

# Neuropsychology of concussion

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Until every child is well™



**HARVARD MEDICAL SCHOOL**  
TEACHING HOSPITAL

# Disclosure statement

- *Co-founder of Gamify, Inc*
- *Consultant for Major League Soccer*

# Objectives

- Define neuropsychology and outline the process of assessment
- Describe the risks for prolonged recovery

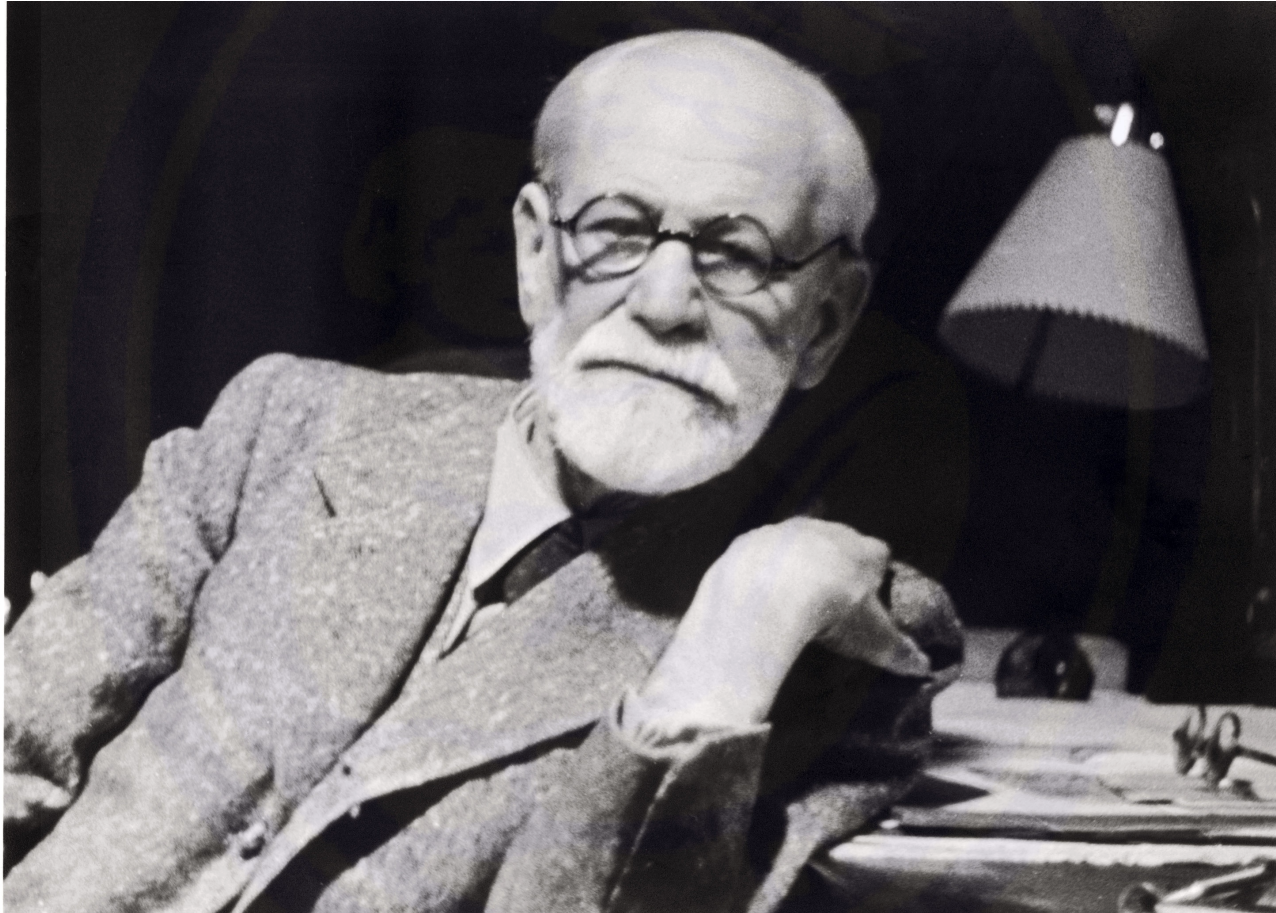
# Do you know why you're here to see me today?

- I crashed.





# What is a neuropsychologist?



# Sport neuropsychology

- Evaluate symptoms, cognitive functioning, and psychological health to monitor recovery and provide interventions or rehabilitation strategies following sport-related brain injury.

# Rationale for assessment

- Objective measurement of function allows for more reliable detection of cognitive impairment as well as reasons for it
  - s/t the absence of self-reported symptoms
  - 53% high-school football players (n = 1,532) failed to report concussion (McCrea et al., 2004)
    - Injury not serious enough
    - Not wanting to be removed from play
    - Lack of awareness
  - Symptoms not specific to concussion
    - Dehydration, anemia, fitness

# Assessment process for concussion

1. Demographics/History
2. Establish diagnosis
  - Is concussion a clear diagnostic entity
3. Determine the temporal sequence of events
  - Empathetic, active listening
  - Note changes over time, modifying events
4. Symptom assessment
  - Consider development
  - Informant input
  - Consistency (do symptoms only occur during “less fun activities”?)

# Assessment process

## 5. Tools

- Cognitive
- Behavioral
- Emotional
- Personality (sometimes)

# Assessment paradigms

## Paper and pencil (traditional)



- ☒ solid norms for peds
- ☐ Limited access
- ☐ Cost
- ☐ Time / labor intensive

## Computerized



- ☒ Capacity to test large #s quickly (baseline)
- ☒ Access
- ☒ Alternate forms
- ☒ Reaction Time
- ☒ Automatized scoring
- ☒ Language
- ☐ Questionable norms for peds
- ☐ Psychometric properties-Reliability/Validity

## Hybrid

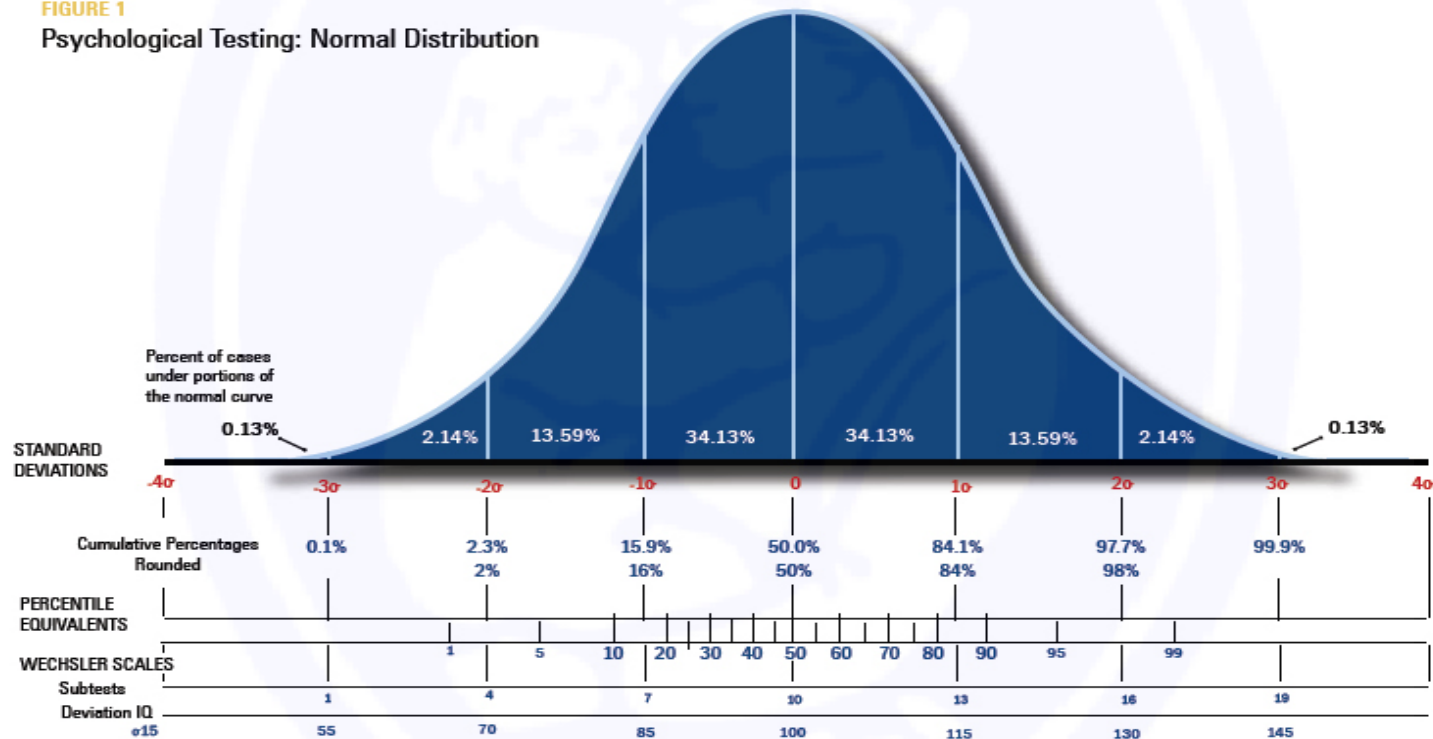


- ☒ *Professional / college model*
- ☒ Paper/pencil & computerized
- ☒ Include behavioral measures

# Normative comparison

**FIGURE 1**

Psychological Testing: Normal Distribution



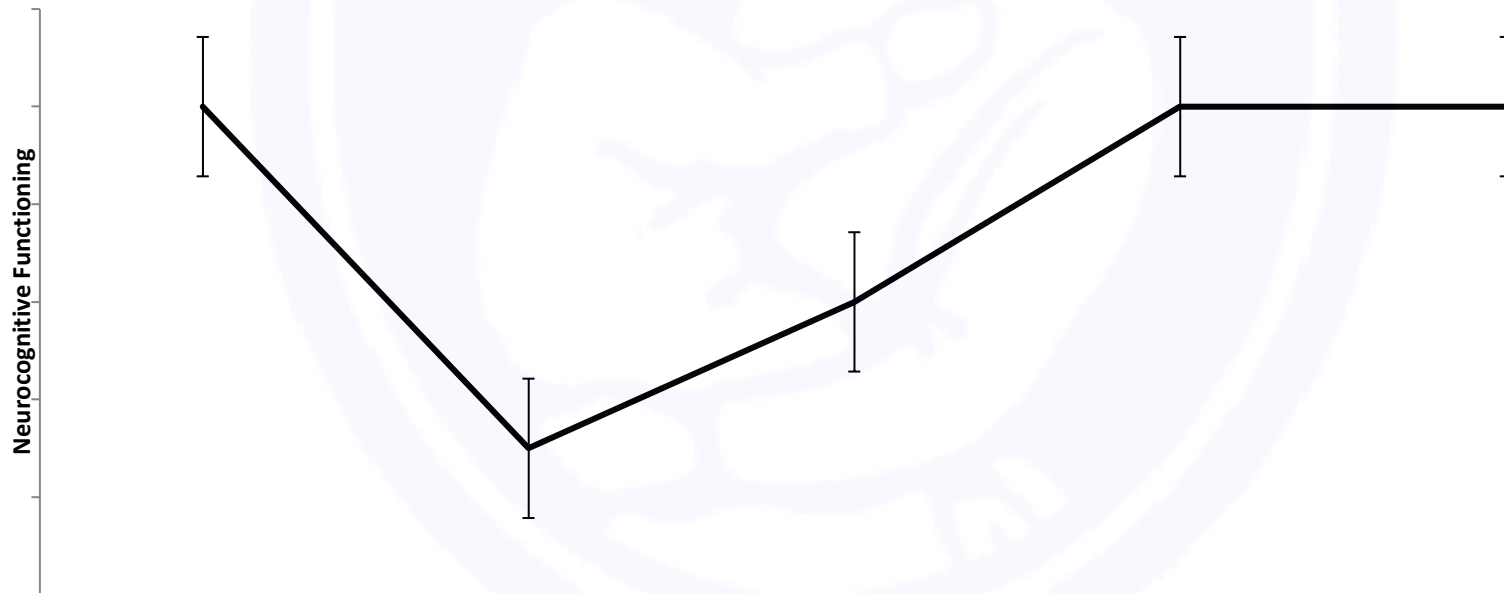


# Baseline comparison

Baseline

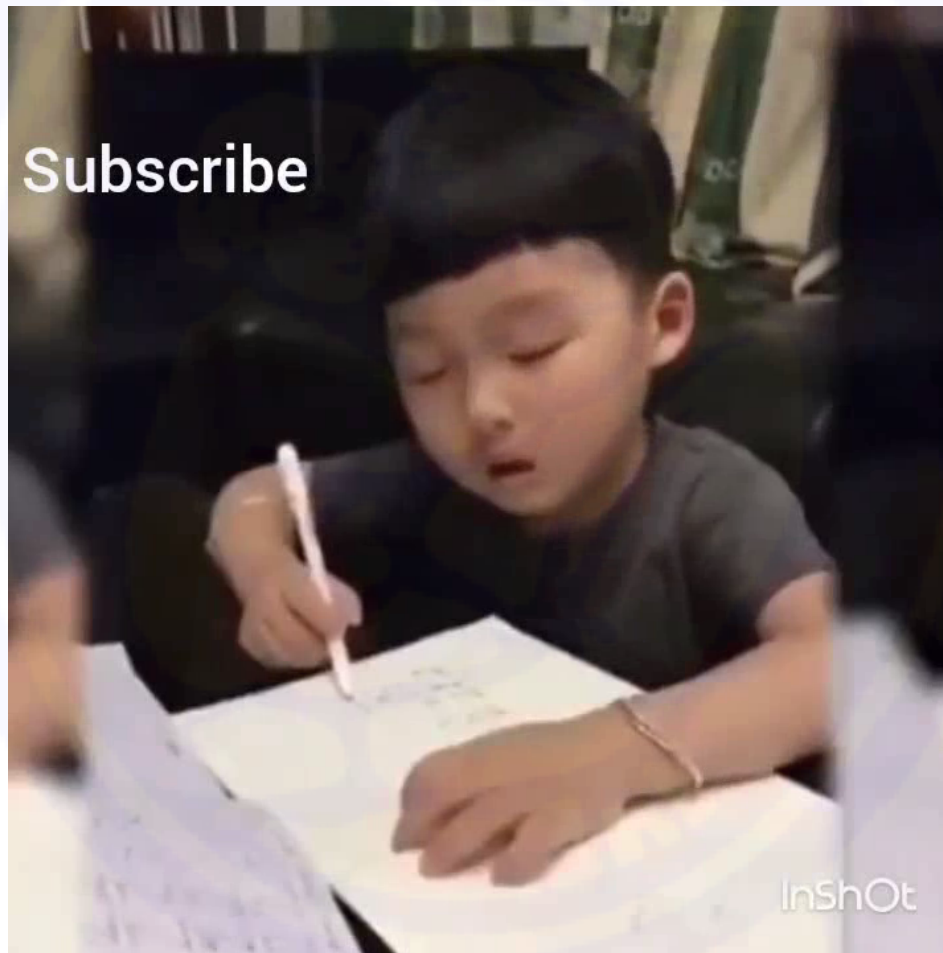


Post-injury //  
clearance





# Interpretive considerations



# Interpretive considerations

- Consider
  - Setting (e.g., group, office)
  - Distractions
  - Time of day
- Arousal / fatigue
- Level of engagement / motivation
- Anxiety / mood
- “Sandbagging” – Performance validity
  - 12% pediatric population provide non-credible effort (Kirkwood et al., 2014)

# Neurocognitive findings

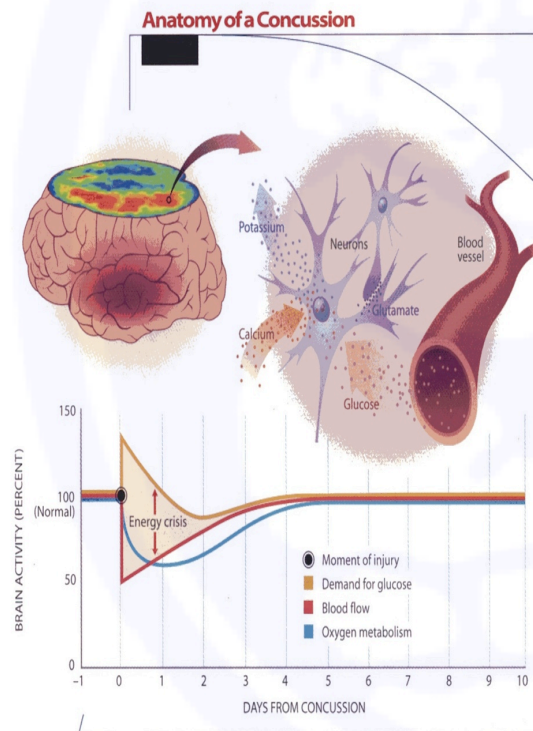
- Areas that are particularly vulnerable
  - Attention / concentration
  - Working memory (online memory)
  - New learning & memory: storage / retrieval
  - Processing speed
  - Reaction time

# Intervention

- Psychoeducation
  - Set realistic expectations
- Healthy brain activities
  - Hydration, nutrition
  - Sleep
  - Stress
  - Exercise
- Cognitive behavioral strategies
  - Concrete, achievable strategies & goals to build self-esteem and sense of control
- AND THEN, **individualized** targeted therapies

# Sensible rest

## Metabolic mismatch



## Exertional effects

- Classroom / school: ↑ demands on the brain
- Exacerbates metabolic mismatch and diverts resources necessary for recovery away from injured cells

# ***“Overdosing” on cognitive rest?***

- Utility of full rest > 3 days questionable (Silverberg & Iverson et al., 2012)
- Prolonged/ elevated symptoms in patients prescribed 5 days of rest following concussion (Thomas et al., 2014)

## **Considerations**

- Standard school year = 180 days
  - 2-week absence = 5% school year or 22% qtr
  - 37% of CPS students who missed 5-9 days of school did not graduate in 4yrs (Allensworth & Easton, 2007)



# Typical injury

## Physical



- Headache
- Nausea
- Audio/photo-sensitivity
- Neck pain

## Cognitive



- Attention
- Processing speed
- New learning & memory

## Vestibular/Visual



- Dizzy
- Off-balance
- Blurred vision
- Tracking

## Emotional



- Sad
- Irritable
- Anxious
- Depressed

## Sleep-related



- Hypo/hypersomnia
- Fatigue

# Factors affecting risk & recovery

- Acute markers
  - Initial symptom score likely best predictor
  - Prolonged LOC / amnesia
  - Multiple collisions / contact prior to removal from play
- Contextual / premorbid considerations
  - Age / developmental
  - Prior concussion
  - Pre-injury symptoms
  - Gender
  - Psychological adjustment
  - ADHD / LD
  - History of migraines
  - Familial



# Developmental considerations

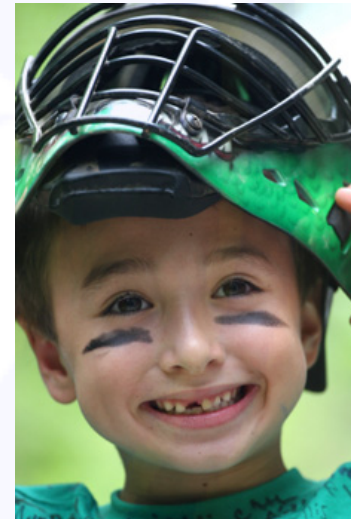
- Brain is not fully developed until around the age of 25

## RELEVANCE

- Stage of development **when injury happened**
- Stage of development **NOW**

# Developmental considerations

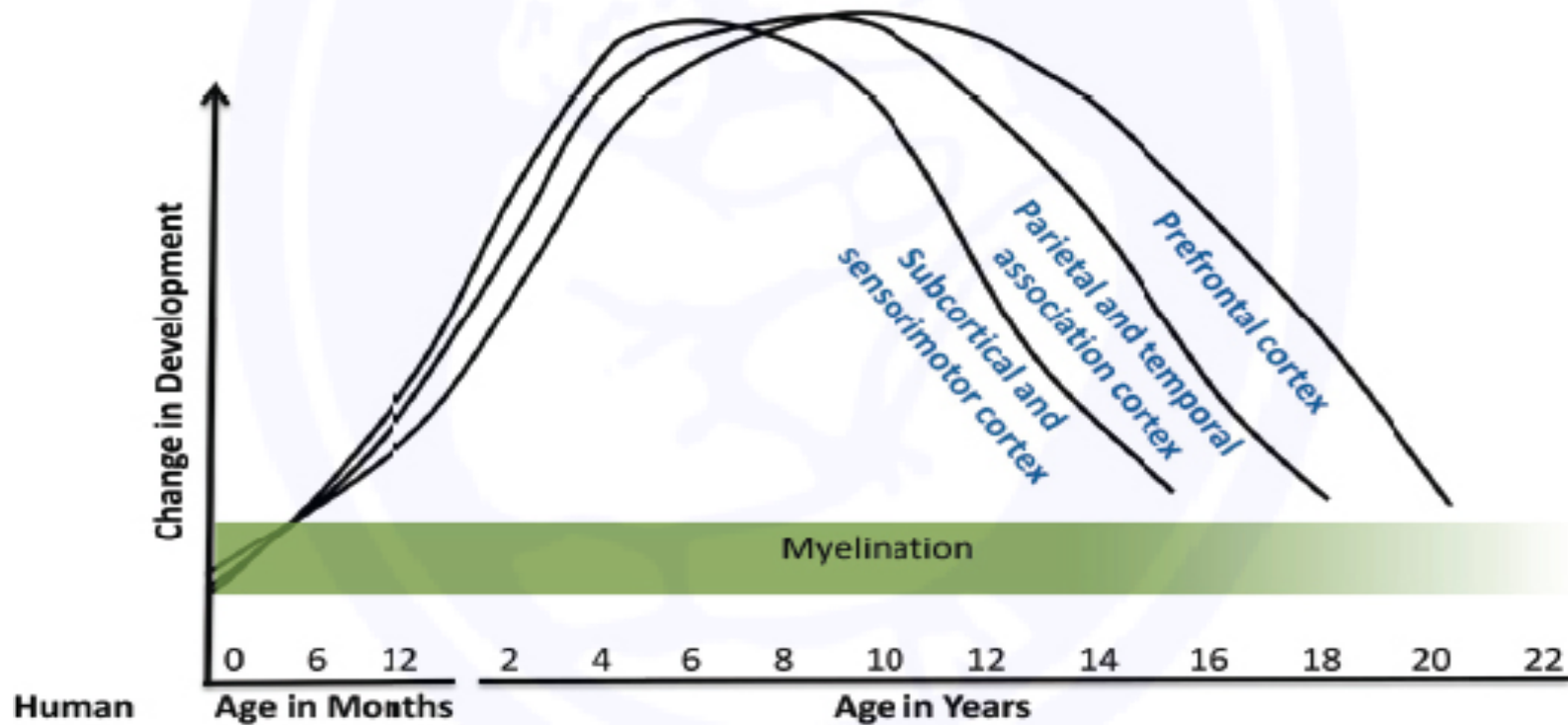
- Brain water content, cerebral blood volume, myelination, skull geometry, and suture elasticity are related to maturation



# Developing brain

## Course of brain development

Regional peak and decline in synapses, cerebral blood flow and metabolism

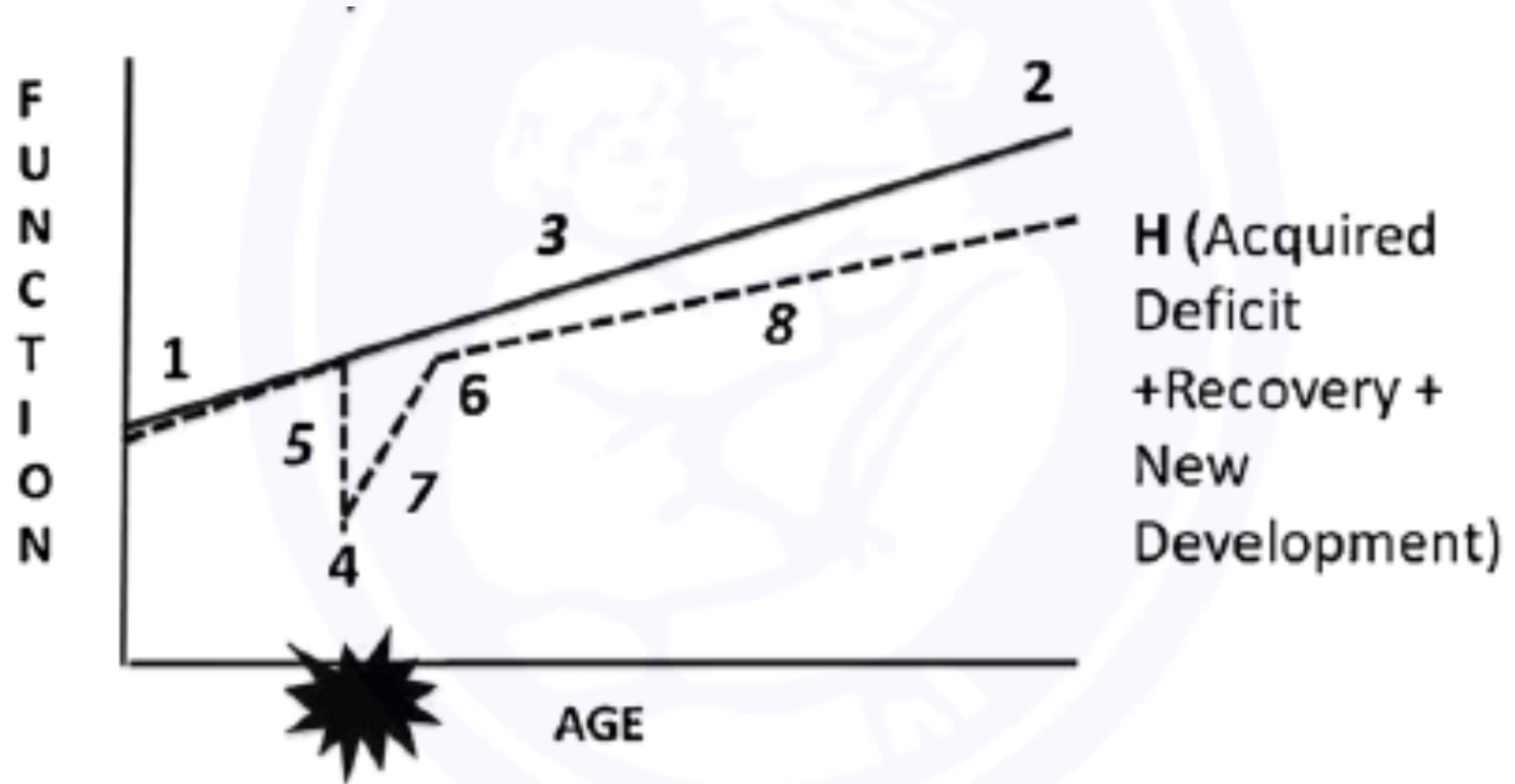


# Trajectory of recovery // Adult



Taylor & Alden 1997

# Trajectory of recovery // Pediatric



Dennis et al, 2014

# Additional considerations



# Individual coping

- Individual response // coping
- Example: **Cogniphobia**

**Instructions:** Please respond to the following statements regarding how you feel about your current/recent headaches by marking the appropriate box. 1 = Strongly Disagree, 2 = Disagree, 3 = Agree, 4 = Strongly Agree

3. My head pain is telling me that I have something dangerously wrong.
4. I worry that when I have to think or concentrate too hard that I will bring on a headache.
7. My headaches put my head & brain at risk for the rest of my life.
10. I'm afraid that I might make my headache pain worse by concentrating too much or being too mentally active.
14. Pain lets me know when to stop concentrating so that I don't injure myself.

# CASE PRESENTATIONS

- 18 year old female
- 16 year old male
- 18 year old male



# Case #1: Neuropsychological consultation

## Referral for DX clarification

- 18 year old female with BPPV and vestibular migraine since 2015 concussion, who describes a new head injury that occurred ~6-7 weeks ago when she turned her head quickly and the visor of her hat struck a shelf
- Current concerns
  - Attention, memory, speed (homework time increased by 2 hrs.)
  - Dizziness
  - Headache
  - Reduced sleep
  - Worries about brain function, but denies feeling anxious
  - School tolerance

## Relevant history

- Occasional migraines around 10 yrs age
- Daily headaches following 1<sup>st</sup> concussion in 5/2015 (field hockey)
- Headaches worsened again after banging head on car door frame
  - Tried on amitriptyline, nortriptyline, topiramate, Medrol dose pack
  - Attempted vestibular PT, prism glasses
  - Evaluated in ophthalmology, neuropsychology, headache clinic, neurology, otolaryngology
- Received counseling around parents divorce at 6 yrs age
- Performs well in school (A/B), but dropped out of AP and has trouble attending consistently
- Parents divorced; lives with father in complicated situation
- Family hx includes anxiety

# CASE #1: Neuropsychological consultation

## Factors affecting risk & recovery

- Acute markers
  - Initial symptom score likely best predictor
  - Prolonged LOC / amnesia
  - Multiple collisions / contact prior to removal from play
- Contextual / premorbid considerations
  - Age / developmental
  - **Prior concussion**
  - **Pre-injury symptoms**
  - **Gender**
  - **Psychological adjustment**
  - ADHD / LD
  - **History of migraines**
  - **Familial**

## Neuropsychological findings

- Healthy appearing adolescent
- *Validity testing: WNL*
- Test results: Attention, executive function, & memory intact
- Significant anxiety and moderate depression on behavioral scales

## Treatment recommendations

- Continue with medical therapies
- CBT
- Exercise
- School

# Case #2: Neuropsychological consultation

## Referral for DX clarification

- 16 year old male with history of multiple concussions, most recently in 11/2017 while playing basketball
- Initial PCSS in Sports Med = 48; then 73 at 2 week f/u
- Started on Zoloft due to concerns about anxiety and mood, but not taking consistently
- Current concerns
  - Headache
  - Dizziness
  - Concentration
  - Feeling slowed down
  - Anxiety & low mood

## Relevant history

- Prior head injuries in March, May, & September 2016; otherwise healthy
- Very strong student
- Family hx unremarkable

# Case #2: Neuropsychological consultation

## Factors affecting risk & recovery

- Acute markers
  - Initial symptom score likely best predictor
  - Prolonged LOC / amnesia
  - Multiple collisions / contact prior to removal from play
- Contextual / premorbid considerations
  - Age / developmental
  - **Prior concussion**
  - Pre-injury symptoms
  - Gender
  - **Psychological adjustment**
  - ADHD / LD
  - History of migraines
  - Familial

## Neuropsychological findings

- Healthy appearing adolescent
- Validity testing: NON-credible effort
- Test results: Well below expectation
- Severe anxiety and depression on behavioral scales

## Treatment recommendations

- CBT
- Exercise
- School

# Case #3: Neuropsychological evaluation

## Referral for DX clarification

- 18 year old male who sustained first lifetime concussion in February 2017, playing hockey. Most symptoms resolved, although slowly, and he returned to play without difficulty ~2.5 months post-injury
- Current concerns
  - Memory
  - Mental foginess

## Relevant history

- Occasional headaches
- Socially and physically active
- Accepted to college engineering program
- Family hx unremarkable

# Case #3: Neuropsychological evaluation

## Factors affecting risk & recovery

- None really, although initial symptoms resolved slowly

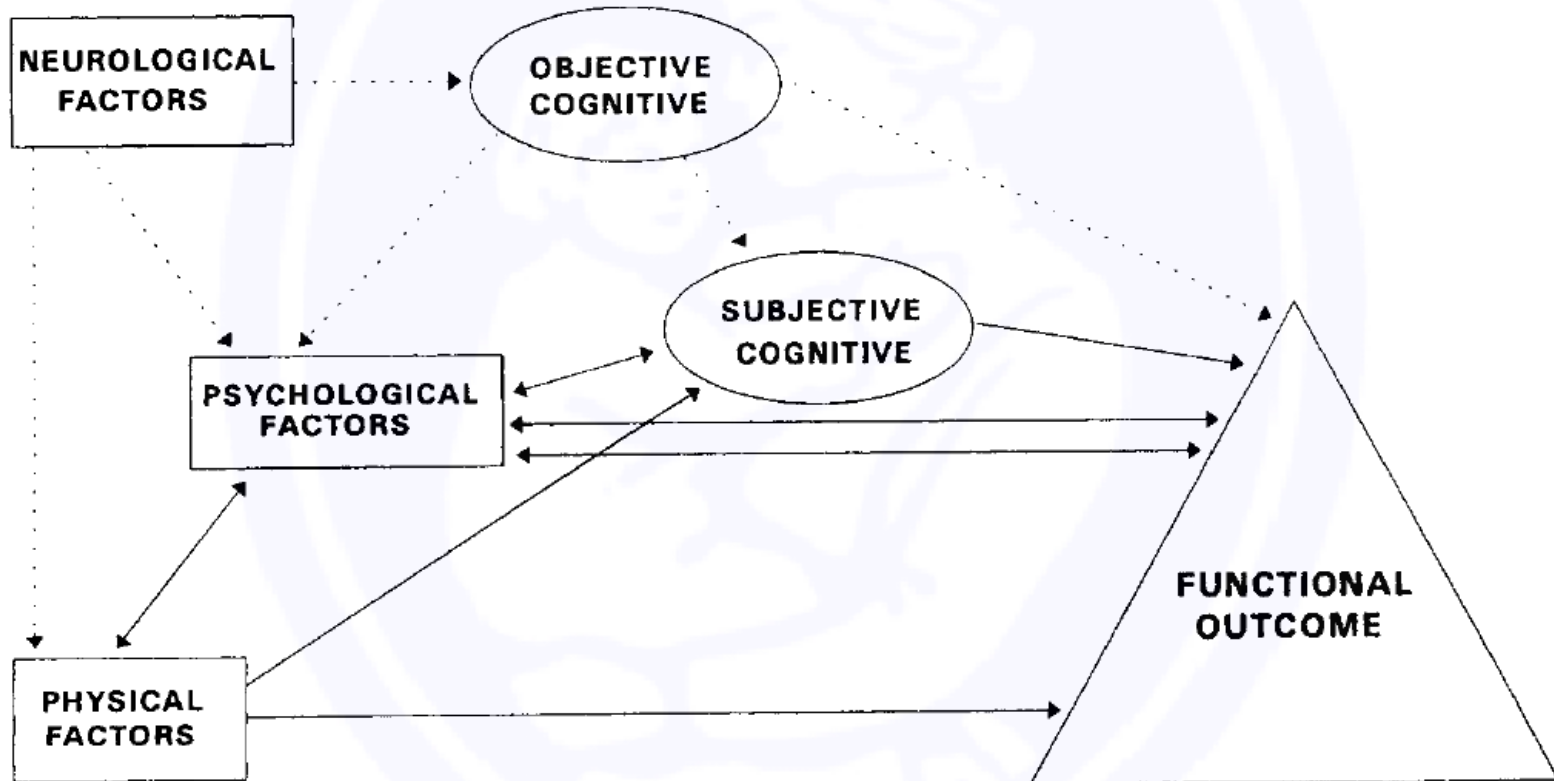
## Relevant history

- Healthy appearing adolescent
- *Validity testing: WNL*
- Test results: **Reduced working memory and auditory verbal learning and memory**
- No elevations on behavioral scales

## Treatment recommendations

- Academic accommodations
- Memory strategies

# Conclusions



Kay et al, 1992

# Conclusions

- Psychoeducation is the primary intervention for concussion at all stages of recovery
- The continued challenge is to identify those who are at greatest risk to prevent persistent symptoms



# Thank you

