NEURO INSTITUTE

Continuing Education for Rehabilitation Professionals

Post-Concussive Syndrome
The Impact on Vision, Perception, Cognition, and Vestibular Functioning

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Objectives

- Understand Post-Concussive Syndrome symptoms and presentation
- Understand how vision, perception, and vestibular functioning are affected after a brain injury
- Understand how cognition and communication are impacted after a brain injury

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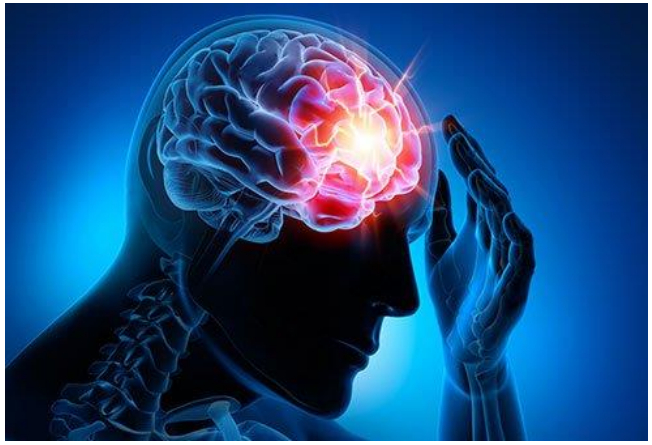
What is a concussion?

A concussion is a type of traumatic brain injury—or TBI—caused by a bump, blow, or jolt to the head or by a hit to the body that causes the head and brain to move rapidly back and forth. This sudden movement can cause the brain to bounce around or twist in the skull, creating chemical changes in the brain and sometimes stretching and damaging brain cells.

Centers for Disease Control (CDC)

This is a type of brain Injury that occurs at the neuronal level, and thus does not always appear in traditional imaging.



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Common Concussion Symptoms:

- Headaches
- Dizziness
- Nausea
- Noise sensitivity
- Sleep Disturbance
- Light sensitivity
- Irritability or Anxiety
- Amnesia
- Tinnitus
- Frustration, Impatient, Easily Angered
- Poor Memory
- Reduced Concentration
- Blurred or Double vision
- Mentally “foggy” or slowed thinking
- Fatigue
- Impaired balance
- Feeling overwhelmed
- Difficulty reading
- Difficulty in busy environments (stores, family gatherings, etc.)

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Diagnosis and Recovery

A concussion EVOLVES over time and symptoms vary by person, the area of impact, and the force of the injury or contact.

There is NO diagnostic test for a concussion and symptoms typically show up days to weeks after the initial insult.

Injury is from a neurochemical and neurometabolic process occurring in the brain.

Recovery is a process of allowing the electrochemical systems to normalize.

- Putting a heavy demand on the brain to think and act, results in drawing away resources from recovery.

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Addressing Gender Differences in Concussion Diagnosis and Treatment

- Compared with men, women have about 1.5 times greater risk of concussion in soccer and 1.4 times greater risk in basketball, and women playing softball have nearly twice the risk of men playing baseball, per the NCAA Injury Surveillance Program.
- In a recent study of 207 male and female athletes at a concussion specialty clinic in Ontario, Canada, it was found that women reported more symptoms of concussion post-injury and also had more objective signs (according to a physical exam and their medical histories), such as migraine and trouble maintaining balance.
- Examples of differences:
    - Differences in ability to read emotions: A study by Leveille E, et al. (2016) found that multi-concussed male athletes were more likely than female multi-concussed athletes to display significantly impaired ability in visually recognizing negative emotions in facial expressions. This also points us back to those gender differences we talked about earlier.

References: Léveillé E, Guay S, Blais C, Scherzer P, De Beaumont L. Sex-Related Differences in Emotion Recognition in Multi-concussed Athletes. J Int Neuropsychol Soc. 2017 Jan;23(1):65-77. doi: 10.1017/S1355617716001004. Epub 2016 Dec 15. PMID: 27974074.

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Addressing Gender Differences in Concussion Diagnosis and Treatment

- There are no female-specific guidelines, protocols, care plans, or education resources for women with brain injury, including concussions.
- Theories for gender differences include:
  - The size and strength of neck musculature, [which are] generally smaller and weaker in females, which may increase the forces experienced during contact and participation
  - Potential relationships to hormonal influences and even phase of the menstrual cycle could play a role

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Visual Symptoms with Post-Concussive Syndrome

- According to Debacker, Ventura, Galetta , Balcer, and Rucker (2018), the high frequency of visual involvement in concussion should not be surprising, as more than half of the brain's pathways are dedicated to vision and eye movement control. These areas include many that are most vulnerable to head trauma, including the frontal and temporal lobes. https://pubmed.ncbi.nlm.nih.gov/30482342/
- Vision issues impact activities of daily living such as self-care, performing in-home activities, medication management, functional mobility, shopping, meal preparation, cleaning, reading, driving, etc.
- Symptom inquiry: double vision, blurry vision, headaches, eye pain or eye aches, light sensitivity, watery eyes/dry eyes, burning/itching, nausea, car sickness, perception of movement/rocking sensation while standing or walking, movement of letters on a page
- Observe for head tilt or head turn, closing an eye, squinting, impaired visual endurance, skipping words or lines while reading, wearing dark lenses indoors, overstimulation with common items such as looking at a food label/newspaper/reading emails or texts, rubbing eyes/forehead/temples, impaired eye-hand coordination, unusual or limited eye movement

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Examples of spacing issues and skipping letters/ words while reading

Justascouragetakesitsstandbyothersinchallengingsituations,so compassiontakesitsstandwithothersintheirdistress.Compassionisa virtuethattakesseriouslytherealityofotherpersons,theirlives,their emotions,aswellastheirexternalcircumstances.Itisanactivedisposition towardfellowshipandsharing,towardsupportivecompanionshipin distressorinwoe.

The eeds of comassion are sown inour ver nature as huma eings. "There some benevolence, howeversmall, inused into our som, somespark friendship forhuman kind, some particle of the dove kneaded intour frame, along with heelements ofthe wolf an serpent," as David Hume once put it. His contemporary Jean-Jac ques Rousseau agreed: "compassion is a natural feeling, which, b moderating the violence ofloveof self in each individual, contributes preservation of the whole species. It is this

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Examples of double vision

Seeing double can be very disruptive in daily life.

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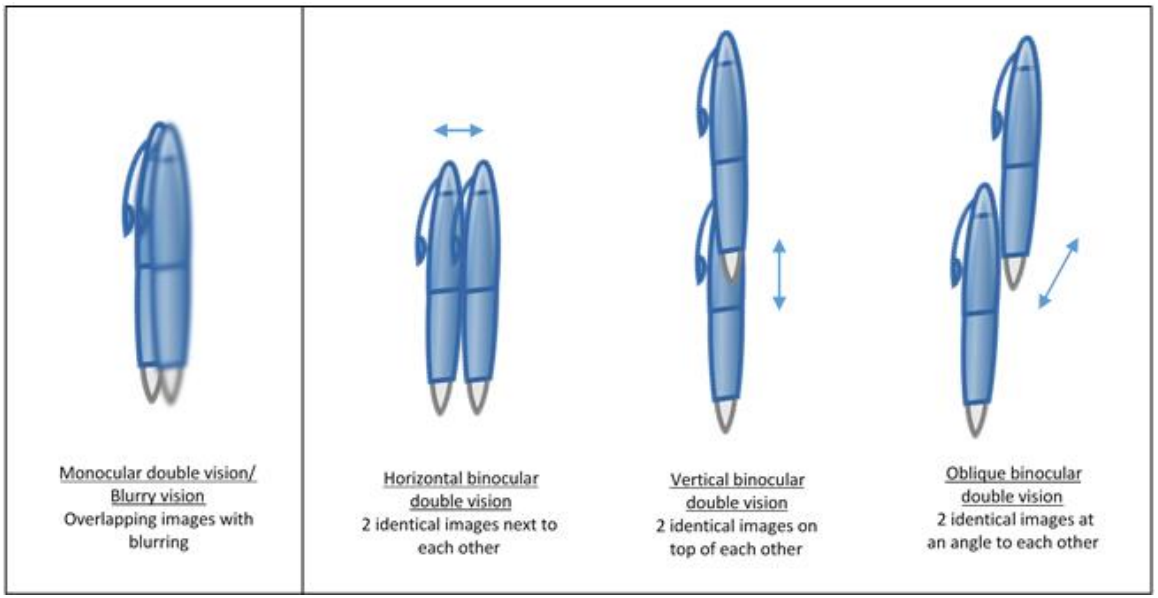

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What to do?

- Screening: acuities, pursuits, saccades, convergence, visual fields, depth perception, scanning, eye-teaming
- Refer to a neuro-optometrist (www.noravisionrehab.org)
- Initially manage symptoms
    a. modify environment to reduce light (close window blinds, dim lights, adjust brightness on screens, reduce blue light on screens, wear a hat, avoid fluorescent lights)
    b. limit visual stimulation (line guide while reading, cover extraneous material, limit amount of information on a screen, avoid busy community environments)
    c. schedule visual breaks
- Increase tolerance to visual stimulation

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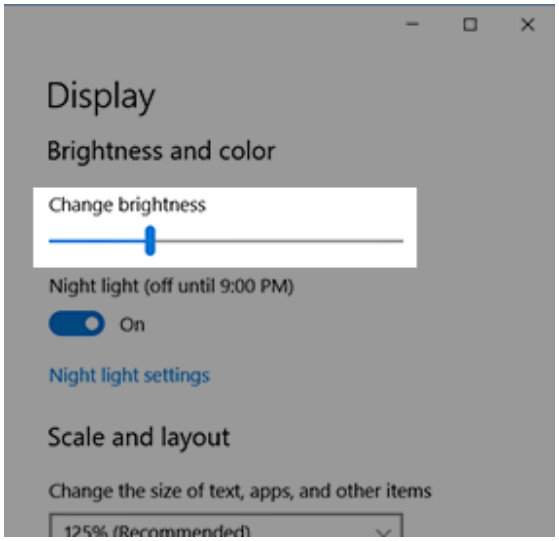
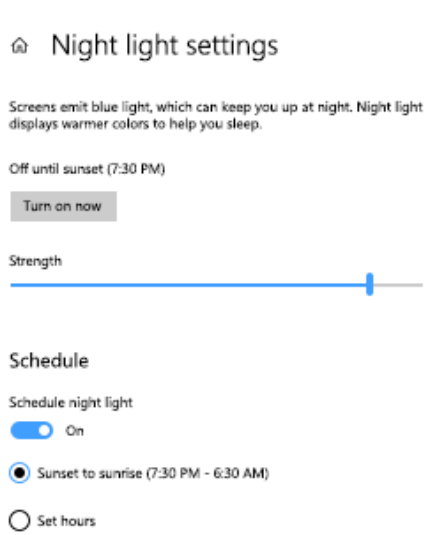
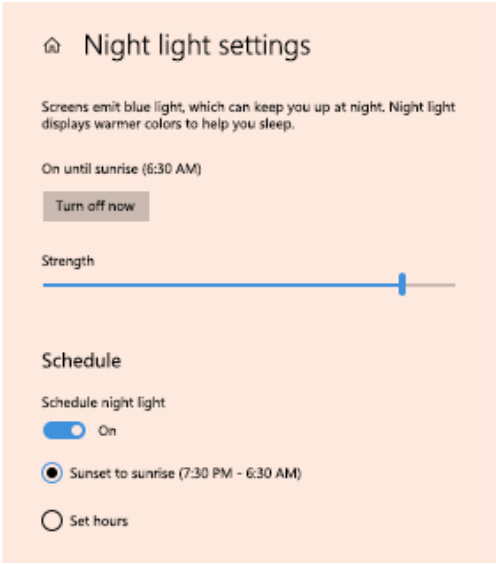
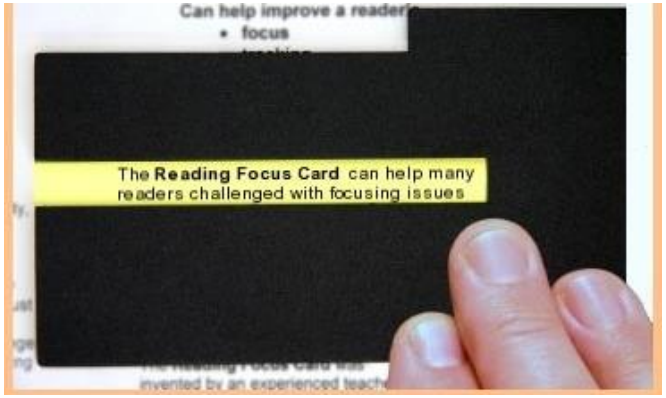
Modify environment to reduce light and limit visual stimulation









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Perception

- Defined as a way of regarding, understanding, or interpreting something; the ability to see, hear, or become aware of something through the senses (Oxford Languages)
- The organization, identification, and interpretation of sensory information, involving signals moving through the nervous system.
- Each person's perception and response are in part based upon their previous experiences, how they interpret and understand exteriorly presented information, and their internal response.

- **Perception vs. Sensation**
  - **Sensation:** defined as the detection of information from the environment

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Perception – the 5 types

There are 5 different types of Perception:

- Auditory - information presented to the ears
- Tactile – information presented to the skin and muscles
- Visual - information presented to the eyes and visual system
- Olfactory – information presented through smell
- Taste – information presented orally

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Auditory Perception

- Appreciating and understanding sound presented to the ears

- Sound comes in different presentations:
  - Vibration (i.e. anticipatory response of an alarm)
  - Inflection (question, statement, alarm, secretive)
  - Intensity (loudness/quietness in response to different situations, pitch)

- What influences auditory perception?
  - Poor or distorted hearing (difficulty hearing different pitches of sound)
  - Receptive Aphasia (impaired ability to understand auditorily presented information)
  - Decreased appreciation of inflection and tone

Impact of Impaired Auditory Perception

- Impaired auditory perception can influence:
  - Understanding of basic communication by a speaker
    - Decreased recognition and subsequent response to situations (i.e. decreased awareness of when an emergency is occurring and initiating the appropriate response)
      - Impaired auditory processing may delay understanding of what is being heard and initiating the appropriate response.
  - An ability to socialize and maintain meaningful interactions with familiar listeners (i.e. friends, family members) or novel partners (i.e. ability to interact with others in community settings to get needs met)
    - Decreased ability to follow instructions necessary to complete tasks (i.e. work, therapy, social situations)
    - May be erroneously perceived as intentionally not listening, being non-compliant, or intoxicated (i.e. drunk, on drugs).

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Tactile Perception

Appreciating different types of sensation and position of the body

- Light touch/sharp, pressure, temperature (sensory), vibration/tapping
- Location(s) of touch on the body (2 point discrimination)
- Position of body in space (proprioception)
- Right vs. left discrimination (being aware right vs. left side of the body)
- Relationship to other people and objects in the environment (spatial relations)

Impact of Impaired Tactile Perception

- Impaired movement or position of the body (tactile awareness) can influence:
  - Awareness of a person's midline posture
    - To maintain upright balance needed for sitting, standing, walking, running, etc.
  - Spatial relations - Awareness of oneself relative to other objects
    - Prevent bumping into items, slamming doors on fingers
    - Awareness of part of body in contact with another item (prevention of burns)
  - Ideomotor apraxia – difficulty motor planning movements, organizing items on oneself
  - Ideational apraxia – difficulty recognizing and understanding the function or how to use an object
- Impaired awareness of one's body in space relative to another person can also impact their relationship and awareness of appropriate social distancing or non-verbal responses
  - Not perceiving social cues (indicative of anger, confrontation) could lead to escalation of circumstance

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Visual Perception

- Appreciating and understanding information presented through the eyes
  - Ability to detect light and dark, colors, movement around the body
  - Differentiation of shapes, letters, symbols
- Impaired visual perception can influence:
  - Poor detection of visual information identifying hazards (i.e. red= stop, green = go, flashing lights, visual signage with printed words, pictures, or shapes)
    - This may result in delayed processing and opportunity for unsafe conditions to develop

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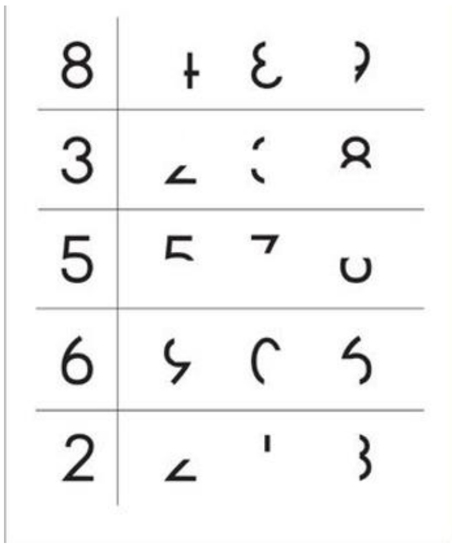
Visual Perception Examples

- Deficits in:
  - **Visual closure** – the ability to recognize a whole when given incomplete information or a partial image
    - May lead to lack of recognition of items if a portion of the image is obscured or missing
    - Poor or slowed reading and/or math (i.e. impaired ability to recognize sight words, impaired ability to recognize numbers influencing calculations)
    - Delay in making inferences (i.e. in an emergency situation)
  - **Visual memory** – the ability to recall information that has been viewed in the past
    - may influence overall recall of information and application in different circumstances
  - **Form constancy** – consistently recognizing items even when presented in different forms, colors, alignment, shape, etc.
  - **Figure Ground** – discriminating between background and foreground; important for depth perception, reading
    - Discriminating between a white object on a white tablecloth
    - Locating a certain item in a refrigerator, cabinet, shelf in the store



Can You Read This:

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Visual Perception Examples

Impairments in visual perception may also directly influence socialization/interaction with others due to difficulty in recognizing faces

- COVID-19 has warranted mask wearing, impacting visual recognition, as well as appreciation of emotions
- May result in withdrawal from meaningful occupations, depression, and isolation, as well as impaired emotional response or matching emotion with auditory response.

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Olfactory Perception

- Appreciating information through smell
  - Recognizing differences between positive (good smells) vs. negative (potentially hazardous smells)
- Impaired olfactory perception can influence:
  - a person's initiation to eat or may result in over-eating if all smells are perceived as positive
    - Smells often evoke memories and influence mood; association with positive smells may also improve recall.
  - a person's ability to recognize and react to hazards (i.e. impaired recognition of smoke of any kind, hazardous chemicals or materials, over-dated or spoiled food items)

Taste Perception

- Appreciating solid food and liquids by mouth
  - Recognizing different textures and being able to be aware of the position of the food/liquid in the oral cavity
  - Recognizing temperature differences
- Impaired taste perception can influence:
  - Interest/initiation to eat and maintain hydration
    - Food groups may be neglected, resulting in weight loss/gain, improper balance of food groups, difficulty following swallowing restrictions
  - Social withdrawal if food is no longer of interest
    - Difficulty with socialization due to restriction of diet or need to thicken liquids for aspiration prevention
  - Impaired feedback about temperature and food position in the mouth could lead to scalding if eating/drinking hot items or aspiration if unable to prevent food/liquids from being prematurely swallowed
  - Impaired perception of texture may impact the force upon which food or liquid items are masticated or swallowed (i.e. using a straw on a thin vs. thickened liquid; chewing a soft vs. textured food item)

Perception - Summary

- Injury or damage to any of the 5 perception types can result in significant functional and safety impairments.

- Vision, perception, cognition and vestibular systems are very inter-related and the impact is rarely found in isolation.

- Identifying the perceptual deficit and targeting that component during treatment will likely require repetition and carryover by other disciplines (i.e. Occupational, Physical, and Speech therapy) to fully address

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Cognition

- Post concussive symptoms bridge not only physical systems, but also cognitive areas. These areas are all densely related and build on one another.

Building Blocks of Cognition
Attention (selective, sustained, alternating, divided) & processing speed
Perception (organization, identification, interpretation of sensory information)
Memory (recall of learned patterns or associations)
Sequencing (procedural knowledge, such as using a fork to eat; understanding cause and effect, being able to put things in order)
Problem Solving and Reasoning
Executive Function (self monitoring, ability to execute and carry out a given plan)

- *all levels work in tandem to create our experience and are mediated and enriched by language; for example, we need to be able to encode memory, pull it from our memory banks, and turn it back into language or symbols to communicate our experience. Thus, aphasia, or language impairment, whether receptive or expressive, is common with brain injury.

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Attention

- Attention (ability to mentally focus that is time dependent and limited by cognitive processing)
  - Often accompanied by increased distractibility and impulsivity
  - Decreased concentration and focus
  - Can be interrupted by anxiety, depression, vestibular dysfunction (reduced balance or tinnitus), visual impairments, overstimulation, pain, and decreased sleep quality, which are common aspects of post concussion

  - Chan (2010) study

  - ***"A thing may be present to a man a hundred times, but if he persistently fails to notice it, it cannot be said to enter his experience."*** *–Williams James in his book Psychology: The Briefer Course.*

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Perception and Cognition

5 Stages of Perception

1. **Stimulation:** selective attention
2. **Organization:** organizing information into schemas
3. **Interpretation:** making decisions and associations between schemas
4. **Memory:** storage of organized events and experiences
5. **Recall:** reconstructing what was learned

- **Perception moves in at least 2 directions**
  - **Bottom-up processing:** perceptions are built from sensory input.
  - **Top-down processing**: how we interpret sensation as influenced by our available knowledge, experiences, and thoughts.

- The impact of post concussive syndromes
  - Altering and reducing speed of processing sensory input, slowed processing speed
  - Increasing the potential for anxiety, depression, and irritability
- Supported in the literature: (McAllister & McCrea, 2017)

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Perception

- Deficits in physical perception create increased strain on systems and result in cognitive fatigue.

Support in the literature: Marion et al (2009), Jonasson A et al (2018).
https://onlinelibrary.wiley.com/doi/epdf/10.1002/hbm.20709
https://onlinelibrary.wiley.com/doi/10.1002/brb3.1056

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Memory and Post Concussive Symptoms

- PURR
- PERCEIVE (attention, perception)
- UNDERSTAND (identify, organize, internalize)
- RETAIN (encode in short term and long term memory as needed)
- RETRIEVE (sequence, problem solve)
  - Types of memory most affected by post concussion: short term and working memory, which includes the sensory register, the memory system that stores information received from our visual, auditory, and tactile receptors.
- Retrospective: memory of people, words, and events encountered in the past
- Prospective: remembering to do something after a delay

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Memory, Sleep, and Headaches

- 2 significant findings:
- Reports of sleep symptoms were found to be significantly associated with poor performance on memory tests.
- Individuals reporting headache symptoms had significantly worse performance on both the memory and attention/processing tests compared to those not reporting any headache symptoms.
- Guty, E., & Arnett, P. (2018). Post-concussion Symptom Factors and Neuropsychological Outcomes in Collegiate Athletes. *Journal of the International Neuropsychological Society, 24*(7), 684-692.
- https://doi.org/10.1017/S135561771800036X

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Memory and Emotion

Pe ML, Raes F, Kuppens P. (2013)

- Working memory and executive function has not only been associated with emotional regulation, but also with modulating, or regulating, the memory of emotionally charged events (N=221 neuro-typical psychology students)
  - Rumination: repetitively thinking about negative feelings, their possible causes, meanings, and consequences; linked to impaired problem solving and prolonged emotional distress
  - Reappraisal: taking on a different perspective when reviewing events to lessen the emotional impact of what occurred; associated with increased positive emotions and better well-being
    - Reappraisals are updates of negative thinking to decrease the maladaptive consequences of rumination
- Found that those who were better at updating emotional information (or accommodating new information) in working memory experienced decreased levels of high emotional arousal when ruminating, and more effective decrease in high arousal negative emotions when they reappraised

https://doi.org/10.1371/journal.pone.0069071

Executive Function

- PRISM
  - PLAN
  - REGULATE
  - INITIATE &
  - STOP actions
  - MONITOR
- Reasoning and problem solving skills can be impacted as well
- Can be subtle or blatant
- Aaron Hernandez: https://www.washingtonpost.com/sports/aaron-hernandez-suffered-from-most-severe-cte-ever-found-in-a-person-his-age/2017/11/09/fa7cd204-c57b-11e7-afe9-4f60b5a6c4a0_story.html
- "In our collective experience…individuals with CTE — and CTE of this severity — have difficulty with impulse control, decision-making, inhibition of impulses for aggression, emotional volatility, rage behaviors."

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Post-concussion and Aphasia

- Aphasia after a concussion is often temporary, but can last for months, years, or even become a lifelong issue
- Symptoms may include expressive and/or receptive aphasia, or anomia (word finding difficulties)
- These fall under the umbrella of cognitive-communication deficits, which include changes in word finding, executive function, reading comprehension, written expression, and social skills

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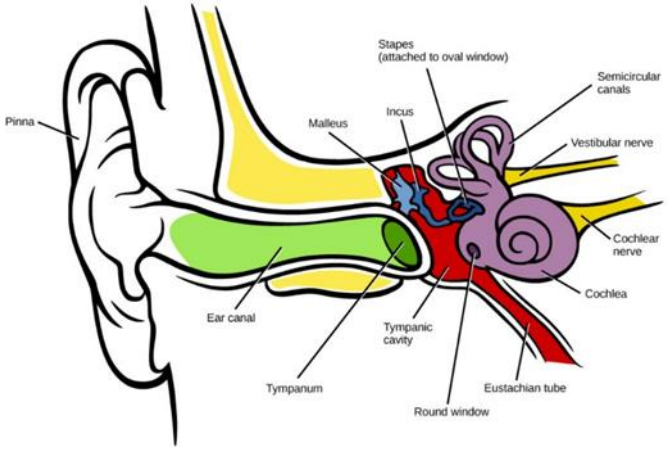
Vestibular System

- The sensory organs of balance (aka vestibular system) are located in each inner ear or labyrinth
- There are three main systems for balance: 1. Vision (Eyes) 2. Somatosensory (Feet) 3. Vestibular(Ears)
- All three systems must work together to maintain Postural Control and Balance.



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Balance Systems

- The vestibular system (Ears) provide the central nervous system with information about the movement and position of the head with respect to gravity and inertial forces.

- The somatosensory (Feet) input from the extremities and spine provide information about the support surface and in what segmental position the body is in. It is especially sensitive to fast movements

- Vision (Eyes) orients us to the environment and provides info about slow movements or static tilts of the head with respect to the visual field

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Vestibular Symptoms with Post-Concussive Syndrome

- Dizziness/Vertigo/Light Headedness
- Decreased Balance
- Decreased functional activities
- Nausea

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What to do?

- Screening: Berg Balance Test, Dynamic Gait Index, Vertebral Artery Test, Dix Hallpike Test
- Begin treatment
  a. Epley Maneuver
  b. Habituation exercises
  c. Education on strategies for managing dizziness
- Refer to an ENT

Your daily walk should not be the challenging part of your day—if you feel challenged to keep your steadiness, then change the way you are moving using your head, feet, or eyes. On days where your dizziness is extremely bad and you feel very unsteady, you can use your assistive device.

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Resources

BIA Brain Injury Association
https://www.biausa.org/

www.pinkconcussions.com/

https://www.pinkconcussions.com/expert-videos
John Leddy video (under Female Athletes)

Neuro-Optometric Rehabilitation Association
https://noravisionrehab.org/

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Questions?

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