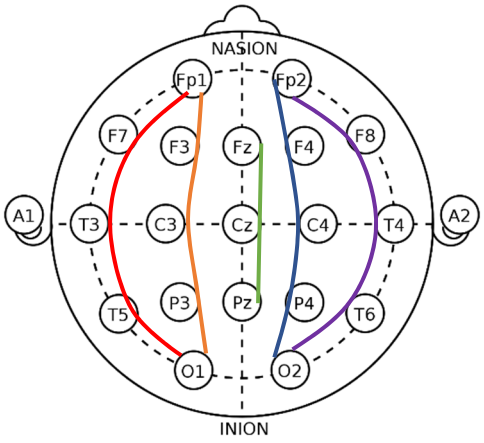
Basics of EEG for the Overwhelmed M4

Compiled by a Previously Overwhelmed M4

Best Resources:

- Jeremy Moeller's "EEG basics" YouTube playlist
- AES: "EEG Resident Course Recordings from 2019 Annual Meeting"
- Rowan's Primer of EEG (free on ClinicalKey)

How EEG works:



<u>*Leads:*</u> **F**rontal **p**ole (*Fp*); **F**rontal; **T**emporal; **C**entral; **P**arietal; **O**ccipital; **A**uricular. *ODD numbers are on the left; even numbers are on the right.* "z" is midline. (A1 and A2 = ears.)

<u>*Channels:*</u> Each channel (e.g. Fp1-F3) consists of two inputs. Input 1 will be a single lead. Input 2 will either be an adjacent lead (***bipolar montage***), a reference lead (typically Cz; ***referential montage***), or the average of all leads (***average reference montage***). The output is the *difference in voltage between input 1 and input 2*. If there is no difference, the line will be flat. *If **input 2** is **more positive** than input 1, there will be an **upward** deflection.* Likewise, if input 2 is more negative, there will be a downward deflection.

"***Double banana***" is one of the most common bipolar montages you will see. The chains (colored lines on the picture above) are arranged on the EEG display in descending order- **left parasagittal**, **right parasagittal**, **left temporal**, **right temporal**, **central**. This allows easy comparison of corresponding left/right regions for asymmetry (i.e. slowing). Other common bipolar montages include transverse (good for sleep EEGs) and circumferential (good for looking at occipital leads).

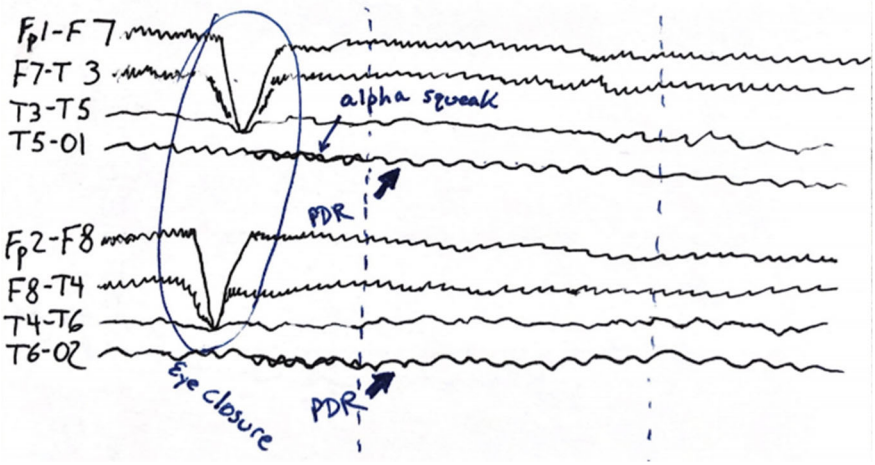
<u>Where to Start:</u> Take note of the **patient's age** so that you can interpret the EEG appropriately. When looking at the EEG, look at the **background rhythm**. How fast is it? Is it **symmetric** in both **frequency** and **amplitude**? If one side is at least 50% lower amplitude, then it is **attenuated**, which may be due to cerebral dysfunction or an intervening fluid collection, like a subdural hematoma (check the history and imaging).

<u>Frequency:</u> **Alpha** waves are *8.5-13 Hz* and are typically seen in the awake, relaxed adult. **Beta** waves are *13-30 Hz* and may be observed in the frontal regions of an awake patient with eyes open. **Theta** (*4-7 Hz*) and **Delta** waves *(<4 Hz*) may be related to slow wave sleep or slowing, depending on context.

Normal Adult EEGs:

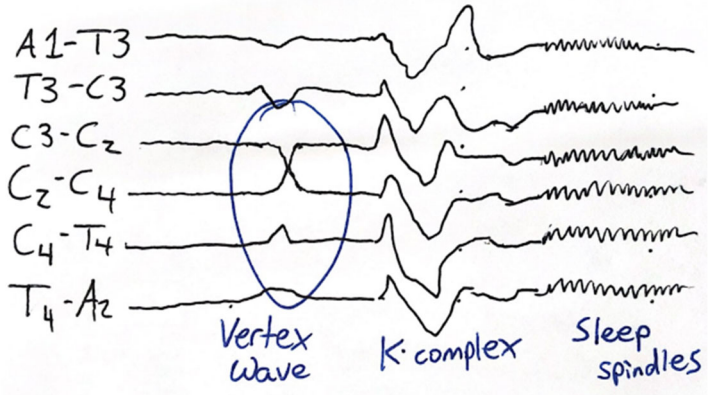
Awake: In the **awake** patients with **eyes closed**, there is a, **most pronounced in the occipital leads**. This is the **posterior dominant rhythm** (PDR). It should be **alpha** frequency in a normal patient. It may be preceded by a brief higher frequency burst immediately after eye closure called the "alpha squeak." Ensure it is **reactive**, attenuated with eye opening. Do not try to look for the PDR during photic stimulation. Instead, look for a **photic driving response**, when occipital waves match the frequency of light flashes (or a harmonic frequency).

Normal adult EEG- Posterior Dominant Rhythm (double banana montage; Figure 1)



Sleep: It is important to look for signs of drowsiness or sleep on EEG. During **drowsiness/stage I sleep**, you should see some dropout of the PDR. You may see **positive occipital sharp transients of sleep (POSTS)**, which resemble the **lambda waves** in figure 1 (*lambda waves are associated with visual scanning)*. **Vertex waves** may also be seen and are maximal in the central leads (i.e. Cz); they are most obvious in **transverse montage**. **K complexes** are impressively large wave forms seen in **stage II sleep**. They are frequently followed by **sleep spindles**, which should be generalized/synchronized.

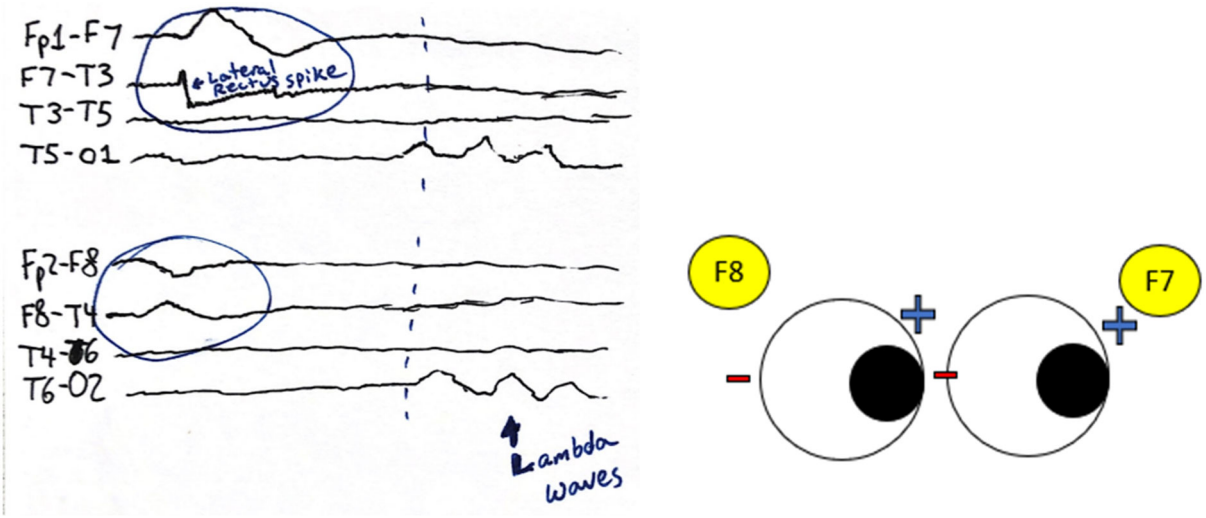
Normal adult EEG- Sleep (transverse montage; Figure 2)



Common EEG artifacts: The large, chaotic patterns on EEG are often artifact. It is helpful to learn these first so they can be separated from the clinically important information on the EEG.

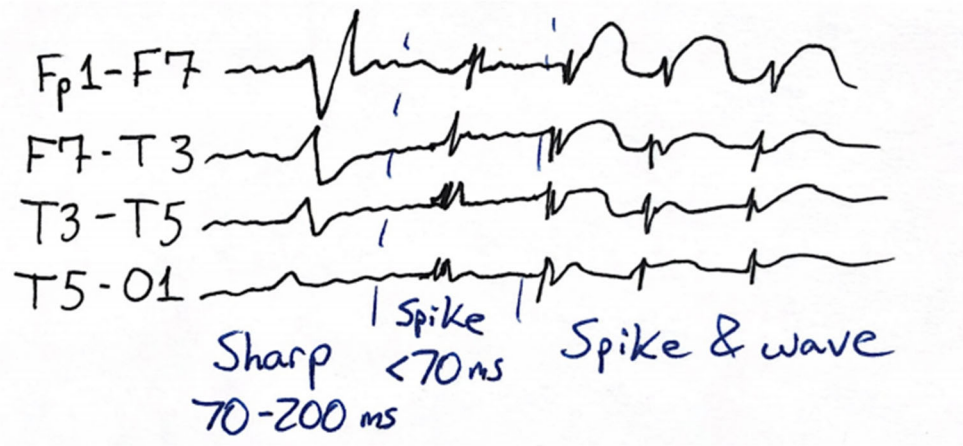
- *EMG:* very high-frequency discharges associated with muscle movement. Can be a clue to awake state. It may be helpful to check the video to see what the patient is up to.
- *Blinking/eye closure:* The eyes roll up during blinking. The cornea carries a net positive charge, which is passed to Fp1 (and Fp2 on the other side). Since Fp1 is now more positive than F3 (and F3 is therefore more negative), there is a large downward deflection.
- *Horizontal eye movement:* With left gaze, the positive pole moves toward the left lateral frontal lead (F7) and away from the right lateral frontal lead (F8). Now F7 is more positive than Fp1 (upward at Fp1-F7) and T3 (downward at F7-T3). On the right side, F8 becomes more negative than Fp2 (downward at Fp2-F8) and T4 (upward at F8-T4). Artifact may also be visible from contraction of the lateral rectus on the side of the saccade ("lateral rectus spike"). See Figure 3.
- *Occipital head movement:* If abnormal waves are seen in the occipital leads, it may be due to head movement pushing on the occipital leads. Check video!
- *Chewing:* High amplitude, high frequency (almost entirely black), rhythmic bursts of EMG artifact.
- *60 Hz alternating current:* This should be removed by the "Notch filter." In US, it is at 60 Hz. 50 Hz in Europe.

Horizontal eye movement (double banana montage; Figure 3)



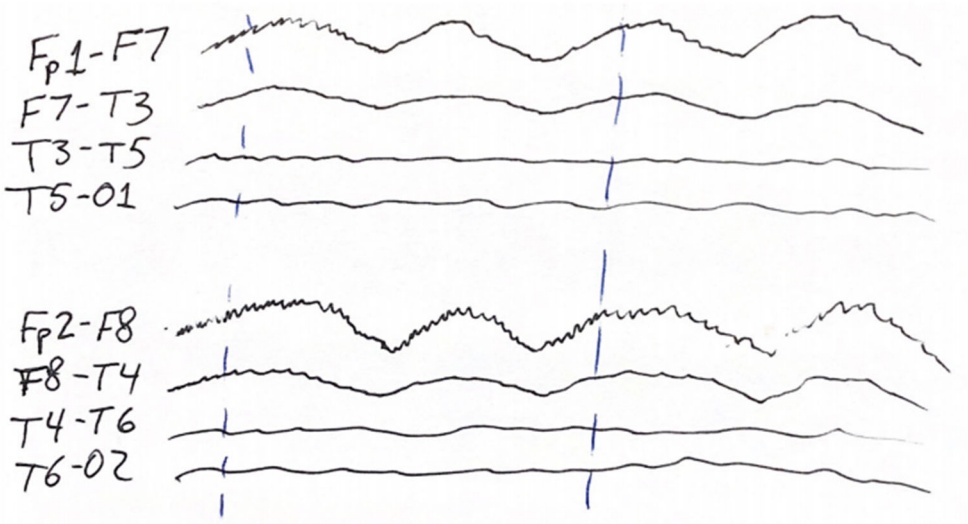
Epileptiform discharges: Epileptiform discharges are a sign of potential for seizure. They are usually ***electronegative***. In Figure 4 (below), there is an epileptic discharge at F7. Since F7 has become more negative that Fp1, there is a downward deflection at the Fp1-F7 lead. T3 is now more positive than F7, so there is an *upward* deflection at F7-T3. This is termed ***phase reversal*** and helps to localize the discharge. Importantly, epileptiform discharges are high-amplitude and disrupt the background rhythm. They are frequently followed by an **after-going slow wave**. Important categories include **sharps** and **spikes**. **Spike-and-wave** patterns are often seen in generalized epilepsy. Sometimes a wave may follow multiple spikes (polyspike and wave). Electrographic seizures generally last at least 10 seconds. **Brief interictal repetitive discharges (BiRDs)** are less than 10 seconds. The word *periodic* (as in "generalized periodic epileptic discharges" [GPEDs]) indicates that discharges occur at regular intervals.

Epileptiform discharges (Figure 4)



Slowing: This is the other key finding of interest in reading EEG. **Generalized slowing** is a sign of overall cerebral dysfunction, and is classified as mild, moderate, or severe. **Focal slowing** may reflect a structural lesion/abnormality. Compare right to left to identify it. Focal slowing is categorized as **rhythmic** or **polymorphic/irregular** (not rhythmic), as well as **intermittent**, **continuous**, or **periodic**. You may hear "**FIRDA**" (frontal intermittent rhythmic delta activity-), "**GIRDA**" (generalized), and "**LIRDA**" (lateralized) rather frequently. Rhythmic delta activity (except FIRDA) may be more likely to have epileptic significance.

Frontal intermittent rhythmic delta (double banana; Figure 5)



Other stuff: Metabolic encephalopathies (e.g. hepatic) classically present with **triphasic waves (< 2.5 HZ)** . These have a small upward deflection, a larger downward deflection, and another small upward deflection (= 3 phases). There is typically an anterior-to-posterior lag associated with these.

3 Hz spike-and-wave is the classic sign of **absence** seizures. **Slow spike-and-wave complexes** (1.5-2.5 Hz) are seen in **Lennox-Gastaut syndrome (LGS)**, the most common form of symptomatic generalized epilepsy. **Generalized paroxysmal fast activity (GPFA)** involves bursts of high-frequency waves with frontal predominance, also associated with LGS. GPFA is associated with **tonic seizures** (the most common seizure in LGS).

Triphasic waves (double banana; Figure 6)