

ANSeR educational support
document: Differentiating seizures
from false detections.

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Introduction

- ANSeR (the **A**lgorithm for **N**eonatal **S**eizure **R**ecognition) is a program designed to detect the rhythmic patterns of seizures newborn babies in real-time.
- Seizures are rhythmic but there are several types of artefact and other sources that can also create rhythmic patterns and cause '**false detections**'.
- Consequently when ANSeR makes a 'detection', this should be viewed by the clinician as a prompt to review that segment of the raw EEG. At that point a decision will need to be made as to whether the detection is a true seizure or a false detection.
- The purpose of this document is to describe some common features of seizures and false detections to increase the ability of clinicians to differentiate them.

ANSeR

((ALARM))



Neonatal seizures

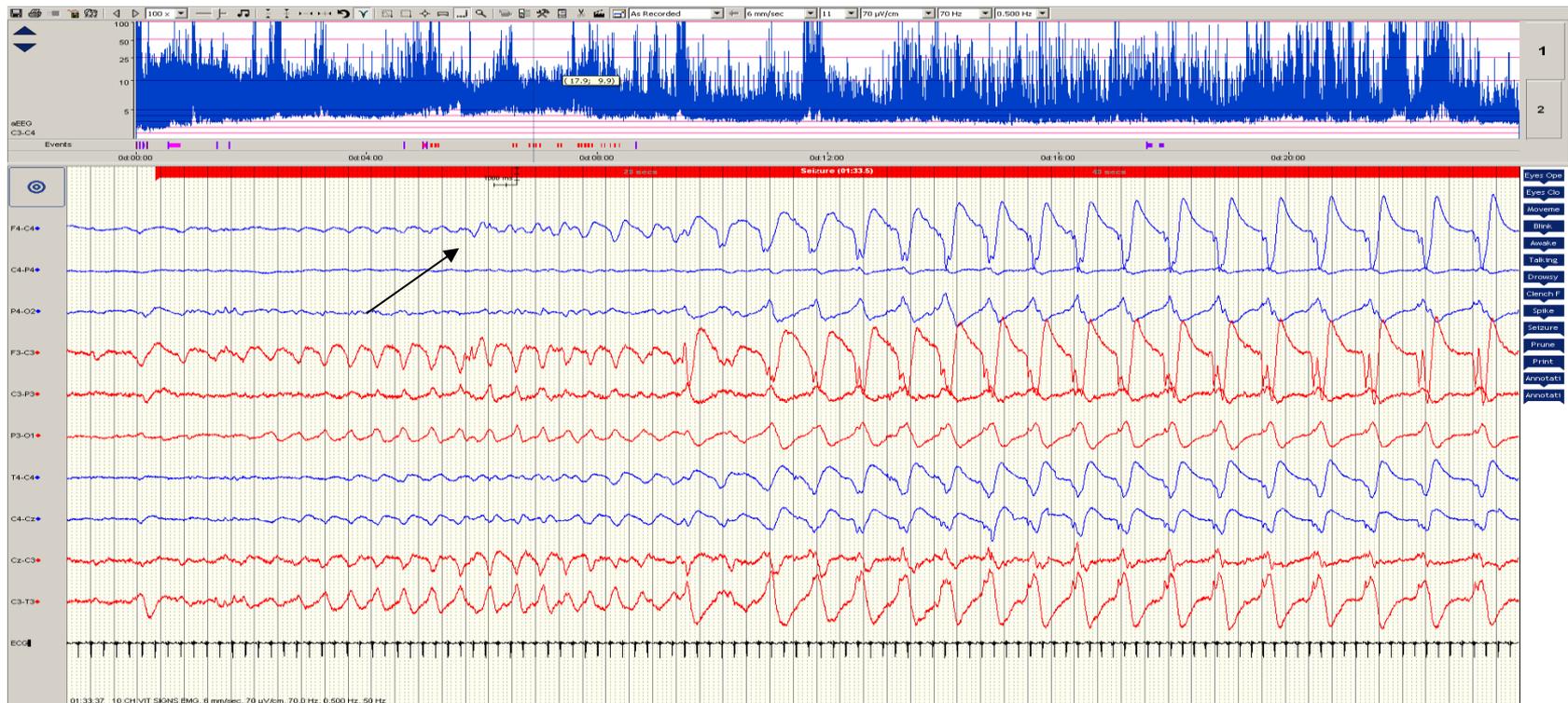
- **Definition**
- Seizures in neonates are defined as *'sudden, repetitive, evolving stereotyped waveforms with a definite beginning, middle, and end'*.
- To be defined as a seizure a minimum duration of **10 seconds** is widely accepted.
- Discharges of shorter duration are termed 'brief interictal rhythmic discharges' (BIRDs) and are of uncertain significance.
- For two runs of seizure activity to be considered as separate seizures, a minimum period of 10 seconds of non seizure activity should exist between them.

Features of neonatal seizures

- Neonatal seizures have a tendency to evolve in ***amplitude, frequency, morphology and propagation*** (appear at increasing number of electrodes as seizure 'spreads' across brain).
- This '**evolution**' of features is one of the clues that can be used to differentiate seizures from other rhythmic artefacts such as respiration and pulse artefact which tend not to 'evolve'.
- **N.B. Some seizures show little or no evolution and the absence of the evolving features does not rule out a seizure.**

Seizure: Amplitude and propagation

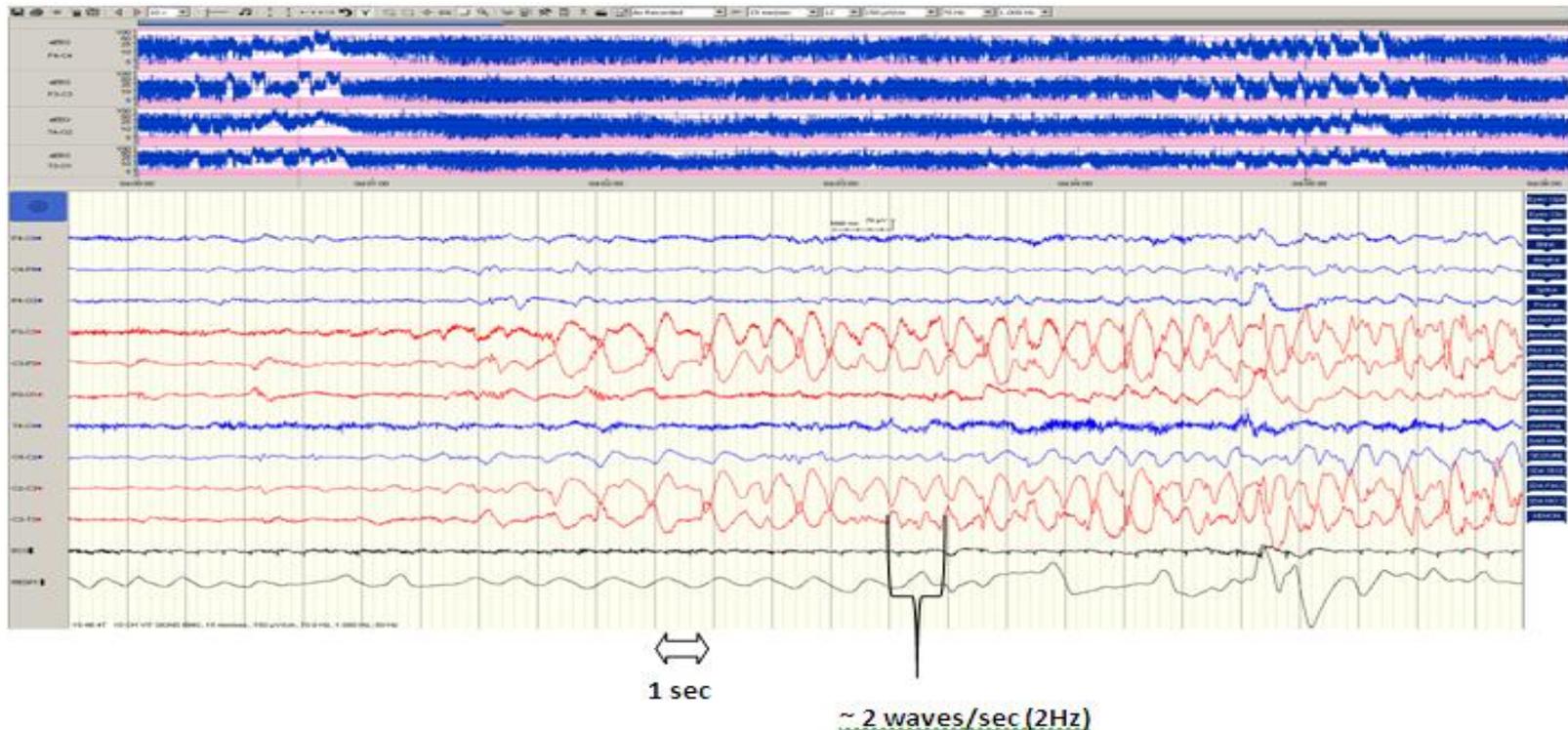
- The evolution in amplitude and propagation is likely due to progressive recruitment of neurons peripheral to site of seizure onset.
- Note how the seizure starts on the left hemisphere (red traces) and spreads to the right hemisphere (blues traces) with time and increases in amplitude as the seizure progresses.



Seizures: Frequency

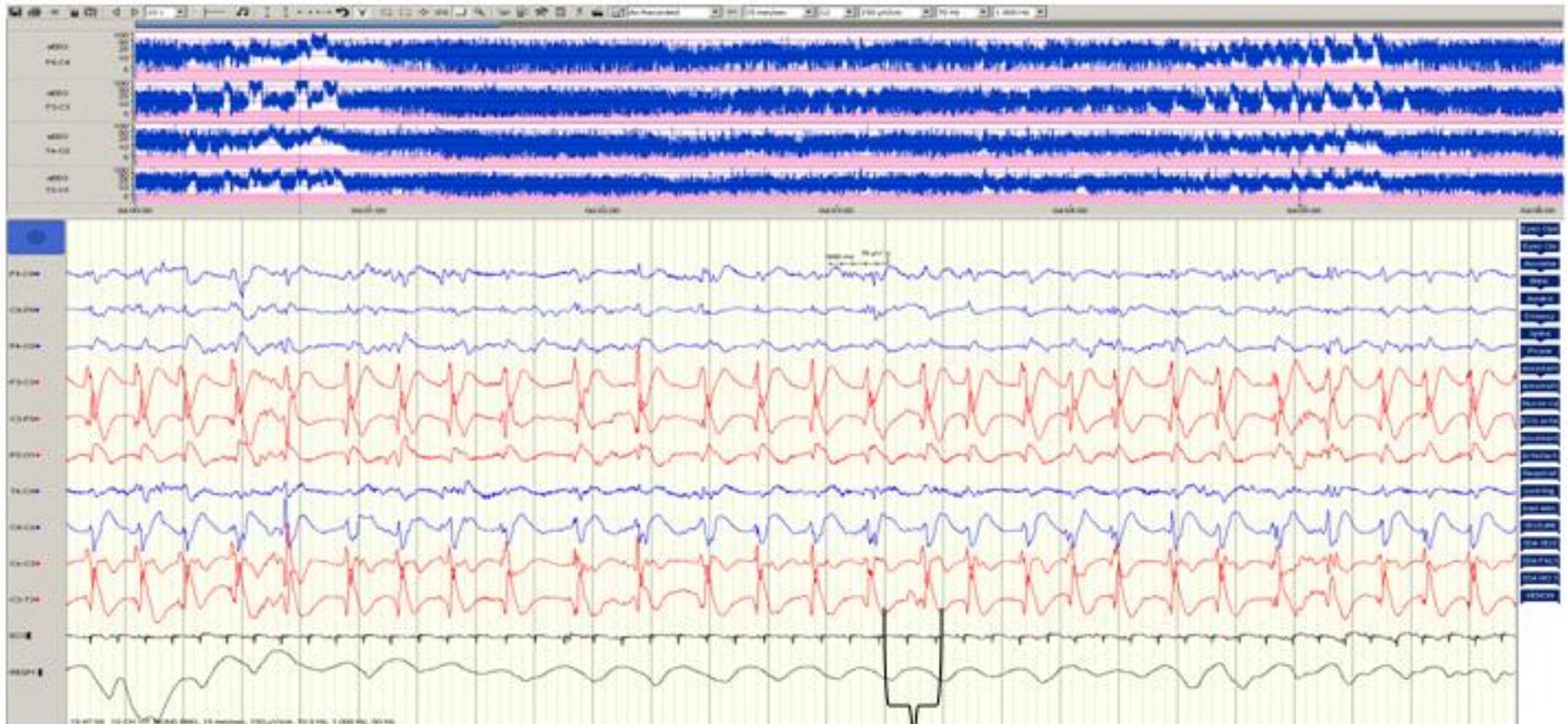
- Seizures often show changes in discharge **frequency**. Quite often faster frequencies are seen at the start, with progressive slowing particularly at the end of the seizure.
- Frequency can be estimated by counting the number of peaks (or troughs) occurring in a second.

Start of seizure



Seizures: Frequency

Middle of seizure



1 sec

~ 1 wave/sec (1Hz)

Seizures: Frequency

End of seizure



1 sec

~ 1 wave every 2
sec = 0.5Hz

Seizures: Discharge morphology

- The **morphology** of the epileptic discharges in neonatal seizures can vary from seizure to seizure and quite often within a seizure.
- Below are some examples of typical seizure morphologies
- **spike and wave complex** - The spike represents concurrent firing of large groups of excitatory neurons. The slow wave represents the inhibitory response to that over-excitation.
- With some seizures the slow wave component is less apparent and the most prominent feature of the seizure is **repetitive spikes**.
- Conversely the **repetitive slow wave** may be the most prominent feature of the seizure and the spike component may be subtle or absent.



Spike and (slow) wave complexes.



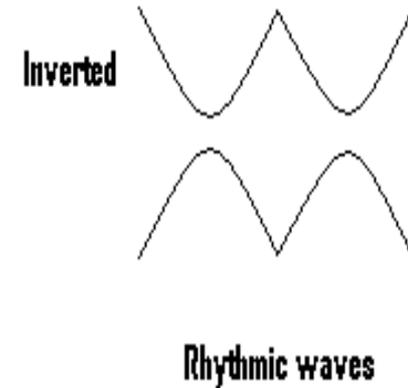
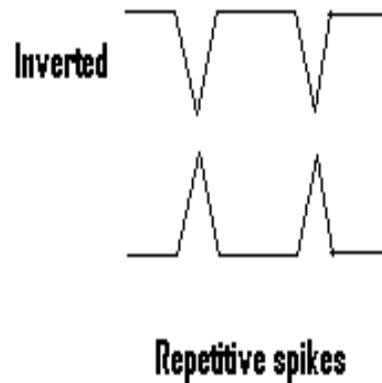
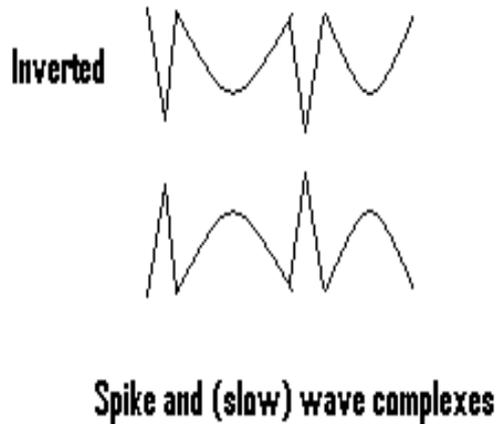
Repetitive spikes (with little or no slow wave)



Repetitive slow waves (with no spikes)

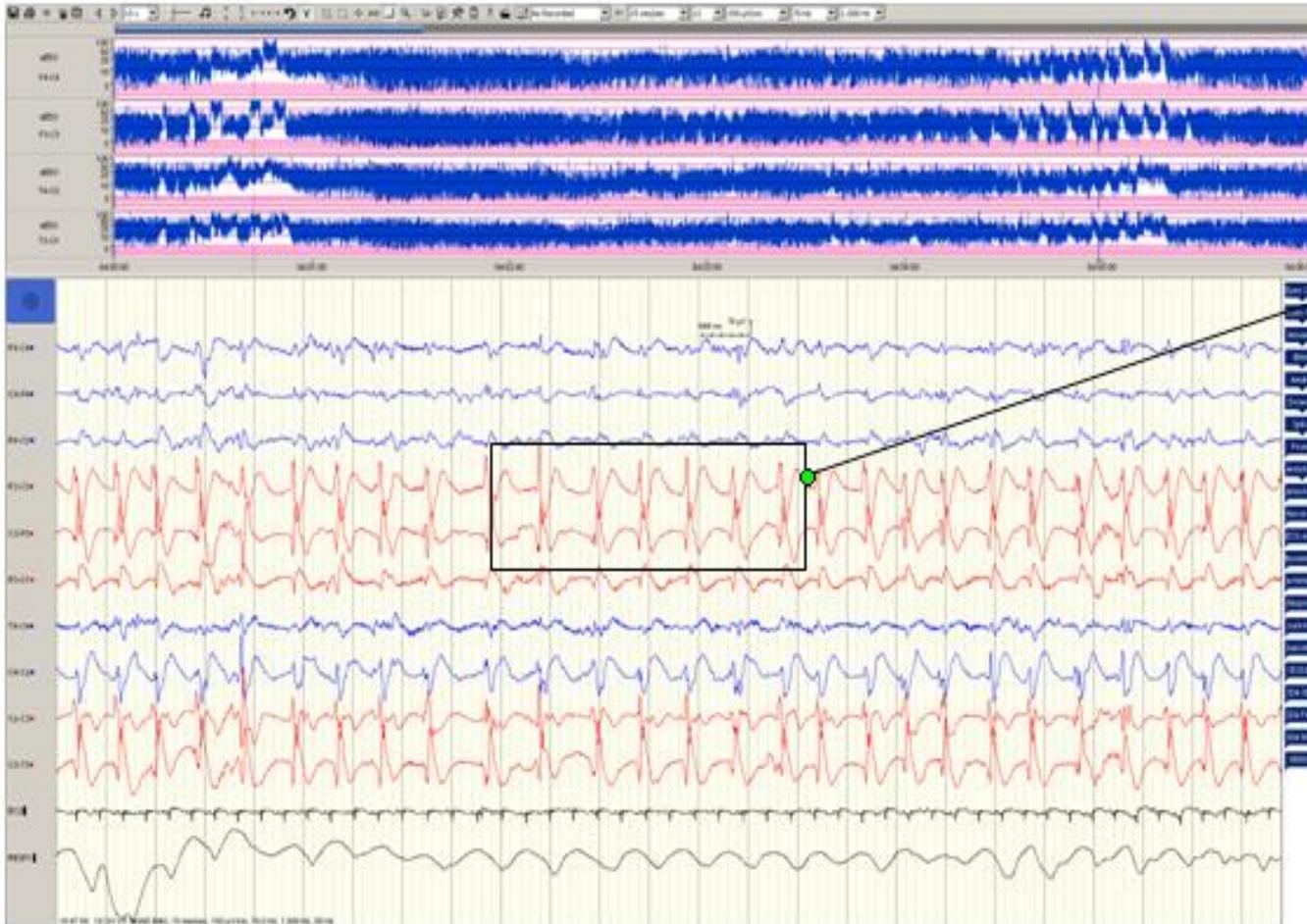
Seizures: Discharge morphology

- However due to the nature of bipolar montages these waveforms can appear **inverted** on some EEG channels and may appear as follows:

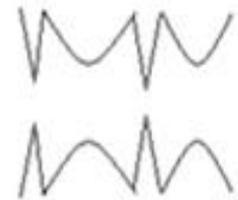


Seizures: Discharge morphology

Spike and wave seizure

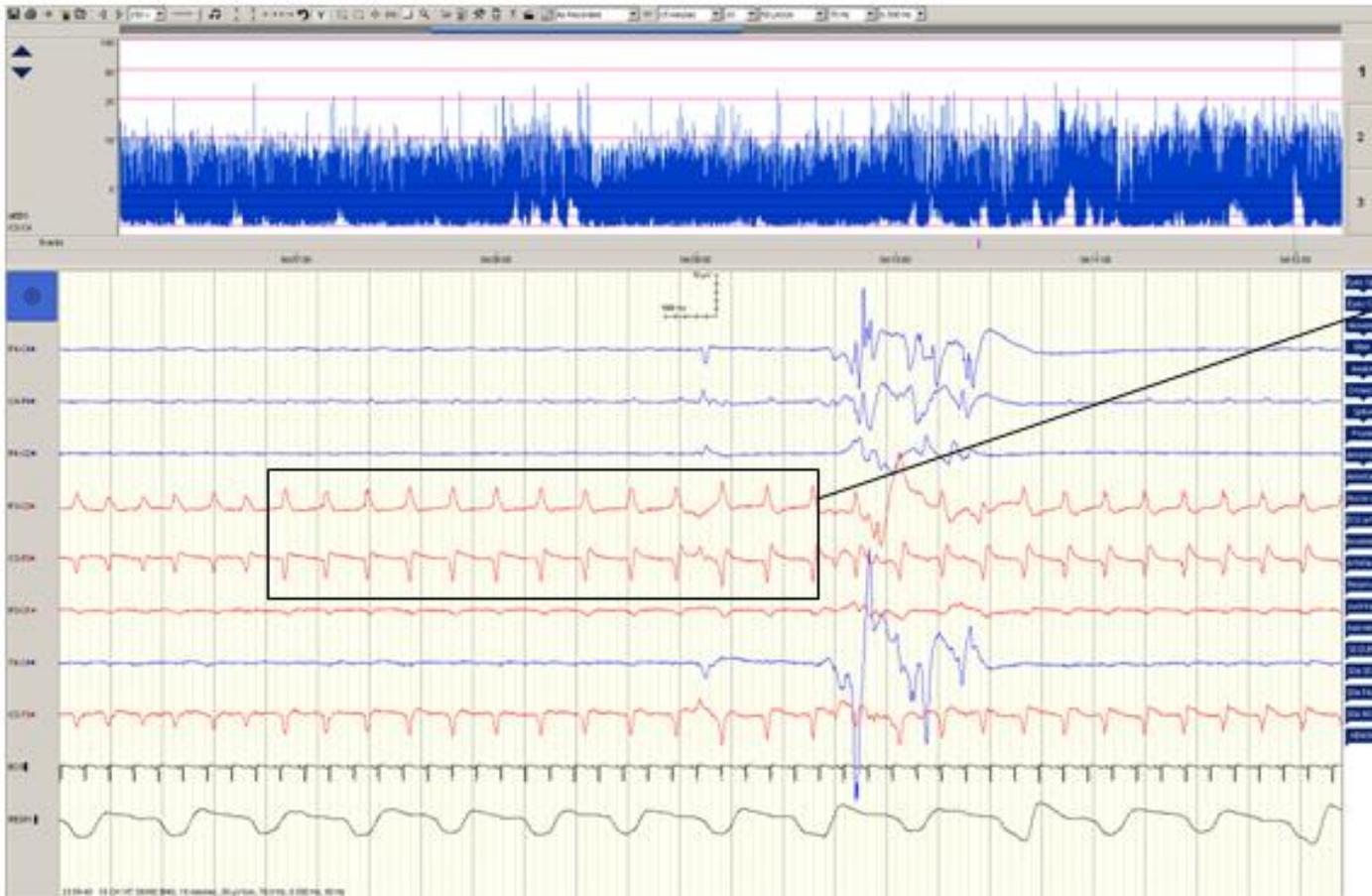


Note the phase reversing spike and wave

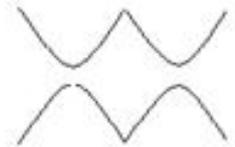


Seizures: Discharge morphology

Rhythmic slow wave seizure

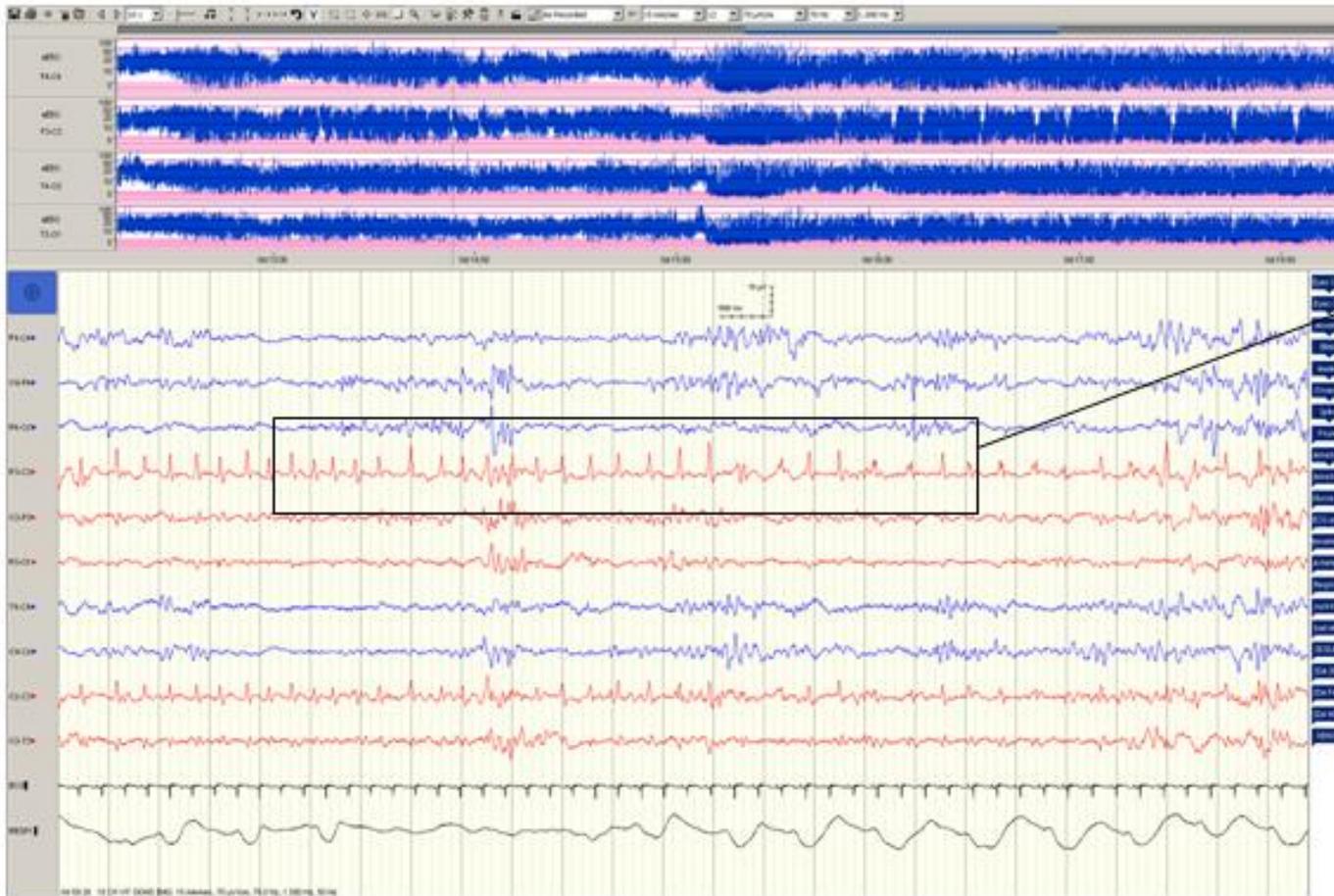


Note the phase reversing slow wave



Seizures: Discharge morphology

Repetitive spike seizures



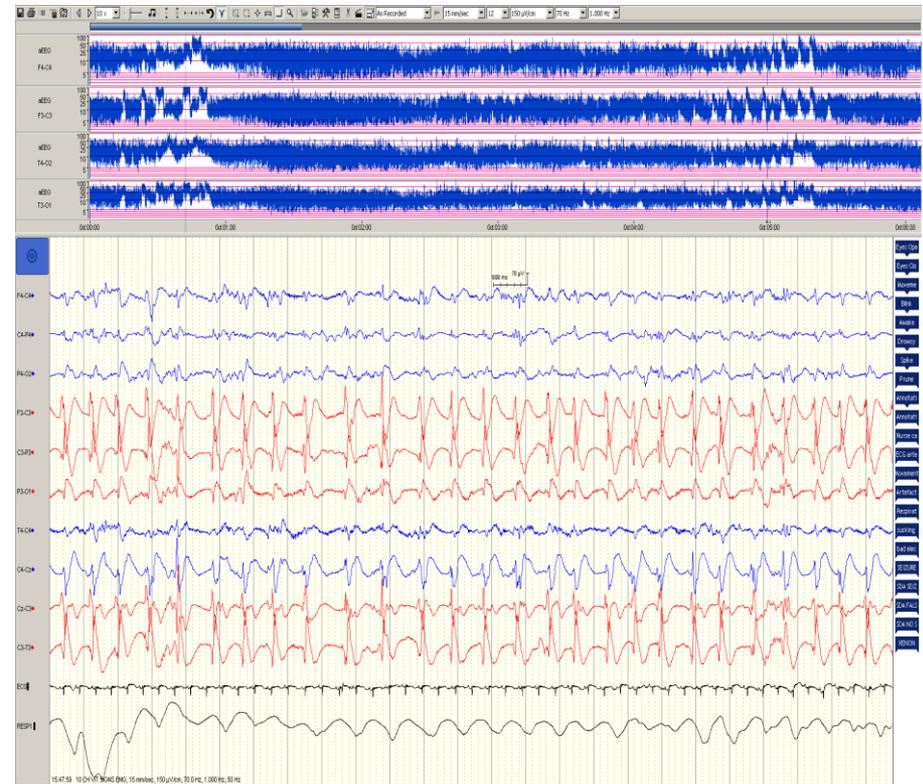
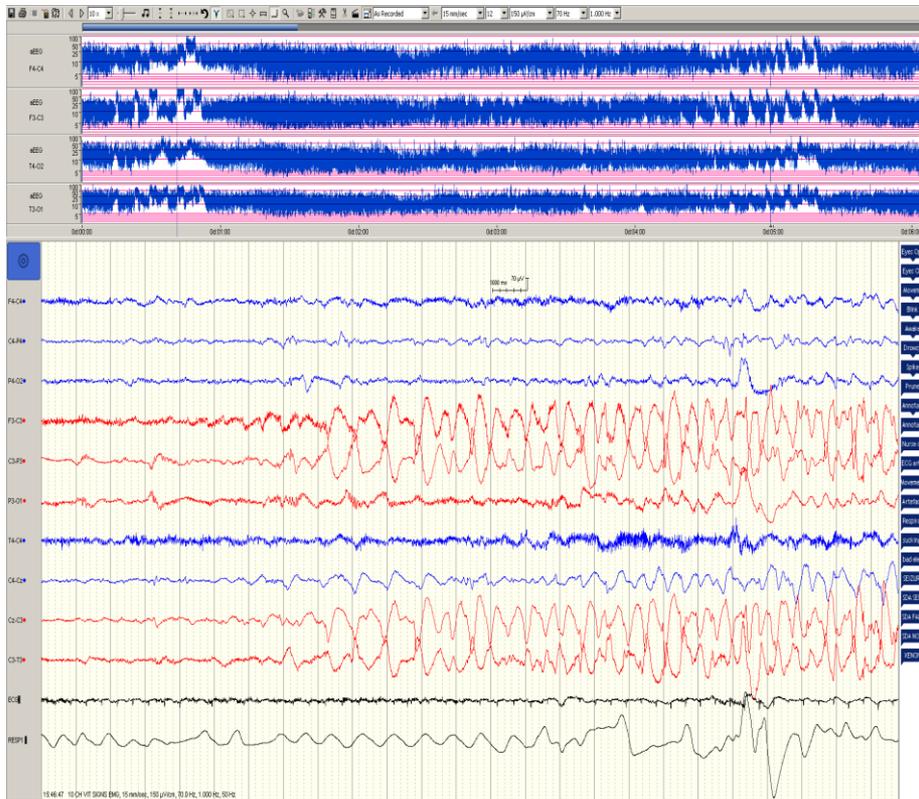
Repetitive spikes.



Morphology may change within a seizure

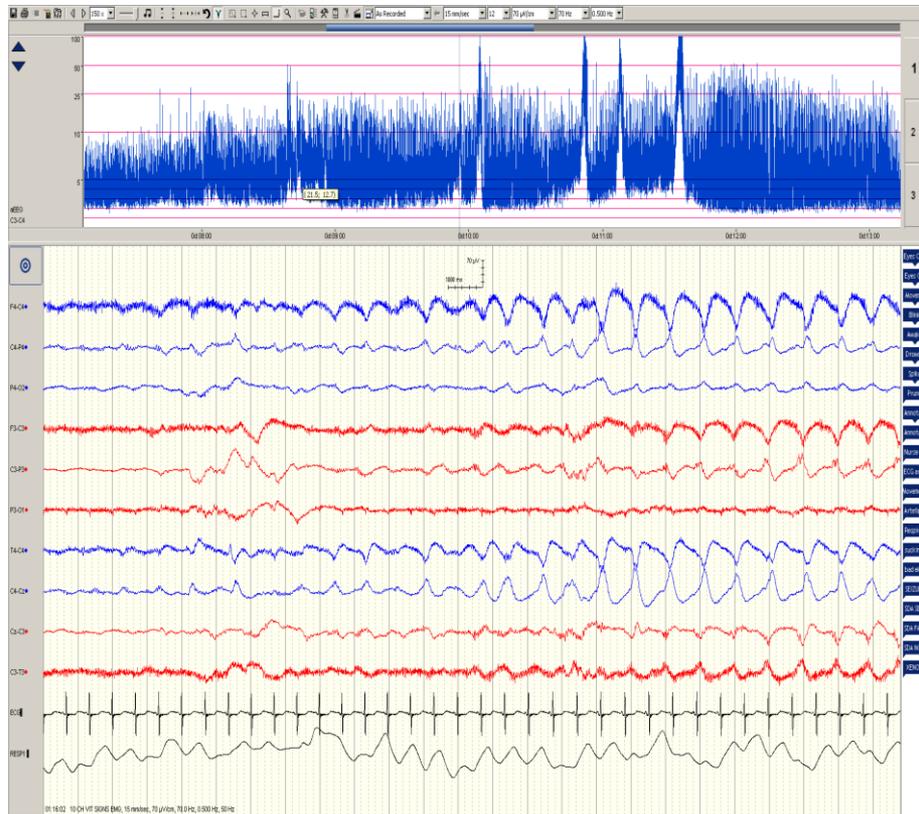
Start of seizure – rhythmic slow waves

Middle of seizure – spike and wave

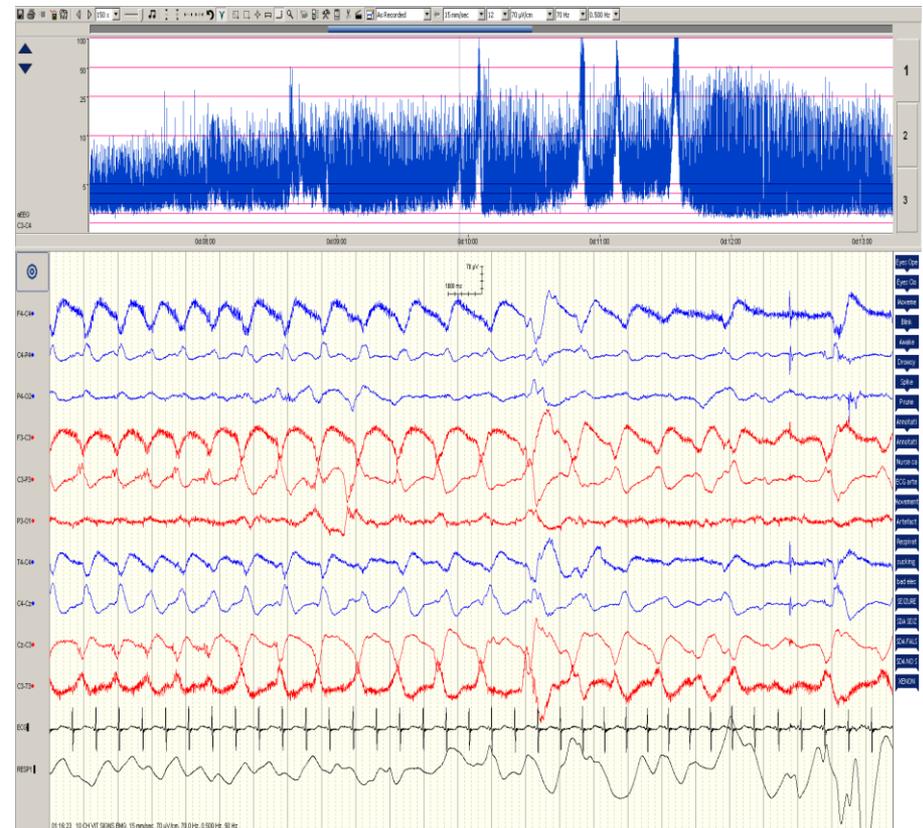


Morphology may stay the same within a seizure

Start of seizure – rhythmic slow waves



Middle of seizure – still rhythmic slow waves



False detections

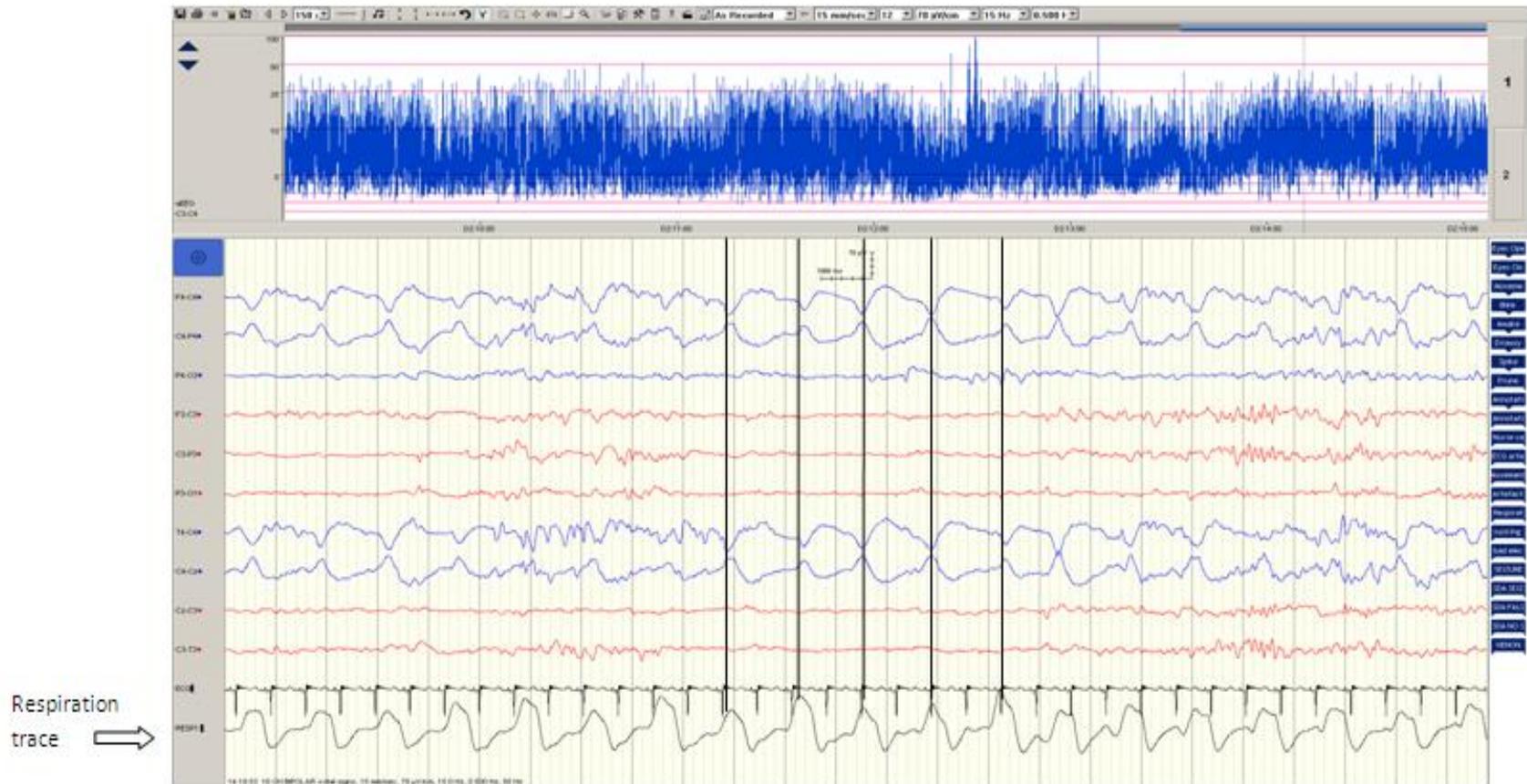
- There are numerous sources of artefact on the neonatal EEG.
- Artefacts with a rhythmic nature can cause **false detections** on ANSeR and will be discussed first here.
- Some other artefacts will then be discussed that are unlikely to cause false detections but are useful for the EEG reviewer to be aware of.
- The main causes of false detection are rhythmic artefacts including:
 - **respiration,**
 - **pulsatile**
 - **sweat artefact**
 - **poor electrode contact.**
- A **highly rhythmic background EEG** (not artefactual) may also cause false detections.

Respiratory artefact

- Respiratory artefact is the most common cause of false detection.
- It is caused by the mechanical movement of the baby's breathing
- If the babies' breathing is supported by a ventilator, the artefact will tend to be very stereotyped and regular.
- If the baby is breathing on its own, the artefact will still be rhythmic but follow the baby's respiratory movements. **It will not progressively slow like seizures.**
- The simplest way to identify respiratory artefact is to compare the EEG rhythm against the respiration trace.
- **If it is a respiration artefact the waves on the EEG will be time-locked to the respiration trace.**

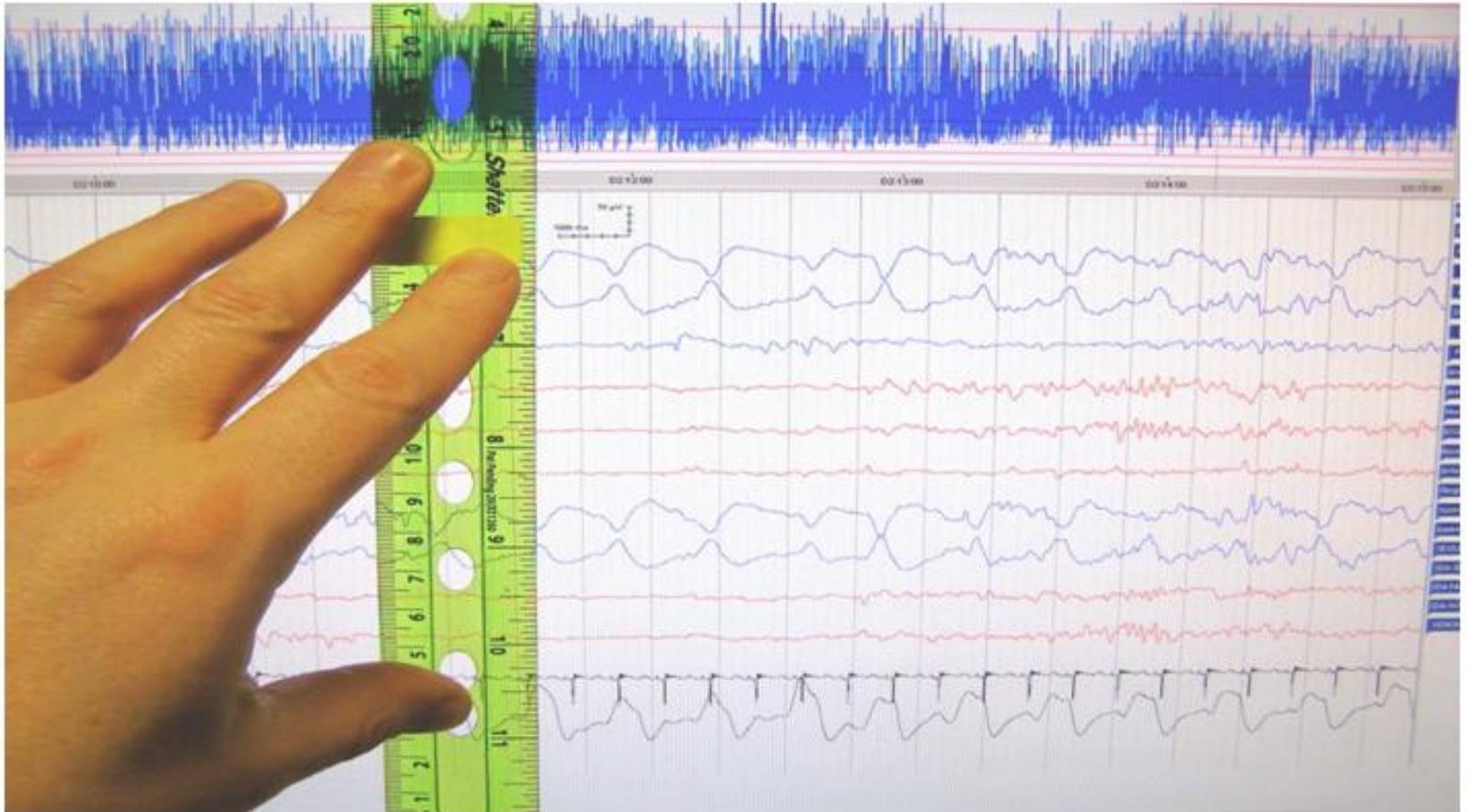
Respiratory artefact

- Markers on the EEG can be used to line up the rhythm with the respiration trace.



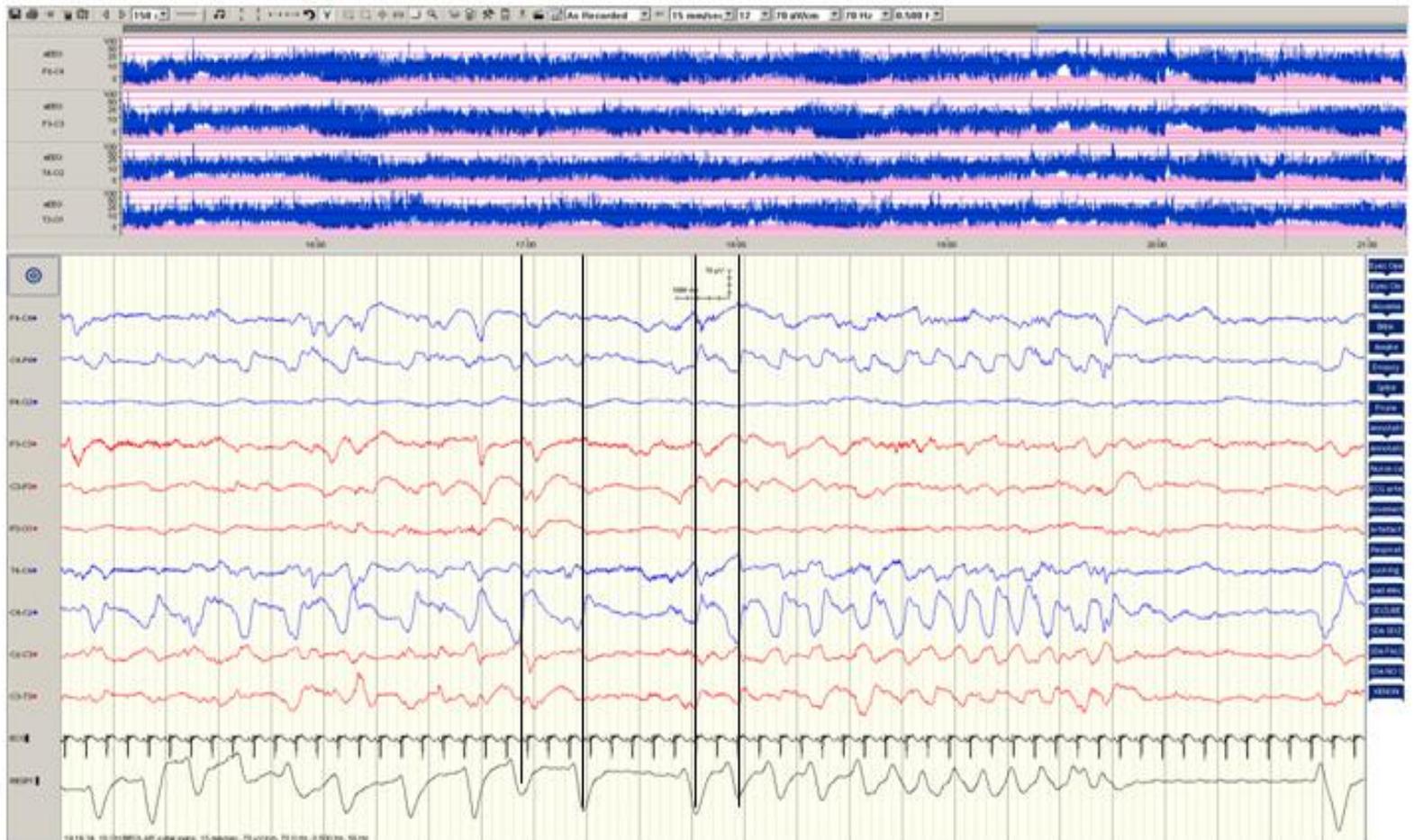
Respiratory artefact

- Or the waveforms can be lined up using a ruler.



Respiratory artefact

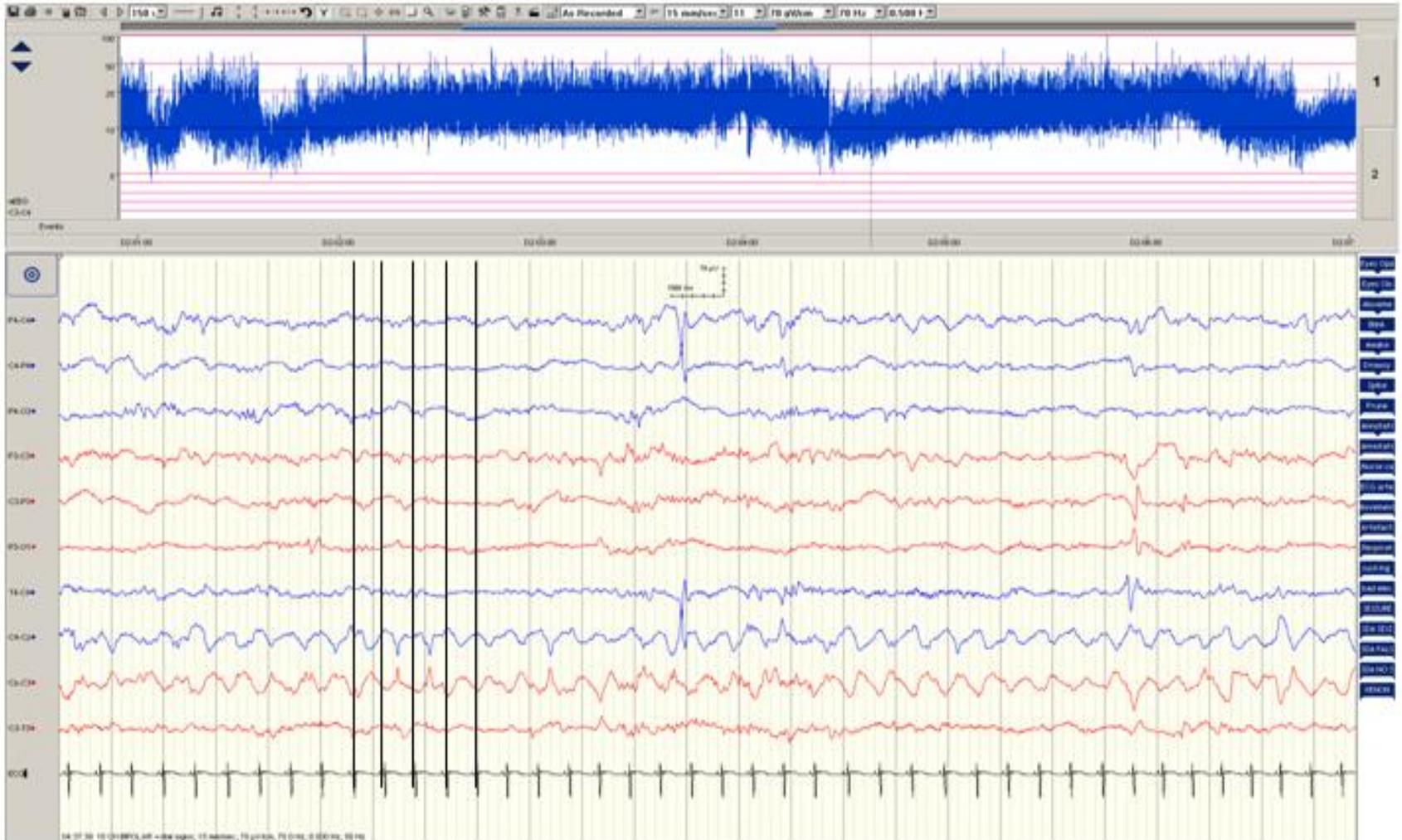
- Respiration artefact in a non-ventilated baby showing some variation.



Pulsatile artefact

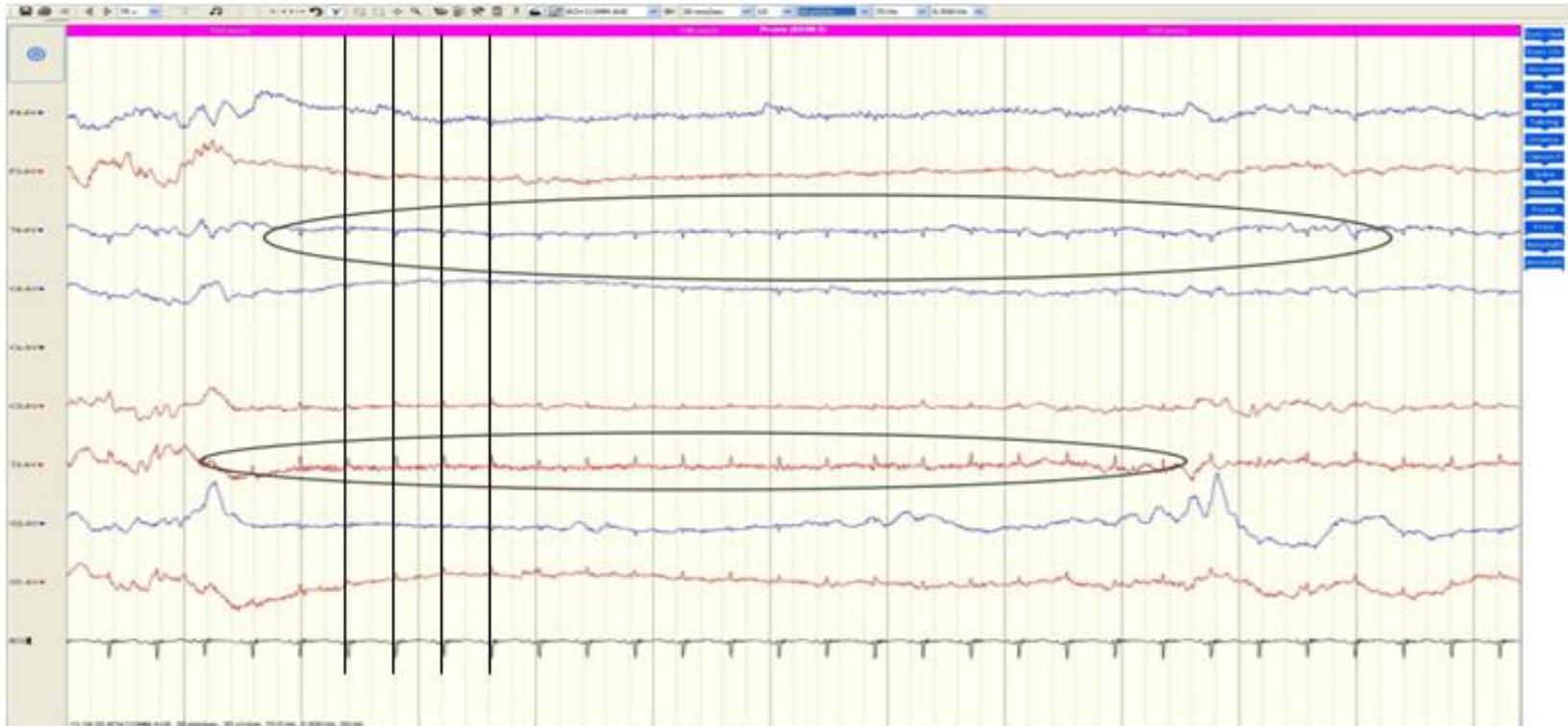
- If an electrode is close to a pulsing blood vessel, a rhythmic artifact may appear on the EEG **which may cause false detections on ANSeR.**
- Similarly to the respiration artefact, pulse artefact **will be time-locked to the ECG trace** which is usually recorded from the shoulders.
- In a similar fashion, vertical markers or a ruler can be used to compare the EEG rhythm to the peaks on the ECG.
- Again the artefact will be quite invariant and not show the evolution in frequency often seen in seizures.

Pulsatile artefact



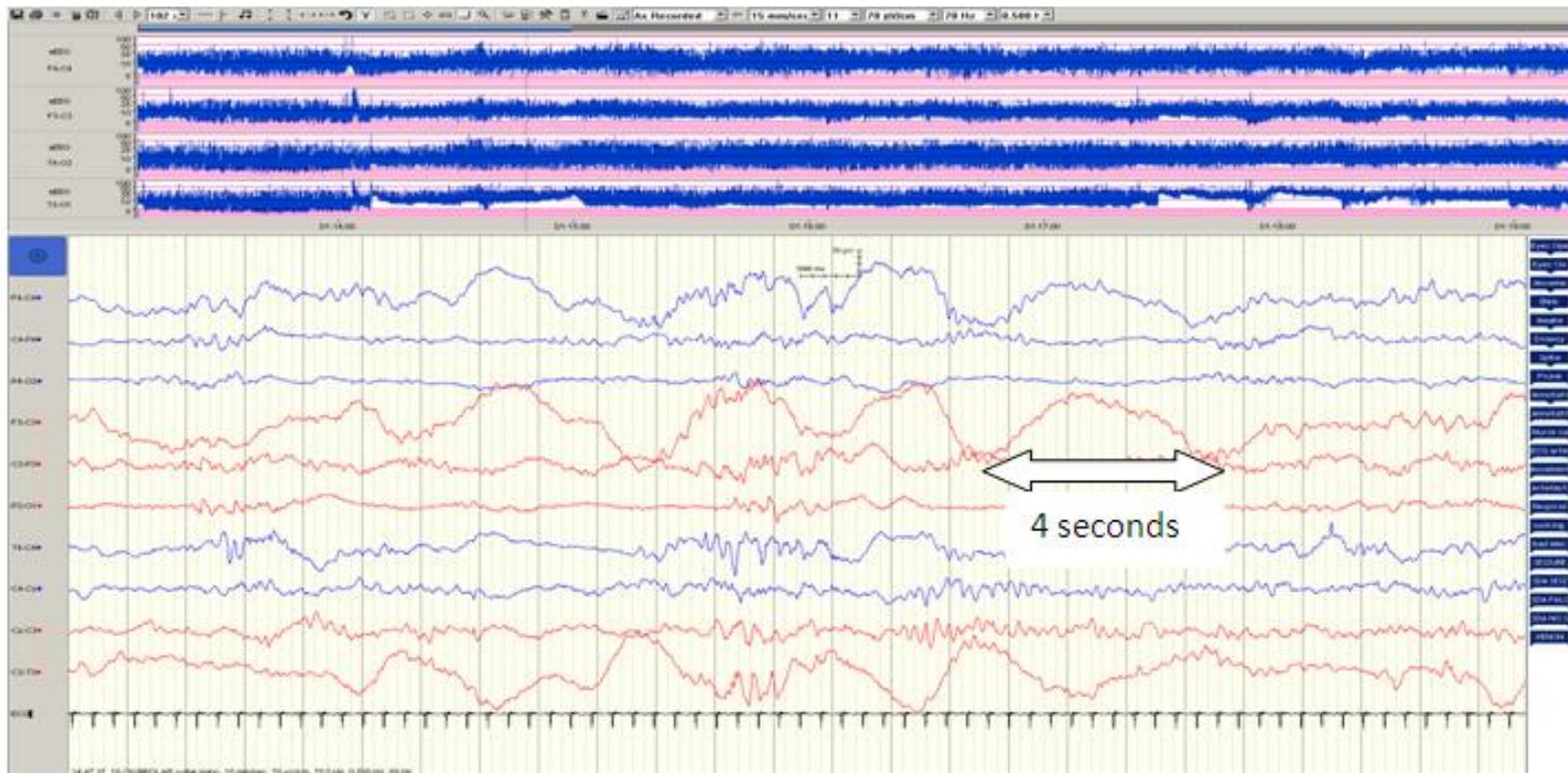
ECG artefact

- The electrical potentials generated by the heart can also be picked up on the EEG recording and constitute an artefact.
- These sharp potentials can be identified as ECG as they will also be time-locked to the ECG trace.
- This form of artefact is quite common **but does not tend to cause false detections on ANSeR.**

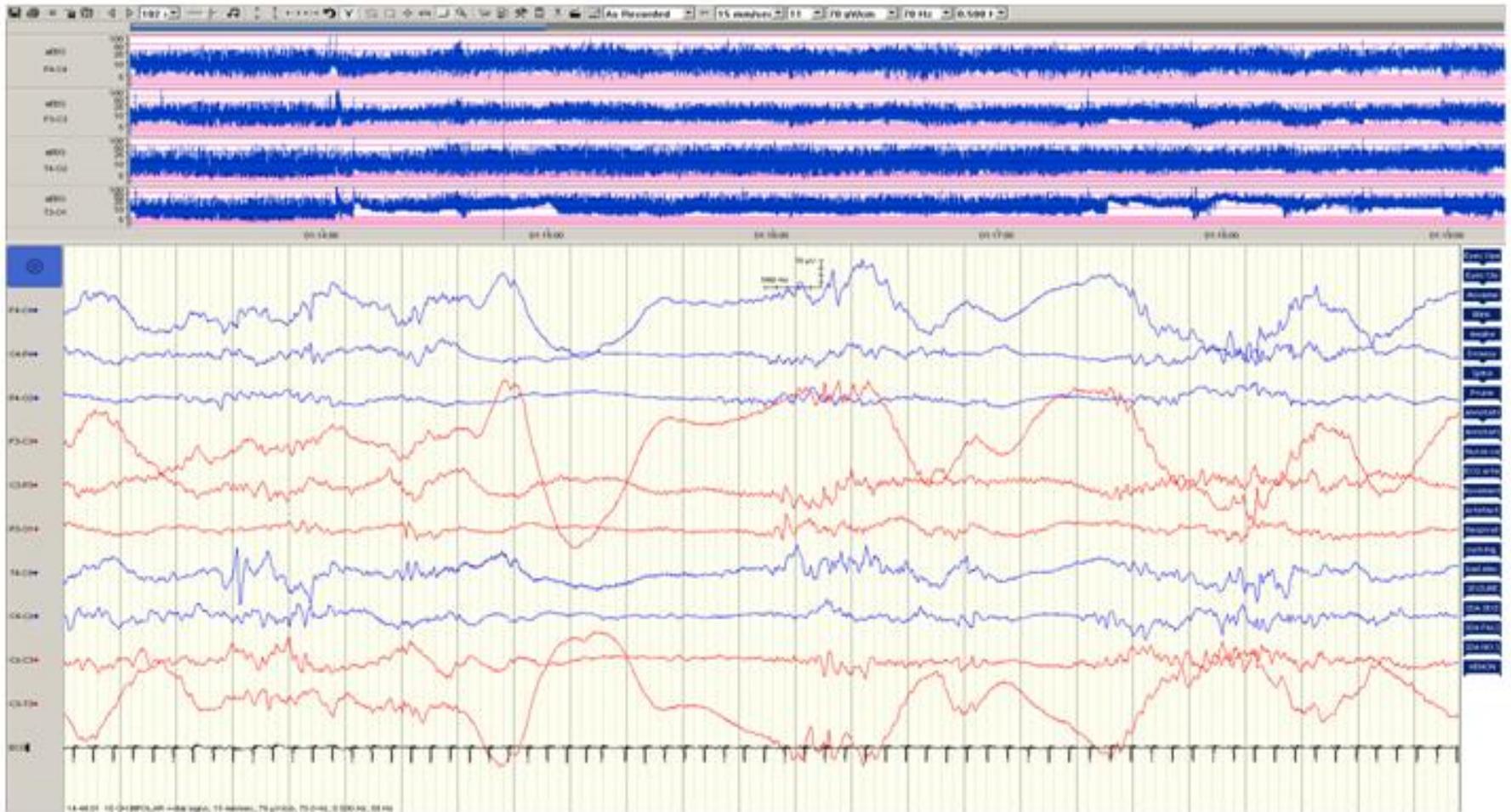


Sweat artefact

- If a baby's head is sweaty, the moisture can partially connect electrodes and cause a high amplitude, very slow, rolling, semi rhythmic artefact on the EEG.
- These slow waves are very distinctive and can be distinguished from seizures as they tend to span several seconds, are only semi-rhythmic and may be intermittent.



Sweat artefact

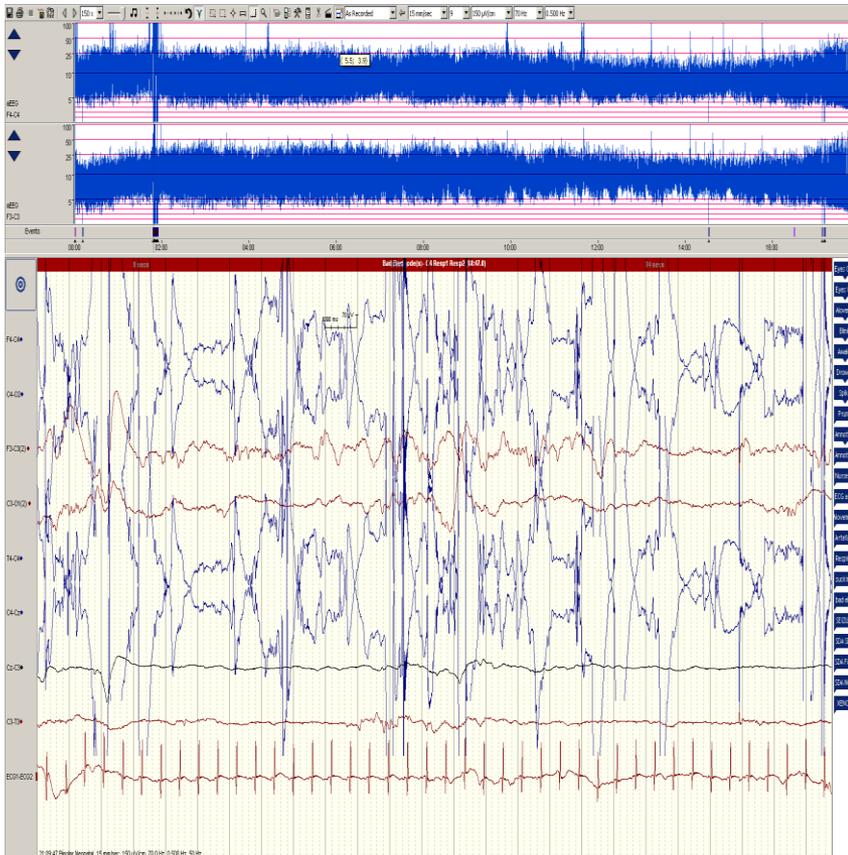


Bad electrode artefact

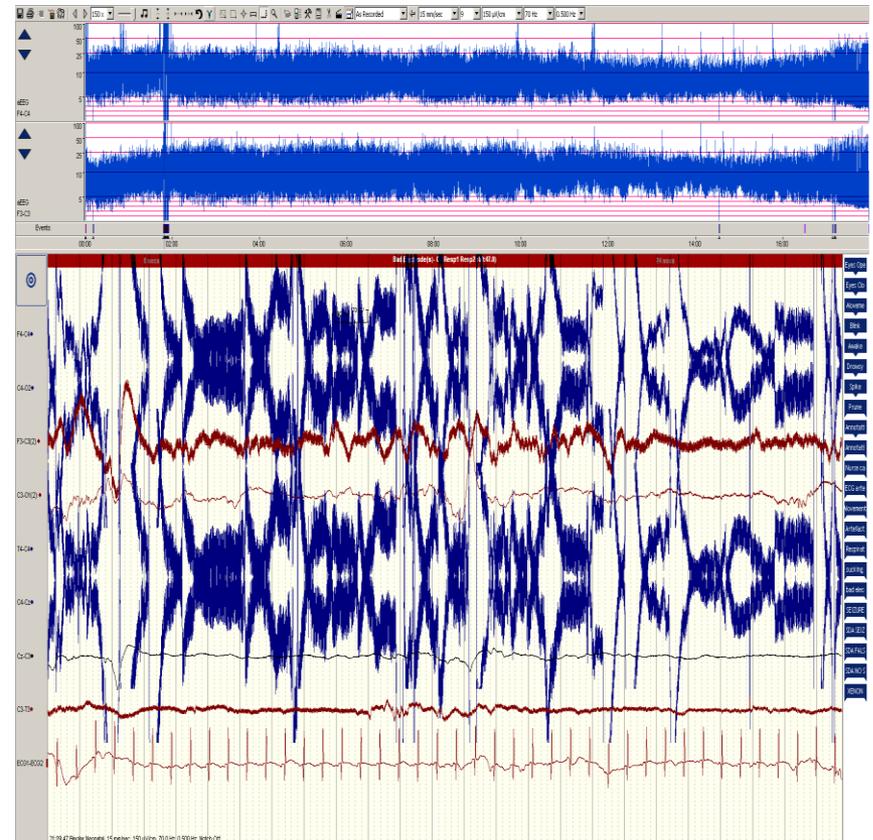
- If an electrode is pulled or disrupted it can partially or fully lose contact with the baby's head.
- Often when this happens it leads to a high amplitude erratic artefact but sometimes the artefact can be quite rhythmic and cause false detections.
- One way to determine if you have a bad contact is to turn off the **Notch filter**  on the machine (the notch filter is a special filter that only takes out 50Hz mains frequency artefact on the EEG).
- A bad contact will have high impedance and tend to pick up mains interference.
- Turning this filter off reveals the overlying fast artefact.
- Alternatively doing an impedance check will reveal a high impedance

Bad electrode artefact

Bad electrode showing erratic artefact

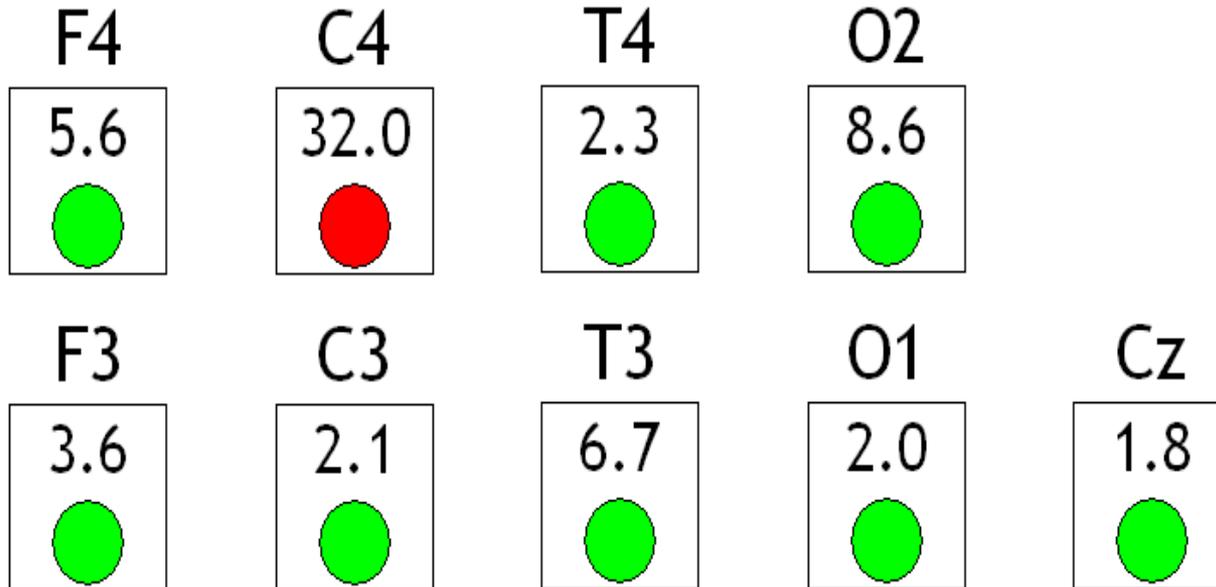


Same trace as left but with notch filter off



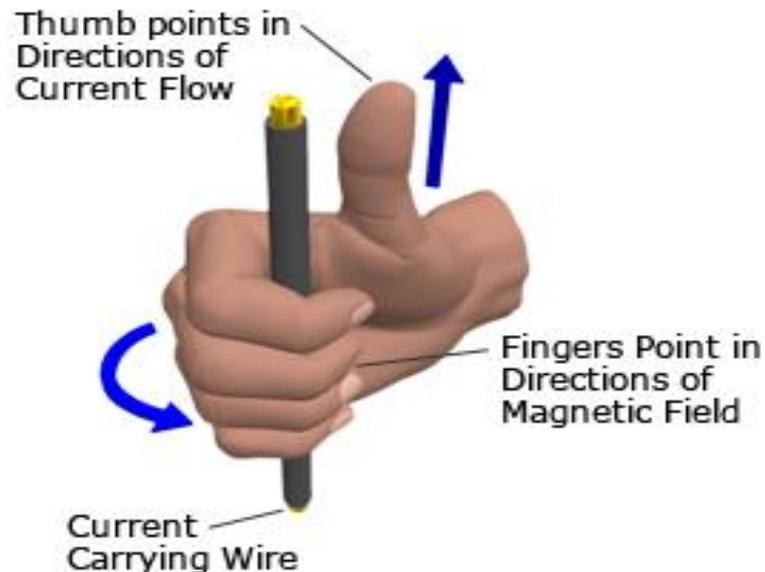
Bad electrode artefact

- Bad electrode will show high impedance.



50Hz mains artefact

- When there is a poor electrode contact at the head, the EEG channel tends to pick up a 50Hz artefact which appears as a thickening of the trace.
- This occurs as any equipment near the baby with a main 50Hz AC current running through it has an electromagnetic field at right angles to the current which can induce a small 50Hz signal in another wire close to it, such as an electrode wire.



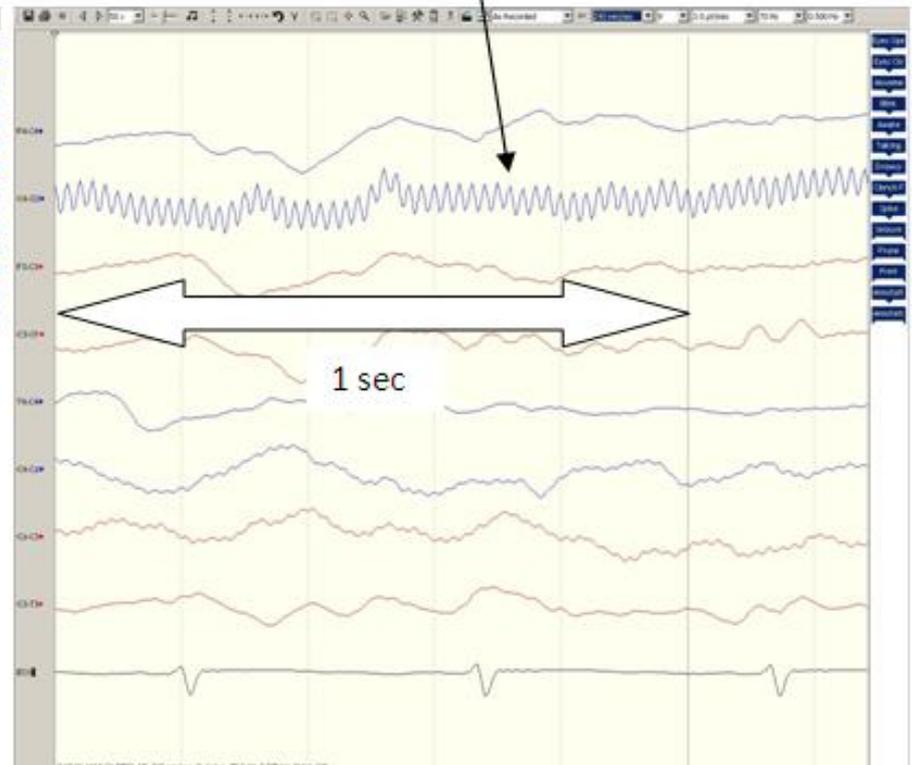
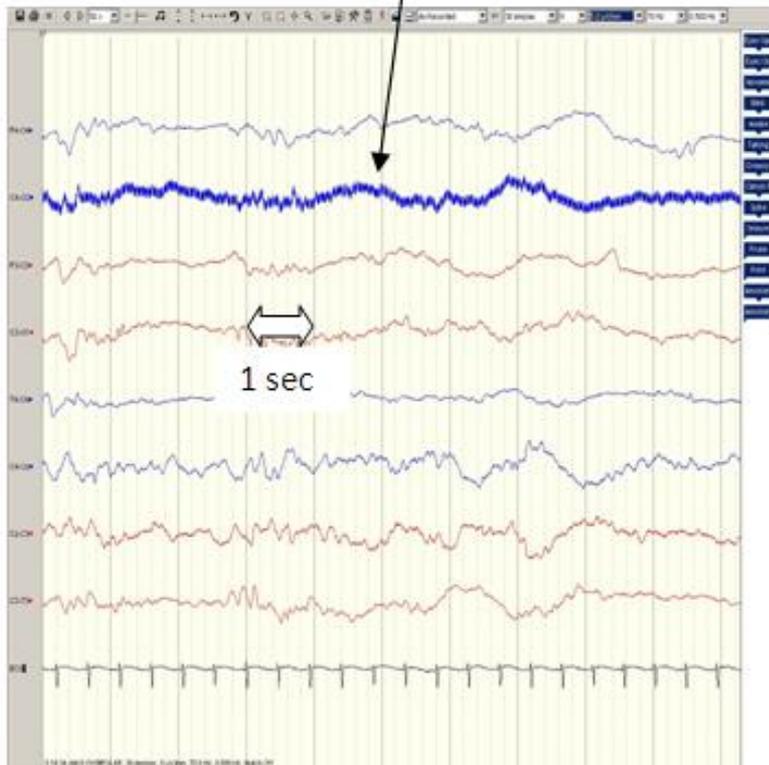
50Hz mains artefact

- Usually the EEG amplifier cancels this artefact out but when there is a bad electrode contact it cannot. The trace can be 'spread' out to reveal the 50Hz signal.
- This type of artefact on its own will not cause false detections as it is too fast a frequency but sometimes an unstable electrode may have a slower overlying frequency that may cause false detection.
- When this artefact is seen the electrode should be reapplied.

50Hz mains artefact

50Hz artefact appears as thickening of trace at normal paper speed

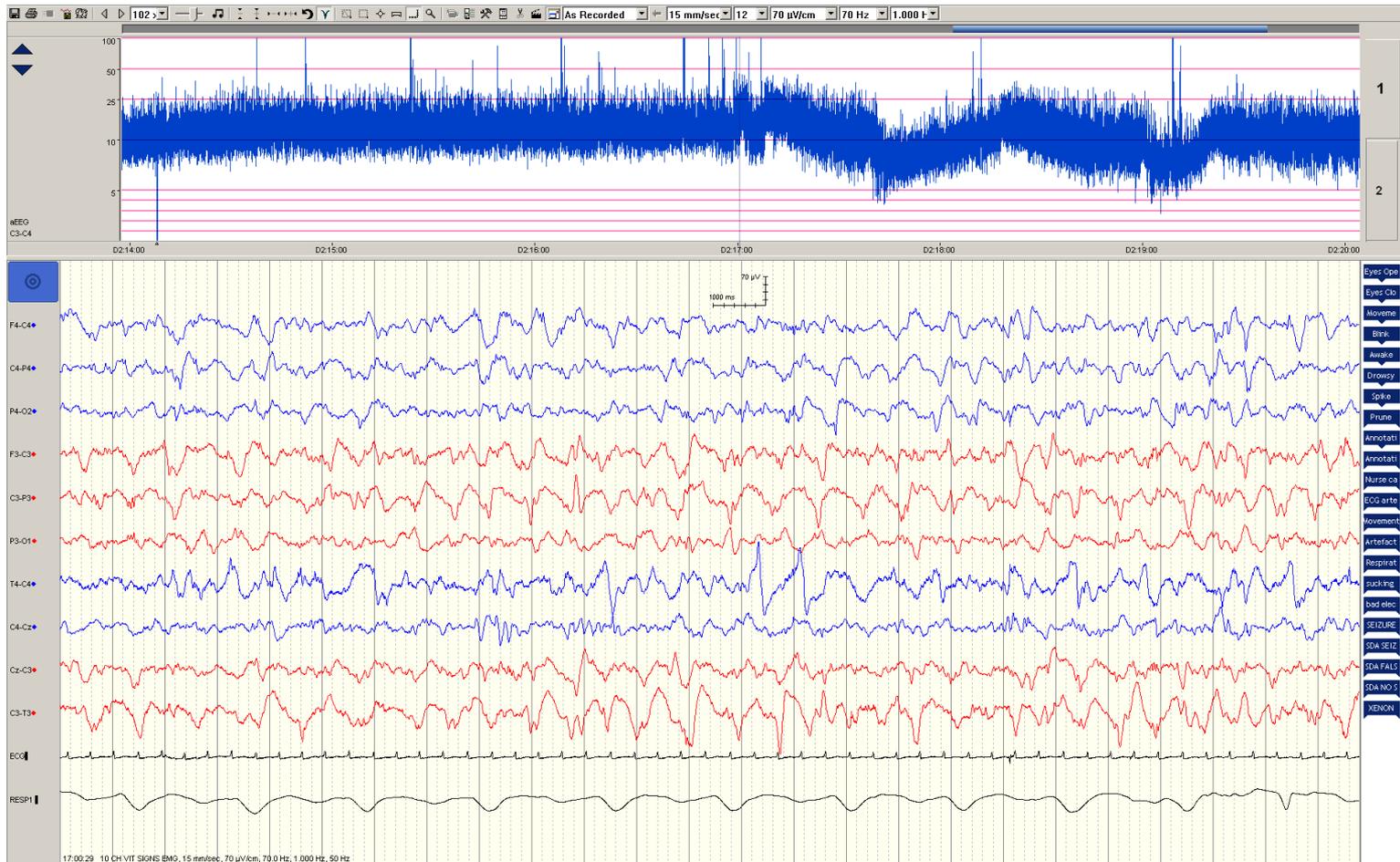
When EEG spread out (1 sec of EEG displayed) the 50Hz oscillation is revealed.



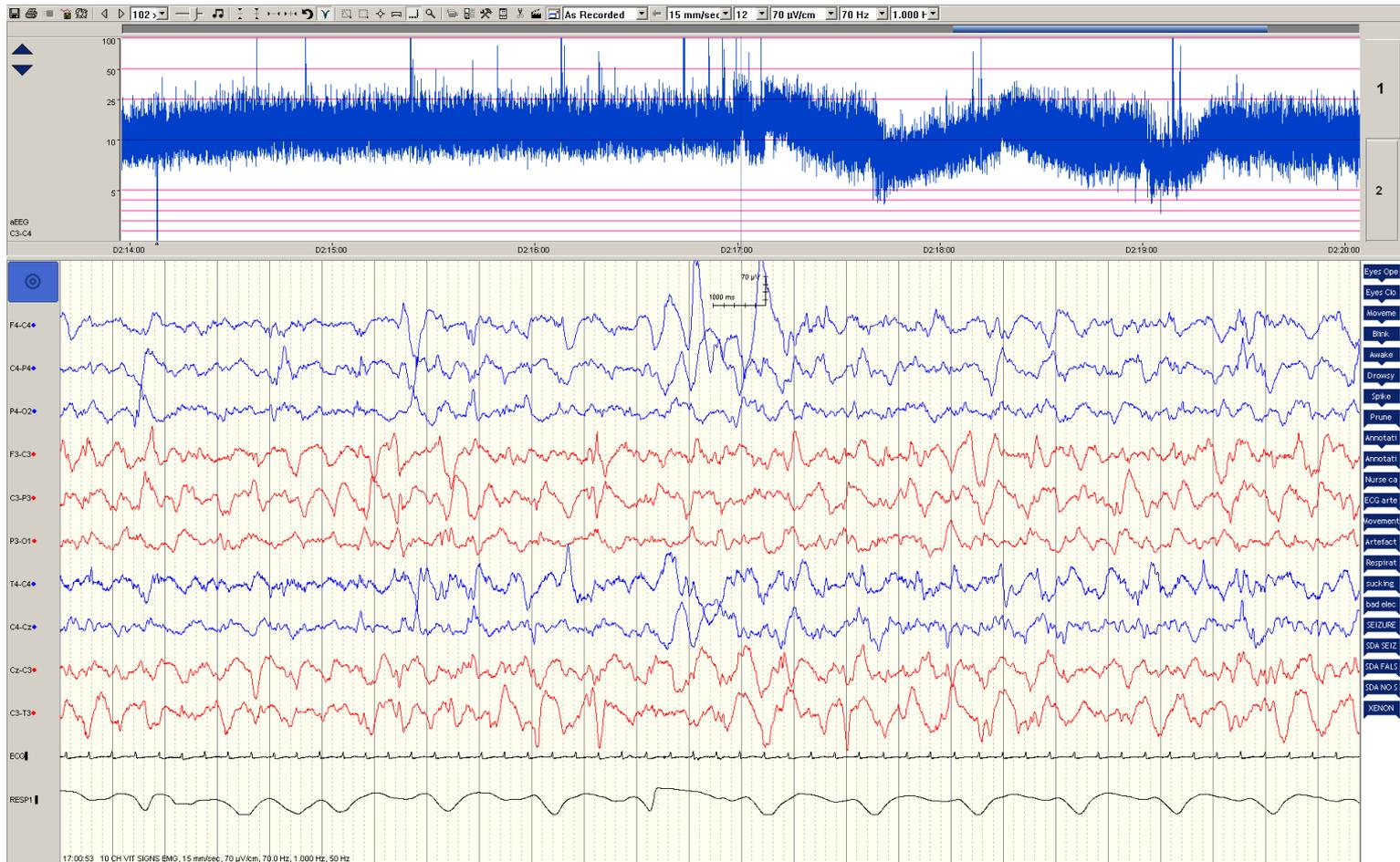
False detections from a highly rhythmic background EEG pattern

- In some patients the background EEG can show a large amount of semi-rhythmic slow (delta) activity, particularly in quiet sleep.
- Because of its rhythmicity, occasionally this type of activity **can cause false detections.**
- Generally this type of activity is:
 - **only semi-rhythmic and not as rhythmic as seizures**
 - **the waveforms are not as regular and stereotyped as seizure waveforms**
 - **the activity does not tend to ‘evolve’ as seizures tend to**

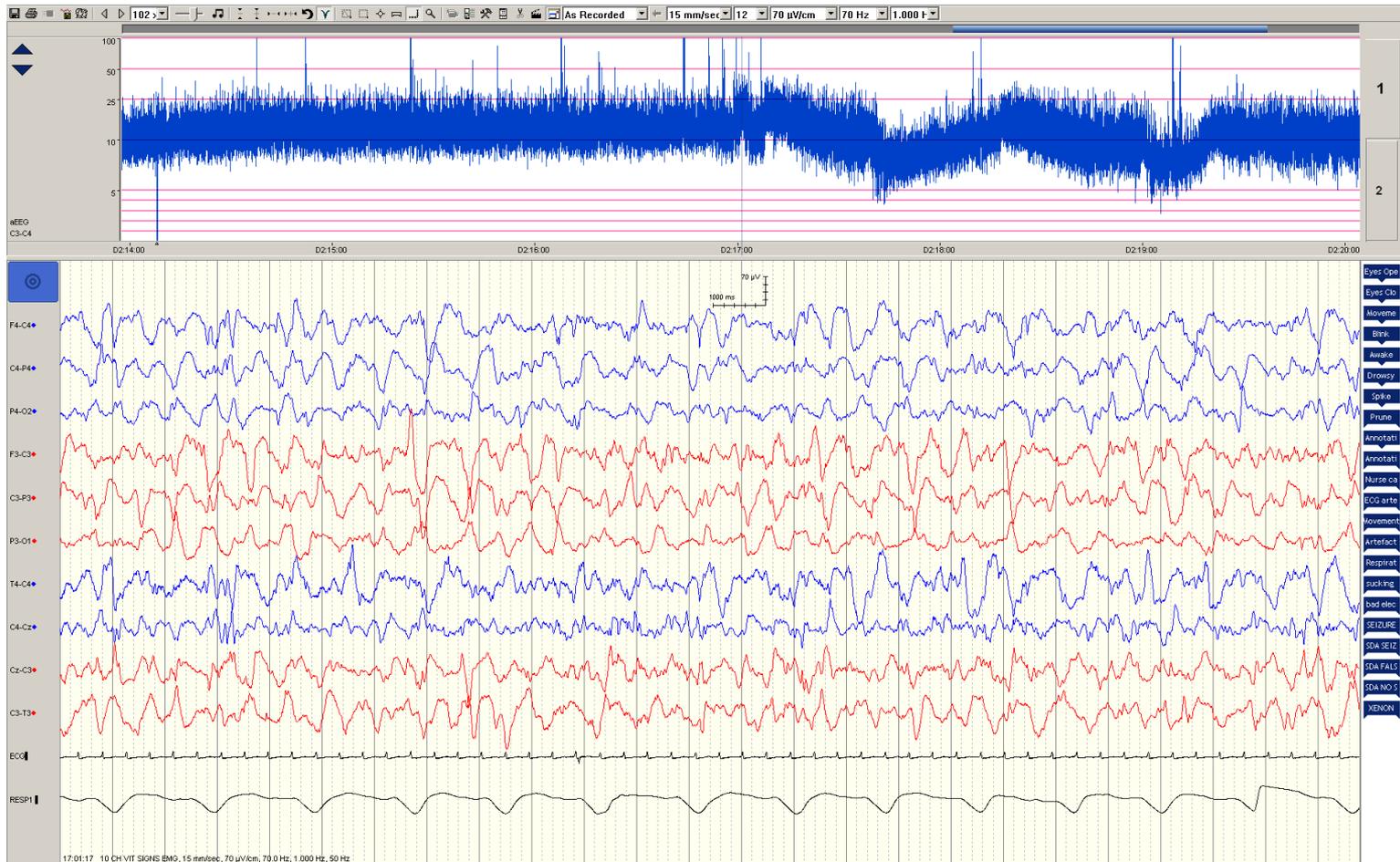
False detections from a highly rhythmic background EEG pattern



False detections from a highly rhythmic background EEG pattern



False detections from a highly rhythmic background EEG pattern

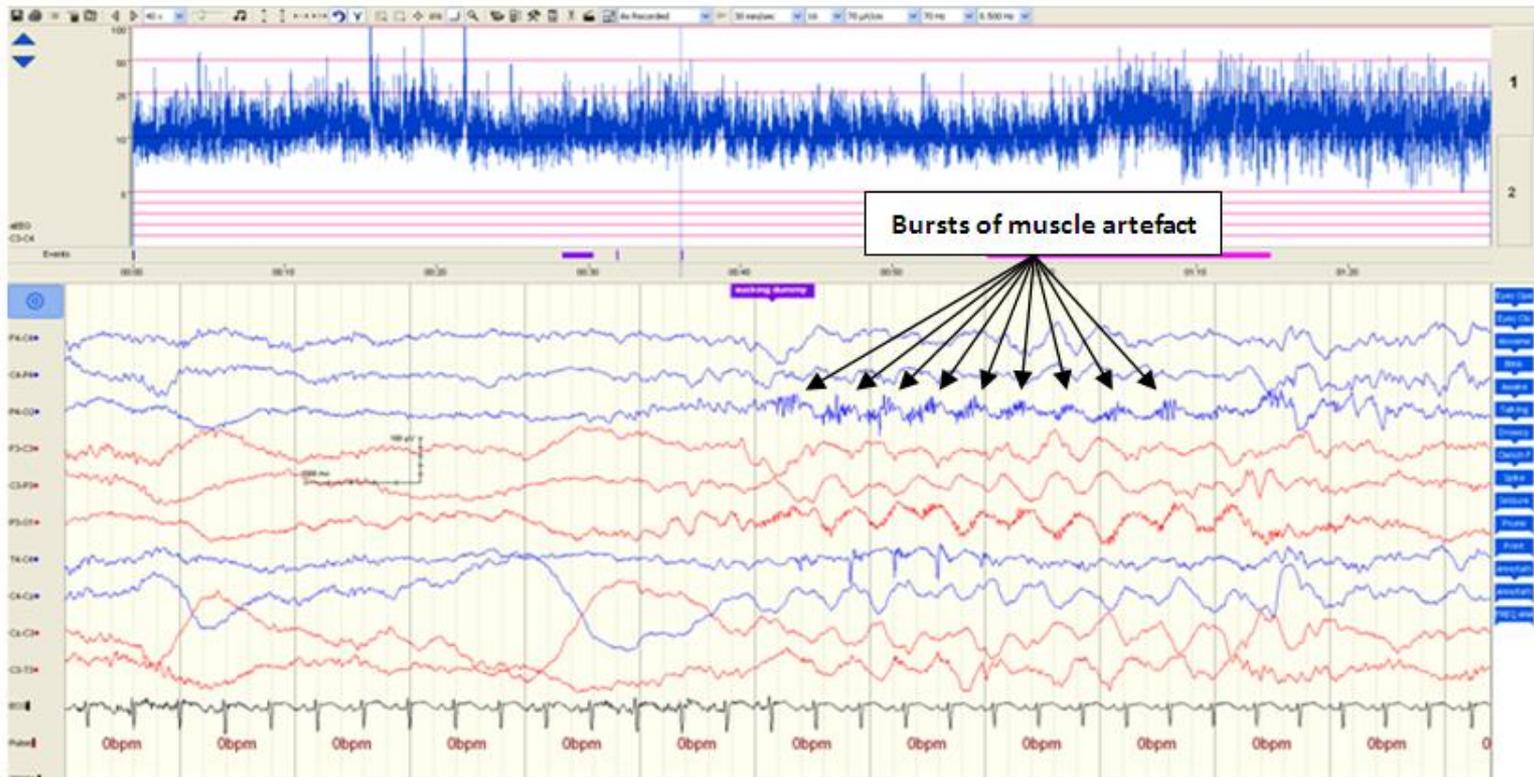


**Artefacts that tend not to cause false
detections but are worth knowing
about.**

Artefact from dummy sucking

Rhythmic head movements from sucking a dummy may cause a rhythmic artefact on the EEG.

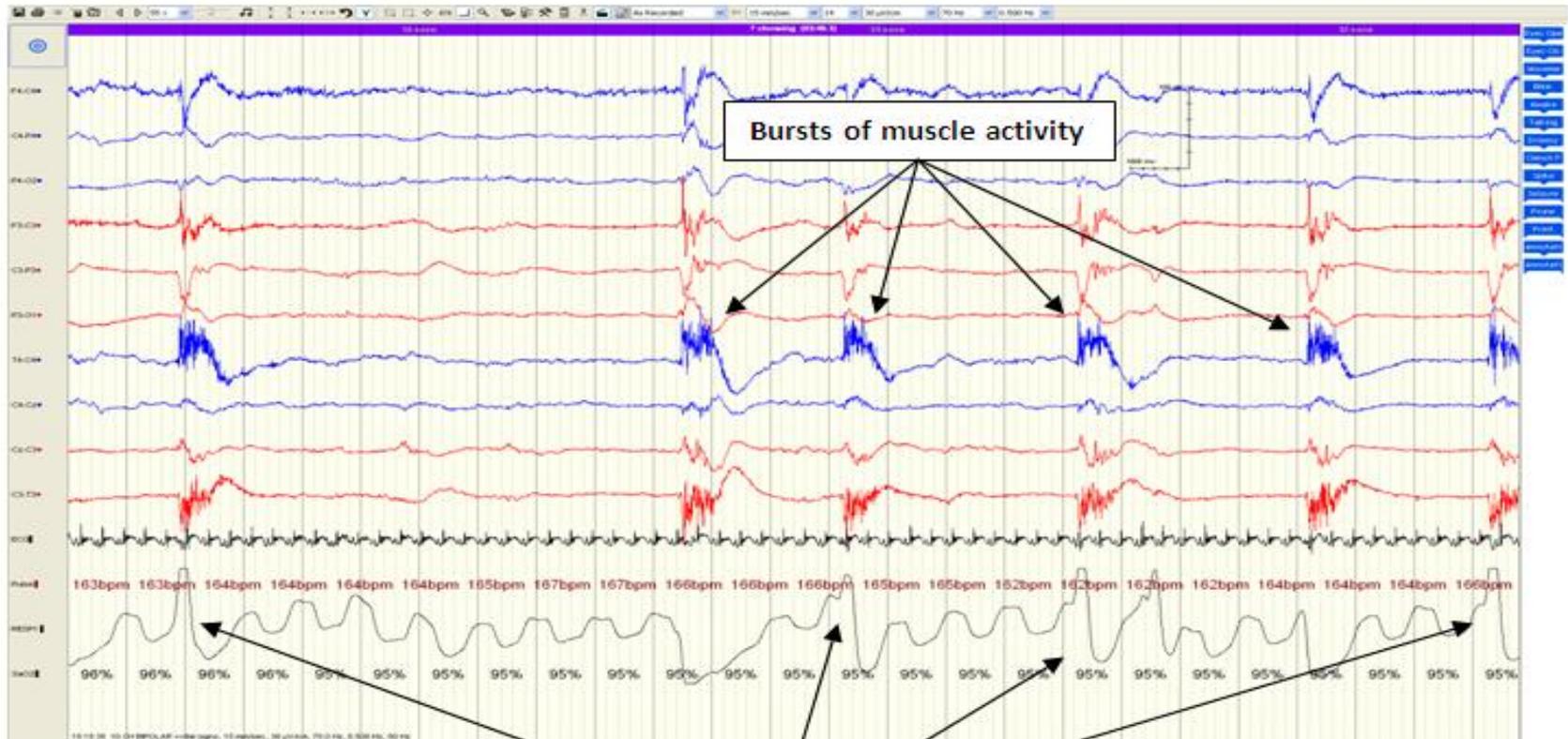
- There are two ways to identify this rhythm as an artefact.
 - Firstly the intermittent activation of the jaw muscle causes short bursts of muscle artefact overlying the slow rhythm,
 - Secondly the **video** can be used to identify the chewing/sucking movements.



Hiccups

- Hiccups can cause a semi-periodic artefact on the EEG with slow waves from the ballistic movement of the head/body which can also be overlain with fast muscle movement from the jaw.
- The respiration trace will also show an abnormal wave coincident with the sharp inspiration of the chest.
- This artefact can also be determined by looking at the **video** recording.
- This form of artefact tends **not** to cause false detections as there are usually several seconds between hiccups.

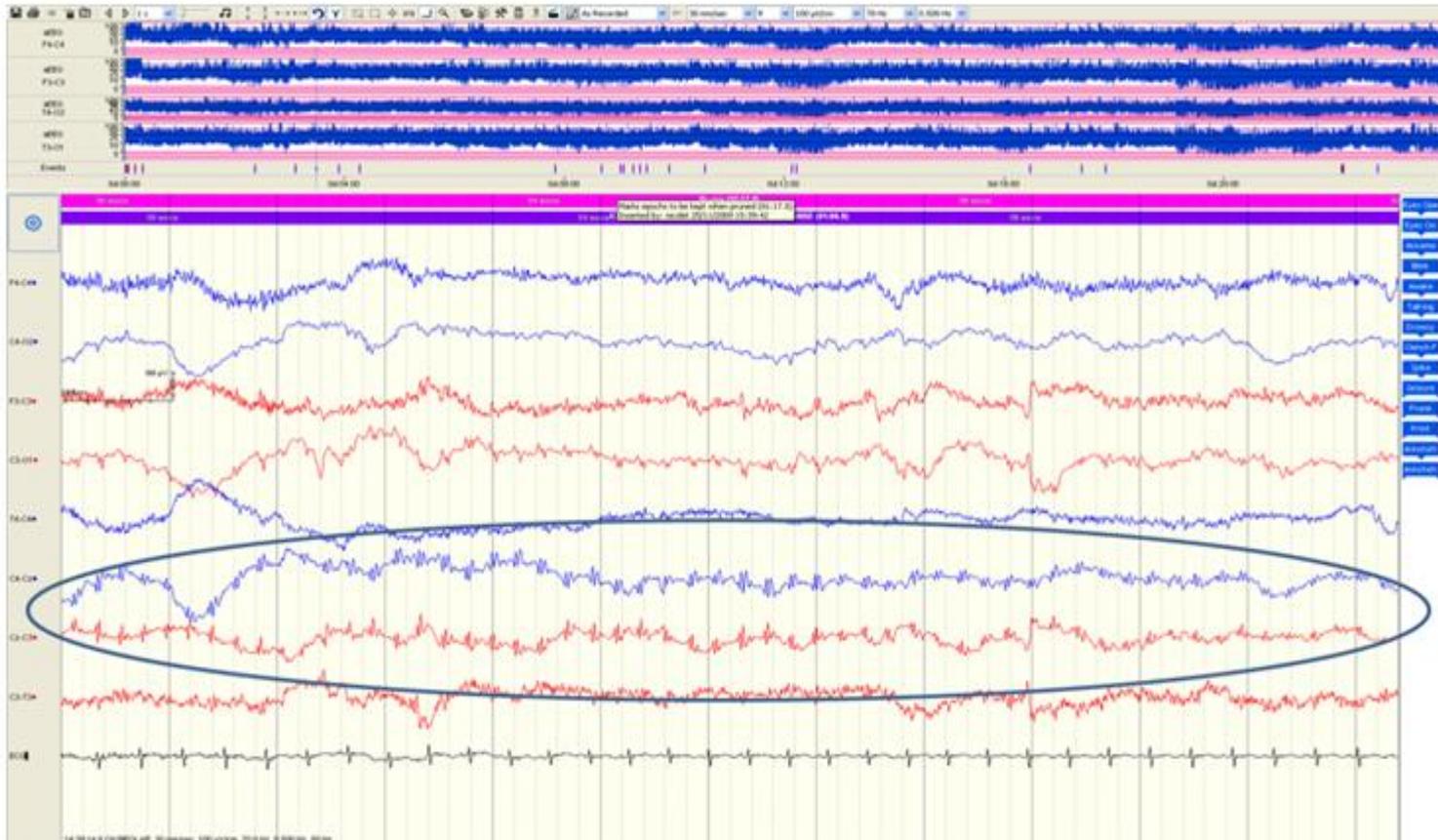
Hiccups



Hiccups showing abnormal deflections of the respiration trace

Patting/stroking artefact

- If a baby is being patted, stroked or manipulated in a rhythmic way, it can cause a rhythmic artefact with variable morphology. The **video** is the best way to determine what was happening at the time.

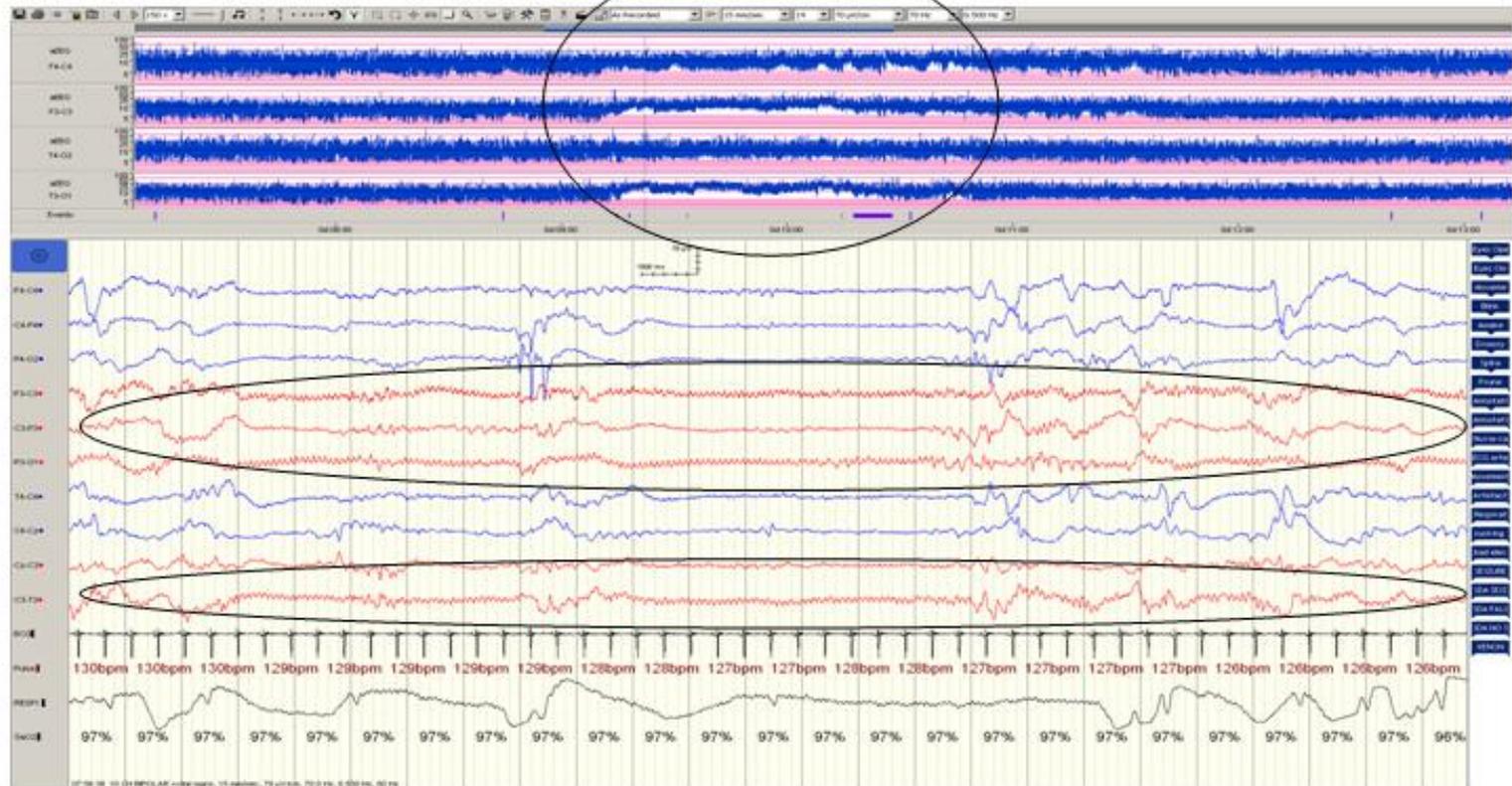


Oscillator artefact

- If a baby is ventilated with an oscillator, the rhythmic vibration of the baby can cause an artefact on the EEG.
- The artefact tends to occur on the electrodes that the baby is lying on and will be at the same frequency as the oscillator (usually around 10Hz) and will be invariant.
- Oscillator frequencies are generally too fast to cause false detection on ANSeR (but can falsely elevate the aEEG baseline on a discontinuous EEG)

Oscillator artefact

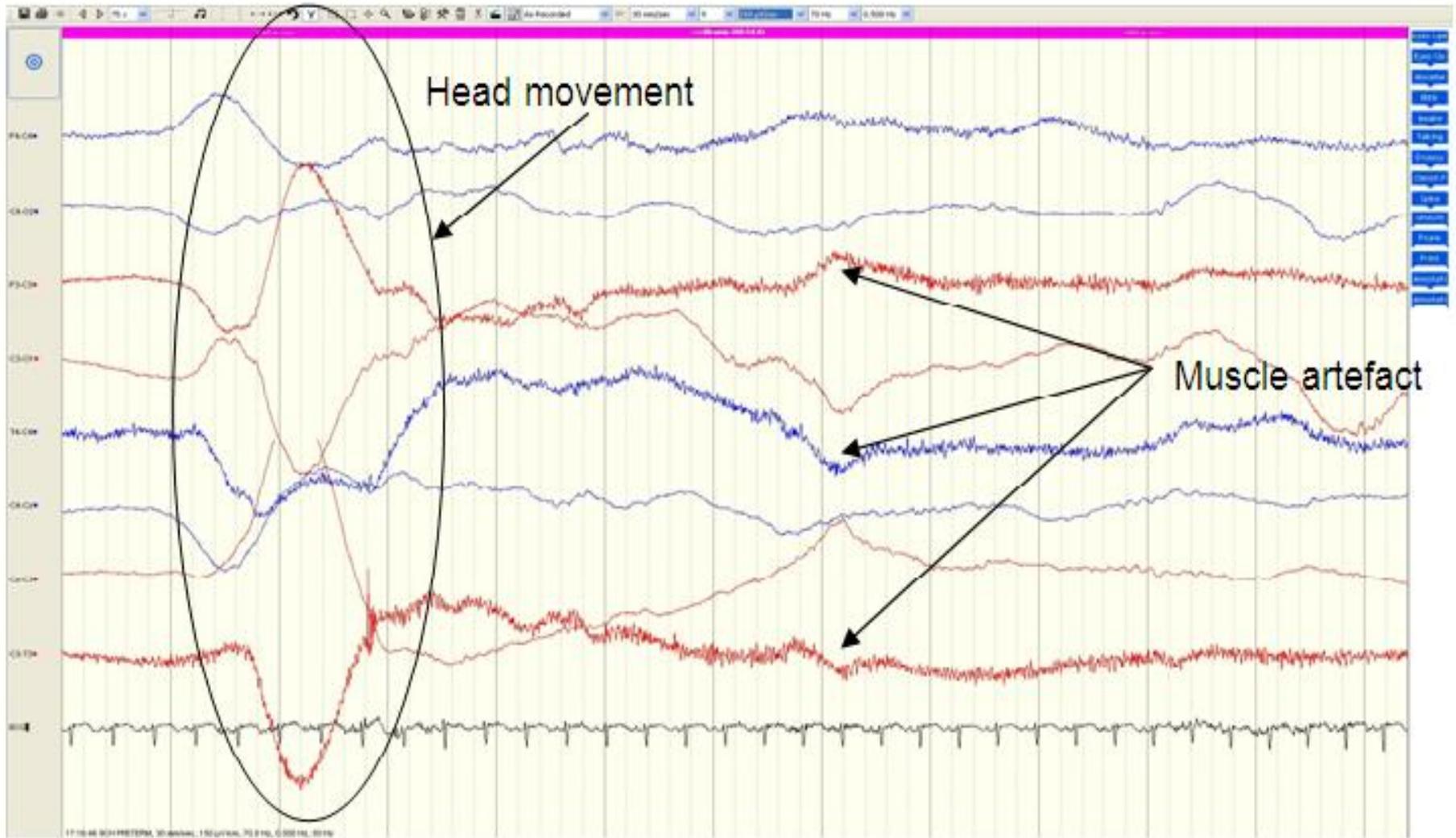
Transient oscillator artefact raises aEEG baseline falsely.



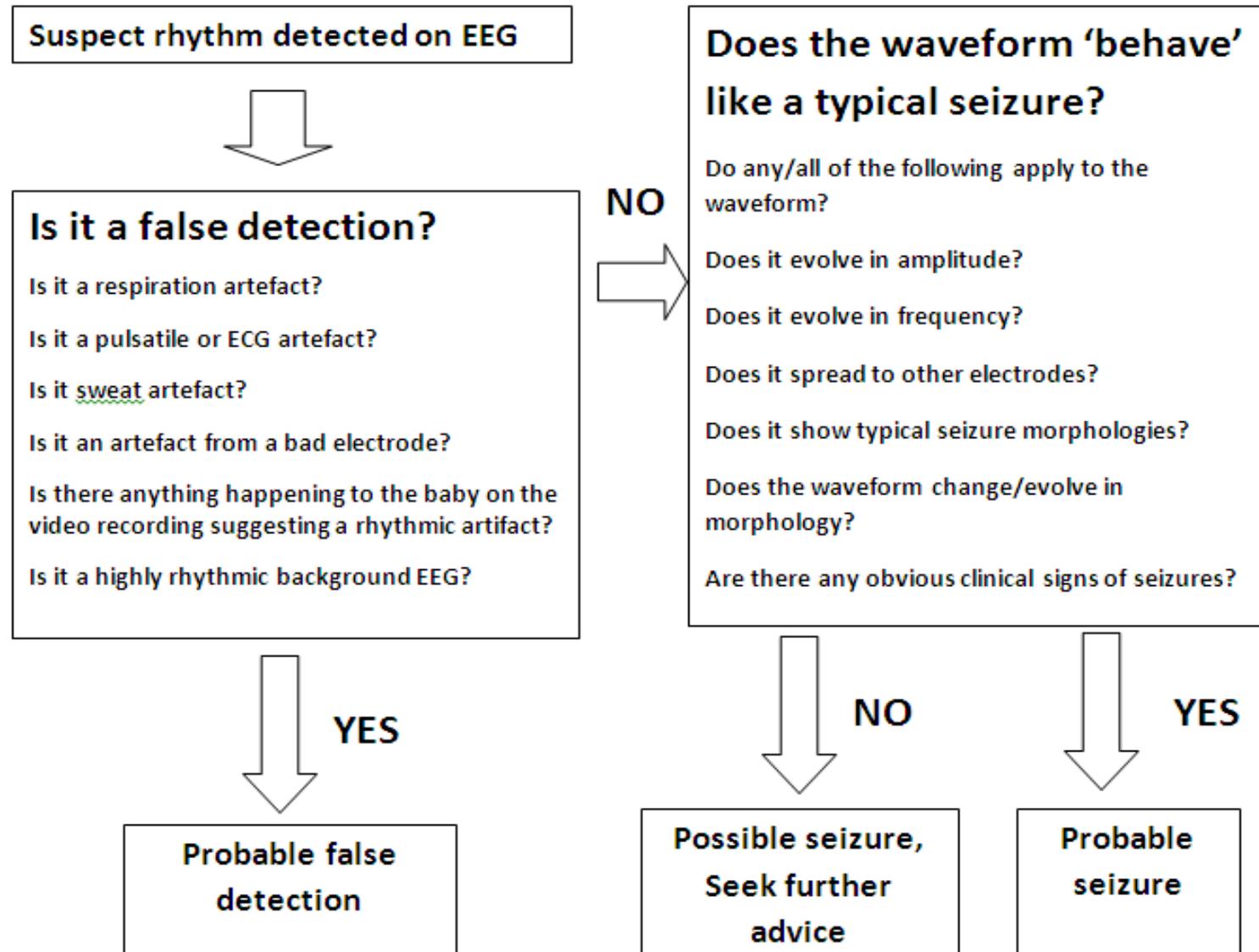
Muscle and movement artefact

- Transient movement of the baby can cause high amplitude slow artefacts on the EEG.
- If the baby is crying, chewing on a dummy, biting on a ventilation tube or frowning, muscle activity will appear on the EEG as fast irregular low amplitude activity.
- Neither transient movement artefact or muscle activity are likely to cause false detections on ANSeR.

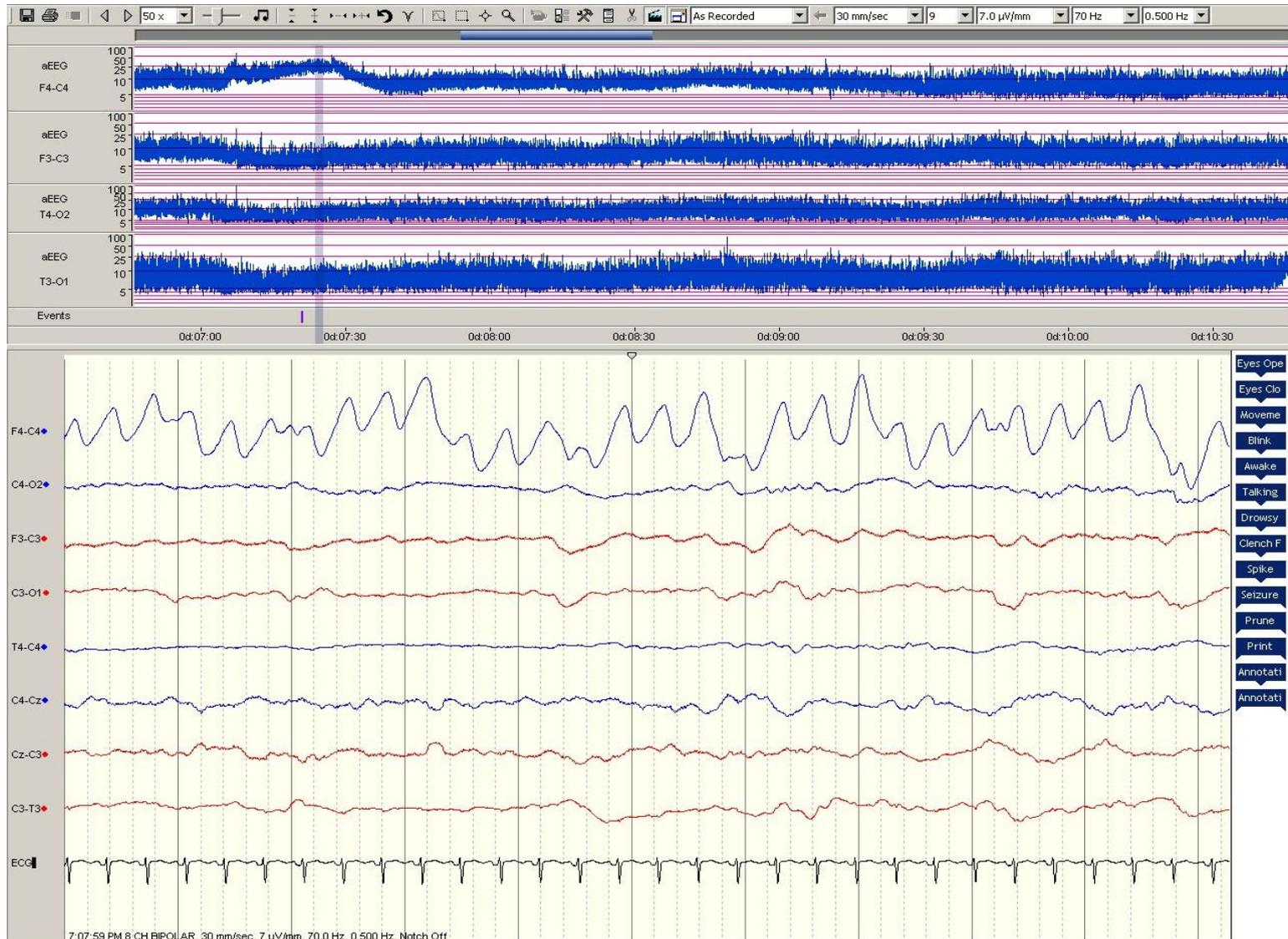
Muscle and movement artefact



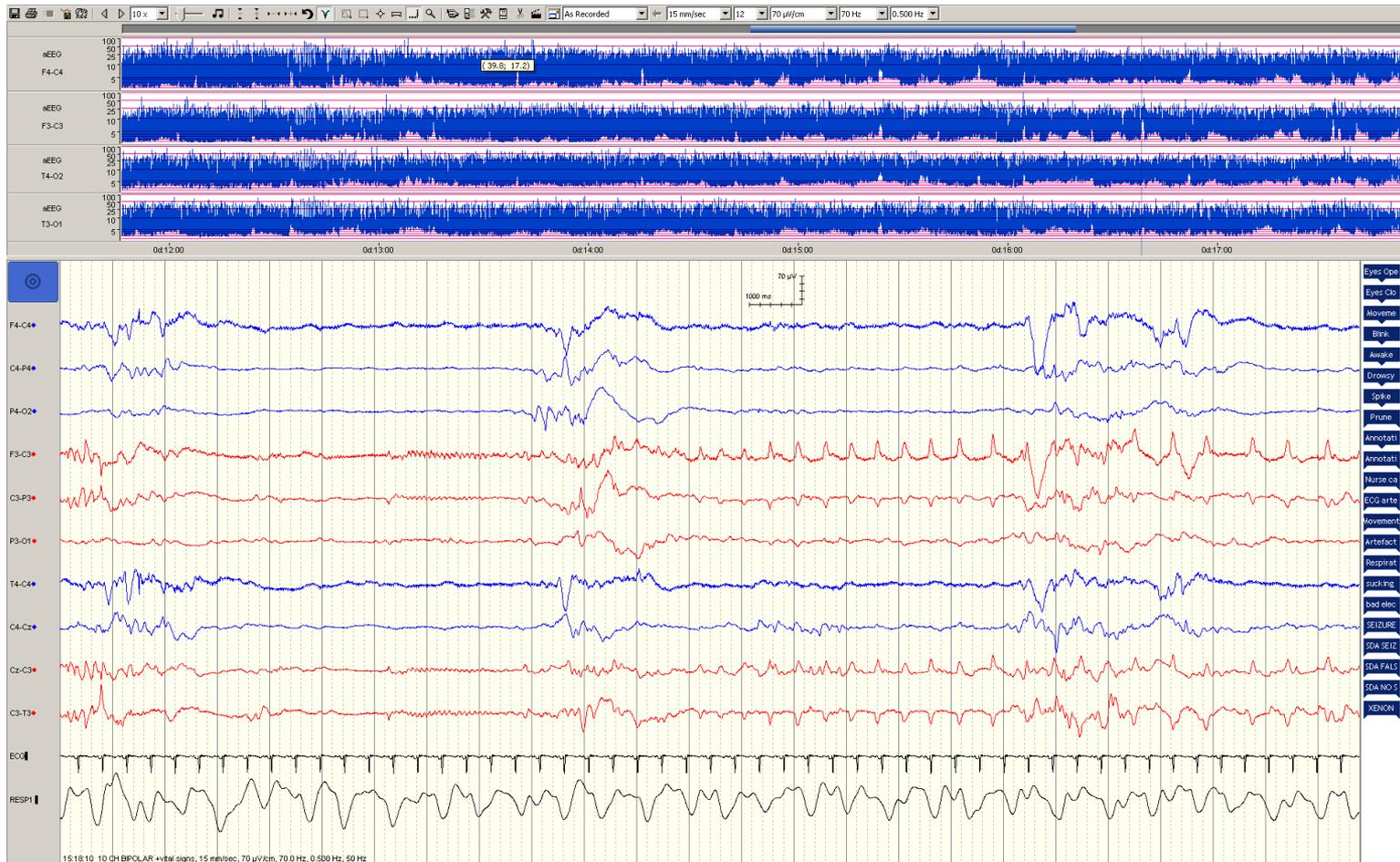
Decision tree for differentiating true seizures from false detection



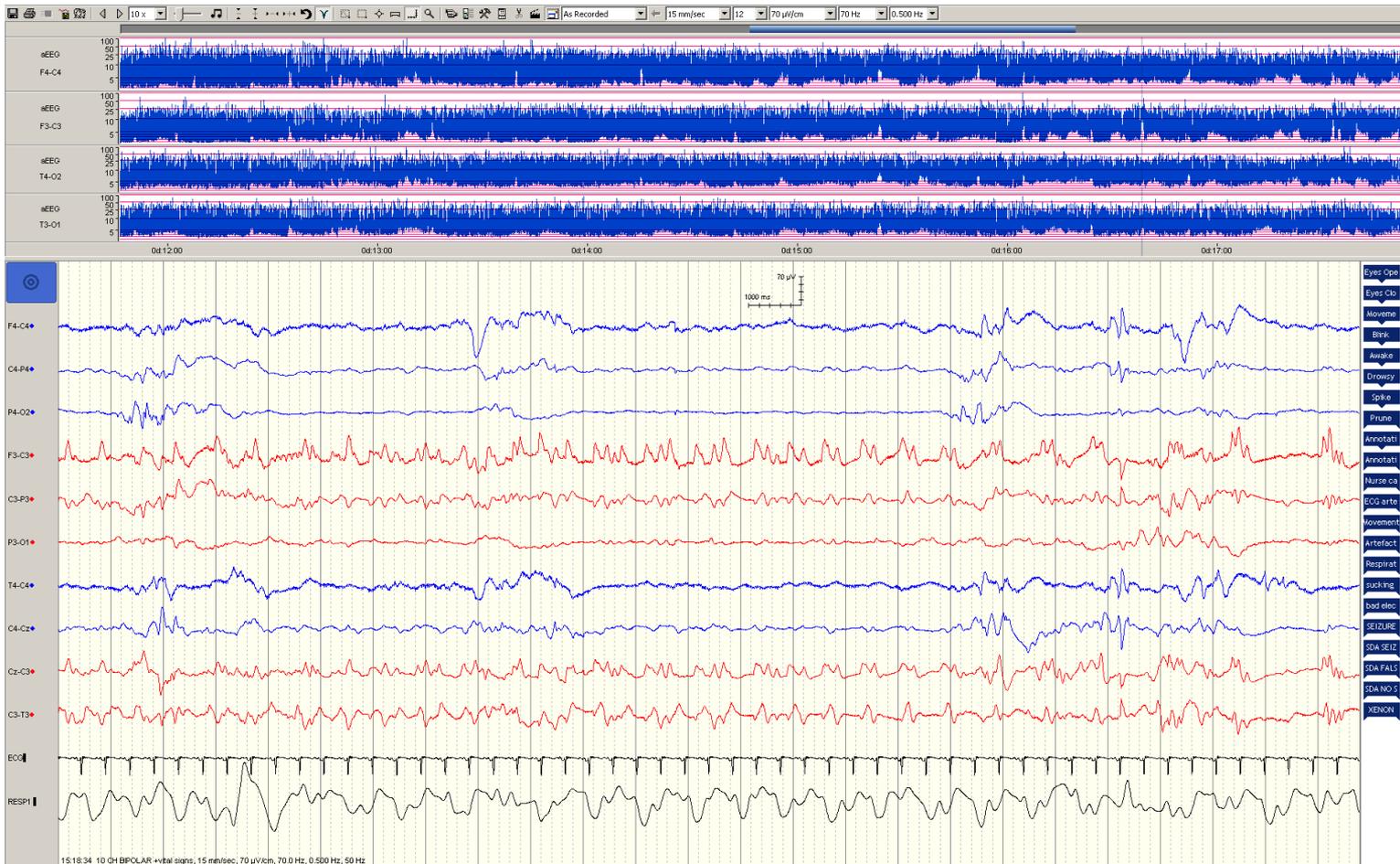
What is this ?



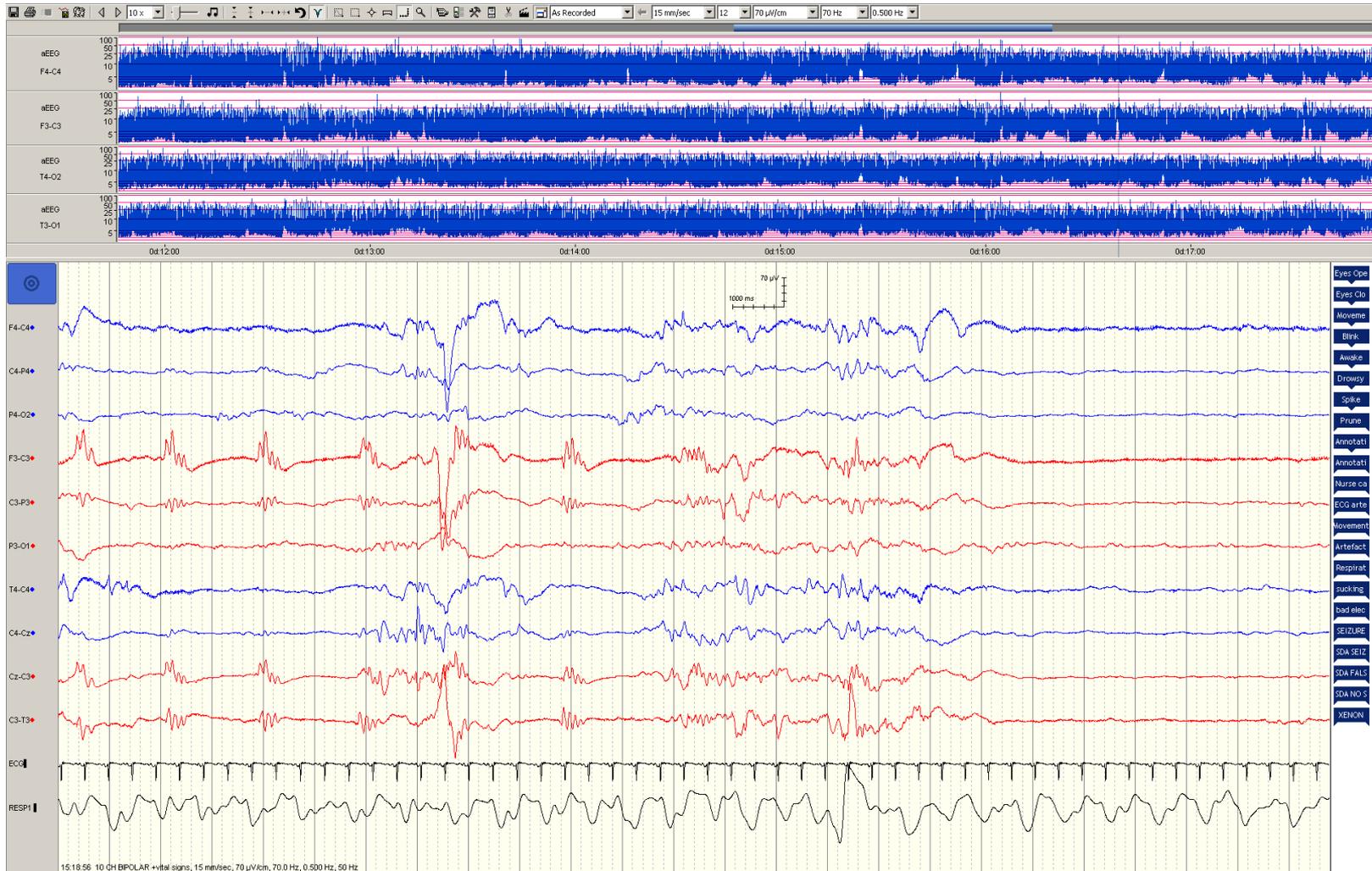
What is this ? (Start)



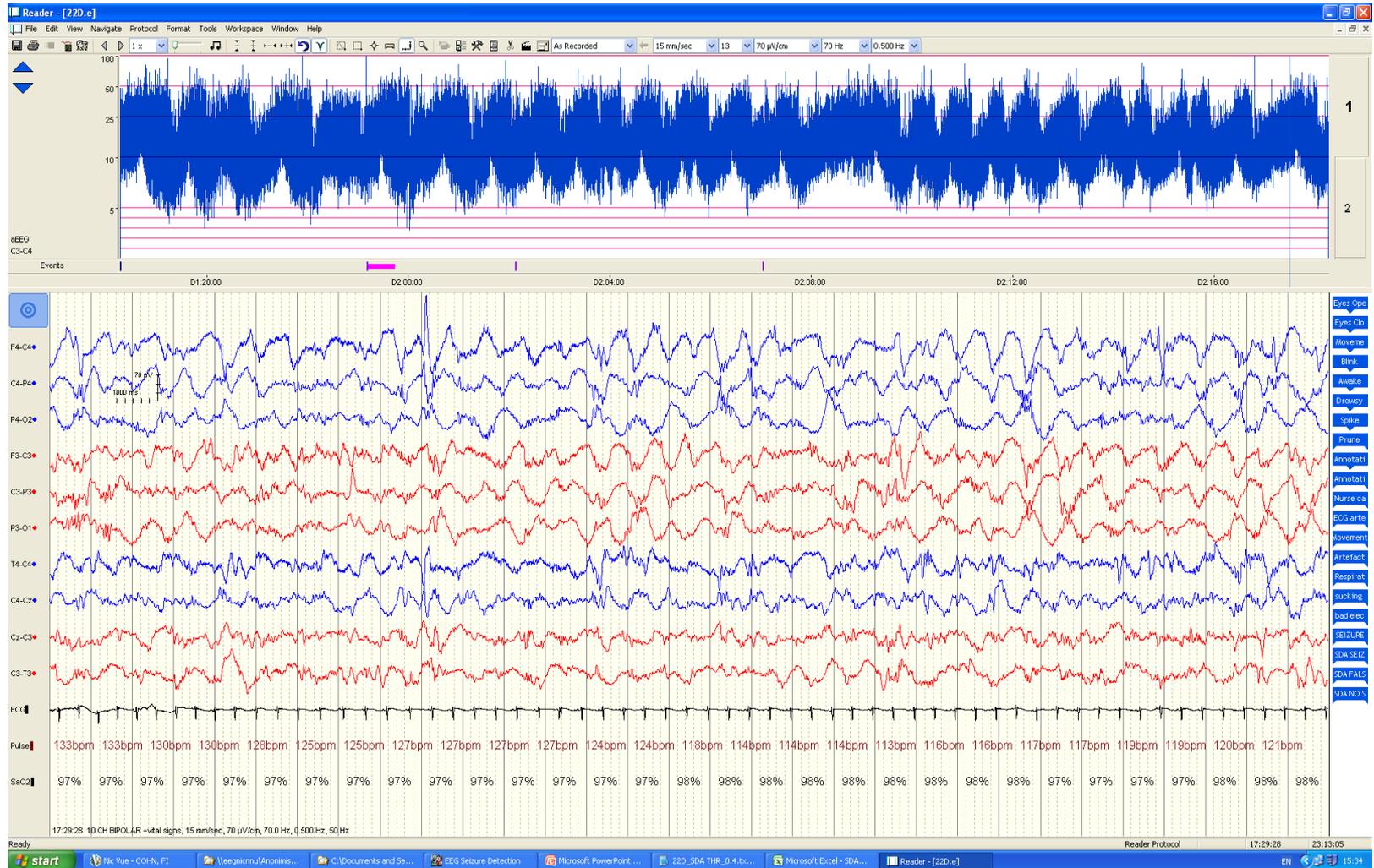
What is this ? (Middle)



What is this ? (END)



What is this ?



What is this ?

