EEG (Electroencephalogram)

Introduction

Electroencephalography (EEG) is an electrophysiological monitoring method to record electrical activity of the brain. It is typically noninvasive, with the electrodes placed along the scalp, although invasive electrodes are sometimes used, as in electrocorticography. EEG measures voltage fluctuations resulting from ionic current within the neurons of the brain. Clinically, EEG refers to the recording of the brain's spontaneous electrical activity over a period of time, as recorded from multiple electrodes placed on the scalp. Diagnostic applications generally focus either on event-related potentials or on the spectral content of EEG. The former investigates potential fluctuations time locked to an event, such as 'stimulus onset' or 'button press'. The latter analyses the type of neural oscillations (popularly called "brain waves") that can be observed in EEG signals in the frequency domain.

EEG is most often used to diagnose epilepsy, which causes abnormalities in EEG readings. It is also used to diagnose sleep disorders, depth of anesthesia, coma, encephalopathies, and brain death. EEG used to be a first-line method of diagnosis for tumors, stroke and other focal brain disorders, but this use has decreased with the advent of high-resolution anatomical imaging techniques such as magnetic resonance imaging (MRI) and computed tomography (CT). Despite limited spatial resolution, EEG continues to be a valuable tool for research and diagnosis. It is one of the few mobile techniques available and offers millisecond-range temporal resolution which is not possible with CT, PET or MRI.

History

In 1875, Richard Caton (1842–1926), a physician practicing in Liverpool, presented his findings about electrical phenomena of the exposed cerebral hemispheres of rabbits and monkeys in the *British Medical Journal*. In 1890, Polish physiologist Adolf Beck published an investigation of spontaneous electrical activity of the brain of rabbits and dogs that included rhythmic oscillations altered by light.

How the Test is Performed

The test is done in the following way:

- You lie on your back on a bed or in a reclining chair.
- Flat metal disks called electrodes are placed all over your scalp. The disks are held in place with a sticky paste. The electrodes are connected by wires to a recording machine. The machine changes the electrical signals into patterns that can be seen on a monitor or drawn on paper. These patterns look like wavy lines.
- You need to lie still during the test with your eyes closed. This is because movement can change the results. You may be asked to do certain things during the test, such as breathe fast and deeply for several minutes or look at a bright flashing light.
- You may be asked to sleep during the test.

If your doctor needs to monitor your brain activity for a longer period, an ambulatory EEG will be ordered. In addition to the electrodes, you will wear or carry a special recorder for up to 3 days. You will be able to go about your normal routine as the EEG is being recorded. Or, your doctor may ask you to stay overnight in a special EEG monitoring unit where your brain activity will be monitored continuously.

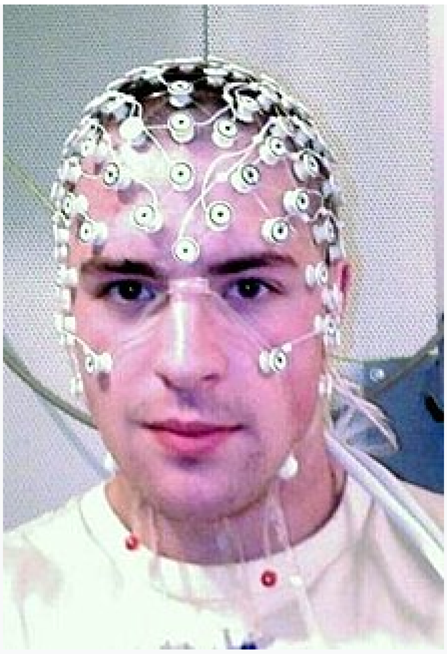
How to Prepare for the Test

Wash your hair the night before the test. DO NOT use conditioner, oils, sprays, or gel on your hair. If you have a hair weave, ask your health care provider for special instructions.

Your provider may want you to stop taking certain medicines before the test. DO NOT change or stop taking any medicines without first talking to your provider. Bring a list of your medicines with you.

Avoid all food and drinks containing caffeine for 8 hours before the test.

You may need to sleep during the test. If so, you may be asked to reduce your sleep time the night before. If you are asked to sleep as little as possible before the test, DO NOT eat or drink any caffeine, energy drinks, or other products that help you stay awake.



An EEG recording setup

EEG is one of the main diagnostic tests for epilepsy. A routine clinical EEG recording typically lasts 20–30 minutes (plus preparation time). It is a test that detects electrical activity in the brain using small, metal discs (electrodes) attached to the scalp. Routinely, EEG is used in clinical circumstances to determine changes in brain activity that might be useful in diagnosing brain disorders, especially epilepsy or another seizure disorder. An EEG might also be helpful for diagnosing or treating the following disorders:

- Brain tumor

- Brain damage from head injury
- Brain dysfunction that can have a variety of causes (encephalopathy)
- Inflammation of the brain (encephalitis)
- Stroke
- Sleep disorders

Why the Test is Performed

Brain cells communicate with each other by producing tiny electrical signals, called impulses. An EEG measures this activity. It can be used to diagnose or monitor the following health conditions:

- Seizures and epilepsy
- Abnormal changes in body chemistry that affect the brain
- Brain diseases, such as Alzheimer disease
- Confusion
- Fainting spells or periods of memory loss that cannot be explained otherwise
- Head injuries
- Infections
- Tumors

EEG is also used to:

- Evaluate problems with sleep (sleep disorders)
- Monitor the brain during brain surgery

An EEG may be done to show that the brain has no activity, in the case of someone who is in a deep coma. It can be helpful when trying to decide if a person is brain dead.

EEG cannot be used to measure intelligence.

Normal Results

Brain electrical activity has a certain number of waves per second (frequencies) that are normal for different levels of alertness. For example, brain waves are faster when you are awake and slower in certain stages of sleep.

There are also normal patterns to these waves.

Note: A normal EEG does not mean that a seizure did not occur.

Advantages

Several other methods to study brain function exist, including functional magnetic resonance imaging (fMRI), positron emission tomography (PET), magnetoencephalography (MEG), nuclear magnetic resonance spectroscopy (NMR or MRS), electrocorticography (ECoG), single-photon emission computed tomography (SPECT), near-infrared spectroscopy (NIRS), and event-related optical signal (EROS). Despite the relatively poor spatial sensitivity of EEG, it possesses multiple advantages over some of these techniques:

- Hardware costs are significantly lower than those of most other techniques [22]
- EEG prevents limited availability of technologists to provide immediate care in high traffic hospitals.
- EEG sensors can be used in more places than fMRI, SPECT, PET, MRS, or MEG, as these techniques require bulky and immobile equipment. For example, MEG requires equipment consisting of liquid helium-cooled detectors that can be used only in magnetically shielded rooms, altogether costing upwards of several million dollars; and fMRI requires the use of a 1-ton magnet in, again, a shielded room.
- EEG has very high temporal resolution, on the order of milliseconds rather than seconds. EEG is commonly recorded at sampling rates between 250 and 2000 Hz in clinical and research settings, but modern EEG data collection systems are capable of recording at sampling rates above 20,000 Hz if desired. MEG and EROS are the only other noninvasive cognitive neuroscience techniques that acquire data at this level of temporal resolution. EEG is relatively tolerant of subject movement, unlike

most other neuroimaging techniques. There even exist methods for minimizing, and even eliminating movement artifacts in EEG data

- EEG is silent, which allows for better study of the responses to auditory stimuli.
- EEG does not aggravate claustrophobia, unlike fMRI, PET, MRS, SPECT, and sometimes MEG EEG does not involve exposure to high-intensity (>1 tesla) magnetic fields, as in some of the other techniques, especially MRI and MRS. These can cause a variety of undesirable issues with the data, and also prohibit use of these techniques with participants that have metal implants in their body, such as metal-containing pacemakers.
- EEG does not involve exposure to radioligands, unlike psitron emission tomography.
- ERP studies can be conducted with relatively simple paradigms, compared with IE block-design fMRI studies
- Extremely uninvasive, unlike Electrocorticography, which actually requires electrodes to be placed on the surface of the brain.

EEG also has some characteristics that compare favorably with behavioral testing:

- EEG can detect covert processing (i.e., processing that does not require a response)
- EEG can be used in subjects who are incapable of making a motor respons
- Some ERP components can be detected even when the subject is not attending to the stimuli
- Unlike other means of studying reaction time, ERPs can elucidate stages of processing (rather than just the final end result)
- EEG is a powerful tool for tracking brain changes during different phases of life. EEG sleep analysis can indicate significant aspects of the timing of brain development, including evaluating adolescent brain maturation.
- In EEG there is a better understanding of what signal is measured as compared to other research techniques, e.g. the BOLD response in MRI.

Disadvantages.

Low spatial resolution on the scalp. fMRI, for example, can directly display areas of the brain that are active, while EEG requires intense interpretation just to hypothesize what areas are activated by a particular response.[33]

- EEG poorly measures neural activity that occurs below the upper layers of the brain (the cortex).
- Unlike PET and MRS, cannot identify specific locations in the brain at which various neurotransmitters, drugs, etc. can be found.

Risks

An EEG test is very safe. The flashing lights or fast breathing (hyperventilation) required during the test may trigger seizures in those with seizure disorders. The provider performing the EEG is trained to take care of you if this happens.

Alternative Names

Electroencephalogram; Brain wave test; Epilepsy - EEG; Seizure - EEG