

Update on Concussion Guidelines

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Conflict of Interest/ Financial Ties

- I have nothing to disclose

Zurich Guidelines 2012 (updated from 2008: new update 2016)

Consensus statement on concussion in sport: the 4th International Conference on Concussion in Sport held in Zurich, November 2012

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Guideline Review

Concussion management

The cornerstone of concussion management is physical and cognitive rest until the acute symptoms resolve and then a graded program of exertion prior to medical clearance and RTP.

Table 1 Graduated return to play protocol

Rehabilitation stage	Functional exercise at each stage of rehabilitation	Objective of each stage
1. No activity	Symptom limited physical and cognitive rest	Recovery
2. Light aerobic exercise	Walking, swimming or stationary cycling keeping intensity <70% maximum permitted heart rate No resistance training	Increase HR
3. Sport-specific exercise	Skating drills in ice hockey, running drills in soccer. No head impact activities	Add movement
4. Non-contact training drills	Progression to more complex training drills, eg, passing drills in football and ice hockey May start progressive resistance training	Exercise, coordination and cognitive load
5. Full-contact practice	Following medical clearance participate in normal training activities	Restore confidence and assess functional skills by coaching staff
6. Return to play	Normal game play	

Key points

- No same day return to play
- Concussions lasting > 10 days should be managed by physicians experienced in treating concussion
- Pre-participation concussion history an important screening tool
- Concussion symptoms are a better reflection of concussion severity than amnesia duration
- Children < 13 report symptoms of depression differently than adults
- No return to sport for children until they have successfully achieved in the class room
- There is no special recommendations for elite athletes that differ from non-elite athletes

How are consensus statements derived?

NIH Consensus statement format

1. A broad-based, non-government, non-academy panel was

3. A number of specific questions were prepared and posed in advance to define the scope and guide the direction of the conference. The principal task of the panel was to elucidate responses to these questions. These questions are outlined below.

4. A systematic literature review was prepared and circulated in advance for use by the panel in addressing the conference questions.

5. The consensus statement is intended to serve as the scientific record of the conference.

6. The consensus statement will be widely disseminated to achieve maximum impact on both current healthcare practice and future medical research.

**National Institutes
of Health**

Question 1

When you assess an athlete acutely and they do not have a concussion, what is it?

Simple answer: we don't know

Complex answer: “transient neurological condition”

Is a cognitive injury the key component of concussion in making a diagnosis?

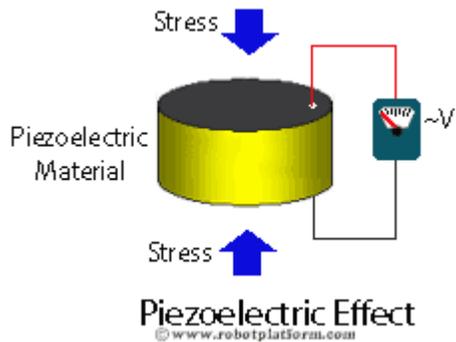
A cognitive deficit is not necessary for acute diagnosis as it either may not be present or detected on examination.



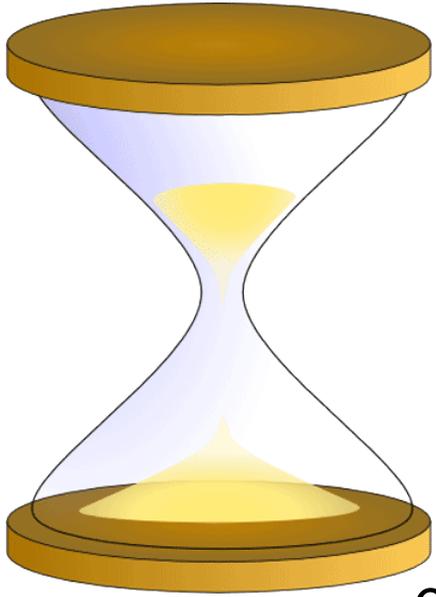
What is the lowest threshold to make a diagnosis of concussion?

[Paul McCrory¹](#), [Willem H Meeuwisse^{2,3}](#), [Ruben J Echemendia⁴](#), [Grant L Iverson⁵](#), [Jiří Dvořák⁶](#), [Jeffrey S Kutcher⁷](#)

Do we have sufficient evidence or knowledge to diagnose something other than a concussion in mild or transient cases?



“In essence, concussion becomes the default diagnosis and must be excluded or ruled out. concussion as the clinical manifestation of an underlying brain injury..... In this way, concussion becomes a possible clinical outcome from a subset of TBI—specifically the subset that causes the metabolic cascade to the degree needed to cause a clinical effect for the injured brain. If there are temporary symptoms such as those that are not caused by the cascade or by any measurable cellular pathology, but by piezoelectric depolarization caused by the biomechanical force, then should they also be labelled as concussion. Given the evolving nature of the injury and the fact that the duration, severity and trajectory of this injury cannot be adequately estimated in the very acute stages, then concussion becomes the default diagnosis. Some concussions also have very brief symptom presentation but may not produce a measurable clinical or cognitive injury and have no detectable sequelae given the current technology”



Concussion is not a point in time

*Embedded in that approach is the concept that diagnosing concussion is often not a 'point in time' event but rather one that requires observation over time and exclusion of other conditions that may mimic a concussion. Management is then based not on whether or not the clinician has diagnosed concussion, but rather whether or not he or she has diagnosed something else. **In the interim, between injury suspicion and concussion diagnosis, the patient is treated as if they are concussed.***

Question 2

Diagnoses- Yes!
Exclusion- No!!

Answer: Several well-validated neuropsychological tests are appropriate for use in the assessment of acute concussion in the competitive sporting environment. These tests provide important data on symptoms and functional impairments that clinicians can incorporate into their diagnostic formulation, but should not solely be used to diagnose concussion.

Review

Day of injury assessment of sport-related concussion

[Michael McCrea¹](#), [Grant L Iverson²](#), [Ruben J Echemendia³](#), [Michael Makdissi⁴](#), [Martin Raftery⁵](#)

“Concussion clearly produces a constellation of self-reported symptoms and impairments

Cognitive, Emotional, Physical

to one domain (e.g., cognitive functioning). That is, athletes, to varying degrees, experience a complex combination of symptoms and exhibit deficits across multiple domains of functioning. As a result, reliance on a single test or multiple measures in a single assessment domain will very likely be less accurate than a multimodal assessment. A multidimensional approach that integrates assessment of self-reported symptoms and other functional domains (e.g., cognitive function and balance) known to be affected by concussion is recommended.”



Question 3

What is the best practice for evaluating an adult athlete with concussion on the 'field of play' in 2012?

Answer: A standardized objective assessment of injury, which includes excluding more serious injury.... the sideline evaluation is based on recognition of injury, assessment of symptoms, cognitive and cranial nerve function, and balance.



Review

On field assessment of concussion in the adult athlete

[Margot Putukian¹](#), [Martin Raftery²](#), [Kevin Guskiewicz³](#), [Stanley Herring⁴](#), [Mark Aubry⁵](#), [Robert C Cantu^{6,7,8}](#), [Mick Molloy⁹](#)

“Although the subcomponents of SCAT3 have been validated separately, SCAT3 itself has not been evaluated and there are limited data related to its sensitivity and specificity in diagnosing concussion or determining the severity of injury. Limited studies exist using SCAT3 which demonstrate individual differences in baseline assessments, preliminary data suggest that SCAT3 is useful in evaluating athletes post injury and able to differentiate concussed vs non-concussed athletes in college athletes.”

The Tyranny of Diagnosis

- Once you commit to a diagnose of concussion, you are obligated to follow the graded return to play guidelines
- It may be preferable to use the term “suspected concussion” until your assessment has been repeated the following day.

Question 4

How can the SCAT2 be improved?

Answer:

A future SCAT test battery (i.e., SCAT3) should include an initial assessment of injury severity using the Glasgow Coma Scale (GCS), immediately followed by observing and documenting concussion signs.

Once this is complete, symptom endorsement and symptom severity, as well as neurocognitive and balance functions, should be assessed in any athlete suspected of sustaining a concussion. **It is recommended that these latter steps be conducted following *a minimum 15 min rest period* on the sideline to avoid the influence of exertion or fatigue on the athlete's performance.**

Pediatric SCAT 3/ Return to Learn

- [Child SCAT 3](#)
- [C:\Users\jmorari\Desktop\Concussion guidelines\Return to learn.pdf](#)
- [Return to Learn](#)

Question 5

Advances in neuropsychology: are computerized tests sufficient for concussion diagnosis?

Answer: No. Computerized tests are validated to assess cognitive decline. They cannot assess emotional or physical symptoms.

At present, there is insufficient evidence to recommend the widespread routine use of baseline neuropsychological testing.



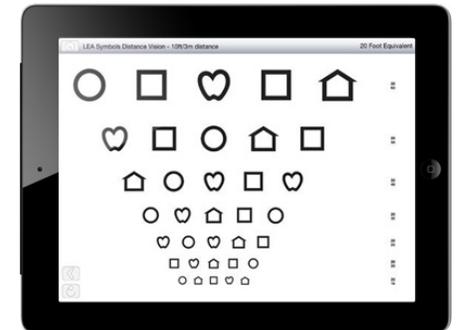
Question 6

What evidence exists for new strategies/technologies in the diagnosis of concussion and assessment of recovery?

(iPhone/smart phone apps, quantitative electroencephalography, robotics—sensory motor assessment, telemedicine, eye-tracking technology, functional imaging/advanced neuroimaging and head impact sensors.)



Answer: At this stage, only limited evidence exists for their role in this setting and none have been validated as diagnostic.



•Review

What evidence exists for new strategies or technologies in the diagnosis of sports concussion and assessment of recovery?

[Jeffrey Scott Kutcher](#)¹, [Paul McCrory](#)², [Gavin Davis](#)^{2,3}, [Alain Ptito](#)^{4,5,6}, [Willem H Meeuwisse](#)^{7,8}, [Steven P Broglio](#)⁹

Head impact sensors.....possible benefit

The first is the ability to monitor impacts during the course of an athletic event for the purpose of screening for potential injury. Although many researchers have analyzed impact counts and characteristics across a variety of settings in the hope of establishing force ‘thresholds’ for injury, no such threshold has been

The second potential clinical benefit of impact monitoring systems stems not from the idea of monitoring impacts for the presence of an acute injury-generating hit, but from the potential advantage of accurately cataloguing the number of hits and post impact head acceleration being experienced by an athlete over time.



Question 7

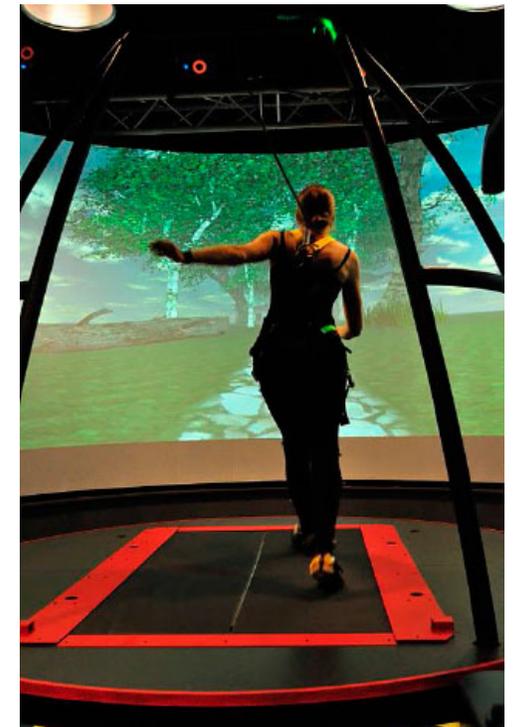


Advances in the management of sport concussion: what is evidence for concussion therapies

Answer: There is a strong need for high-level studies evaluating the effects of a resting period, pharmacological interventions, rehabilitative techniques and exercise for individuals who have sustained a sports-related concussion.



Chinese Skullcap For Concussion



Review

The effects of rest and treatment following sport-related concussion: a systematic review of the literature

[Kathryn J Schneider¹](#), [Grant L Iverson²](#), [Carolyn A Emery^{1,3,4}](#), [Paul McCrory⁵](#), [Stanley A Herring^{6,7}](#), [Willem H Meeuwisse^{1,3}](#)

- The current evidence evaluating the effect of rest and treatment following a sport-related concussion is sparse.
- In the absence of evidence-based recommendations, a sensible approach involves the gradual return to school and social activities (prior to contact sports) in a manner that does not result in a significant exacerbation of symptoms.
- There is some evidence that vestibular rehabilitation is effective for dizziness and balance problems in children and adults who have sustained an MTBI.
 - gaze stabilization exercises [in which the individual maintained a fixed gaze position while turning the head from side to side] in sitting and standing positions), standing balance (e.g., standing with feet apart and feet together on foam with eyes open and closed), walking with balance challenge (e.g., walking with head turns, tandem walking, and obstacle avoidance), and, in a few cases, canalith repositioning maneuvers
- There is evidence that cases with a secondary diagnoses may respond to medical intervention
 - Migraine
 - Cervicogenic symptoms
 - Sleep issues
 - depression

Review

The difficult concussion patient: what is the best approach to investigation and management of persistent (>10 days) post concussive symptoms?



[Michael Makdissi^{1,2}](#), [Robert C Cantu³](#), [Karen M Johnston⁴](#), [Paul McCrory¹](#), [Willem H Meeuwisse⁵](#)

Currently, there is no evidence that prolonged rest is beneficial for patients with **persistent** symptoms. Preliminary studies demonstrate that an active rehabilitation program

may be useful for the management of cases where symptoms are prolonged

The important components of an active rehabilitation program include:

- Commencement even in the absence of complete symptom resolution;
- Prescriptive advice regarding the intensity, duration and timing of exercise;
- Working to a level that does not aggravate the symptoms (subsypptom threshold exercise);
- Slow progression of rehabilitation with monitoring of clinical outcome.



The difficult concussion patient: what is the best approach to investigation and management of persistent (>10 days) post concussive symptoms?

[Michael Makdissi^{1,2}](#), [Robert C Cantu³](#), [Karen M Johnston⁴](#), [Paul McCrory¹](#), [Willem H Meeuwisse⁵](#)

Table 3
Active rehabilitation

Paper	Study type/setting	Subject characteristics	Inclusion criteria	Outcome measures	Findings/results
Gagnon <i>et al</i> ⁶³	Prospective cohort (tertiary referral centre)	N=16 Children and adolescents (aged 10–17 years)	Postconcussion symptoms >4 weeks	Symptoms checklist, clinical examination, balance testing, coordination testing	Used a graded rehabilitation programme (beginning with submaximal aerobic training that is, 15 min on a treadmill or stationary bike, then introducing sports-specific training drills for 10 min) Found a significant increase in exercise tolerance and reduction in symptom score (30.0±20.8 at presentation to 6.7±5.7 at discharge) Mean duration of intervention 4.4±2.6 weeks
Leddy <i>et al</i> ⁶⁴	Prospective cohort (University concussion clinic)	N=12 (6 athletes, 6 non-athletes)	Symptoms >6 weeks following concussion (5 sports related, 1 motor vehicle accident)	Graded symptom checklist, graded exercise treadmill test (Balke protocol)	Exercise at an intensity of 80% of the maximum heart rate achieved on the treadmill test before the exacerbation of symptoms 10 of the 12 reported being symptom-free at rest Athletes recovered faster than non-athletes Rate of symptom improvement was directly related to exercise intensity achieved
Baker <i>et al</i> ⁶⁵	Retrospective case series	N=91 (63 had follow-up phone assessment 4–73 months postinjury)	Symptoms >3 weeks	Subjective symptom reporting, graded exercise treadmill test (Balke protocol)	41/57 Who completed the exercise programme returned to full daily functioning

Question 9

Revisiting concussion modifiers: how should the evaluation and management of acute concussion differ in specific groups?

Answer:

1. The literature demonstrates that the number and severity of symptoms and previous concussions are associated with prolonged recovery and/or increased risk of complications.
2. Children generally take longer to recover from concussions and assessment batteries have yet to be validated in the younger age group.
3. Currently, there are insufficient data on the influence of genetics and gender on outcome following concussion.
4. Children with concussion should be managed conservatively, with the emphasis on return to learn before return to sport.

Table 2. Concussion modifiers

Factors	Modifier
Symptoms	High number, long duration (>10 days), high severity
Signs	Prolonged loss of consciousness (>1 min), amnesia
Sequelae	Prolonged convulsive convulsions*
Temporal	Frequency: repeated concussions over time Timing: injuries close together in time 'Recency': recent concussion or traumatic brain injury
Threshold	Repeated concussions occurring with progressively less impact force or slower recovery after each successive concussion
Age	Child and adolescent (<18 years)
Co- and pre-morbidities	Migraine, depression or other mental health disorders, attention deficit hyperactivity disorder, learning disabilities, sleep disorders
Medication	Psychoactive drugs, anticoagulants
Behaviour	Dangerous style of play
Sport	High-risk activity, contact and collision sport, high sporting level

*Convulsive convulsions or impact seizures are occasionally observed following concussion in sport. These are usually brief in duration (<1 minute) and

Question 10



What are the most effective risk reduction strategies in sport concussion?—from protective equipment to policy?

Answer: No new valid evidence was provided to suggest that the use of current standard headgear in rugby, or of mouth guards in American football, can significantly reduce players' risk of concussion.

No evidence was provided to suggest an association between neck strength increases and concussion risk reduction. There was evidence to suggest that eliminating body checking from Pee Wee ice hockey (ages 11–12 years) and fair-play rules in ice hockey were effective injury prevention strategies.

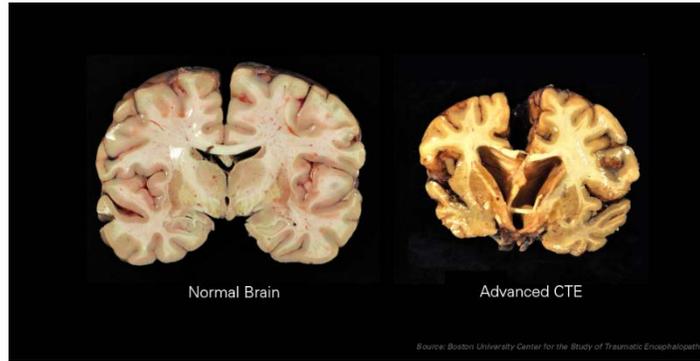


Rule Changes in High School Football



- [State football guidelines.pdf](#)
 - Full-contact should be limited during the regular season, as well as during activity outside of the traditional fall football season.
 - Member state associations should consider a variety of options for limiting contact in practices.
 - Pre-season practices may require more full-contact time than practices occurring later in the regular season, to allow for teaching fundamentals with sufficient repetition
 - During pre-season twice-daily practices, only one session per day should include full contact
 - Each member state association should review its current policies regarding total quarters or games played during a one-week time frame

Question 11



What is the evidence for chronic concussion-related changes?—behavioral, pathological and clinical outcomes

Answer: It was agreed that **CTE represents a distinct tauopathy** with an unknown incidence in athletic populations. It was further agreed that **CTE was not related to concussions alone or simply exposure to contact sports.**

At present, there are no published epidemiological, cohort or prospective studies relating to modern CTE. Owing to the nature of the case reports and pathological case series that have been published, it is not possible to determine the causality or risk factors with any certainty.

As such, the **speculation that repeated concussion or sub concussive impacts cause CTE remains unproven.**

What is the evidence for chronic concussion-related changes in retired athletes: behavioral, pathological and clinical outcomes?

Paul McCrory,¹ Willem H Meeuwisse,^{2,3} Jeffrey S Kutcher,⁴ Barry D Jordan,⁵
Andrew Gardner⁶

CLINICAL SYNDROMES OF LONG-TERM PROBLEMS
FOLLOWING CONCUSSION

Acute Concussion

Symptoms 5-10 days with complete recovery in 85-90%

Prolonged post concussion symptoms

Persistent post concussion symptoms

Permanent post concussive symptoms

Symptoms >10 days: 5-10%, recovery in a matter of weeks

Symptoms > 3months, prolonged recovery in 80% in months to years, attentional deficits, normal structural neuroimaging

Permanent symptoms, 15-20% of persistent concussion, F-MRI and electro physiologic changes may be present, structural imaging normal

Proposed CTE, phenotypical symptoms but *negative* neuropathological findings

Proposed CTE, phenotypical symptoms of chronic cognitive and neurobehavioral changes *with positive* neuropathological findings

Time to Re-think the Zurich Guidelines?

A Critique on the Consensus Statement on Concussion in Sport: The 4th International
Conference on Concussion in Sport,
Held in Zurich, November 201

Neil Craton, MD, MHK † and Oliver Leslie, MD**

Clin J Sport Med Volume 24, Number 2, March 2014

- <C:\Users\jmoriari\Desktop\Concussion guidelines\Time to Re think the Zurich Guidelines A.1.pdf>

Question 12

From consensus to action—how do we optimize knowledge transfer, education and ability to influence policy?

Answer: The value of knowledge transfer (KT) as part of concussion education is increasingly becoming recognized. Target audiences benefit from specific learning strategies. Concussion tools exist, but their effectiveness and impact require further evaluation.

Knowledge Transfer

KT or translation is 'the exchange, synthesis and ethically-sound application of knowledge within a complex system of interactions among researchers and users to accelerate the capture of the benefits of research...through improved health, more effective services and products, and strengthened healthcare system.'

Really??

Us contemplating ourselves!



Scalable Neuroscience and the Brain Activity Mapping Project

Thomas Dean
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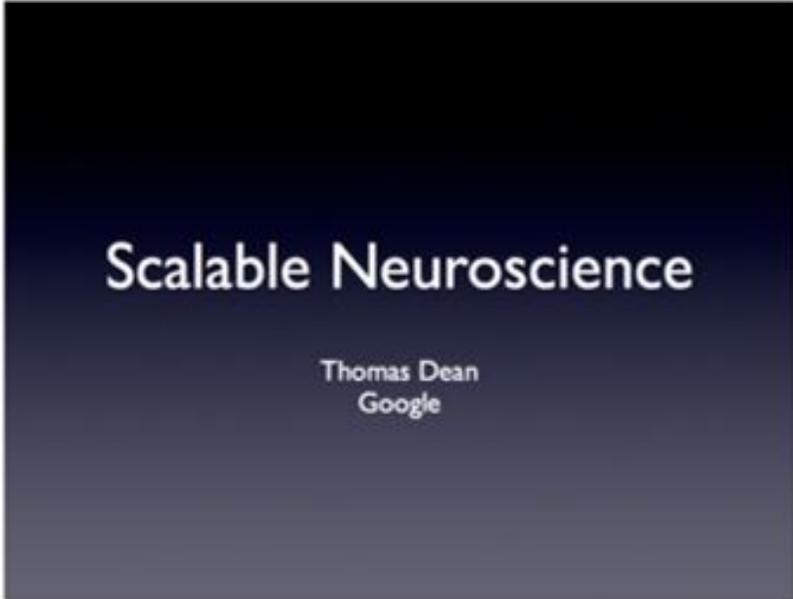
Helen Wills Neuroscience Institute¹, Berkeley, July 26, 2013

Abstract

Since the beginning of the year, the European Union and United States have separately announced major initiatives in brain science. The latter is called the Brain Activity Mapping (BAM) Project² and the size of the effort and the implications for science and medicine have been compared to the Human Genome Project. A key part of the effort involves developing new scientific instruments capable of observing the activity of large ensembles of neurons in awake behaving humans with the goal of understanding the neural basis for cognition and diagnosing a wide range brain disorders from Parkinson's to Alzheimer's.

The problem these instruments are intended to solve can be divided conceptually into two parts: recording and reporting. Recording involves sensing and coding for transmission neural activity including membrane potentials, protein expression levels, calcium concentrations and their correlates. Reporting involves conveying the coded information from the locus of the recording — typically deep within the neural tissue of an awake subject — to some external computing or storage device.

The technical challenge involved in building these instruments is considerable, perhaps on a par with constructing the Large Hadron Collider (LHC), but while the LHC accelerator ring is 27 kilometers in circumference, the components comprising BAM instruments may include billions of nanoscale parts and be contained entirely within a human skull. This lecture explores several of the key technologies being considered to address the reporting problem including nanoscale communication networks, micron-diameter fiber-optic cables, light and ultrasound microscopy, recombinant DNA and synthetic biology.



Scalable Neuroscience

Thomas Dean
Google

Numbers Every Neuroscientist Ought to Know

- Average number of neurons in the brain = 100 billion (10^{11})
- Diameter of neuron = 4–100 μm (micron) [granule, motor]
- Ratio grey to white matter = [1.3, 1.1, 1.5] by age [20, 50, 100]
- Percentage of oxygen consumption by white matter = 6%
- Percentage of oxygen consumption by gray matter = 94%
- Number of neocortical neurons 20 billion (10^{10})
- Average loss of neocortical neurons = 100,000 per day (10^5)
- Number of synapses in cortex = 0.1 quadrillion (10^{14})
- Number of cortical layers = 6
- Thickness of cerebral cortex = 1.5–4.5 mm
- Total surface area of the cerebral cortex = 2,500 cm^2

Numbers Every Neuroscientist Ought to Know

- Number of synapses for a “typical” neuron = 1,000 to 10,000
- Single sodium pump transport rate = 200/100 Na/K ions/sec
- Number of sodium pumps = 1000 per μm^2 of membrane
- Total number of sodium pumps for a small neuron = 1 million
- Voltage-gated sodium channels at each node = 1,000 per μm^2
- Voltage-gated sodium channels between nodes = 25 per μm^2
- Sodium channels in unmyelinated axon = 100 per μm^2
- Membrane surface area of a “typical” neuron = 250,000 μm^2
- Area of 100 billion neurons = 25,000 m^2 (four soccer fields)
- Neurotransmitter molecules in one synaptic vesicle = 5,000
- Action potential [1, 10, 100] m/sec by diameter [0.1, 1, 10] μm

The number of neurons is perhaps less important than the number of active connections or synapses. Scott McNealy at SUN Microsystems was fond of saying “It’s the network stupid”

Summing Up

Trauma to the head at any level disturbs the network. Most often, it will fix itself if we give it time, nourishment and rest. We don't function well while the network is disturbed. We really don't even know how the network really works.

Sometimes, its necessary to reboot the system (read, give it more time) or even reprogram the drive (read, a trial of rehab/exercise). Rarely, but it does happen, the circuits are damaged and can't be repaired and we lose some of our humanness. We don't know how to repair the circuits, but someday we will.

Till then, let's not pretend that we confidently know what we are doing. Let's not claim to be experts on a subject we can't begin to comprehend.

But, as physicians, let us be arbiters of reasonable policy, mitigators of risk, champions of fair play, and protectors for those who, like us, hold a skull in our hands and wonder how this magical creation works.