Free Guide

Optimizing EEG Signal Quality

A Guide to Minimizing Artifacts

Dr. André Keizer

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Introduction

High-quality EEG recordings are essential for reliable quantitative EEG (qEEG) analysis. This guide provides best practices for minimizing artifacts, ensuring accurate data collection, and optimizing the signal quality for interpretation. Proper patient preparation, correct electrode application, and awareness of common artifacts are crucial in obtaining a clean and interpretable EEG.

This document is part of the qEEG Interpretation Report service offered by **Dr. André Keizer**, an expert in EEG and neuroscience. The qEEG Interpretation Report service provides professional EEG analysis, offering insights into brain function for clinical and research

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Pre-Recording Patient Preparation

To ensure the highest EEG signal quality, patients should follow these preparation guidelines:

Avoid caffeine

Patients should not consume any caffeine-containing drinks (coffee, energy drinks, cola, tea) on the day of the recording. Herbal tea is acceptable.

Stimulant medications

If the patient uses stimulant medication like methylphenidate on an 'on-demand' basis, discuss whether it is possible to skip the medication on the recording day. However, medications that must be taken daily (e.g., antidepressants, antipsychotics) should be taken as usual.

Substance Use Restrictions

The patient should refrain from consuming alcohol, cannabis, or any other psychoactive substances on both the day of the recording and the day before. This includes hard drugs such as cocaine or opiates, as well as psychoactive supplements like valerian root, which may alter brain activity and affect EEG results.

Hair washing

The patient must wash their hair on the day of the recording and not use any hairstyling products such as gel, mousse, or hairspray.

Preparing & Applying the EEG Cap

Preparing the Equipment

For wet-electrode systems:

- Prepare a syringe with conductive gel and a blunt needle.
- Ensure the EEG cap, electrodes, and cables are clean and in good condition.
- Ensure a comfortable chair for the patient to minimize movement-related artifacts.

For dry-electrode systems:

- Check that all electrodes are intact and free from debris
- Ensure the electrodes make good contact with the skin without hair
- There is no need for skin preparation or conductive gel.

Positioning the Cap

- Place the EEG cap on the patient's head, ensuring a snug but comfortable fit.
- Align the midline electrodes (Fz, Cz, Pz, Oz) with the nasion (bridge of the nose) and inion (bump at the back of the skull).
- Ensure that Cz is at the halfway point between the nasion and inion and also equidistant from the left and right preauricular points. (upper attachment point of where the ear meets the skull).
- For patients with voluminous hair, use an elastic strap to secure the cap. Voluminous hair can create challenges in maintaining consistent electrode contact.
- A bald scalp can also be difficult due to thickened skin from sun exposure; ensure proper skin preparation and sufficient conductive gel.

Placing Reference and Ground Electrodes

- For earlobe electrodes, avoid placing them over piercing holes. Instead, select an area adjacent to piercings where the skin is more conductive.
- If the earlobe is too small, use an alternative position on the upper ear, but avoid the auricle (pinna), which consists of cartilage and does

not conduct electrical signals effectively.

- Gently stroke the earlobe with a blunt needle to improve conductivity before applying gel and electrodes.
- Some EEG systems use an additional external ground electrode. This is usually placed on the forehead, between the nasion and the edge of the cap. The ground electrode serves to reduce common-mode noise and stabilize the signal. Ensure this electrode is well-prepared and has good skin contact to avoid introducing additional artifacts.

Preparing the Scalp Electrodes

Skin Preparation

- Insert the blunt needle into each electrode opening and part the hair as much as possible to improve skin contact. The electrode has only a tiny hole, so the skin itself will not be fully visible. Once the needle is in contact with the skin, perform 5 light scraping motions to remove dead skin cells and improve conductivity.
- Fill the electrode with conductive gel while slowly retracting the needle to prevent air bubbles.
- Ensure the electrode is fully filled but avoid excessive gel, which can cause 'conductive bridges' between adjacent electrodes, leading to inaccurate readings. Bridging results in two electrodes essentially acting as one, displaying the exact same signal. If excessive gel is applied, it cannot be reversed by simply removing gel from the surface. The only solution is to remove the cap, wash the patient's hair thoroughly with shampoo, dry it completely with a hair dryer, and reapply the cap. If this is not feasible within the session, rescheduling the recording may be necessary.

Checking Electrode Impedance

- Select the 'linked ears' montage and check impedance values
- Ideally, all electrodes should be below **5 kΩ** and must be under **10 kΩ.**
- If impedance is too high, reapply gel or adjust electrode contact.

Minimizing Artifacts During EEG Recording

General Patient Instructions

- The patient should not chew gum or have anything in their mouth, such as mints, candy, or a toothpick, as this can cause jaw movement artifacts.
- The patient should sit comfortably with a relaxed posture.
- The patient should fixate on a point straight ahead. A fixation cross is commonly used in research settings and is presented on a computer screen positioned in front of the patient.
- The patient may shift gaze occasionally to avoid prolonged staring, which could induce changes in alpha activity.
- Ensure that the EEG cap does not touch the headrest of the chair, as this can introduce mechanical artifacts and cause discomfort, potentially leading to muscle tension artifacts.

Blinking and Eye Movement Artifacts

- Blinking is allowed but should be limited to less than **5 blinks per 10 seconds.**
- If the patient blinks excessively, instruct them to consciously reduce the blink rate.
- In case of excessive blinking, consider implementing 'blink breaks' periods of 15-20 seconds where the patient keeps their eyes open without blinking, followed by a short pause to allow blinking.
- A sudden eye movement (saccade) is visible in the EEG as a sharp upward trend in one frontolateral channel (e.g. F7) and simultaneous sharp downward trend in the ‘opposite’ frontolateral channel (e.g. F8), typically lasting less than 100 ms.

Facial and Forehead Muscle Artifacts

- High-frequency muscle artifacts resembling 'barbed wire' waveforms in the EEG, particularly at **Fp1 and Fp2**, indicate excessive forehead muscle tension.
- Continuous raising of the eyebrows, often due to excess eyelid skin obstructing vision, can cause persistent forehead muscle activation.
- This muscle strain can lead to tension headaches by the end of the day.
- If the patient unconsciously raises their eyebrows, instruct them to relax their forehead consciously.
- Similarly, excessive forehead muscle tension can be the result of continuous frowning.

Jaw Clenching and Temporal Muscle Artifacts

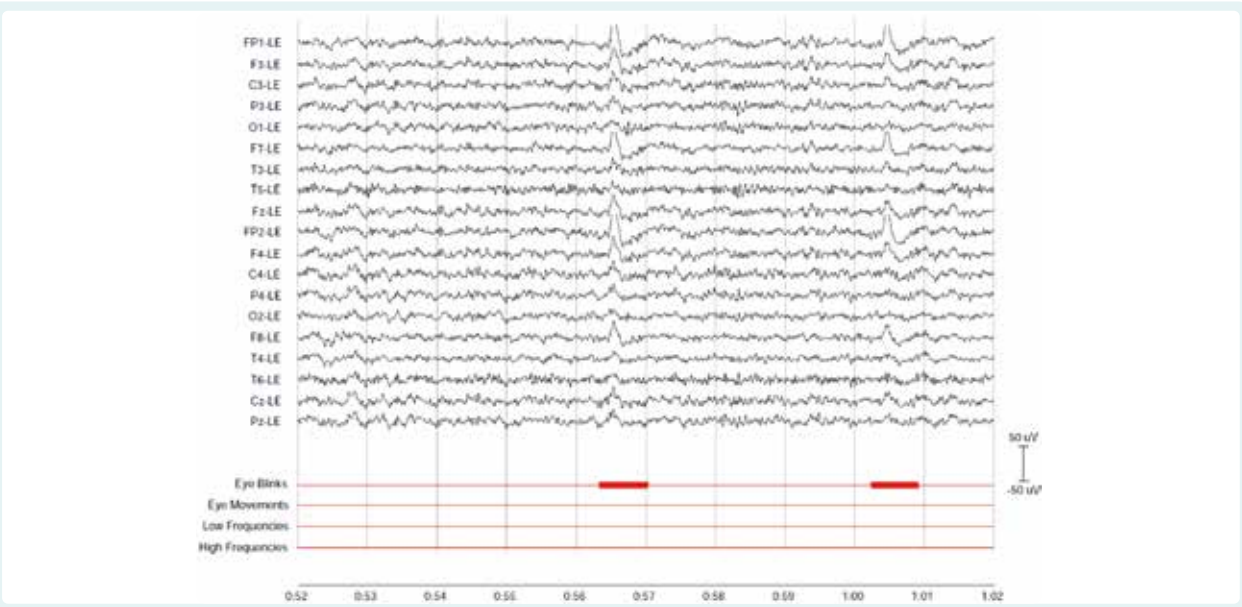
- (Unconscious jaw) clenching can cause significant high-frequency EEG artifacts at **temporal electrodes (T3, T4, T5, T6).**
- To address this, ask the patient to clench their jaw for a few seconds and then consciously relax it.
- Provide verbal feedback to reinforce relaxation.

Neck and Shoulder Tension Artifacts

- Neck and shoulder tension can introduce high-frequency artifacts into the EEG.
- If observed, instruct the patient to take a deep breath, roll their shoulders, and consciously relax their neck and shoulders.
- Ensure the patient's neck and shoulders are supported.

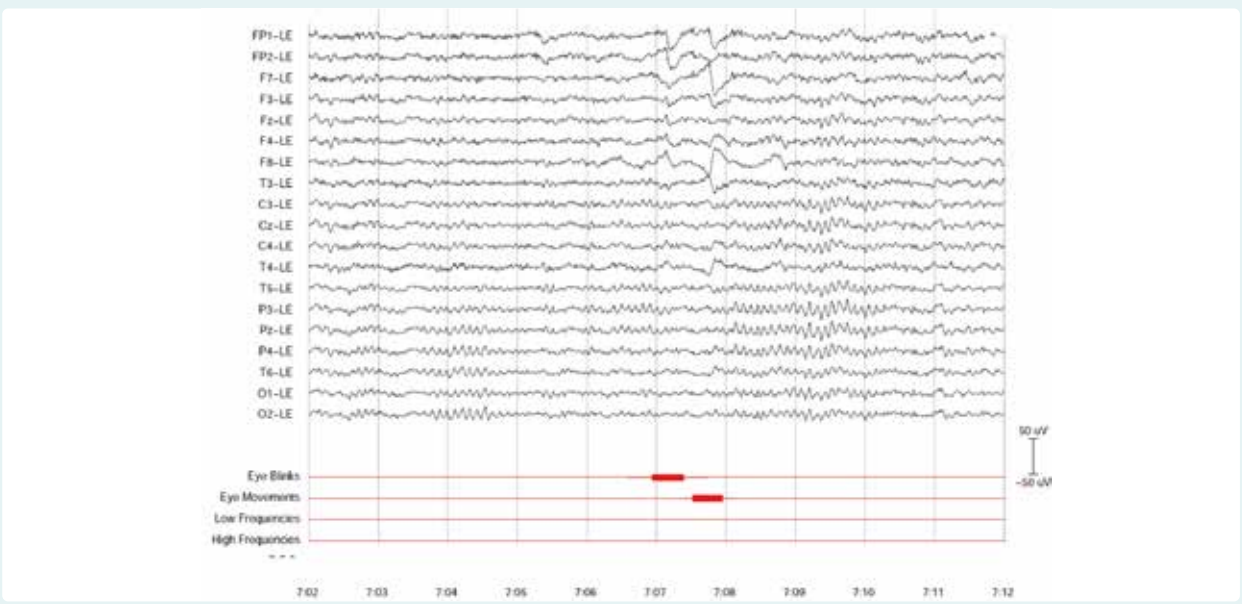
Recognizing & Interpreting Artifacts in qEEG Results

The following figures provide visual examples of EEG recordings in different conditions:

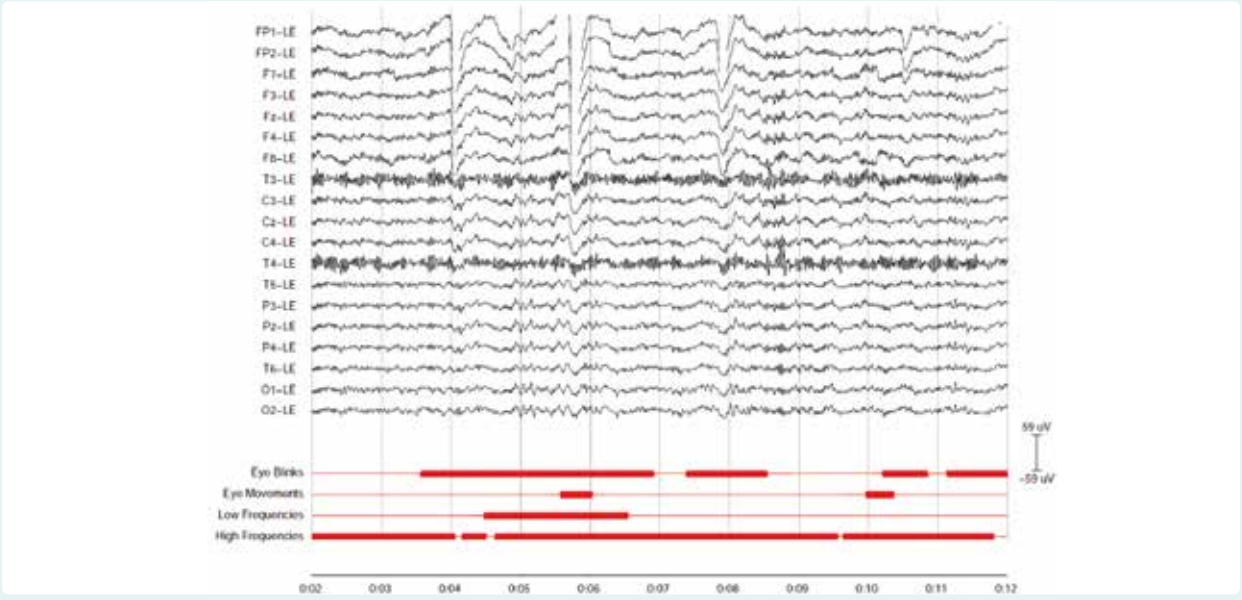


Normal EEG during eyes-open condition, including occasional eye blinks characterized by large slow waves (~0.5-4 Hz) in frontal electrodes (Fp1, Fp2).

Normal EEG during eyes-closed condition, with dominant alpha activity at posterior electrode sites, reflecting healthy inhibition of the visual cortex



Eye movement artifact, showing a sharp upward trend in one channel (e.g.F7) and simultaneous sharp downward trend in the opposite channel (e.g.F8), typically lasting less than 100 ms. In this figure, the eye movement occurs just after a blink, right before the 7-minute 8-second mark.



Continuous muscle tension artifact from jaw clenching, presenting as high-frequency artifact (~30-100 Hz) at temporal electrodes (T3 and T4).

Morphology and Localization of Common Artifacts

Artifact Type	Electrode Locations	Morphology in EEG	Common Cause
Eye blinks	Fp1, Fp2	Large slow wave (~0.5-4 Hz) in frontal leads	Blinking
Eye movements	Fp1, Fp2, F7, F8	Sharp upward trend in one channel (e.g. F7) and simultaneous sharp downward trend in the 'opposite' channel (e.g. F8) duration typically below 100 ms)	Saccades (shifting gaze)
Forehead muscle tension	Fp1, Fp2	High-frequency (30-100 Hz)	Raised eyebrows, frowning (shifting gaze)
Jaw clenching	T3, T4, T5, T6	High-frequency (~30-100 Hz) 'barbed wire' pattern	Clenching or grinding teeth
Neck/shoulder tension	C3, C4, Cz	High-frequency (~30-100 Hz) 'barbed wire' pattern	Postural tension
Conductive bridging	Multiple adjacent electrodes	Identical waveforms	Excess gel causing electrode cross-talk

Jaw Clenching and Temporal Muscle Artifacts

Determining the minimum duration of artifact-free data for reliable qEEG analysis is challenging, but based on experience, at least **3 minutes** of clean data is required. The standard neurological convention is to record **10 minutes of eyes-open EEG** and **10 minutes of eyes-closed EEG**, meaning that a maximum artifact percentage of 70% is generally acceptable.

However, high artifact percentages (>50%) combined with relatively short artifact-free segments can lead to unreliable qEEG results, especially if the artifacts consist of a large number of short-duration disturbances. If artifacts are removed manually or automatically by cutting out contaminated segments, the resulting numerous cut points can introduce new artifacts into the data, further degrading the reliability of the qEEG analysis.

Disclaimer

The information provided in this document is intended for educational and professional use only. While every effort has been made to ensure accuracy, this guide does not replace professional medical advice or regulatory guidelines. EEG recordings and qEEG analyses should be conducted by trained professionals, and interpretation should always be done in conjunction with clinical expertise.

Summary & Final Checks

- Ensure all electrodes have low impedance (<5 kΩ preferred, <10 kΩ required).
- Confirm that no excessive gel bridging is present.
- Have the patient practice relaxing their facial, jaw, and shoulder
- Begin recording and continuously monitor the EEG signal for artifacts.

By following these steps, you can significantly reduce artifacts in EEG recordings and ensure high-quality data collection for accurate qEEG analysis.