EEG EEG (electroencephalogram) - Mayo Clinic Mayo Clinic: Private academic medical center Measures electrical activity in the brain Uses small, metal discs (electrodes) that attach to the scalp that records the electrical impulses communicated between brain cells Shows up as wavy lines on an EEG recording Precautions for testing Wash hair the night before or day of (but no conditioners, hair creams, sprays or styling gels sleep EEG: sleep less or not to sleep the night before your EEG.

Microsoft PowerPoint - How to Interpret and EEG and Its report.ppt [Read-Only] [Compatibility Mode] (wayne.edu) Wayne university medical school, Marie Atkinson, Comprehensive Epilepsy Program Managing Montages Sensitivity - the amplitudes of the wave lines from the scan The lower the voltage used (in microvolts) the larger of the amplitude, the more you will see Usually 7.5 microvolts Filters Low Frequency (LF) Filter: If you set a frequency at frequency x, eeg will not amplify any frequencies below that number Usually set at 1.0 Hz High Frequency (HF) Filter: If you set a frequency at frequency x, eeg will not amplify any frequencies above that number Usually set at 35 Hz Notch Filter: Cuts off any activity above and at 60 Hz The current through plugs is often at 60 Hz and allows people to ignore outside artifacts by other machinery in the room. How to read Background activity Just based on the frequency (delta, theta, alpha, or beta), we get an overall sense on how the person being tested is doing Deta 1-3 Hz: Marked slowing Theta 4-7 Hz: Mildly slow Alpha 8-13 Hz: Normal background Beta ¿13 Hz: Barbiturates/Benzos (awaken state https://www.ncbi.nlm.nih.gov/books/NBK390343/.) Usually evaluated in the posterior channel (back part of the complete cerebral cortex) and often in occipital (visual processing area of the brain within the posterior channel). The person being tested must have their eyes closed. Symmetry Asymmetric slowing Asymmetric slowing is seen with focal lesions, surgery, etc. Asymmetric slowing is easy to see with A montage It can be seen by hyperventilation or photic stimulation PLEDs (Periodic Lateralized Epileptiform Discharges) It occurs throughout the entire EEG at a frequency of 1-2 Hz and only in one hemisphere It is usually seen in acute lesions (stroke, bleed, etc.), postictal, Herpes Encephalitis, CJD, and etc. Controversial over reading meaning (thought to be inconclusive?) Stage of alertness Abnormality Epileptiform Activity This classification means the EEG reader saw some abnormalities that is related to seizures (but needs clinical correlation) These abnormalities include sharp waves, spikes, or slow waves Spikes The duration of the abnormal wave is 70 microvolts or less. It stands out from the background On a Bipolar Montage, it needs to have phase reversal to be real Sharp Wave The duration is about 70-200 microvolts. It stands out from the background On a Bipolar Montage, it needs to have phase reversal to be real Both sides of the slope should be sloped. If it's straight on one side, it's usually an artifact (a noise or disturbance in the data not from the brain). Slow Wave The duration is greater than 200 microvolts. It stands out from the background. Actual Seizures The EEG reader can tell if it's partial or generalized, status epilepticus, or consistent with primary generalized syndrome Seizure should be like a wave, and have a buildup and let down Triphasic Waves It usually indicates metabolic or toxic encephalopathy (usually liver failure or renal disease) Patients always have some degree of encephalopathy (mild to moderate) It can be seen with Cefepime encephalopathy and Li intoxication Usually anterior dominant, diffuse, and bilaterally synchronous It has 3 phases to the waveform: negative, positive, negative It will have a lag anterior to posterior in wave 2 peak "Looks like a backward check mark" Guru Dr. Shah Primary Generalized Epilepsy Generalized bursts of activity Secondary generalized bisynchrony: generalized burst following a localized focal abnormal epileptiform waveform (not primary generalized epilepsy) Burst Suppression When spontaneous, very poor prognosis Brain Dead/Electrocerebral Silence Specialized eeg protocol that is not performed very often due to the required time period and artifacts that may be mistaken for brain activity Breech Rhythm Seen over a skull defect, namely surgery and has the same frequency as rest of EEG (with a higher amplitude) Hypsarrhythmia Seen in infantile spasms (West Syndrome) with a "chaotic" background. Will have a decremental appearance when child is actually having a spasm SSPE (Subacute Sclerosing Panencephalitis) Encephalitis that tends to affect young boys after experiencing measles illness Mortality is high and those that survived have intellectual sequelae The pattern is different from burst suppression because in between bursts, the background is not suppressed Artifacts Eye blink artifact Only seen in prefrontal channels If you look at the eye channel, the waveform occurs at the same time just in opposite directions Muscle artifact Appears to be too sharp and usually occurs when patient is agitated or moving If the HF filter is removed, the results get even worse EKG artifact Corresponds with the QRS complex on the EKG and usually looks like regular spikes transmitted throughout the EEG Stages of sleep Often mistaken as abnormal and best seen on bipolar montage in Cz channels K complexes, Vertex waves, Spindles Normal EEG A normal EEG should have alpha frequency background activity, no abnormalities (nothing stands out in the background), no changes in the EEG provoked by photic, hyperventilation, and no asymmetry Words in EEG report Epileptiform - waveforms are seen that have the potential to cause seizures but clinical correlation still needed Photic Stimulation - provoking procedure done to induce primary generalized epilepsy or asymmetries Driving response - patient reacting normally to the stimulation No driving response - no EEG change with photic stimulation Hyperventilation - procedure performed to provoke primary generalized epilepsy and provoke asymmetrics. Symmetric physiological slowing is normal Stage 1 sleep - presence of vertex waves and theta slowing during EEG Stage 2 sleep - presence of K complexes and sleep spindles with delta slowing during EEG Drowsiness provoke epileptiform activity (the reason why sleep deprived EEG is recommended to truly rule out seizure disorder) Diffuse slowing - background is theta or delta frequency. It's seen with encephalopathic state, medication effect, prostical, dementia, and bilateral structural defect Focal slowing - seen over lesions like tumors, stroke, hippocampal sclerosis, usually indicates structural lesion in area If the patient is seizing, the report will say seizure or status epilepticus

https://www.learningeeg.com/montages-and-technical-components The 10-20 System Standard placement of the electrodes (splits the skull in to increments of 10 percent or 20 percent to place the electrodes). This ensures each electrode is relatively positioned to all the others and making it possible for every EEG study to be consistent despite a person's head shape and size. Each electrode is identified with a letter and a number Each letter corresponding to its region of the brain: F Frontal, T Temporal, P Parietal, and O Optical). Exceptions are F7 and F8, both of which are over the anterior temporal region The number corresponds to the side of the brain (odds on the left and evens on the right) and the particular area for each region. For the midline/central electrodes, the number is replaced with z Example:

Brain Area Left Right Frontopolar Fp1 Fp2 Frontal F3 F4 Antenor Temporal F7 F8 Mid Temporal T3 T4 Posterior Temporal T5 T6 Central C3 C4 Parietal P3 P4 Occipital O1 O2

Midline electrodes: Fz, Cz, Pz Setup for standard electrodes 1) Find the nasion (the top of the nose bridge, between the eyes) and the inion (the small bump in the middle of the back of the head). 2) Divide the head into consecutive increments of 10The article contains step by step images on how to set it up Special electrodes Subtemporal electrodes (T1 and T2) provide more information about the anterolateral temporal region. A1 and A2 electrodes (or M1 and M2) are placed on the auricle of the ear for referential montages Bipolar montage Each electrode's voltage is linked and compared to an adjacent one to form a chain of electrodes Double banana (most common bipolar montage): each electrode is linked and compared to the one behind it (e.g. Fp2 is compared to F8, F8 is compared to T4, etc.) Two chains per side: Outside temporal chain and inside parasagittal chain Central train The article contains step by step images In each chain, an electrode's voltage is compared to that of the electrode behind it, so each tracing line is a pair of electrodes in which the voltage of the second electrode is subtracted from the voltage of the first If the first electrode in the tracing line is more positive/higher than the second, you get a positive, downward deflection If the second electrode is more positive/higher, you get a negative, upward deflection The article contains step by step images Phase reversal: the closest electrode to a nearby discharge sees the greatest voltage and the other electrode tracings "point" towards the closest electrode to a nearby discharge on the tracing. The middle electrode of the pair that makes the reversal is the electrode of maximal voltage. Negative discharges cause the surrounding tracings to point toward the electrode of maximal voltage Positive discharges cause the surrounding tracings to point away from the electrode of max voltage Generally negative phase reversals are seen with epileptiform activity and positive ones are seen with various artifacts Negative phase reversals move towards one another and positive phase reversals more away from each other End of chain phenomenon: you only see half of any possible phase reversals at these electrodes because for the first electrode in each chain there is not an electrode in front to compare it to, and the last electrodes don't have one behind them to compare to Bipolar circumferential montage: the electrodes are linked not in an anterior to posterior chain but in a circle around the head No end of chain phenomenon because the all electrodes in the chain have a point of comparison Does not include much of middle regions/parasagittal electrodes so this montage shouldn't be used to screen tracings but only to clarify particular discharges Bipolar TI-T2 montage: similar to the double banana but places the parasagittal chains on top and includes the subtemporal T1 and T2 electrodes. Suffers from end of chain issue. Transverse montage: makes chains not front to back but side to side. Helps lateralize activity if the dominant hemisphere for a discharge is unclear on double banana Referential montage Useful to clarify the point of maximal electronegativity if it remains unclear on a bipolar view. Compares all of the electrodes to single reference point (usually the average of the voltage of all electrodes, average montage, or the electricity silent auricle of the ear) Every wave that goes up is negative and every wave that goes down is positive. There are no phase reversals so the highest amplitude waveform is the one with the greatest voltage (downward or upward) Makes it easier to find the point of maximal voltage in a tracing but makes it harder to see epileptiform discharges when screening (no phase reversal to stand out from the background) Page speed Reading speed determines how many seconds of the study are displayed across your computer at one time. The standard adult reading speed is 30 mm/sec and the standard neonatal speed is 15 mm/sec The higher your reading speed the fewer seconds displayed on your screen at a time, and the more stretched out the waves appear EEG tracings used to be recorded by ink nibs fluctuating on a continuously scrolling ream of paper. The ink nibs fluctuate at the same speed for any speed of the paper as they recorded the electrophysiologic signal. The more mm the paper moved per second, the more drawn out each second of tracing was Sensitivity The higher the number the lower the sensitivity (same reasoning as page speed) The higher numbers for sensitivity lead to smaller appearing waveforms

5 Types Of Brain Waves Frequencies: Gamma, Beta, Alpha, Theta, Delta - MentalHealthDaily All five type of brains waves will be displayed but one can be more dominant depending on your state of consciousness Gamma waves Involved in higher processing tasks as well as cognitive functioning Important for learning, memory, and information processing. It has a frequency of 40 Hz (which is important for the binding of our senses in regards to perception and involved in learning new material) to 100 Hz. (highest) People with learning disabilities and those who are mentally challenged tend to have lower gamma activity on average. Too much means: Anxiety, high arousal, stress Too little means: ADHD, depression, and learning disabilities Optimal for binding senses, cognition, information processing, learning, perception, and REM sleep Meditation increases gamma waves Beta Waves High frequency and low amplitude brain waves that are usually observed while the person is awake. They are involved in conscious thought, logical thinking, and tend to have a stimulating effect. Correlated to how concentrated and focused we are. It has a frequency of 12 Hz to 40 Hz (high) Too much means: Adrenaline, anxiety, high arousal, inability to relax, stress Too little mean: ADHD, daydreaming, depression, poor cognition Optimal for conscious focus, memory, and problem solving Coffee, energy drinks, and various stimulants increase beta waves Alpha Waves This frequency range bridges the gap between our conscious thinking and subconscious mind (between theta and beta). It helps us calm down and promotes feelings of deep

relaxation If we become too stressed, “alpha blocking” may occur (excessive beta activity and little alpha activity because the beta waves “block” out the production of alpha waves due to high arousal) It has a frequency of 8 Hz to 12 Hz (moderate) Too much means: daydreaming, inability to focus, too relaxed Too little means: Anxiety, high stress, insomnia, and OCD It is optimal for relaxation Alcohol, marijuana, relaxants, and some antidepressants increase alpha waves Theta Waves This frequency wave is involved in daydreaming and sleep. Theta waves are correlated to us feeling deep and intense emotions. It has a frequency range of 4 Hz to 8 Hz (slow) Too much means: ADHD, depression, hyperactivity, impulsivity, inattentiveness and being in a “highly suggestible” state (due to being in a deeply relaxed, semi-hypnotic state) Too little means: Anxiety, poor emotional awareness, stress It is optimal for creativity, emotional connection, intuition, and relaxation Depressants increase theta waves Delta waves They are most often found in infants and young children. As we age, we tend to produce less delta waves even during sleep. They correlate to the deepest levels of relaxation and restorative, healing sleep and unconscious bodily functions (e.g. heartbeat and digestion) Adequate production of delta waves helps us feel completely rejuvenated after we wake up from deep sleep. It has a frequency range of 0 Hz to 4 Hz (slowest). Too much means: brain injuries, learning problems, inability to think, and severe ADHD Too little means: inability to rejuvenate body, inability to revitalize the brain, and poor sleep It is optimal for the functioning of your immune system, natural healing, and restorative/deep sleep.

Study reveals a universal pattern of brain wave frequencies — MIT News — Massachusetts Institute of Technology Mammalian brain waves are found to be slower in deep cortical layers, while superficial layers generate faster rhythms and that these layers show a distinct pattern of electrical activity in the prefrontal cortex. The topmost layers’s neuron activity is dominated by rapid oscillations (gamma waves) The deeper layers have slower oscillations (alpha and beta waves). According to a study done by Bastos, animals had lower-frequency rhythms in deeper layers that regulated the higher-frequency gamma rhythms in the superficial layers while performing memory tasks. The brain’s cortex is responsible for thought, planning, and high-level processing of emotion and sensory information with neurons being arranged in 6 layers (each layer having its own distinctive combination of cell types and connections with other brain areas). Note: Many studies in brain activity reported having difficulty understanding where the activity of neurons originated from within those layers due to each layer being a millimeter thick. A model from Miller’s lab proposed that the brain’s spatial organization helps it to incorporate new information (with it being carried by high-frequency oscillations into existing memories and brain processes and maintained by low-frequency oscillations)