform discharges or seizures in the same patient (definite BIRDs)

Interictal epileptiform discharges in same patient:



BIRD: 

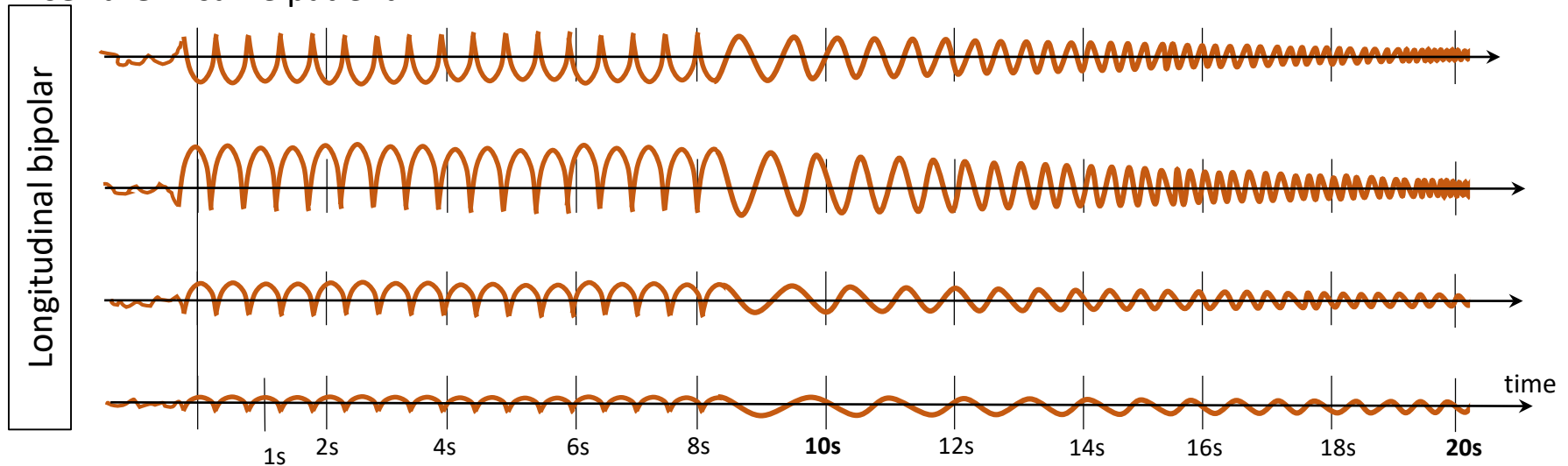




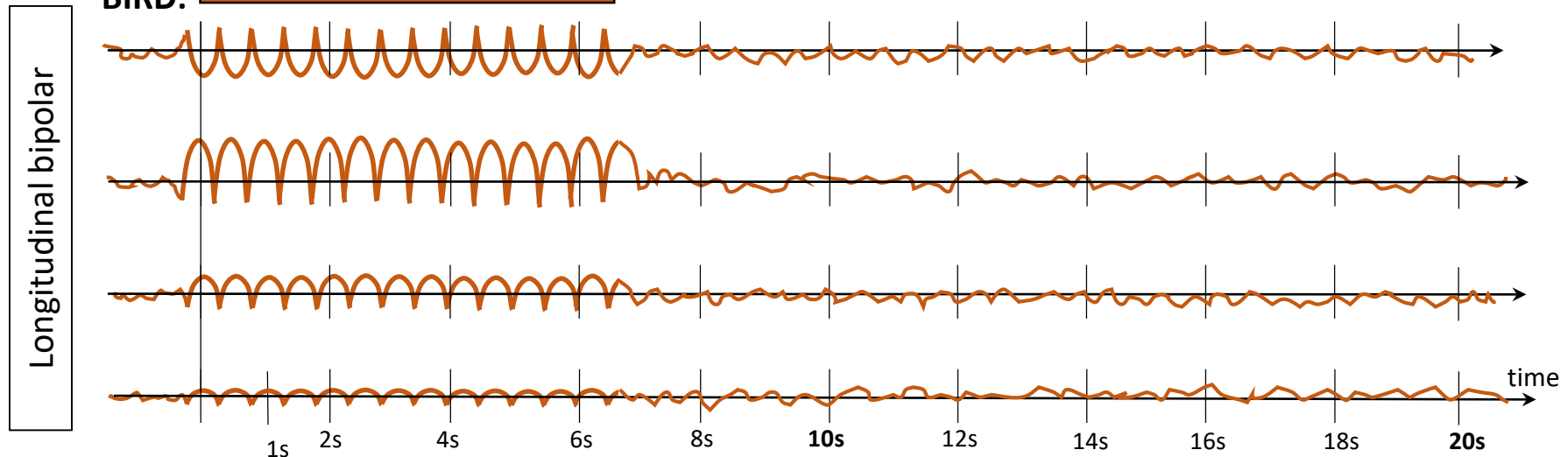
Brief Potentially Ictal Rhythmic Discharges (BIRDs):

b. Similar morphology and location as interictal epileptiform discharges or seizures in the same patient (definite BIRDs)

seizure in same patient:



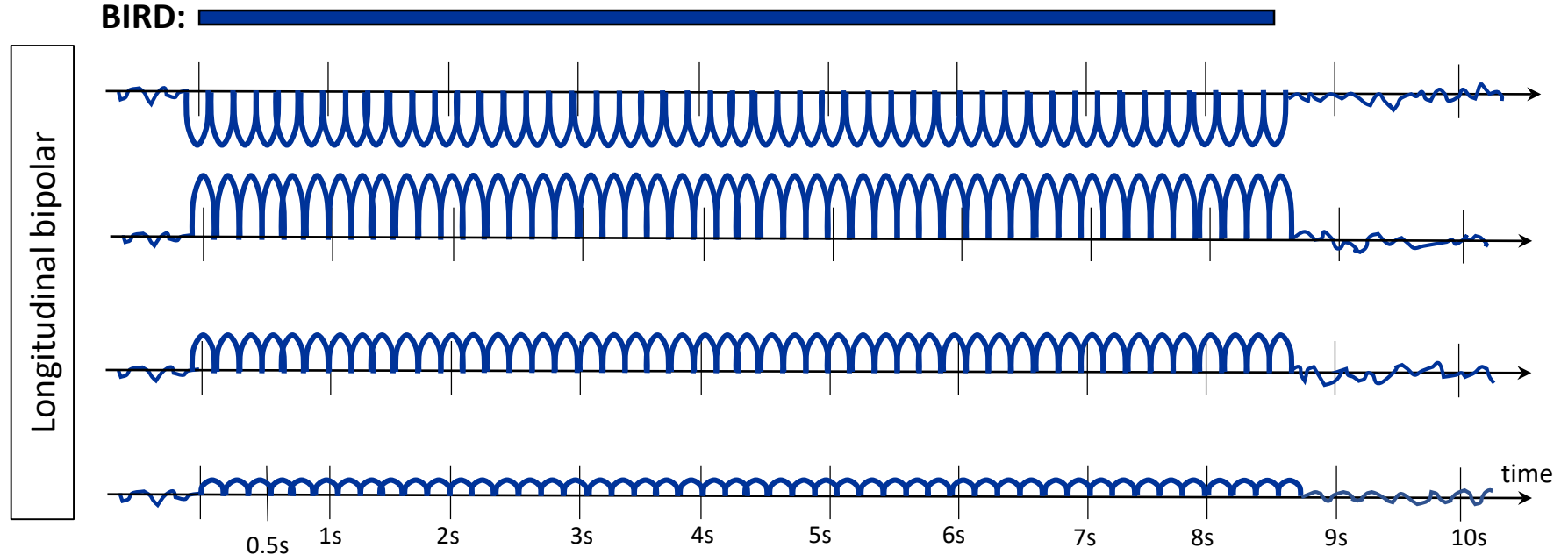
BIRD:





Brief Potentially Ictal Rhythmic Discharges (BIRDs):

c. Sharply contoured but without (a) or (b) (possible BIRDs)





The Ictal-Interictal Continuum (IIC):

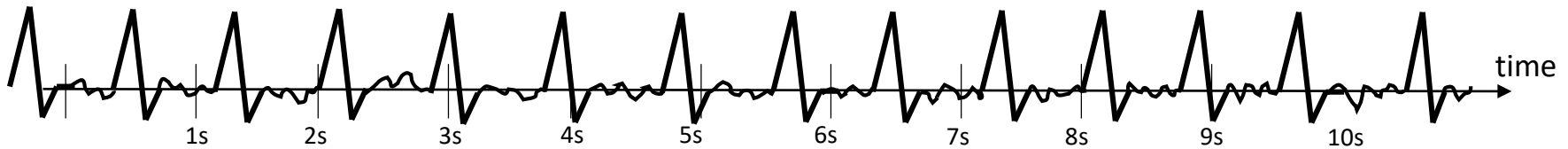
Does not qualify as an electrographic seizure or electrographic status epilepticus, but can be considered with any of the following features:

A. Any PD or SW pattern that averages >1.0 Hz and ≤ 2.5 Hz over 10 s (>10 and ≤ 25 discharges in 10 s);

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

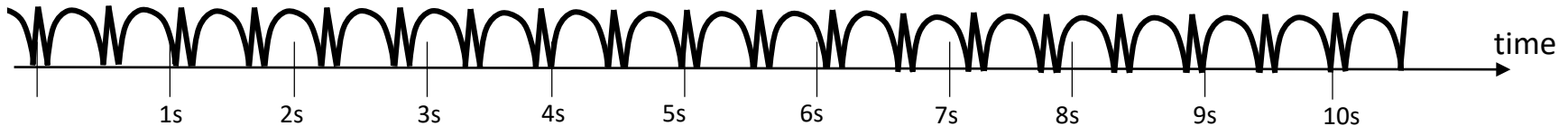
PD

Example: 12 EDs per 10 s



SW

Example: 18 EDs per 10 s



OR

to be continued

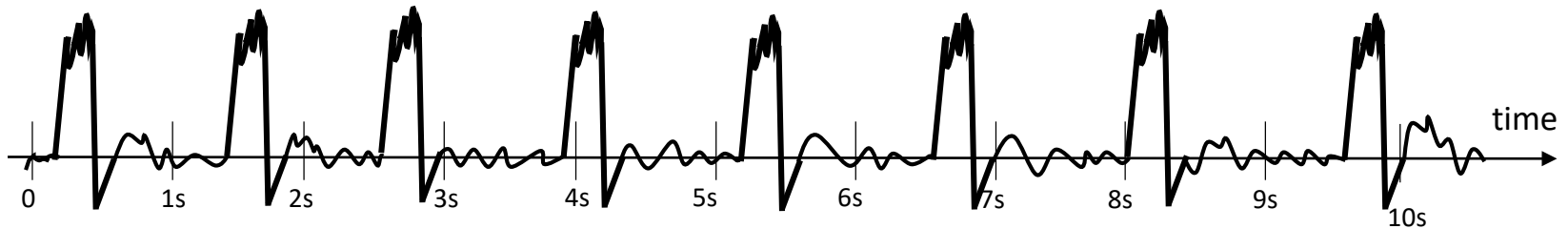


The Ictal-Interictal Continuum (IIC):

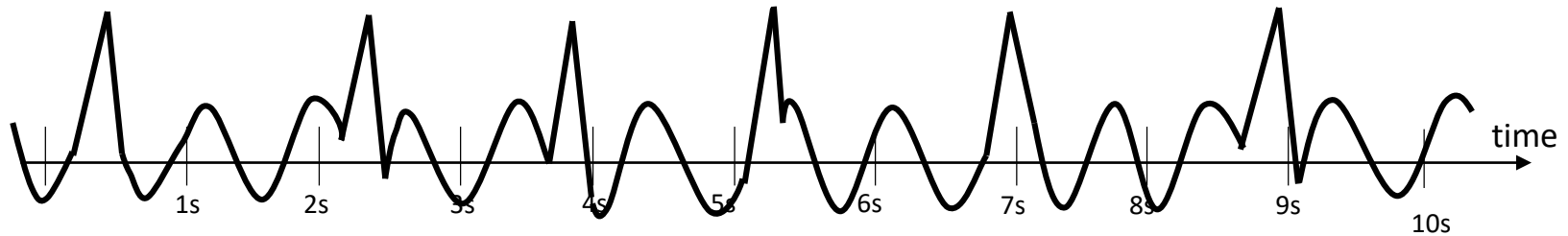
B. Any PD or SW pattern that averages ≥ 0.5 Hz and ≤ 1.0 Hz over 10 seconds (≥ 5 and ≤ 10 discharges in 10 s), AND has a plus modifier or fluctuation;

PLUS-MODIFIERS

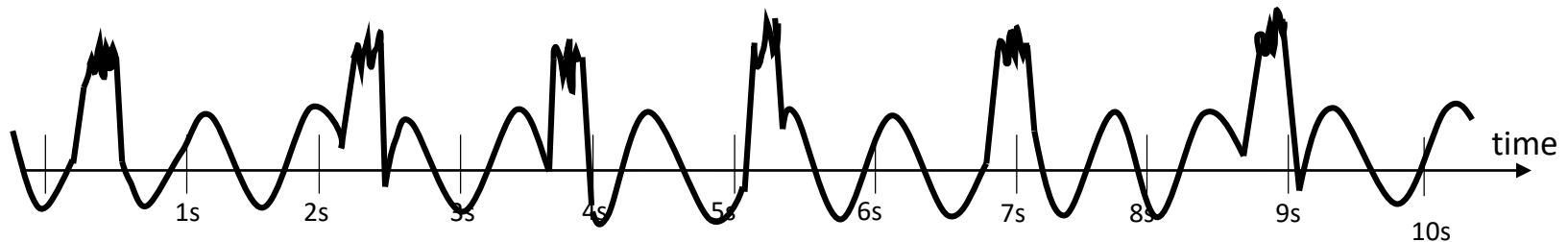
PD+F



PD+R



PD+FR



OR

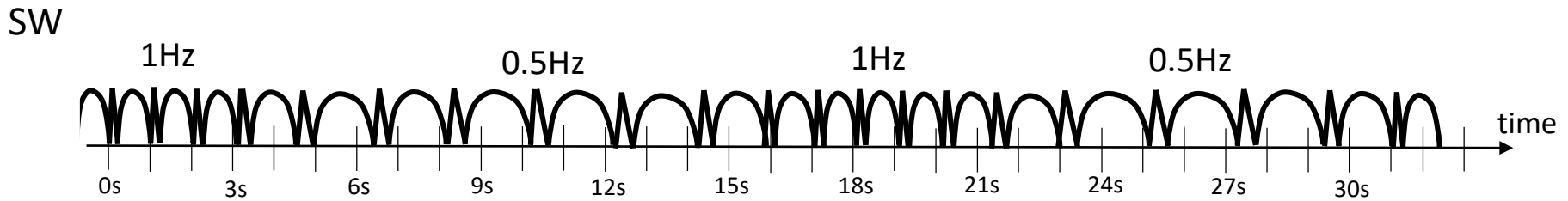
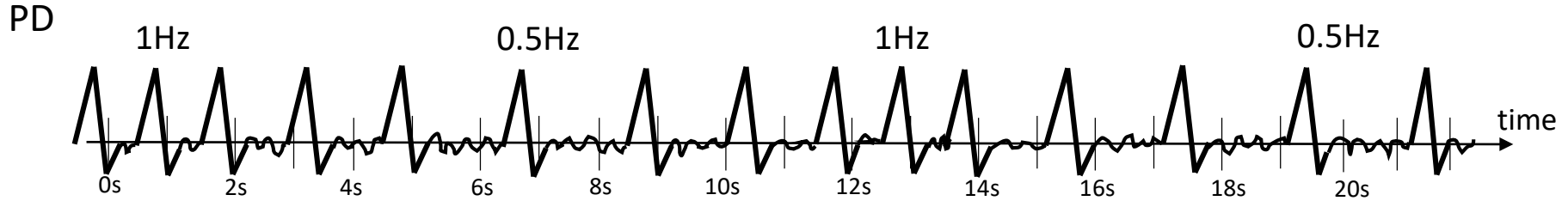
to be continued



The Ictal-Interictal Continuum (IIC):

B. Any PD or SW pattern that averages ≥ 0.5 Hz and ≤ 1.0 Hz over 10 seconds (≥ 5 and ≤ 10 discharges in 10 s), AND has a plus modifier or fluctuation;

Fluctuation



OR

to be continued

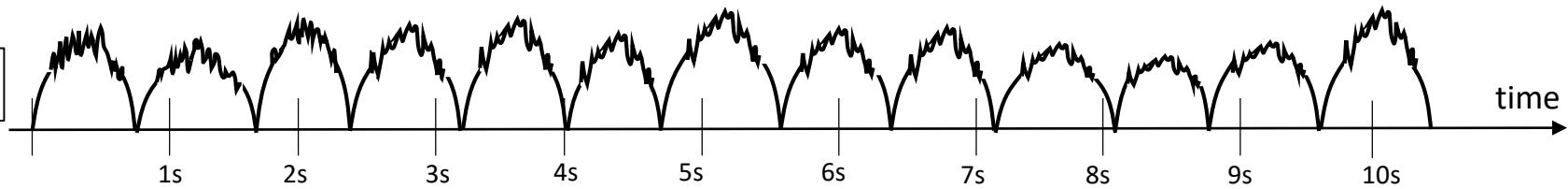


The Ictal-Interictal Continuum (IIC):

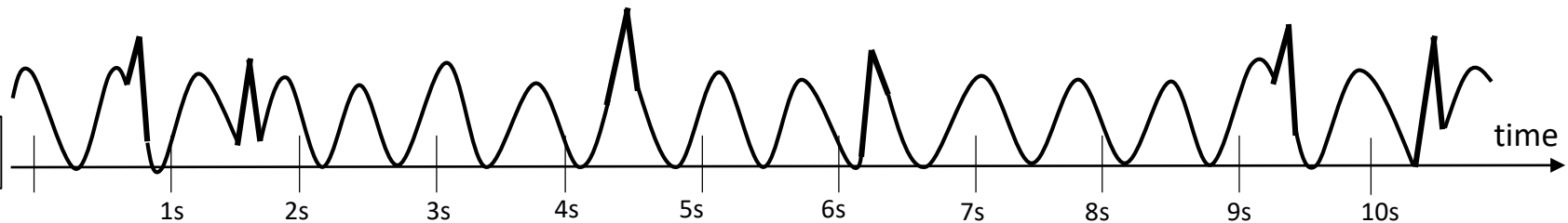
C. Any lateralized RDA (LRDA, BIRDA, UIRDA, MfRDA) averaging >1 Hz for ≥ 10 s (at least 10 waves in 10 s) with a plus modifier or fluctuation.

PLUS-MODIFIER

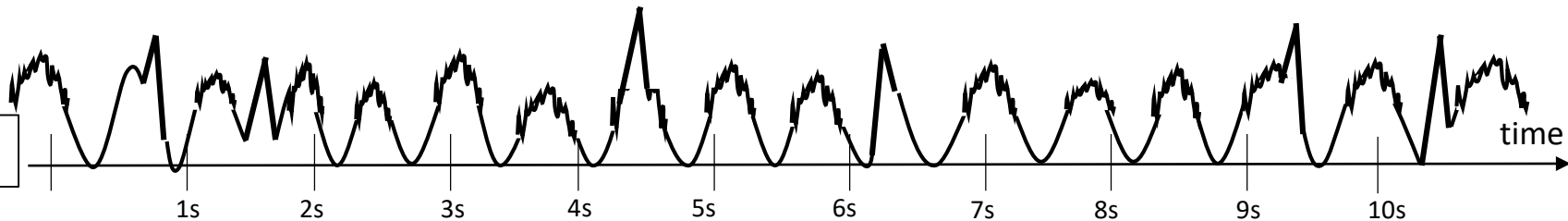
RDA+F



RDA+S



RDA+FS





The Ictal-Interictal Continuum (IIC):

C. Any lateralized RDA (LRDA, BIRDA, UIRDA, MfRDA) averaging >1 Hz for at ≥ 10 s (at least 10 waves in 10 s) with a plus modifier or fluctuation.

