CONCUSSIONS
FOOTBALL
COMMON SENSE

It is time to bring some common sense to the concussion problem in the sport of football. In this essay I will explain how concussions occur and what helmets cannot do to ameliorate the problem. However a solution exists and has been used for millions of years by woodpeckers. We will see that simple physics is all that is needed to explain everything, just as was the case for deflate-gate (http://www.fefox.com/ARTICLES/SbD.pdf).

Woodpeckers eat beetle grubs that bore tunnels in the bark of trees. The birds gain purchase on the side of the tree with their sharp talons and rapidly, rat-a-tat-tat, pound their long sharp bills into the tree bark in order to wheedle out the grubs. Sometimes the rat-a-tat-tat goes on for many minutes. Why doesn't the woodpecker suffer a concussion with each hit and soon become disabled? Typical collisions between beak and tree are at 15 miles per hour and may occur 12,000 times a day in a single bird.

The solution used by woodpecker evolution is simple to understand. First we need to understand a concussion in a human. The brain is held inside the skull by a series of three membranes, the *meninges*. The outer most layer is the thick *dura mater* that is attached to the inside of the skull. Attached to the brain is the *pia mater*. In between and attached to the *dura* and the *pia* is the *arachnoid mater*. This last connection is quite loose and flexible. During a strong impact with the exterior of the skull the brain is quickly forced up against the inside of the skull adjacent to the exterior impact point. This compresses the meninges, so that the impact from the outside causes the brain to impact the inside and rebound through the interior of the skull and have an interior impact on the opposite side of the skull from the exterior impact point. Both the initial impact and compression and the rebound forced transit across the skull to the other side create bruises, i.e. concussions. An external helmet will protect the scalp from being torn or the face from being blemished but the brain on the inside is still going to be strongly jostled side to side. Perhaps the helmet will absorb some of the impact, as well as the flexibility of the meninges, so that the initial concussion is lessened relative to the exterior impact, but the collision

between the helmet and the ground or with another helmet will still create a situation that produces significant damage to the brain.

What does the woodpecker do about the same problem? Inside the woodpecker's skull is a spongy bone mass made up of *trabeculae* in the form of a tight, flexible supporting mesh. This material works as a shock absorber on the inside of the skull. Because of this protection the bird's brain never actually hits the inside of its skull during tree-bark-beak impacts.

Now we can present our solution for football players. Drill several small holes into their skulls, large enough to insert a thin knife used to cut away some of the *dura*. This will enable us to extrude into the holes polystyrene in its liquid phase at 100^{o} C and for it to get past the *dura* in order to fill all of the available meningeal space. This is a bit warm for the brain but it can be done quickly so that when it cools enough a soft rigid material solidifies inside the skull. By doing research on additives the liquefaction temperature of polystyrene can surely be reduced and the flexibility of naturally brittle polystyrene solid increased. Of course the cure may come with side effects, such as *frixum cerebri* syndrome or *foramen in capite* disorder. These are minor momentary inconveniences compared with the life-long complications from concussions.

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