

EEG Artifacts, Type, Identification and elimination

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- 1. Introduction, basics, electrode placement
- 2. Artefact classification
- 3. Who to eliminate during recording & during reviewing





- Human Brain signals recorded by German psychiatrist Hans Berger in 1929
- he published 14 reports about his studies of qualitative EEGs, 1929-1938
- **G. Dietsch** applied <u>Fourier analysis</u> to seven records of EEG and became the first researcher of what is called **QEEG** (quantitative EEG) **1932**
- Calibration and 10-20 electrode placement system: introduced in **1958** by the int. federation of EEG and CINP(Ref. 1.Jasper, H. H. (1958). The ten-twenty electrode system of the International Federation. Electroencephalography and Clinical Neurophysiology, 10, 371–375. 2.Teplan, M. (2002). FUNDAMENTALS OF EEG MEASUREMENT,)

Introduction & artefact

- Human Brain is divided into different lobes (F,C,T,P,O) electrode placement accordingly.
- Left and right sided electrodes: Odd and Even number
- EEG records:
 - action potential, activities of the brain from its different areas.
- It also records
 - noise from within and out of the body- artefacts/ artifacts
- Physiologycal artefacts
 - Body of the subject is the main source
- Non-physiological or External artefacts

Recognition, identification and elimination of artefacts is an important process to minimize the chance of misinterpretation of EEG

- Clinical and non-clinical fields such as brain computer interface, intelligent control system robotics etc. all require removal of artefacts.
- Artefacts can be removed very easily using manual and filtering methods because of their morphology and electrical characteristic.

What is the effect?

- Artefacts can imitate nearly all types of EEG patterns and as such, artefacts included in automatic analysis can seriously affect the results, eventually leading to mistaken interpretations.
- Substantial amount of artefacts render the analysis of EEG unacceptable.
- Several times artefacts themselves may contain valuable information as in sleep study where eye movement and muscle artefacts in the EEG recordings might expedite sorting of sleep stages



What does the EEG record?

Mainly NOISE!!

Volume Conduction

- The electrical activity flows through the tissue between the electrical generator and the recording electrode.
- Thus, the EEG is a 2-D representation of a 3-D reality, which poses a problem in localizing the sources of the electrical activity

Inverse problem



EEG Rhythms



EEG, fallacy



1.Brain is no a sphere, Its surface is not directly parallel to the overlying structure where electrodes are placed

2. Each small electrode is averaging the activity within 1inch area, limit of such region depends on many factors

3. Slight alteration of electrode placement would result in the electrode averaging the activity from a different region of the brain

4. Appropriate electrode placement and Montage setting is important for localizing the disturbed area

5. All EEG record are practically bipolar event when theoretically unipolar

For optimum output

- Equipment setting
 - Sensitivity, paper speed, HFF, LFF
- Accessories:
- Appropriate montage setting
- Bio-calibration
- Impedance testing
- Electrode placement
- Recording technique, patient's position, age & state
 - Consider patient's clinical problems and clinical question
- Reviewing with appropriate montage
- Reporting with full description
- Clinical correlation

Artefact during recording

How EEGs can be contaminated?

- Physiological artifacts
- Ocular activity: eye blinking, eye ball side to side movement
- Muscle activity, chewing, stiffening, talking,
- Cardiac activity
- Perspiration
- Respiration
- Non-physiological / Technical artifacts/ environmental
- Electrode pop
- Cable movement
- Incorrect reference placement
- AC electrical and electromagnetic interferences, Phone
- Body movements, Body part attached to mom
- Transmission-line artefact: bandwidth of EEG is 0.5Hz-60/70Hz and the frequency of transmission lines is 50Hzor 60Hz, the signal easily mixes with beta band of EEG signal. This artefact can be removed by using notch filter 50-60Hz

- EKG,
- pulse,
- pacemaker,
- eye movements,
- myogenic,
- shivering,
- sniffling,
- hiccupping,
- glossokinetic and
- sway artifact as well as
- non-physiologic artifacts such as loose electrodes, 60 Hz artifact, and bed movements.

What are the skin artifacts?

- Biological processes and/or defects may alter impedance and cause artifacts.
 - Sweat is a common cause. Sodium chloride and lactic acid from sweating reacting with metals of the electrodes may produce huge slow baseline sways.
- Subgaleal haematoma under skin
- Skull defect
- Operation mark
- Wide open font.



Subgaleal haematoma

Craig Hacking 2018 CC-BY-SA-NC Radiopaedia.org

Artefact detection and Elimination

- Laboratory arrangement
 - Lighting
 - AC
 - External sound and noise
 - Far away from X-ray dept
 - Crowd, external noise
- Good recording protocol
 - Instruction to the patient and family
 - Phone to keep out of the EEG recording room
 - Good skin prep
 - Measuring and electrode placement
 - Biocalibration
 - VIDEO, and annotation

• Experience

- Visual analysis
- Re-montaging
- Digital filtering
- Check recheck electrode impedance

Table 1. Electrical characteristics of artefacts and Morphology with actual EEG

Muscle artefacts

Artefact	Source/ Cause	Frequen cy range	Amplitu de	Morphology
cardiac	Heart	>1Hz	1-10mv	Epilepsy
Transmissi on line noise	Transmis sion line	50-60Hz low		Beta or gamma wave
Muscle Artefact	Body Muscle	<=35Hz	low	Beta frequency
EOG	Eye	0.5-3 Hz	100mV	Tumor , delta wave
Phone Artefacts	Mobile and landline phone	high	high	Morphology different from actual EEG
Electrode artefact	Electrode and	Very low	High	Morphology different from actual
	sweating			EEG
Physical movement artefact	Physical moveme nt	Very low	Very high	Morphology different from actual EEG

Ref: Classification of Artefacts in EEG Signal Recordings and EOG Artefact Removal using EOG Subtraction. Communications on Applied Electronics (CAE)–ISSN: 2394-4714Foundation of Computer Science FCS, New York, USA Volume4–No.1, January 2016– www.caeaccess.org12



Fig4:- A) EEG signal without EOG artefact B) EEG signal with EOG artefact C) EOG signal to be remove D) Recovered signal

Eye blinks are one of the most common artifacts you'll see, and are marked by very high amplitude negative waveforms in the bifrontal regions. They arise due to **Bell's Phenomenon**. The eyes' cornea is positively charged and retina is negatively charged; when you blink, the eyes roll up slightly, and the cornea moves closer to the frontal electrodes Fp1 and Fp2, which thus see a positive signal that is reflected on EEG.





During blinking the eyelid slides down over the cornea, which is positively charged with respect to the forehead. Thereby the lid acts like a "sliding electrode," short-circuiting the cornea to the scalp and producing artifacts in the EEG signal (Barry and Jones, 1965; Matsuo et al., 1975; Antervo et al., 1985; Lins et al., 1993a,b).

Figure 5. Eyelid-induced signal changes. (A) ERP traces for voluntary (gray) and spontaneous (black) blinks measured at a frontal electrode (inset, red circle). Voluntary blinks are of longer duration and result in higher amplitudes than involuntary blinks. Note that blink onset as defined by the eye tracker (time 0, vertical dashed line) corresponds to the point at which the pupil is not visible anymore. The actual eyelid movement already starts around 100 ms earlier, when the signal deflects from the zero line (horizontal dashed line). (B) Although spontaneous and voluntary blinks differ in amplitude and duration, they share the same topographic pattern (i.e., the normalized amplitude distribution across the scalp). (C) Topographic patterns of corneo-retinal dipole offsets related to upward saccades, blinks, and post-saccadic eyelid movements (upper row) and the differences between them (lower row). Bold black dots indicate electrode sites with statistical significant









Chewing and tongue (hypoglossal) artifact are rather hard to miss on EEG.





End a,^+ З

Low frequency EMG artifact, due to sucking, appears symmetricall

ECG artifact is marked by waveforms that are **time locked to the QRS complex** on the ECG tracing. They tend to be present more so or entirely on the left side, because the heart is in the left half of the chest, and tend to be relatively low amplitude. However, as the example below shows, they can at times be quite prominent, but don't mistake them for posterior discharges or POSTS (which are not time locked to the QRS).



Electrical artifact most commonly arises from interference from the 60 Hz electrical activity (in the USA; 50 Hz in Europe and elsewhere) that that runs through wires; so, it can be caused by anything from an electrical appliance to a cell phone charging, though most modern EEG equipment is quite good at minimizing it. Electrical artifact is a very fast, very monotonous activity, and you can use the **notch filter** to selectively remove all the EEG activity at 60Hz (this won't affect your interpretation of the signal, as no cerebral activity is that fast on scalp EEG). In the example below, the notch filter is not on, and the Fp1 electrode is likely not on quite right, leading to a lot of electrical interference



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Muscle artefact



Motion artifact

Head movement:

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Movement between the head and the pillow



Sweat artifact. This is characterized by very low-frequency (here, 0.25- to 0.5-Hz) oscillations. The distribution here (midtemporal electrode T3 and occipital electrode O1) suggests **sweat** on the left side. ... The morphology is very unusual for any cerebral waveform, and the distribution is limited to a single electrode.



We present an interesting EEG finding of persistent unilateral sweat artifacts in a 47 years old male patient with right hemiplegia secondary to left thalamic bleed with extension of hemorrhage into the left internal capsule, the left midbrain and ventricles. The EEG was done for altered sensorium. It showed unilateral (right sided) sweat artifacts throughout the EEG recording. The anhydrosis on left side of the face was due to left sided Horner's syndrome because of involvement of first order neurons in the left midbrain. This EEG finding is highlighted because of it being relatively less common but interesting finding.





Fig 5: Eye movement artefact shown in window

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Lead moves artefact

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NON-PHYSIOLOGICAL / TECHNICAL ARTIFACTS Electrode pop





Figure. Notice the distortion in F3 produced by touching the sensor. The effect in time and frequency depends on the type of popping (touching, spontaneous,...). In this case we can see the frequencies of the touching artifact on F3.





Electrode pop:



A sudden change in the electrical potential between the electrode and scalp gives rise to the 'pop'

Lead movement



Multiple channels demonstrate the artifact through activity that is both unusually high amplitude and low frequency and also disorganized without a plausible field

NON-PHYSIOLOGICAL / TECHNICAL ARTIFACTS

Powerline interference





Figure. Notice the high frequency signal overlapping the eeg data in all channels. A clear peak appears in 50 Hz. The eeg was recorded in Spain and the powerline frequency is 50 Hz.

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The use and misuse of the EEG



Girl aged 13 with 2 seizures described as simple focal motor "eyes and head turned to the left" for 2 minutes



Girl aged 13 with frequent brief absences associated with eyelid flickering This EEG was reported as normal because the discharges were considered as artefacts of "eye movements"



1Use and misuse of EEGs. Two girls with similar EEG abnormalities of generalised spike/multiple spike and slow wave discharges either spontaneous or elicited by intermittent photic stimulation

Top: proper use of EEGs. This girl gave a clear-cut history of two seizures that, on clinical grounds, had all the elements of focal motor seizures. Her eyes first and then her head turned to the left and 'I could not bring them back to normal' for 2 min. The <u>EEG</u> clearly documented that she had generalised not focal epilepsy.

Bottom: misuse of the <u>EEG</u>. A 26-year-old woman with <u>JME</u> had the onset of seizures at age 13 years. These consisted of brief absences with eyelid jerking. Her first EEG documented the epileptic nature of the attacks, but the reporting physician and the EEG technologist considered the discharges as artefacts produced by the concurrent eyelid jerking. The EEG was erroneously reported as normal.

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Technician informs, the child was restless, movement artifact?

Why not movement artifact?

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Why technicians need to get training on childhood epilepsies?

Why not movement

What do you notice? What is happening here?

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At ICU



FIG. 7. Electroretinogram (ERG) artifact, maximal in channels with Fp1 an electrodes, is time locked to photic stimulation in an EEG with marked backg suppression.



FIG. 8. Electroretinogram (ERG) artifact is eliminated in channels with the Fp1 electrode by covering the left eye and returns when the left eye is uncovered.

EMG artifact often occurs when the patient is tense or anxious and has difficulty relaxing or holding still. In the ICU this type of artifact is commonly caused by the patient biting down on the endotracheal tube which connects the patient to the ventilator. EMG artifact can simulate fast mid-voltage irregular single or serial spikes (Figure 1). This activity can simulate cerebral beta activity with the use of the high frequency filter, especially when used in combination with the 60 Hz notch filter.





Attempts to eliminate muscle artifact are often futile, especially when the patient is not able to follow commands. 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. In some cases relaxation will come eventually, so be patient and record as long as needed to get an interpretable recording. Occasionally sleep

In wake pt:

- less interaction
- Relax
- Jaw drop
 Sleep/ unconscious?

Thank you

Next class: EEG reviewing technical aspect 4th April at 4pm