

Chulalongkorn University
จุฬาลงกรณ์มหาวิทยาลัย
Pillar of the Kingdom



EEG ARTIFACTS: SOURCE AND HOW TO FIX

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Normal

Abnormal

- Epileptiform abnormalities
- Non-epileptiform abnormalities

Benign variants

Artifacts

- Biological (EKG, EMG, EM, tongue)
- Non-biological (electrode, movements)

**Outline of
thought
When you see
the brain waves**

Talk overview

- 1. Type of EEG artifacts**
- 2. Suspicious features of the EEG that suggest artifacts**
- 3. How to fix**

1. TYPE OF EEG ARTIFACTS

EEG Artifacts

Physiological Artifacts

- Ocular Movements
- Cardiac Activity
- Muscle Activity
- Sweat

Biological field
(meaningful)

Non-physiological Artifacts

- Electrode Artifacts
- Movement Artifacts
- Devices
 - ✓ External
 - ✓ Internal

No biological field
(meaningless)



1. TYPE OF EEG ARTIFACTS

Ocular movements

Corneal has
positive potential
relative to retina

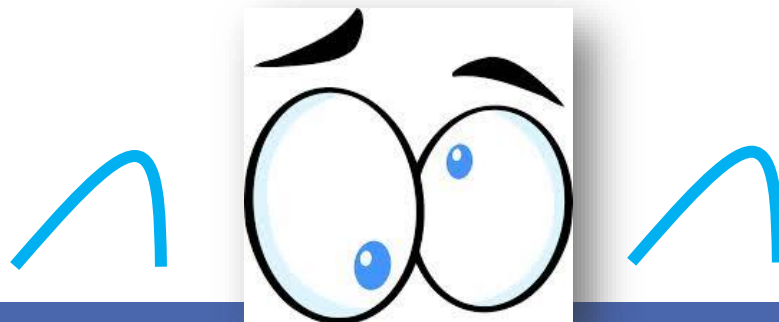
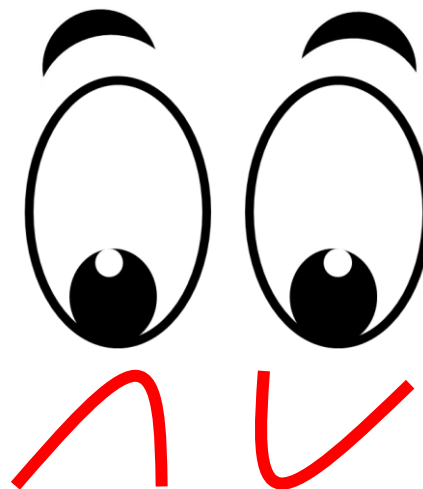
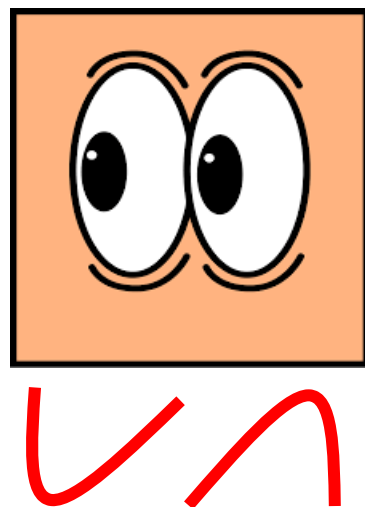
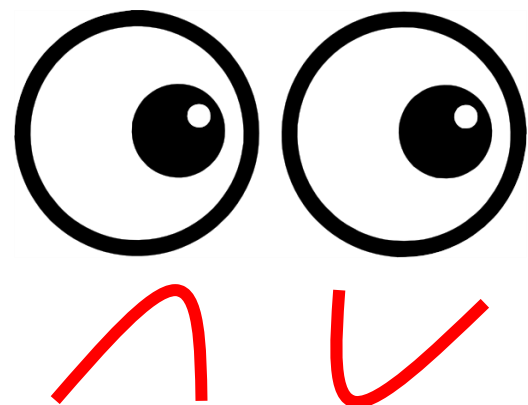
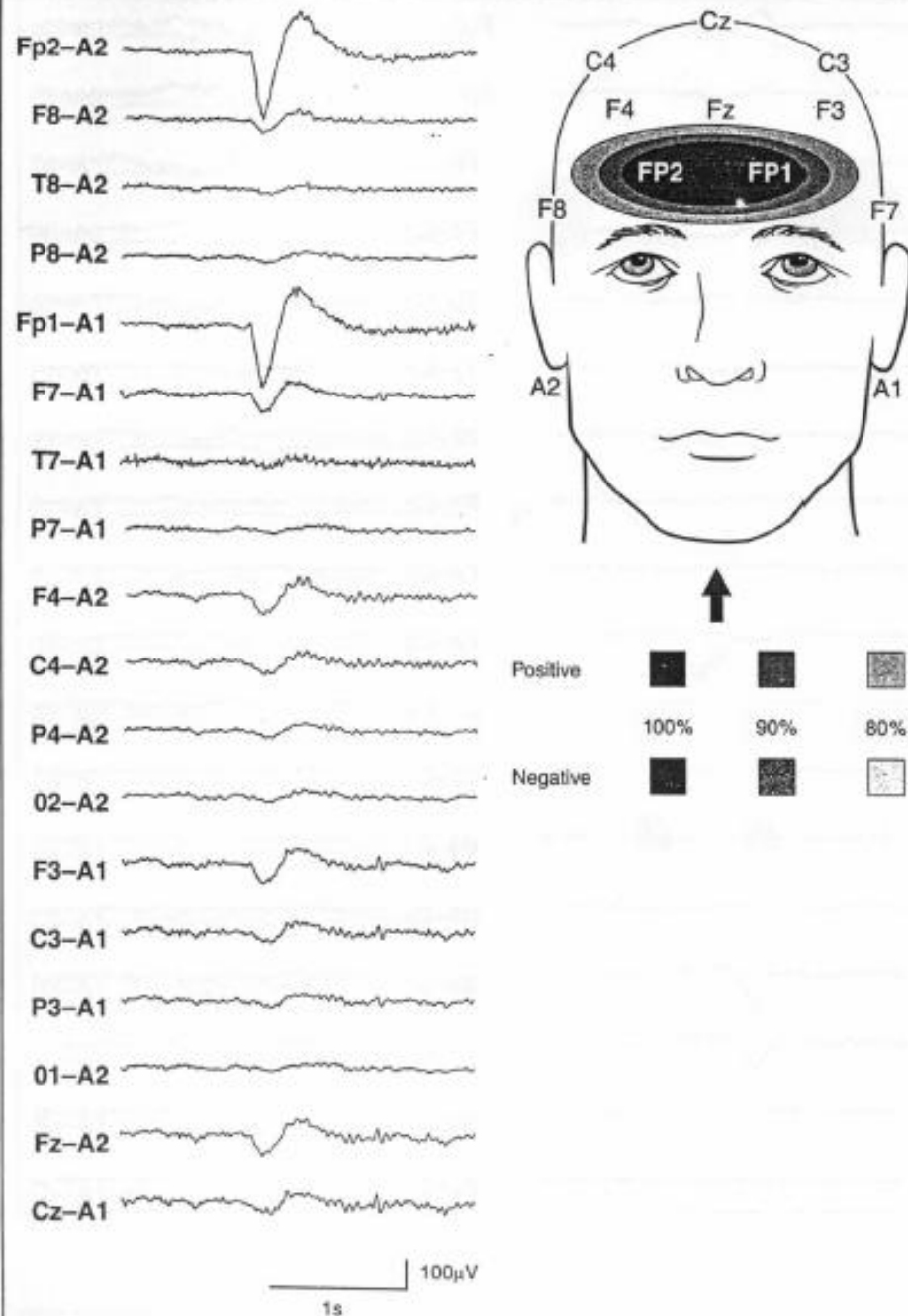
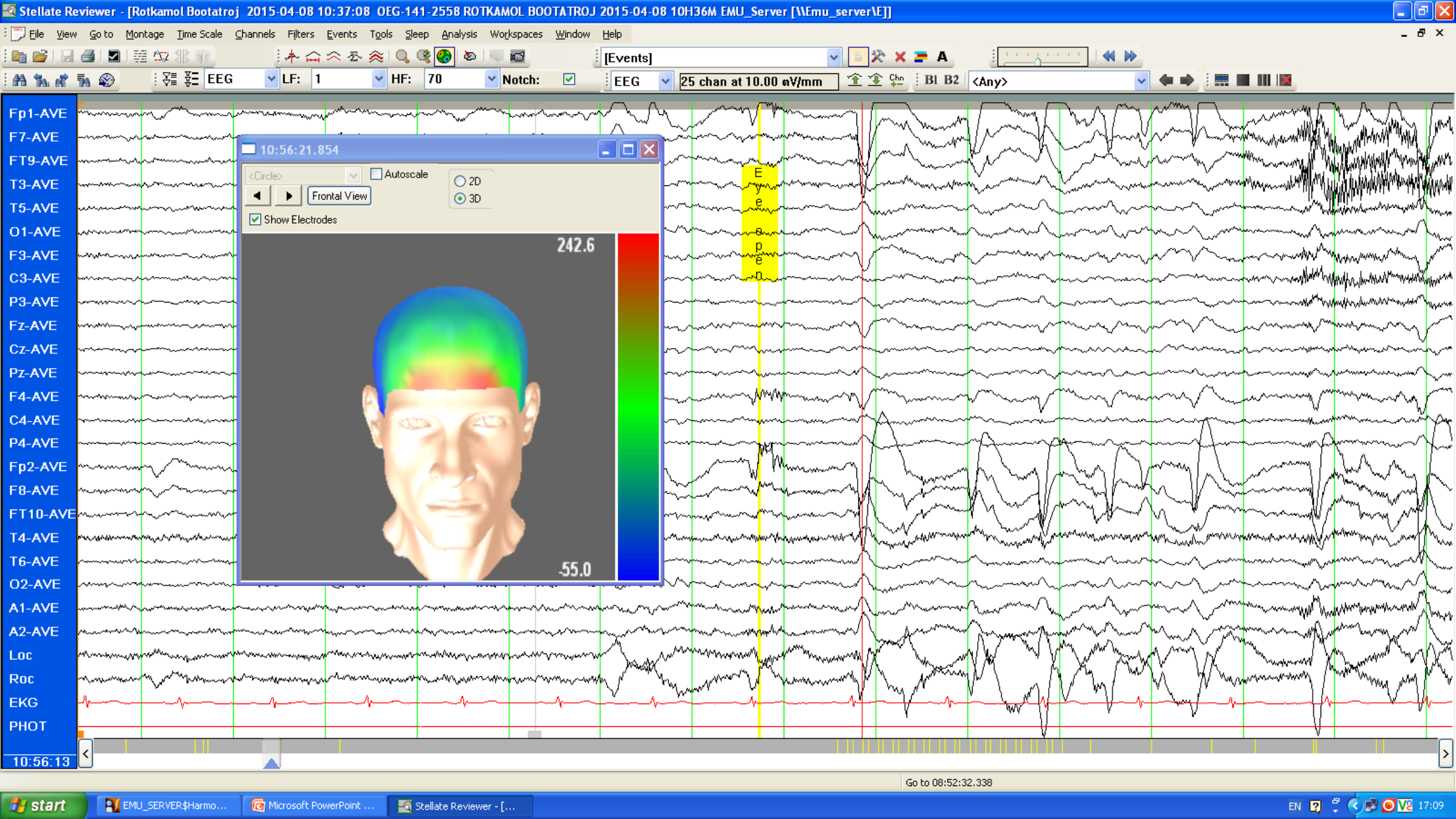


FIGURE 111a. Continued.



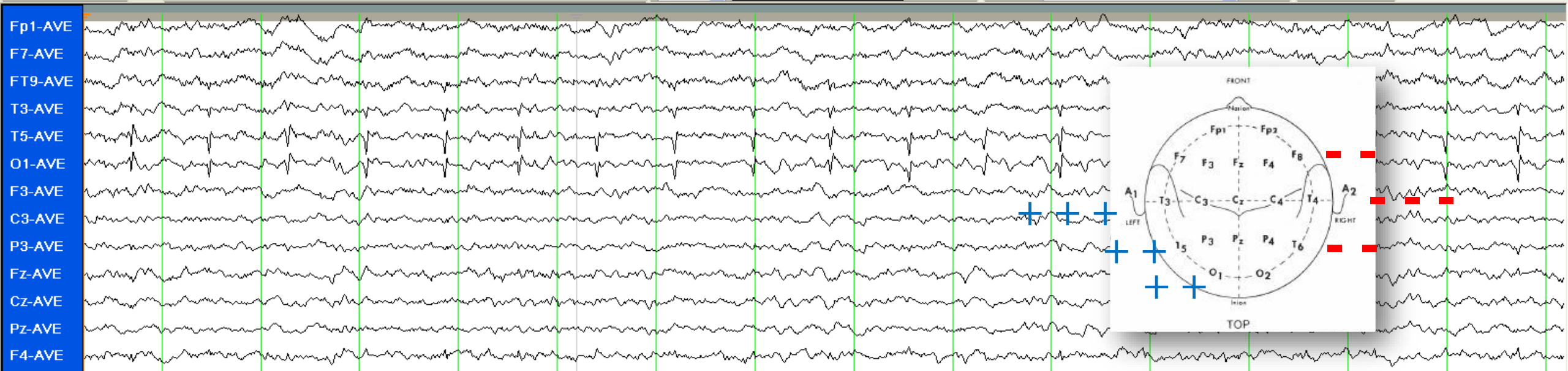
An upward eye movement is shown in bipolar longitudinal and transverse montages and referential derivations to the vertex (CZ) and ipsilateral ear (A1, A2). Upward eye movements are typically seen with blinks. This vertical eye movement artifact causes significantly higher deflections in channels 1, 5, 9, and 13 than in channels 2, 6, 10, and 14 of the bipolar longitudinal montage. The maximum positivity (cornea) occurs at electrodes FP1 and FP2. A dipole is not seen because no electrodes are placed over the inferior face area. Note that in Figure 111a-h, right-sided electrodes are depicted over left-sided electrodes.



1. TYPE OF EEG ARTIFACTS

EKG artifacts





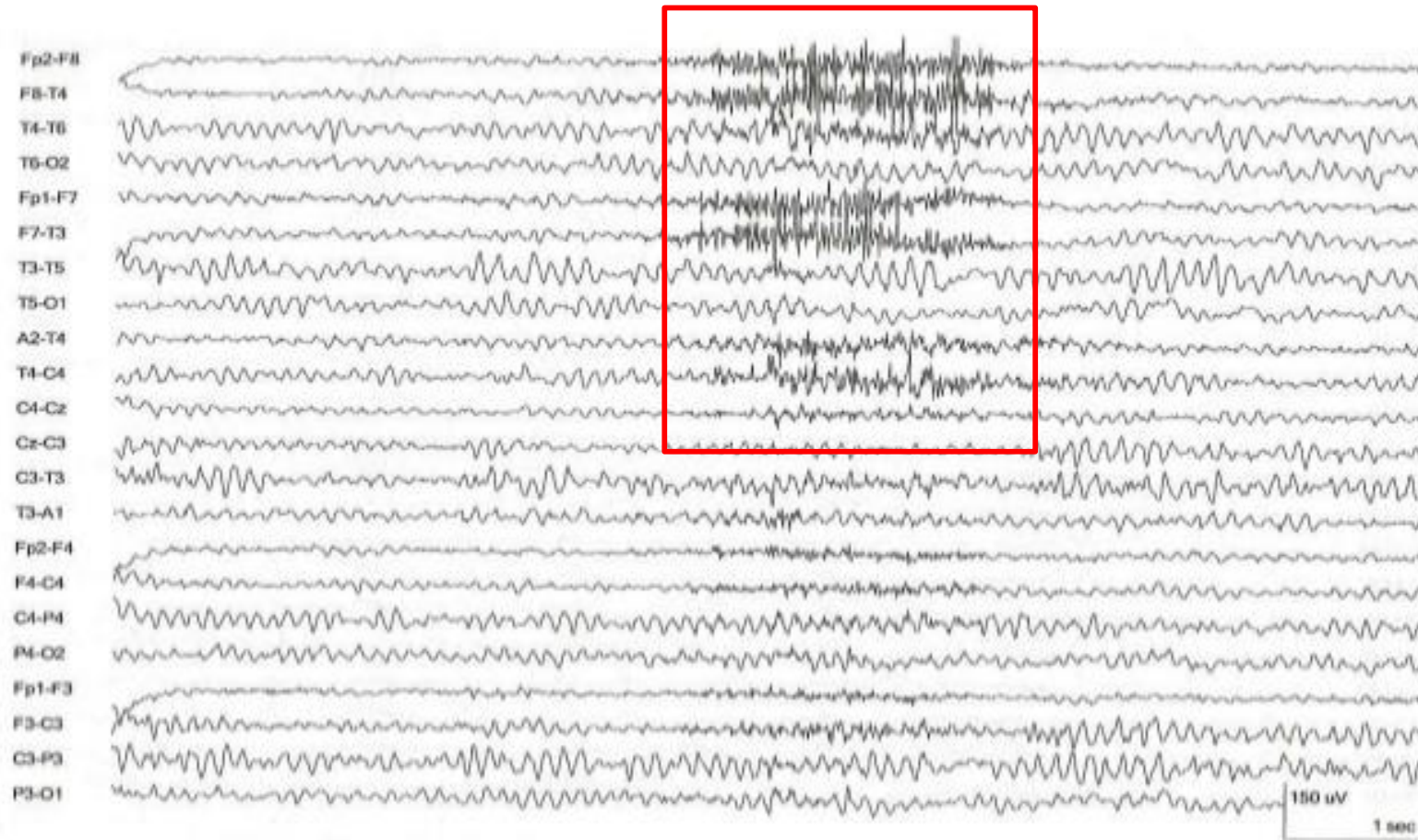
Channel Zoom 1X



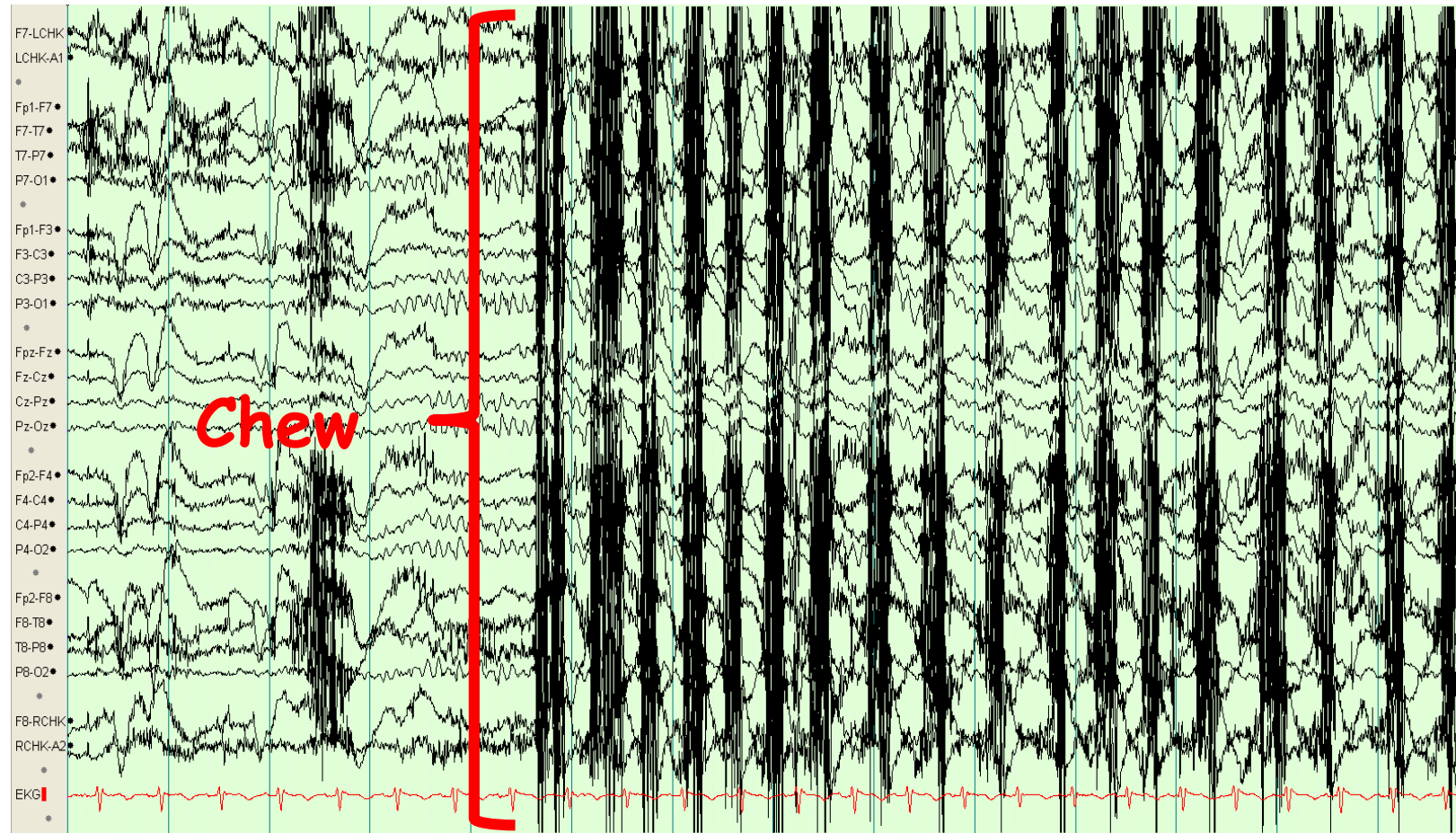
1. TYPE OF EEG ARTIFACTS

Muscle artifacts

Muscle artifact



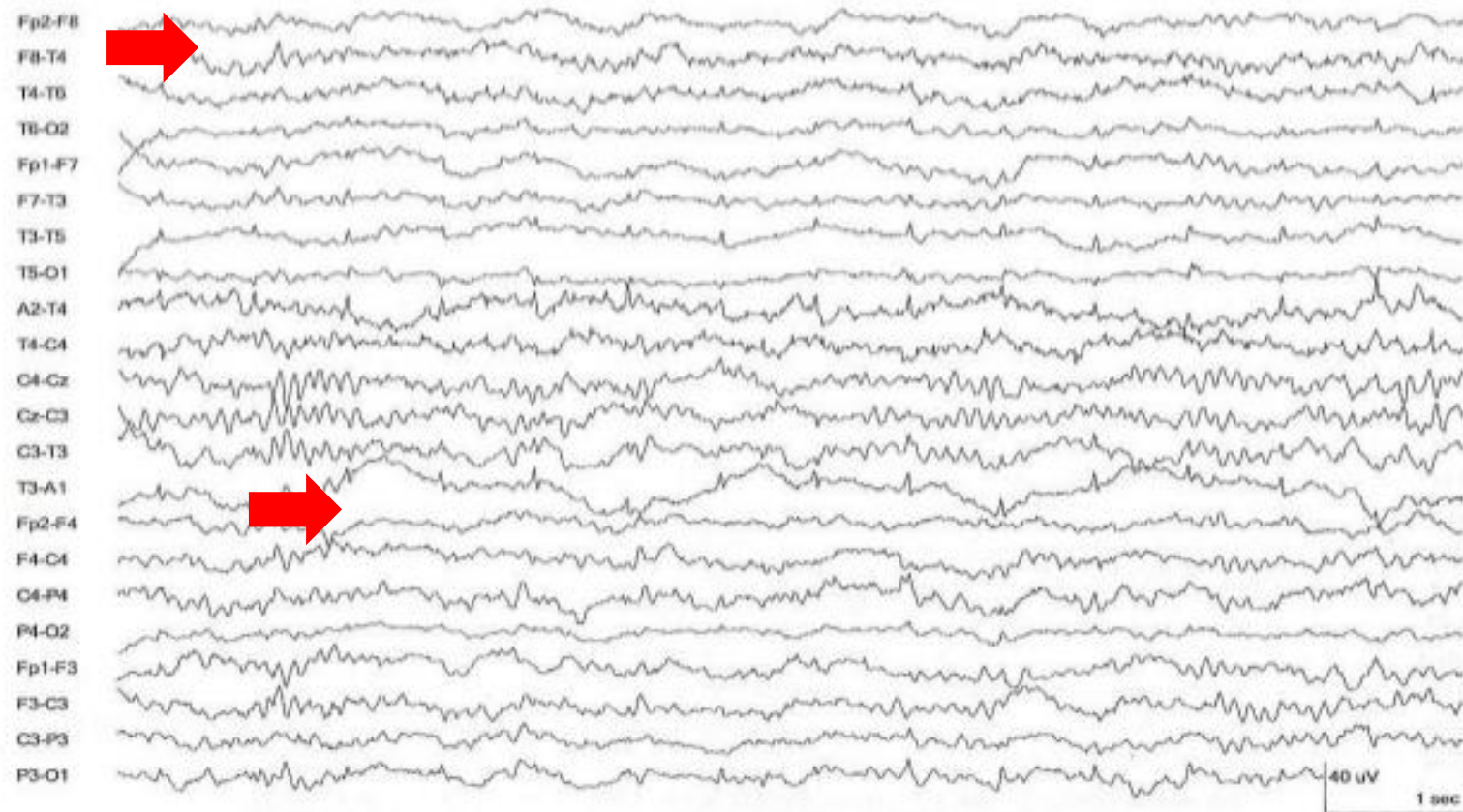
Chewing

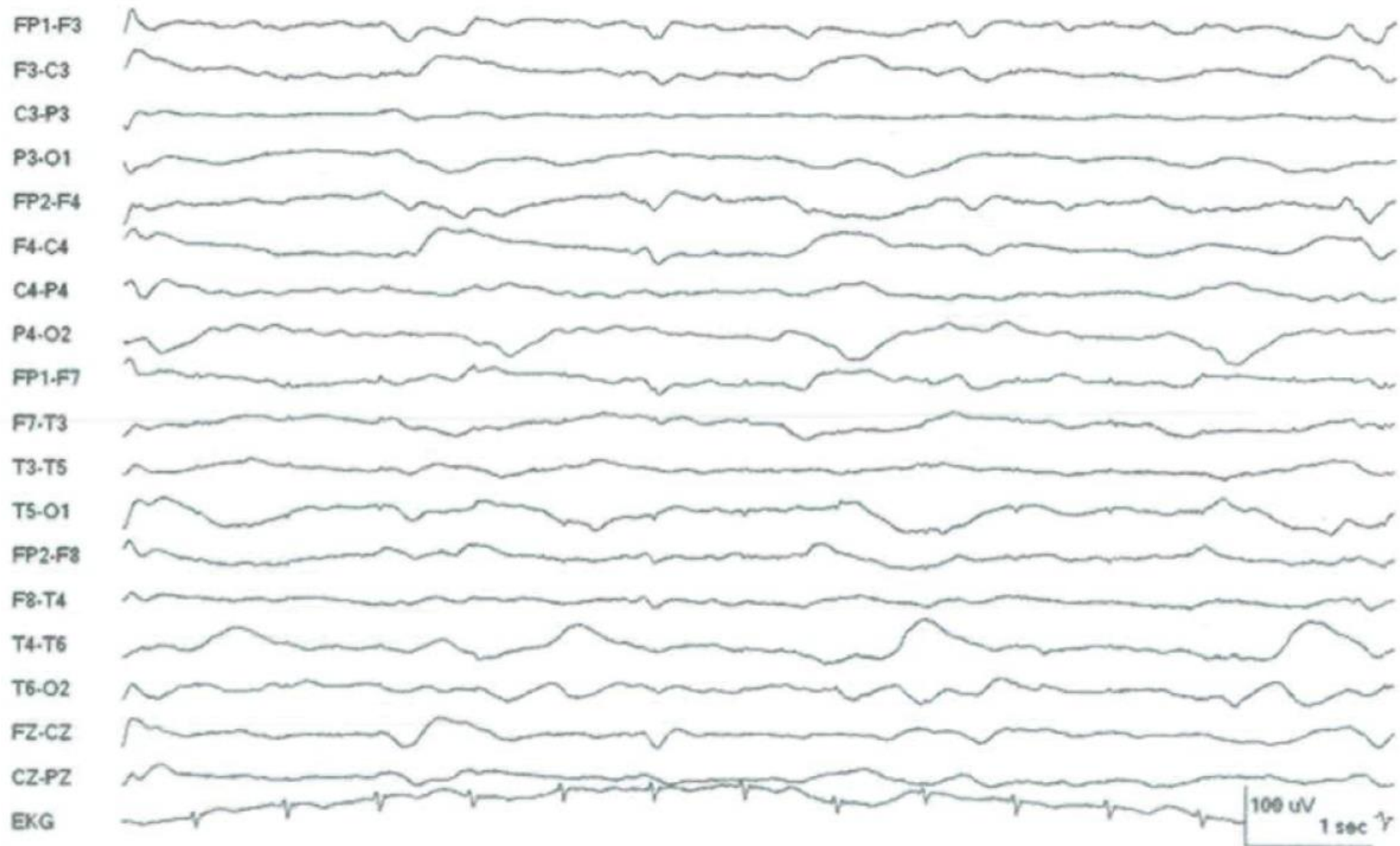


1. TYPE OF EEG ARTIFACTS

Sweat artifacts

Sweat

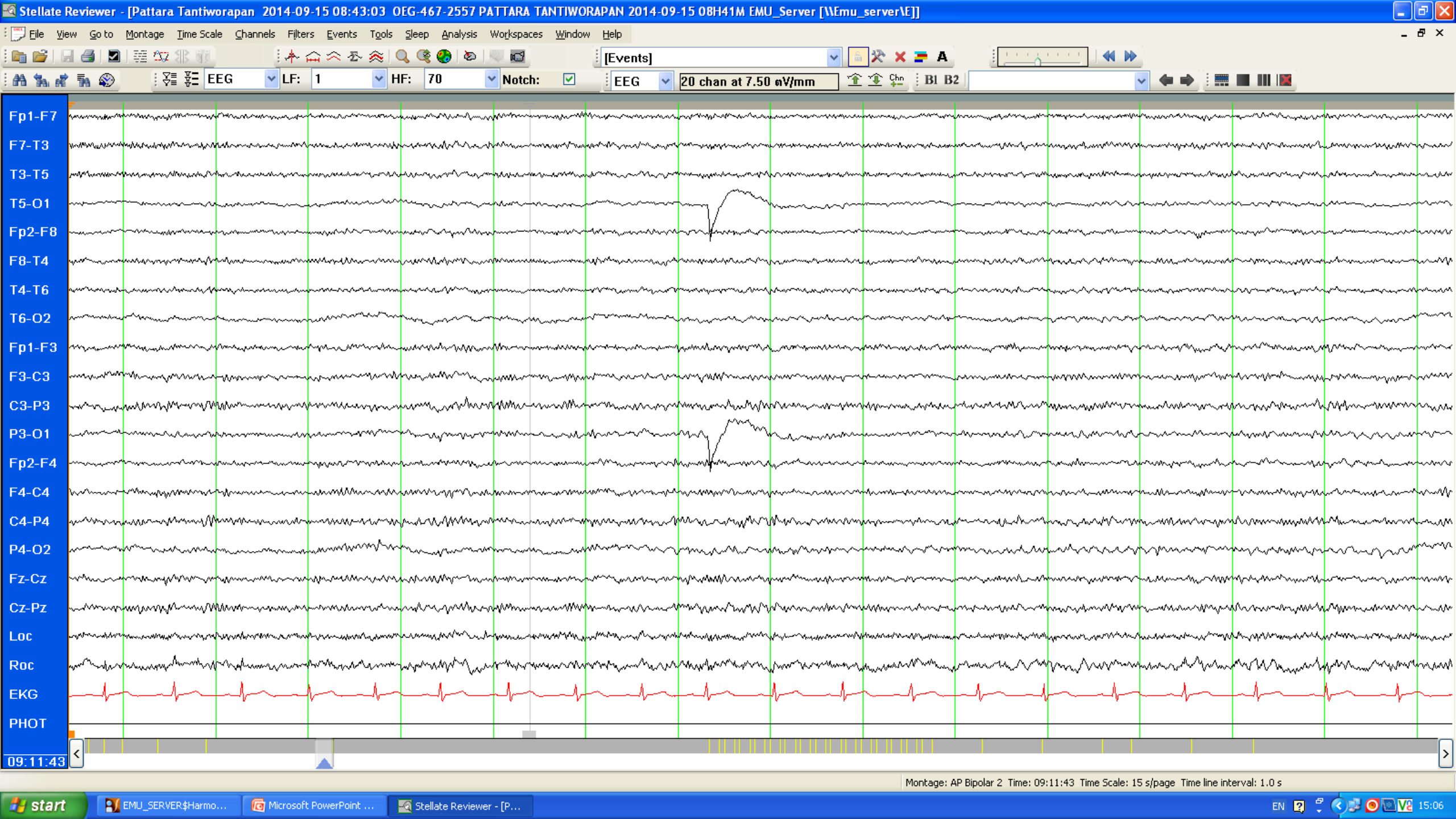


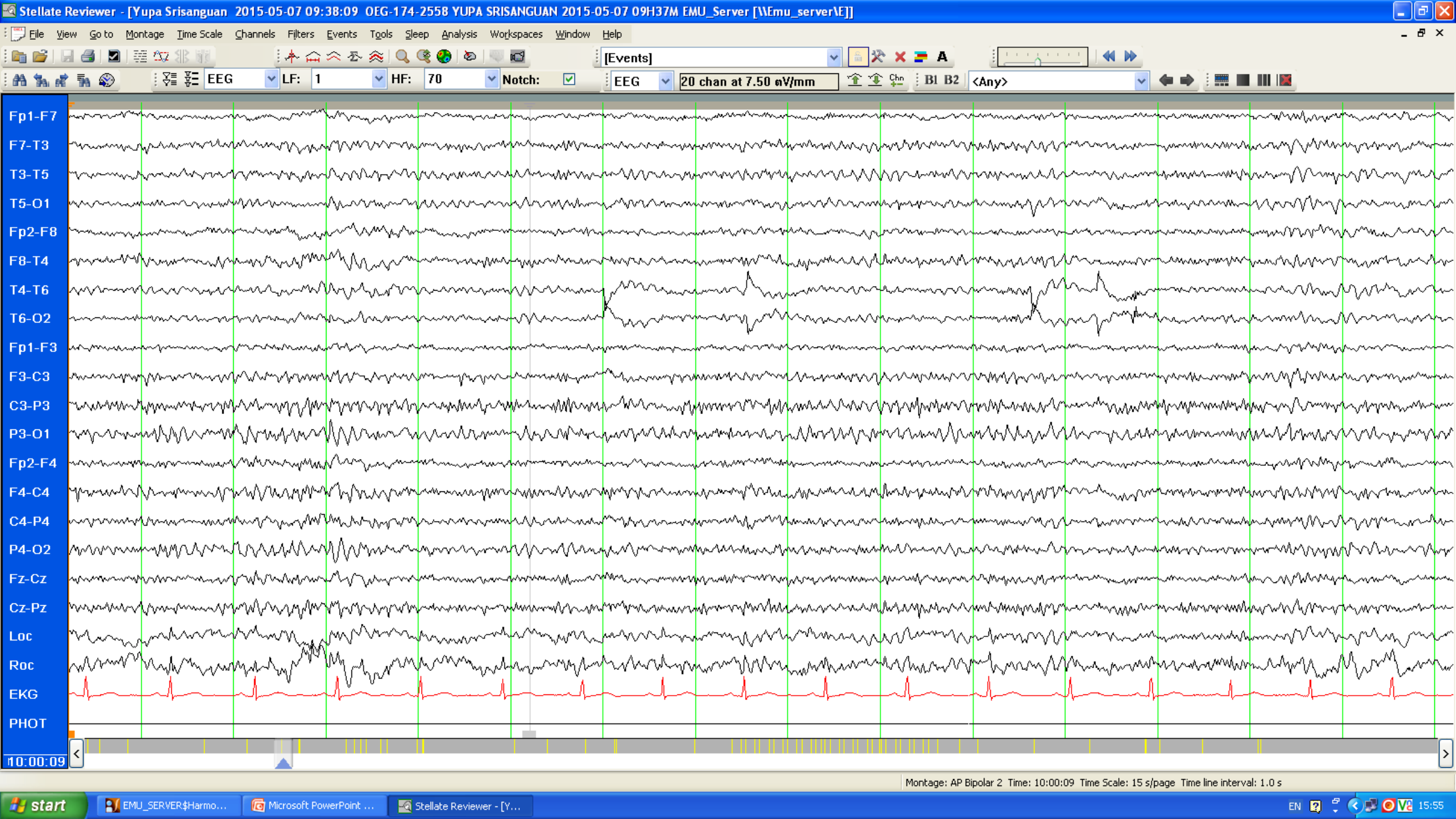


Sweat artifact

1. TYPE OF EEG ARTIFACTS

Electrode artifacts

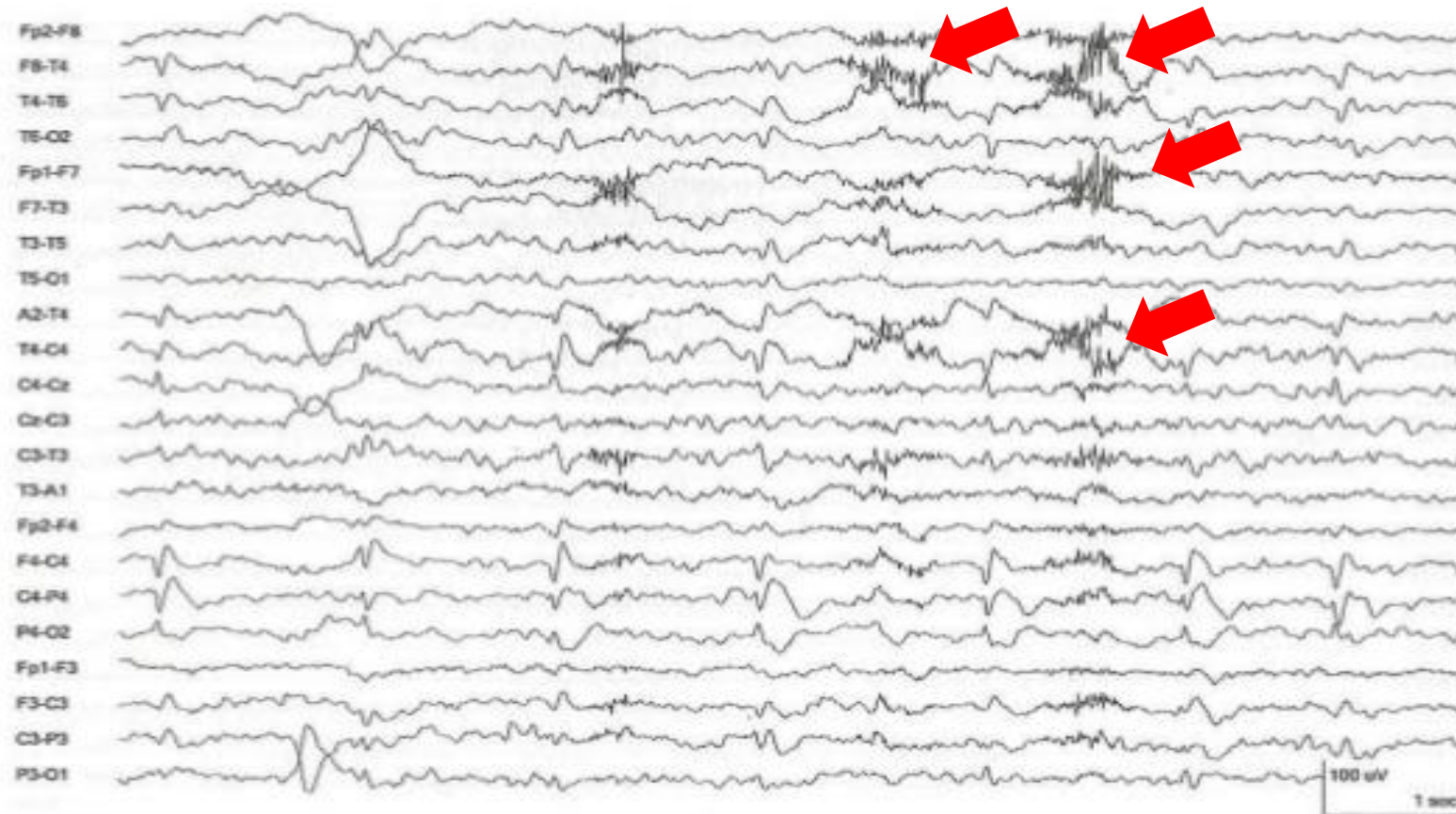


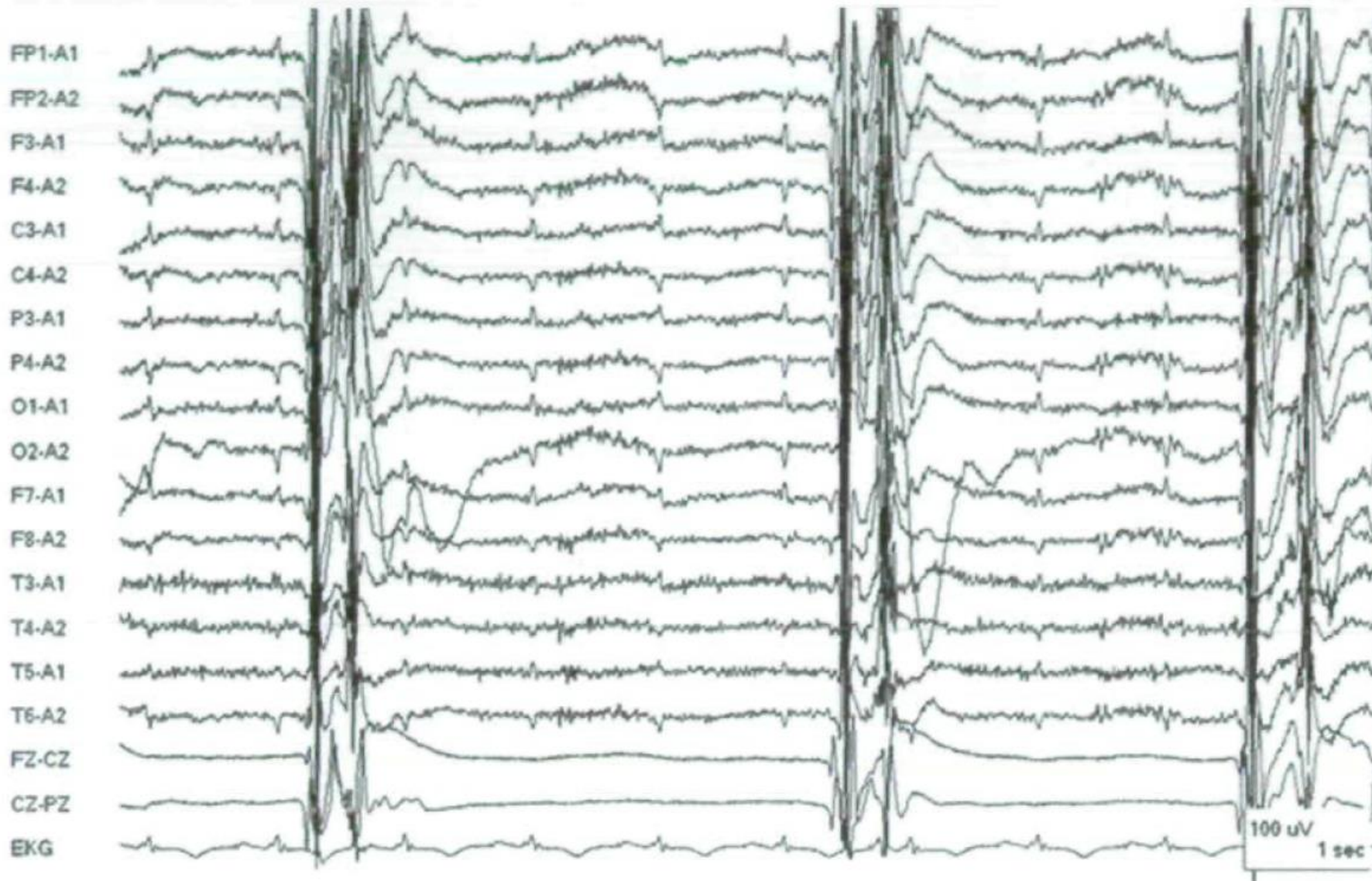


1. TYPE OF EEG ARTIFACTS

Movement artifacts

Muscle and movement artifact





**Motor
movements**

1. TYPE OF EEG ARTIFACTS

Devices



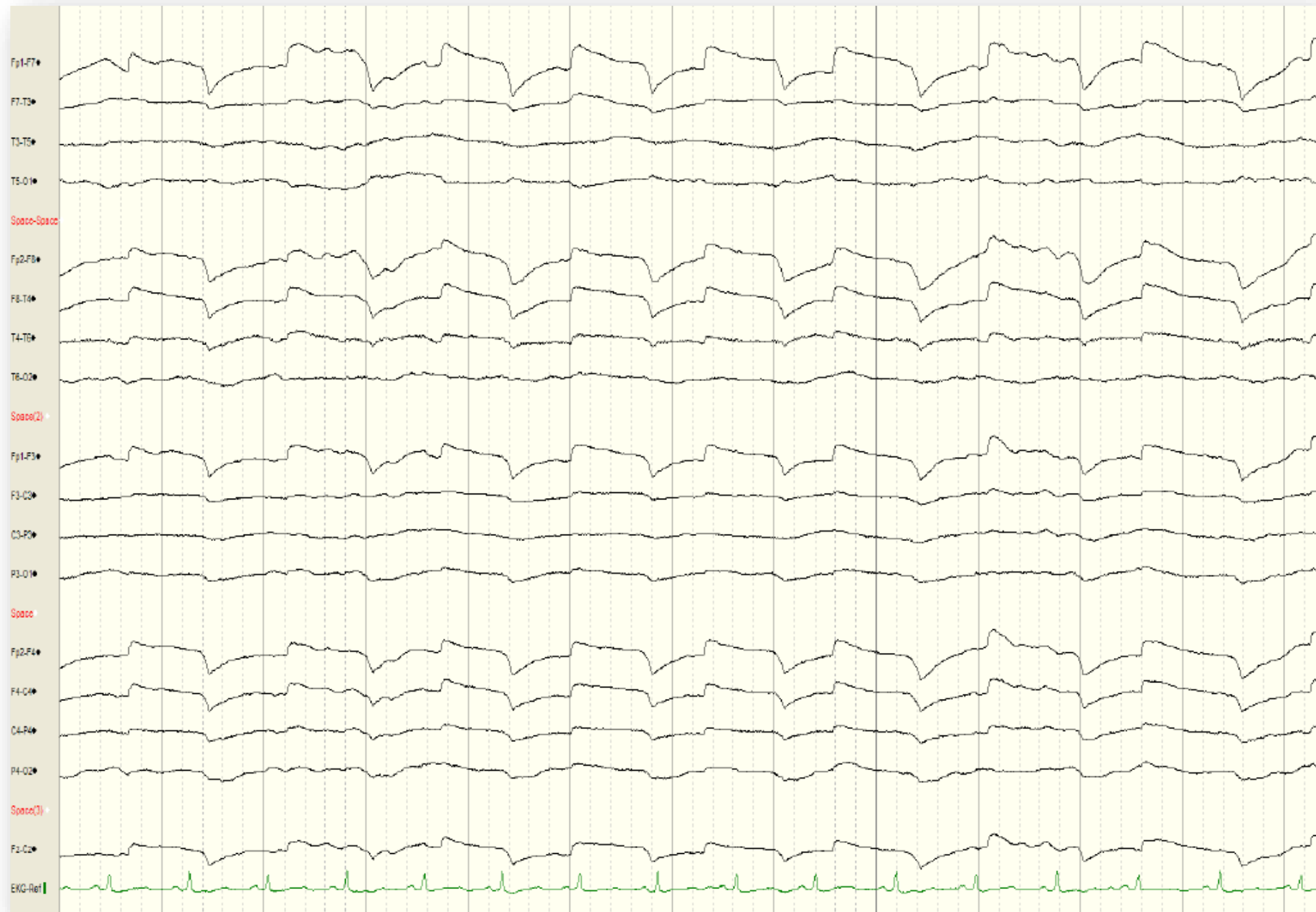
**Ventilator artifact,
mimicking
generalized
periodic discharges**



**Ventilator
artifact**



**Water condensation
(water settling
within the ventilator
tubing), mimicking
generalized
polyspike waves**



ECMO artifact

2. SUSPICIOUS FEATURES OF THE EEG THAT SUGGEST ARTIFACTS

Table 2 Suspicious features of the EEG that suggest artifact

Restricted activity or waveform to only 1 channel

Artifact until proven otherwise

Activity that appears in >1 noncontiguous head region

Suggests a discontinuous generator such as artifact

Complex waveforms with alternating double and triple phase reversals

Implies a field that is not due to a cerebral generator

Activity that appears at the end of an electrode chain

May imply a source that is distant to the brain

Atypical generalized waveforms

Suggests the potential for an equipment artifact involving all channels

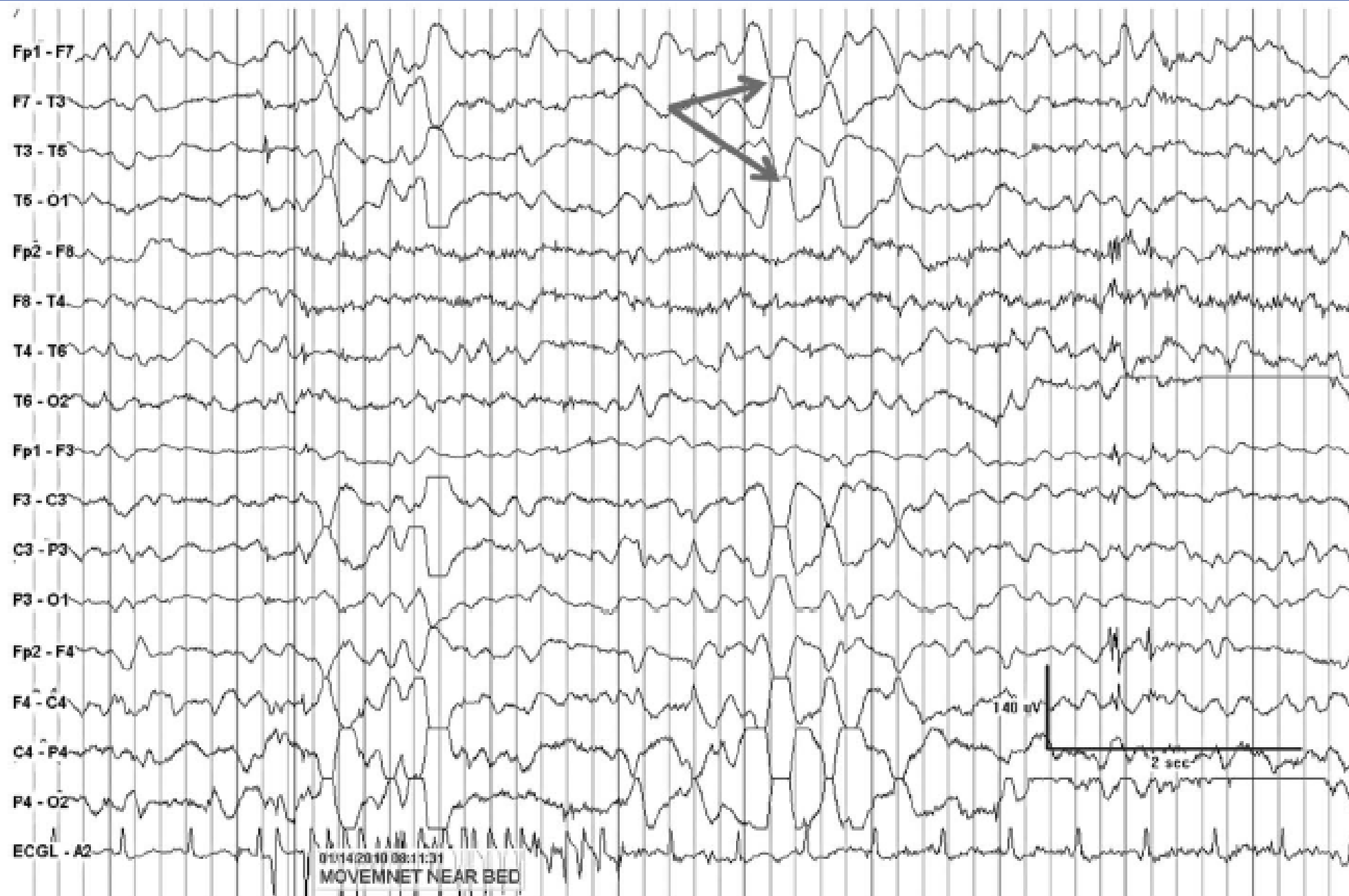
Periodic patterns

Precise periodicity and morphology suggests artifact

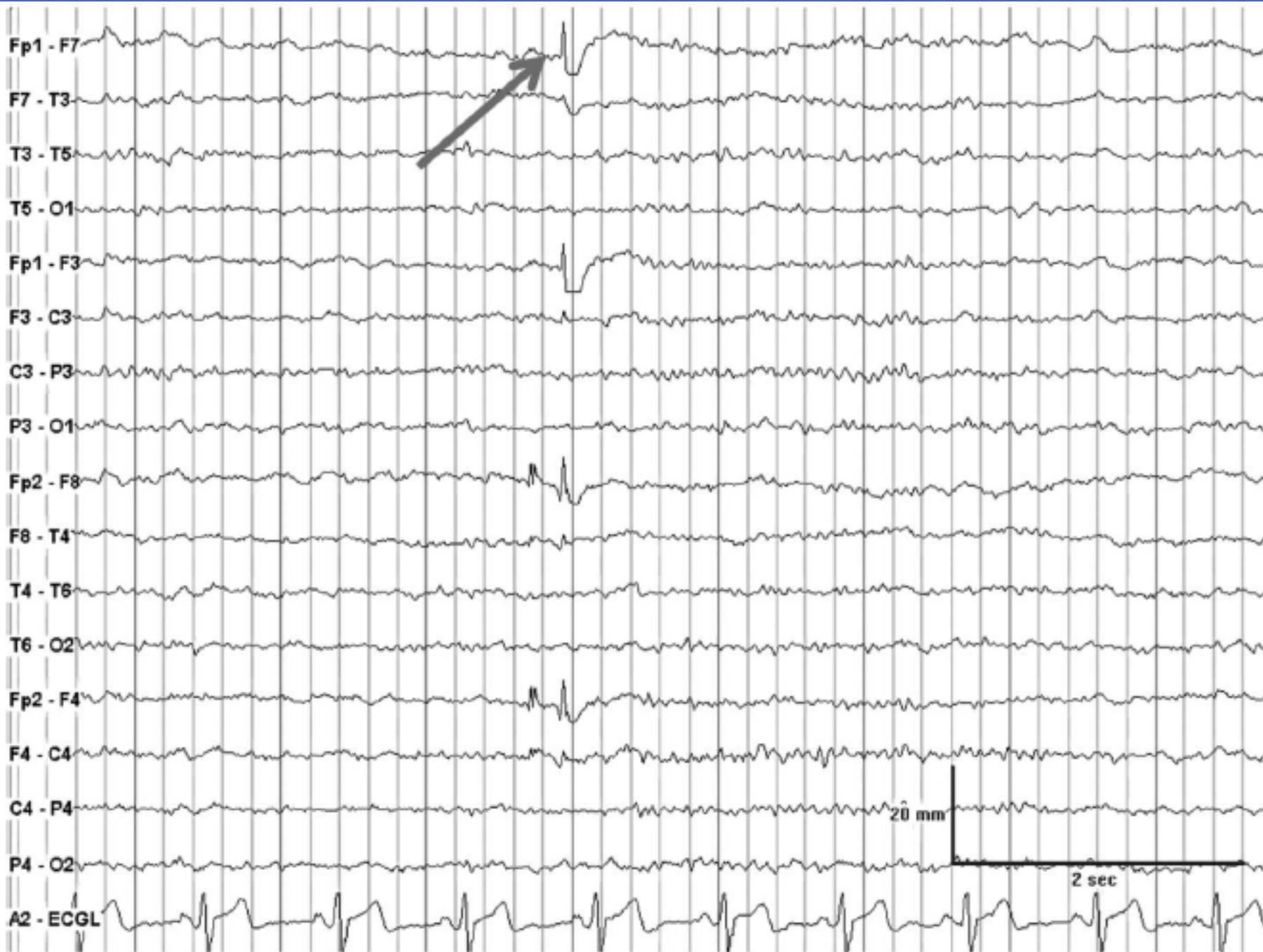
Very high or very slow frequencies <1 Hz or >70 Hz

Most cerebral activity lies between 1 and 35 Hz

Adapted from Tatum WO, Dworetzky BA, Schomer DL. Artifact and recording concepts in EEG. *J Clin Neurophysiol* 2011;28:252-263.⁴



**Alternating
double and
triple phase
reversal
indicates
multiple
electrode
artifact**



**Frontalis-induced
myogenic
potentials
mimicking
abnormal bilateral
frontopolar spikes**

Wave duration

- ✓ Spike: < 70 ms
- ✓ Sharp: 70-200 ms
- ✓ **Muscle motor unit: < 20 ms**

*Tatum WO et al; J Clin
Neurophysiol 2011*



**Double
negative phase
reversal in > 1
noncontiguous
head region
(T5 and F8)**

3. HOW TO FIX

Coordinating

Monitor

Reposition



Cause of artifacts	Appearance on EEG	How to prove	Troubleshooting
<p>Muscle artifact</p> <ul style="list-style-type: none"> - EMG artifact often occurs when the patient is tense or anxious and has difficulty relaxing or holding still - The patient is biting down on the endotracheal tube which connects the patient to the ventilator 	<ul style="list-style-type: none"> - fast mid-voltage irregular single or serial spikes; intermittently or continuously 	<ul style="list-style-type: none"> - Can be eliminated with neuromuscular-blocking drugs (e.g. vecuronium bromide, trade name Norcuron®) making it possible to evaluate brain activity more accurately 	<ul style="list-style-type: none"> - The technologist should make sure the patient is not cold and that his/her head is resting comfortably - Try to interact as little as possible with the patient <p>Coordinating</p>
<p>Motor movements</p> <ul style="list-style-type: none"> - body twitching, tremor, tics, and tonic-clonic activity 	<ul style="list-style-type: none"> - rhythmic artifact on the EEG recording that can resemble focal seizure activity - can be recorded in one or more channels during EEG monitoring 	<p>Monitoring involuntary movements of the face, arm, or leg with two electrodes referred to each other can be correlated simultaneously with the artifact on the EEG recording</p>	<p>Monitor/Coordinating</p>
<p>Muscle paralyzing drugs have no known effect on consciousness and therefore do not alter brain function like sedatives</p>			

Cause of artifacts	Appearance on EEG	How to prove	Troubleshooting
Cardiac artifact - the recording of the electrical field of the heart potential over the surface of the scalp	- spike or sharp morphology	- Routinely recording EKG simultaneously during the EEG is the best solution for this and other cardiac-related physiological Artifacts	- In some instances turning the patient's head will change the EKG field over the head and lower the amplitude of the artifact - the use of a bipolar montage rather than a referential (A1/A2) montage usually reduces the voltage of the EKG artifact. Monitor/ Repositioning
Cardioballistic artifact - typically an issue when there is marked suppression of background EEG activity or electrocerebral silence (ECS)	- widespread rhythmic delta activity on scalp EEG and may be misinterpreted as generalized slowing of cerebral activity - time locked to cardiac depolarization The waves occur at the same frequency as the BKG, but are slightly delayed, beginning just after the QRS		Monitor

Cause of artifacts	Appearance on EEG	How to prove	Troubleshooting
Pulse artifact - Pulse artifact can occur when an electrode is placed over a pulsating artery or tissue	- can simulate focal slowing of cerebral origin - The rhythmic slowing caused by the pulse wave does not occur simultaneously with the QRS complex of the EKG, but is typically delayed by about 200 to 300 msec after the QRS complex	- A pulse artifact is easily identified by touching the electrode producing it.	- the artifact can be eliminated or reduced by moving the electrode slightly away from the pulsating tissue - Repositioning the patient's head may also prove to be helpful. Monitor/ Repositioning
Glossokinetic potential artifact (GKP) - occurs with tongue movem - the tip of the tongue is electrically charged and is relatively more negative than the base of the tongue - The amplitude of the potential is greatest near the tongue and is detected best in the leads located near the mouth including lip leads, infraorbital leads, and Fp1/Fp2.	- burst of generalized slow wave activity on scalp EEG which may be misinterpreted as being cerebral in nature - resembles spike-wave or other transient discharges	- With a cooperative patient, this physiological artifact can be reliably reproduced by asking the patient to repeat words that cause significant movement of the tongue such as "lalala". "Tom Thumb", or "lilt" and stopped by asking the patient not to talk or move the tongue - In an uncooperative patient or in the ICU setting, an EEG channel devoted to monitoring tongue movement with electrodes placed above and below the patient's lips will correlate with the artifact. The technologist should note whenever the clinical symptoms occur by indicating on the EEG that the patient is moving his tongue	Monitor/ Repositioning/ Coordinating

Cause of artifacts	Appearance on EEG	How to prove	Troubleshooting
Electroretinogram (ERG) Artifact - recorded during photic stimulation - the result of the response of the eyes' retinal cells to the light	- Maximal in frontopolar electrodes (Fp1 and Fp2), since they are closest to the eyeballs - ERG can be noted at all or some flash frequencies, is usually bilateral, and is time locked to the photic stimulus	This physiological artifact will disappear when the light source to the eye is blocked by covering the patient's eye during photic stimulation	Monitor
Sweat artifact - most often recorded in patients with high body temperature associated with fever - Perspiration causes slow shifts of the electrical baseline by changing the impedance between the electrode and the skin	- Sweat artifact almost always appears in more than one channel, but can be lateralized or asymmetric - Sweating causes long duration slow wave artifact that is smooth in outline and of high amplitude particularly in the temporal and frontal electrodes and may be misinterpreted as slowing associated with cerebral dysfunction		Coordinating

Cause of artifacts	Appearance on EEG	How to prove	Troubleshooting
<p>Alternating Current (60 Hz Artifact) Thailand – 50 Hz</p> <p>- 50 Hz interference is caused by an alternating current which supplies power to electrical wall outlets</p> <p>- comes from the electrical equipment in the patient's room including such devices as: the electrically powered bed. The mechanical ventilator, intravenous infusion devices. Sequential Compression Devices (SCD) or Flowtron® Excel machines, EKG monitors, dialysis machines, fluorescent lights, and heating/cooling lamps or blankets</p> <p>- Poor electrode contact associated with inadequate skin preparation, defective cables, lead wires, or faulty grounding can also cause 60 Hz artifact</p>	<p>- 60 Hz artifact reverses directions cyclically — changing from positive to negative and back again 60 times a second</p> <p>- 60 Hz artifact produces a "fuzzy" appearing baseline and can sometimes be confused with muscle artifact or fast cerebral activity.</p>		<p>- If electrode impedances are low (5K ohms or less) and 60 Hz artifact is still present, begin to unplug individual electrical equipment from the outlet, one plug at a time, and make a note of it on the EEG</p> <p>Never unplug the mechanical ventilator under any circumstance.</p> <p>- 60 Hz can sometimes be eliminated simply by not letting the jackbox cable touch the floor</p> <p>- Occasionally 60 Hz can easily be eliminated by keeping cables from touching each other</p> <p>- If all else fails and 60 Hz artifact persists even after making every effort to identify and remove the source of the 60 Hz, the 60 Hz notch filter can be used as a last option</p>
<p>It is important to remember that when the notch filter is used other faster frequencies, including cerebral activity, within the range of the filter is also attenuated. Hence, an epilepticform spike may have its displayed amplitude lowered because some components of the spike have frequency characteristics at or near 60 Hz</p>			
<p>Coordinating</p>			

Cause of artifacts	Appearance on EEG	How to prove	Troubleshooting
<p>Electrode Artifact</p> <ul style="list-style-type: none"> - EEG surface electrodes are metal discs secured directly to the scalp with a conductive paste. A wire is attached to each electrode connecting the electrodes to the inputs of the EEG amplifiers. Any interruption in this path, from the scalp to the jackbox, can produce an EEG electrode artifact - Electrode artifact is primarily caused by improper contact of the electrode on the skin, a broken electrode wire, lead movement, or a loose electrode wire within the jackbox - Electrode artifact is likely to occur if the skin is not well prepped. if not enough conductive paste is used, or if the paste dissipates 	<ul style="list-style-type: none"> - Electrode artifacts can have different appearances depending on the site and type of the disruption, but are always confined to the channels that have the electrode in either input 1 or input 2 - When there is an abrupt change in the electrode impedance, a sudden potential appears causing an electrode "pop." - An electrode "pop" has a characteristic morphology of a very steep rise and shallow fall resembling a direct current (DC) calibration signal - An electrode "pop" can simulate a focal spike or sharp wave on the EEG. 	<p>If there is questionable activity on the EEG that seems to be seen in one channel or channels with one common electrode, corrective measures must be taken</p>	<ul style="list-style-type: none"> - Reprep the area and reapply the same electrode with electrolyte paste. - If reapplying the electrode doesn't correct the artifact, replace with another electrode you know is good or try a new one. - Finally, make sure the electrode is properly plugged into the jackbox <p>Coordinating</p>

Cause of artifacts	Appearance on EEG	How to prove	Troubleshooting
Ground and reference electrode artifact	Generalized or Widespread Electronic Artifacts	If there is questionable activity on the EEG that seems to be seen in one channel or channels with one common electrode, corrective measures must be taken	<ul style="list-style-type: none"> - Reprep the area and reapply the same electrode with electrolyte paste. - If reapplying the electrode doesn't correct the artifact, replace with another electrode you know is good or try a new one. - Finally, make sure the electrode is properly plugged into the jackbox <p>Coordinating</p>

Cause of artifacts	Appearance on EEG	How to prove	Troubleshooting
Mechanical Ventilator Artifact - Mechanical ventilation artifact is caused by switching magnetic fields within the ventilator motor and by the movement of the electrodes or leads as the body is moved by the device	- The mechanical ventilator can cause bursts of rhythmic high amplitude slow waves maximal over the frontal leads bilaterally - can simulate a burst suppression pattern of cerebral origin, especially if the background EEG activity is suppressed	- Ventilator artifact on the EEG can be directly correlated with mechanical breaths per minute ventilator settings or with the patient's observed respirations. - If the artifact cannot be eliminated it should be monitored by placing one electrode above and one electrode below the lips or by carefully attaching two electrodes to the ventilator tubing or dial	-Occasionally, just repositioning the patient's head will eliminate or reduce the artifact - As a last option, the ventilator can briefly be disconnected from the endotracheal tube by the respiratory staff to determine if the activity is related to the ventilator Coordinating
Movement Artifact in the Environment - It is likely to occur as a result of movement of the patient by the nurse or doctor or movement of other personnel or family members near the patient's bed including the EEG technologist or the electroencephalographer.	- The morphology of the artifact on the EEG varies with the motion or activity of the person in close proximity of the patient.	It is helpful if the technologist asks the person in the room to repeat the activity or motion to reproduce the artifact on the EEG and simultaneously notes it on the recording	To eliminate this type of artifact, it is best to prevent people from moving in the room, often a daunting task in the ICU Coordinating

Cause of artifacts	Appearance on EEG	How to prove	Troubleshooting
Prisma® Hemoperfusion Device Artifact	<ul style="list-style-type: none"> - generalized, saw-toothed waveform appeared that in frequency and morphology (resembled psychomotor variant rhythm) - Harmonic frequencies at 5.5 Hz and 11 Hz - it also appeared on the EKG channel. 	<ul style="list-style-type: none"> - Stop and restart machine 	Coordinating
Rhythmic Artifact of Physiotherapy - During chest physiotherapy	<ul style="list-style-type: none"> - a saw-toothed wave form, similar to that seen in the psychomotor variant rhythm - The occipital electrodes were most commonly involved, but various anterior electrodes could also be affected, sometimes more than other electrodes. 		Coordinating

THANK YOU FOR YOUR ATTENTION