

Does Heading a Soccer Ball Cause Brain Injury?

- by Dave Siever

The question “Does heading a soccer ball lead to brain injury?” has been debated by many professionals for quite some time and the debate continues.

If an MRI is used to diagnose a head trauma, it will rarely show this type of injury and in fact MRIs only show 15 to 25% of Traumatic Brain Injury (TBI) (Thatcher, et al., 1989).

In the past, neuropsychologists did their best to look at raw brain waves and determine if there were cognitive impairments. Unfortunately, their skills were limited to being able to identify only the more severe cases of a brain injury, which were obvious to anyone observing the person. As new tools in electroencephalography (EEG) were developed, neuropsychologists developed advanced techniques to observe subtler forms of brain dysfunction using standard EEG systems (known as a linked-ears referential system). The analysis of the brainwaves over a period of time using complex waveform analysis called Fourier analysis advanced the diagnosis of brain maladies substantially. But comparing a person’s brain waves against a normative database excelled diagnostics even further. In this example, we are using the SKIL database (Serman & Kaiser, 2001).

Before we begin, it’s important to understand that there are a few types of head injuries:

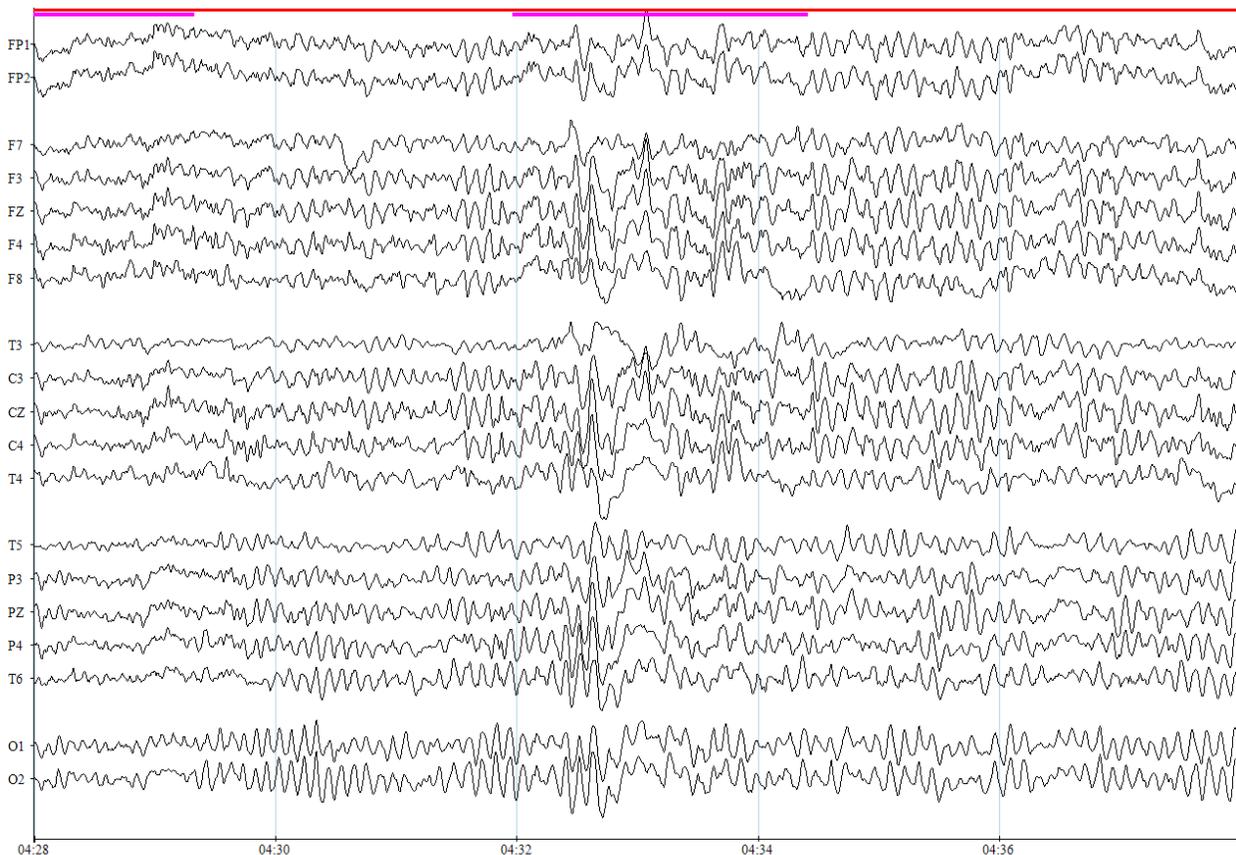
- 1) **Cortical injury:** This kind of injury refers to damage to the neurons. Neurons make up the 2 mm outer layer of the brain. They appear grey in color and so are called “grey matter.” An active (thinking and processing) brain is mostly dominant in the beta brainwave range. With a cortical injury, the neurons struggle to talk with one another and as a result, activity-based brainwaves such as beta and to a lesser extent, alpha, drop off considerably. Cortical injuries are recognized as slowing of the resting EEG, with high amplitude in the delta and theta frequency bands (Thatcher, et al., 1989).
- 2) **Diffuse axonal injuries (DAI):** Neurons that form the hundreds of networks within the brain have long tails, called axons. These axons connect and transmit signals to other neurons in other networks in the brain. These axons are often over 5 to 10 cm in length. They are covered in myelin, a sheath of fat that electrically insulates them from the axons of other neurons and also speeds up the transmission speed of the signals. Because fat is white in color, these axons are called “white matter.” When these axons get damaged in some way and the signals can no longer get through, this is called a diffuse axonal injury. It’s called diffuse because it usually affects a broad area of the brain.
- 3) **Thalamocortical disconnect (TCD):** A lesser known brain injury which I have been researching for a few years now. A TCD is a break in the loop between the neurons and the main oscillator, the thalamus. This loop is responsible for brain timing and the alpha rhythm. This loop often shuts down during inflammation most likely as a protective

mechanism for the brain even if there isn't any actual physical breakage in the neurons, their axons or the loops themselves.

Case Study of a Teen Heading Soccer Balls

This is a case study of a man in his 30s who reported heading soccer balls often as a teenager. We recorded a full-head EEG. We can see from his brain waves in Fig. 1 that there is mild epileptic activity, called a pseudo-seizure (a partial seizure where there are no physical symptoms), just past the 4:32 mark (and throughout the remainder of his record). This pseudo seizure is most likely the result from the hundreds of headings with soccer balls. He shows no actual physical signs of these seizures but can have moments where he's not quite engaged with what is going on. Common examples are needing someone to repeat themselves or missing road signs while driving a motor vehicle. Also, his frontal alpha activity (right at 4:34 in Fig. 1) isn't stacked in uniform clusters as it should be, but continues in long, large and slow brainwaves, which are typically associated with a foggy head. The feelings this person is experiencing are common in a cortical TBI, Attention Deficit Disorder (ADD) and even Seasonal Affective Disorder (SAD).

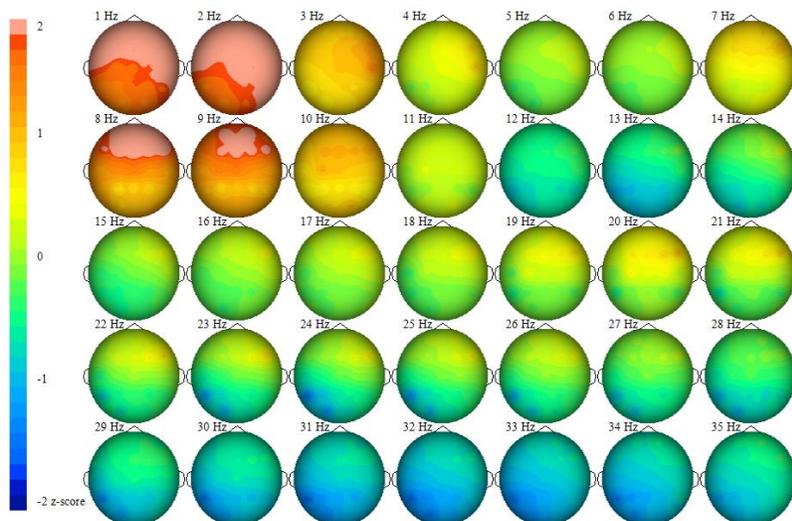
Figure 1. Raw EEG During an Eyes-Closed Condition Using a 19-Channel, Linked-Ears, 10-20 Montage



However, there are plenty of factors that determine brain function which are difficult to ascertain without some hard-core mathematics to parse out these abnormalities. This is where quantitative EEG (qEEG) (Kropotov, 2009), as it is called in the neuropsychology profession, comes in. QEEG processes all kinds of timing information using advanced mathematical algorithms such as Fourier analysis that breakdown meaningless looking brainwaves into components of frequency, magnitude and other network measures such as comodulation, coherence and phase. Network measures are those that measure how well various parts of the brain are talking with each other.

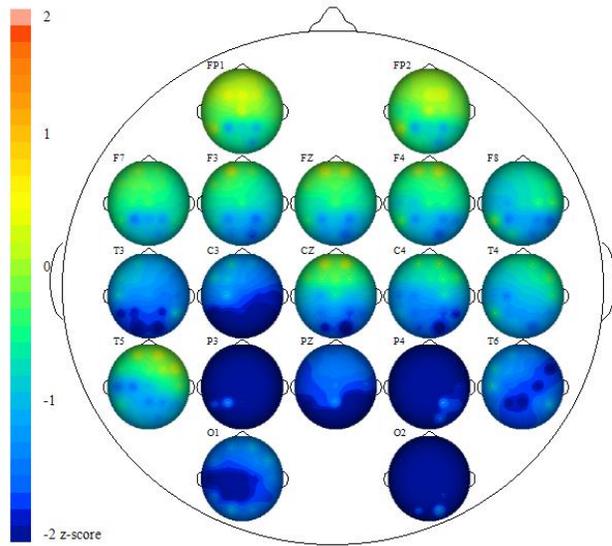
Normal eyes-closed (EC) alpha rhythm should be near 10 Hz. Using the SKIL database (Serman & Kaiser, 2001), we can see in Fig. 2, that the brainwaves on his forehead (where the soccer ball would have made contact) have slowed down to closer to 8 Hz, which is 20% slower than normal and similar to Attention Deficit Disorder of the non-hyperactive type. This person would struggle on an IQ or any timed test. Learning at a college-level pace would also be difficult. Many special needs and ADHD children show dominant EC alpha EEG at around 7 to 8.5 Hz. Most of the activity at 2 Hz and 1 Hz is artifact from eye movements.

Figure 2. Eyes-closed EEG Spectral Analysis as Compared to a Normative Database (2SD)



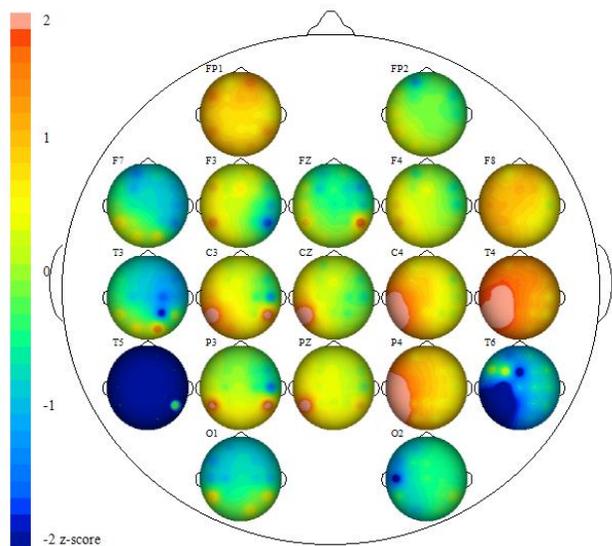
The brain typically takes short breaks known as alpha spindles. It's important the breaks are synchronized, so that the whole brain is communicating and resting at the same time. This measure is known as comodulation. Normal is at "0" standard deviations (greenish-yellow color). We can see in Fig. 3 that the active/break alignment between the front and back of the brain is desynchronized, indicating that sensory awareness and cognitive processing will be more challenging than normal.

Figure 3. Comodulation in the Alpha Band Shows Desynchrony



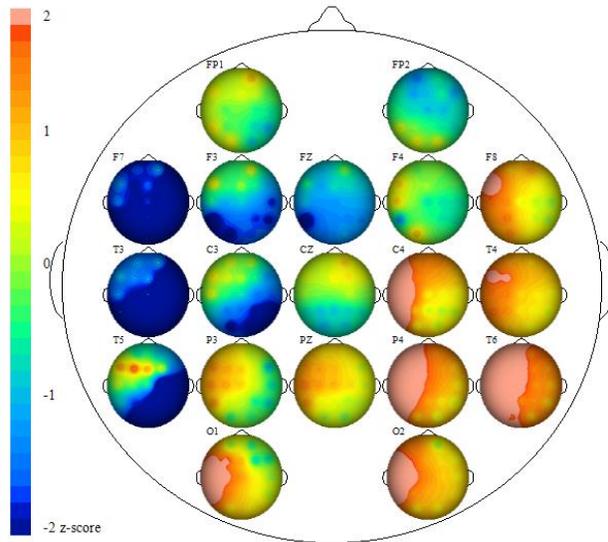
But this isn't all that happens. A condition associated with TBI known as *diaschisis* ("Dia" meaning to cut and "schisis" meaning from a distance) comes into play. This means that when there is a TBI at one location, there is likely another seemingly unrelated area that also shuts down, as it is heavily networked with the damaged area. In Fig. 4, showing phase analysis, we don't know for certain if this is diaschisis or actual network, but we see it affects language in Wernicke's area, the main language area located on the left rear side of the brain and spatial/social areas on the back right-hand side during relaxed attention.

Figure 4. Phase Analysis (Beta 1) Shows Slowing of Signals Between Language and Social/Spatial Areas



As the frequency increases to a more active and attentive mind state, the issues become more serious. In Fig. 5, we see phase delays in both language and speech (Broca's) areas. Broca's area is on the front left side as well as regions on the right side dealing with spatial ability and socialization. Other frequency bands ranging from theta to high beta are also affected but are not shown for the sake of brevity in this article and as the evidence already shown makes the point and is unmistakable.

Figure 5. Phase Analysis in the Beta 2 Region Showing Slowing of the Brain Signals



These results don't necessarily mean that the person is impaired and unable to function in life. This person is certainly functional. He has a job and is married, but it means that more mental effort will be required to perform tasks that others can do more easily. As we age, our brains slowly lose functionality. To have lost so much functionality at such a young age may mean that this person will struggle with age-related cognitive decline earlier than other seniors. Of course, quality of sleep, nutrition, lifestyle, socialization and both mental and physical exercise keep a brain in good shape well into old age. It would be well advised for a person with this brain signature to develop this lifestyle now as this would delay cognitive decline while heading into old age.

Conclusion

By using modern high-tech brainwave analysis techniques such as qEEG and normative databases, with the ability to view phase, comodulation, coherence and other measures that are not perceivable to the naked eye, but represent significant brain problems, it is now possible to diagnose and guide treatment for a multitude of mental health issues.

References

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