Neuropsychological Assessment in Persisting Concussion Symptoms

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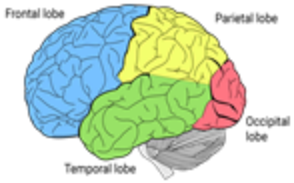
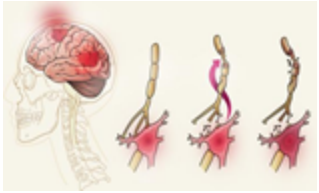
Overview

I. How various regions of the brain contribute to thinking skills

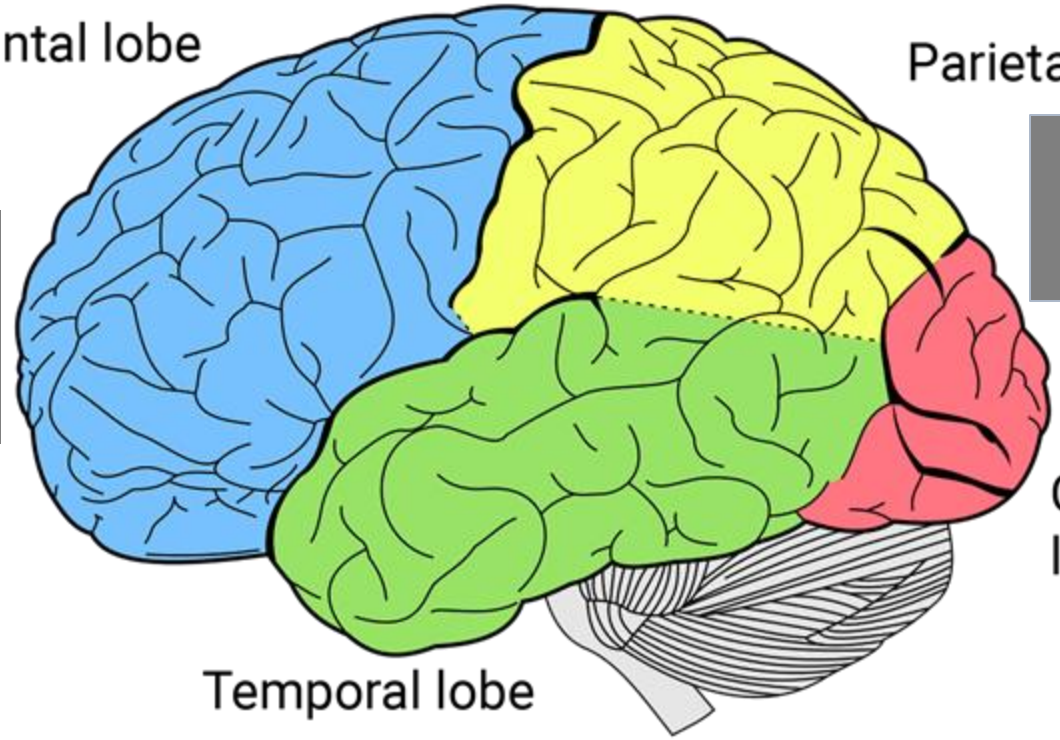


II. How brain injury can impact thinking skills



III. How we evaluate thinking skills in neuropsychology

What is cognition?



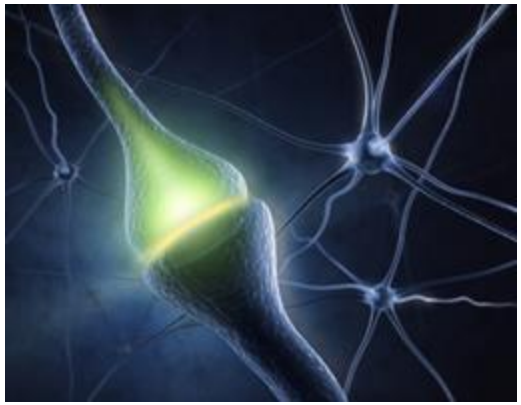
Executive Function

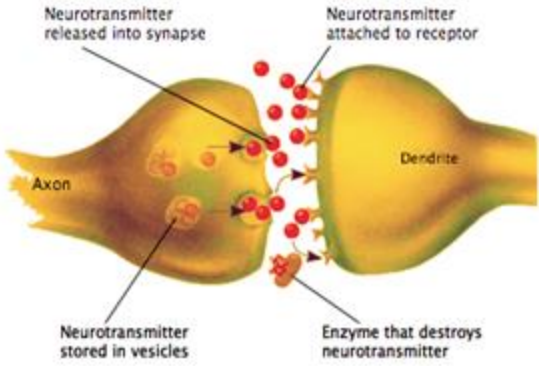
Visuospatial skills

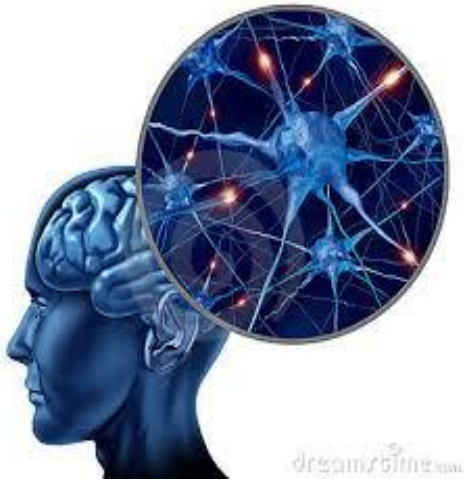
Seeing

Memory & Language

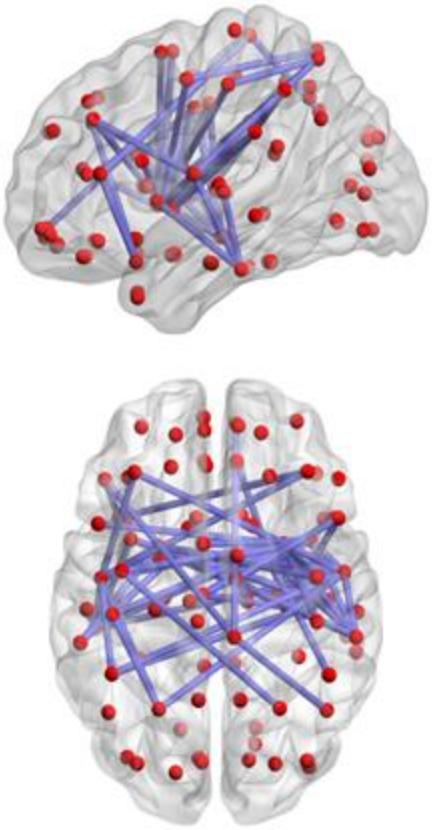
How does our brain produce cognition?



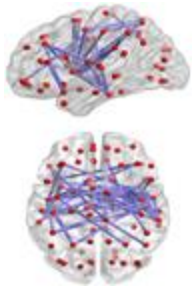




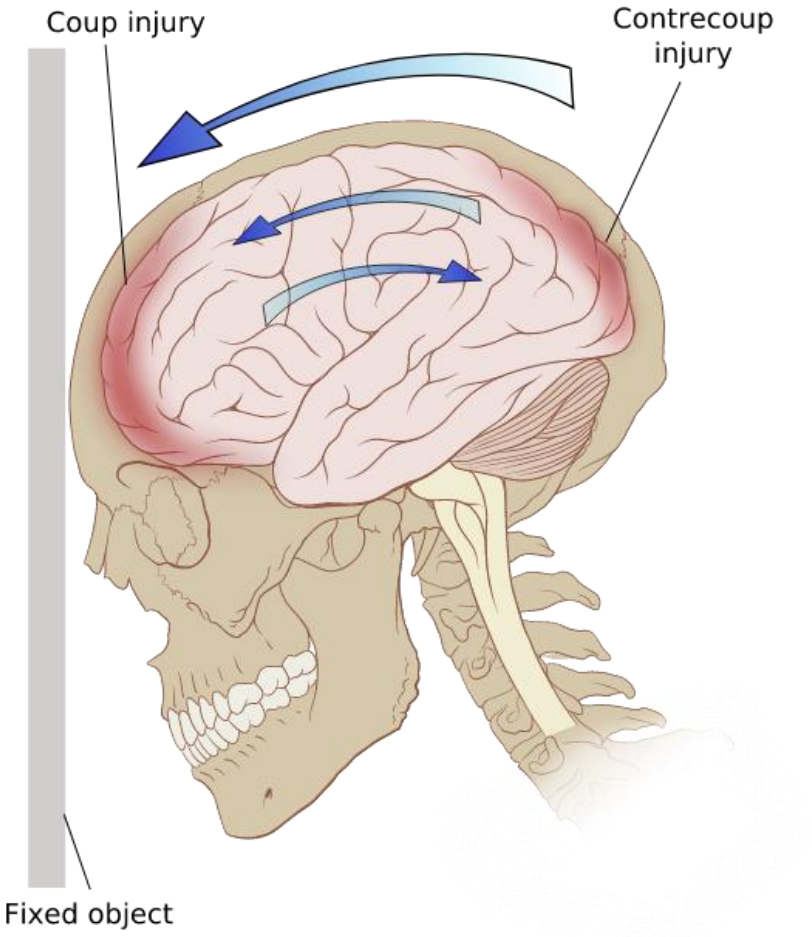
Cognition requires Neuronal Network Activation



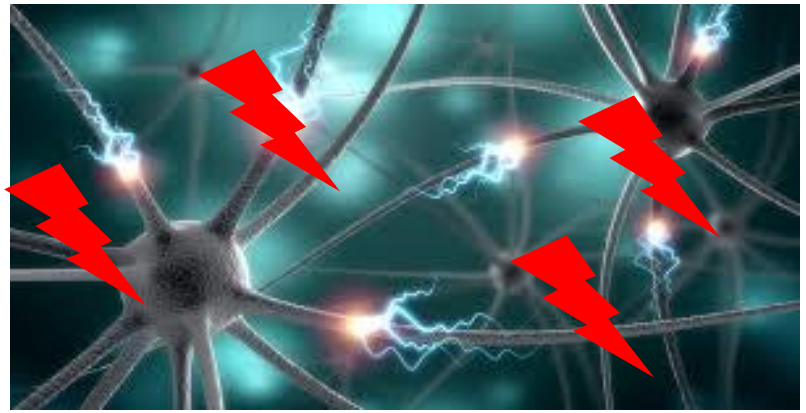
The Brain as a Symphony



What happens if we disrupt the flow of information in the brain?

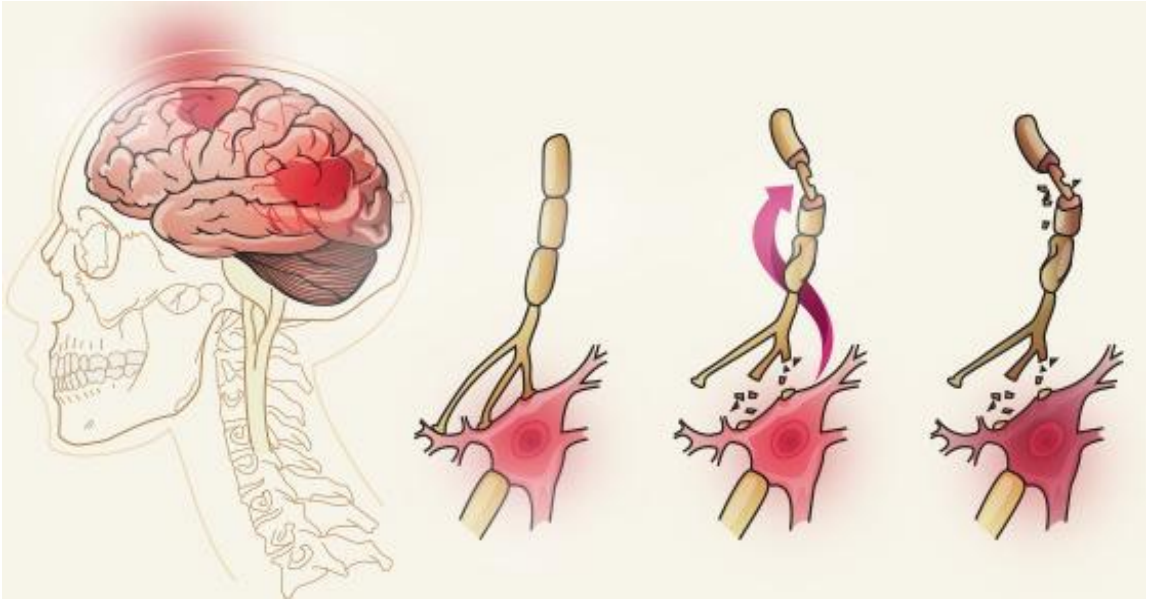


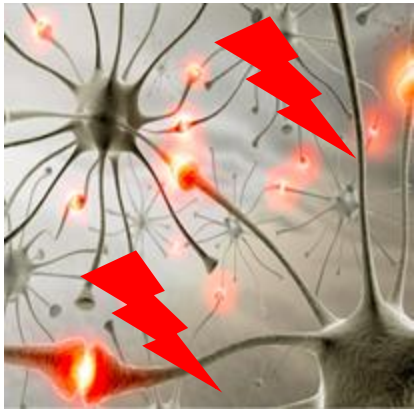
Disrupted neuronal communication



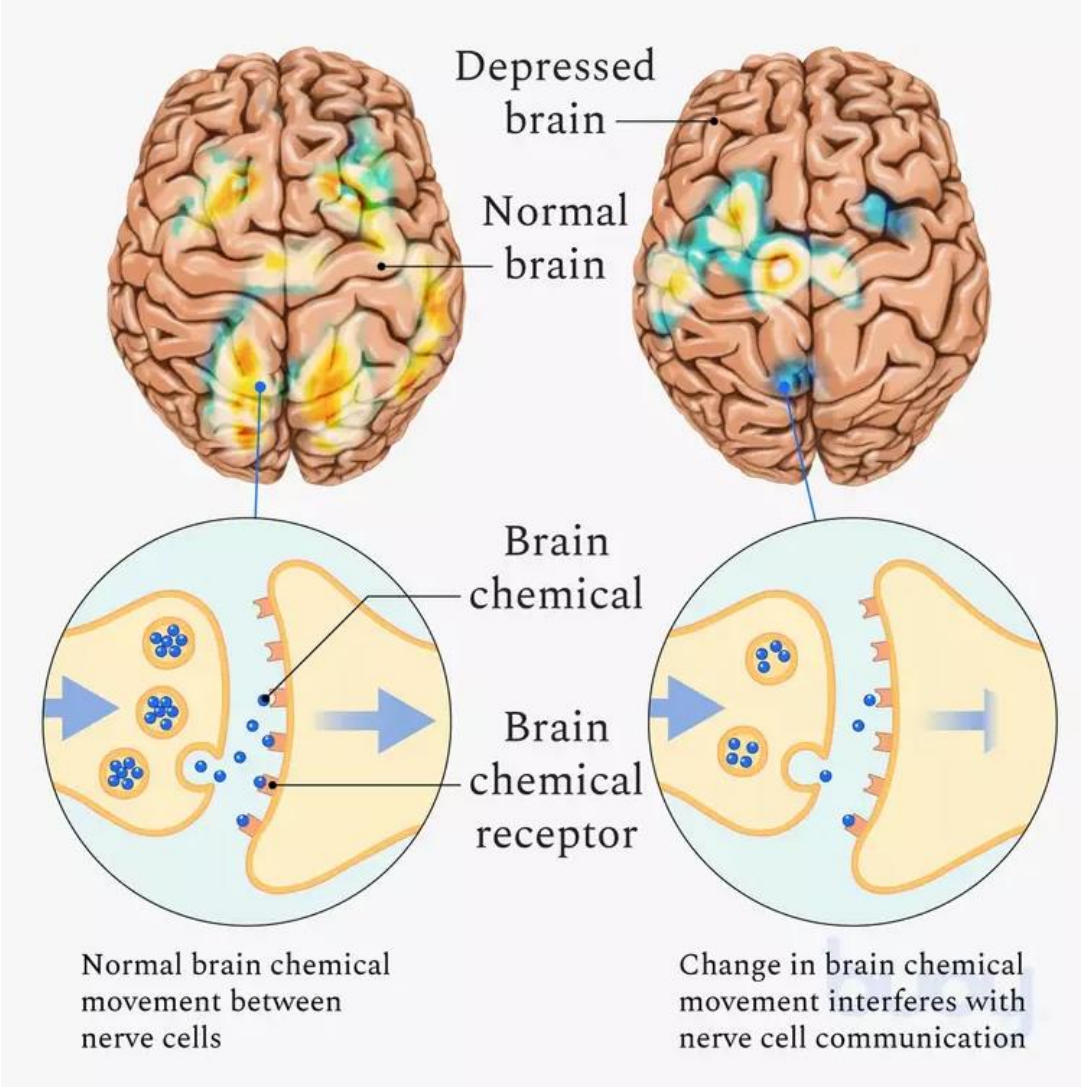
Concussive injuries can damage neurons

Primary damage to neurons





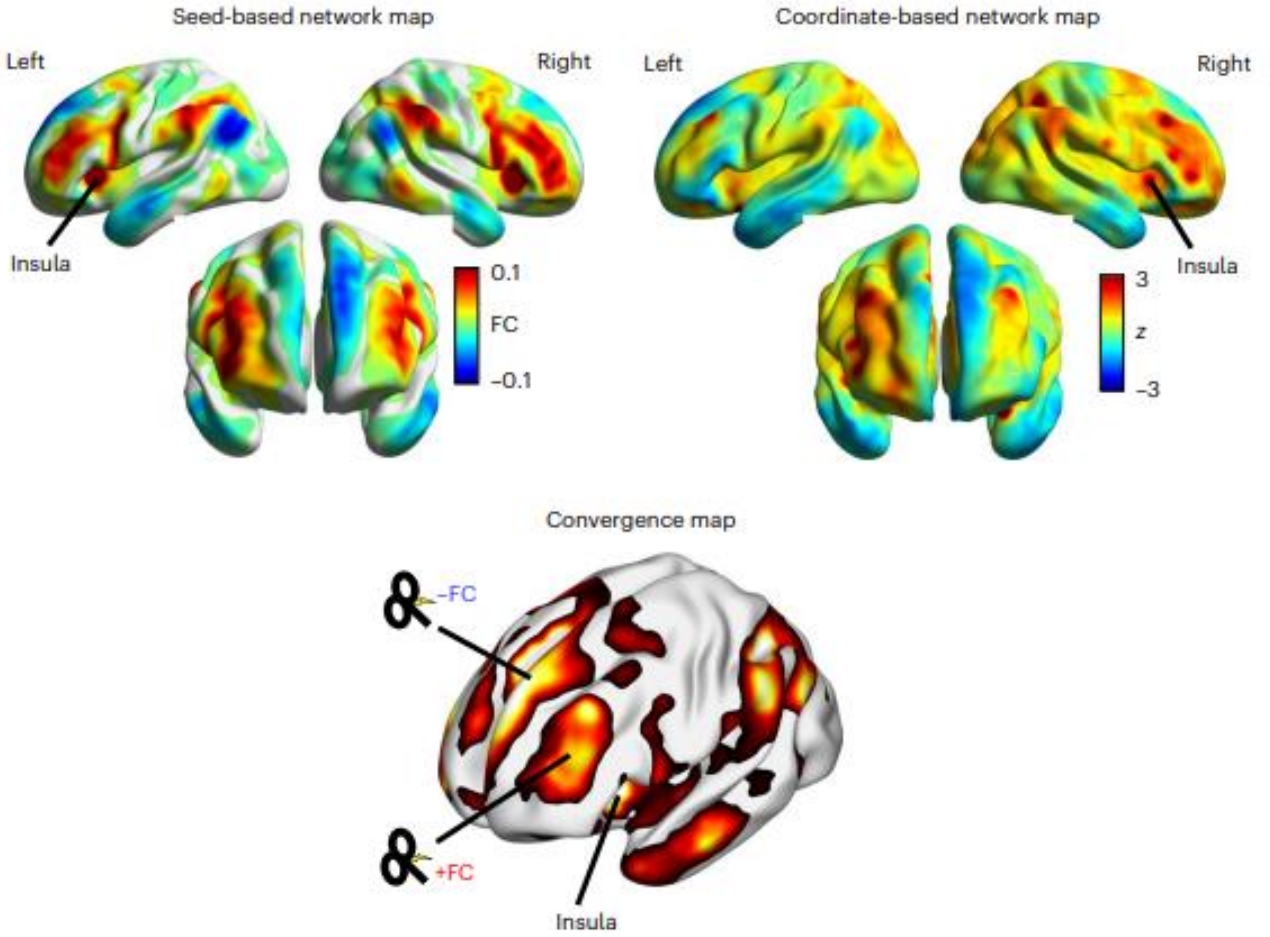
Concussion as a network brain injury

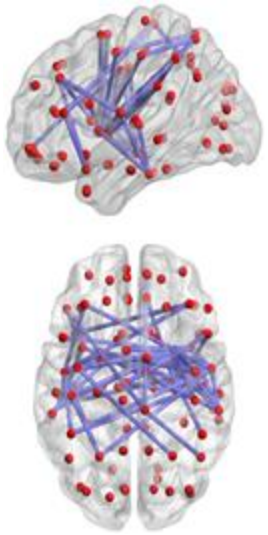


Concussion as a network brain injury

Analysis

https://doi.org/10.1038/s44220-025-00503-6





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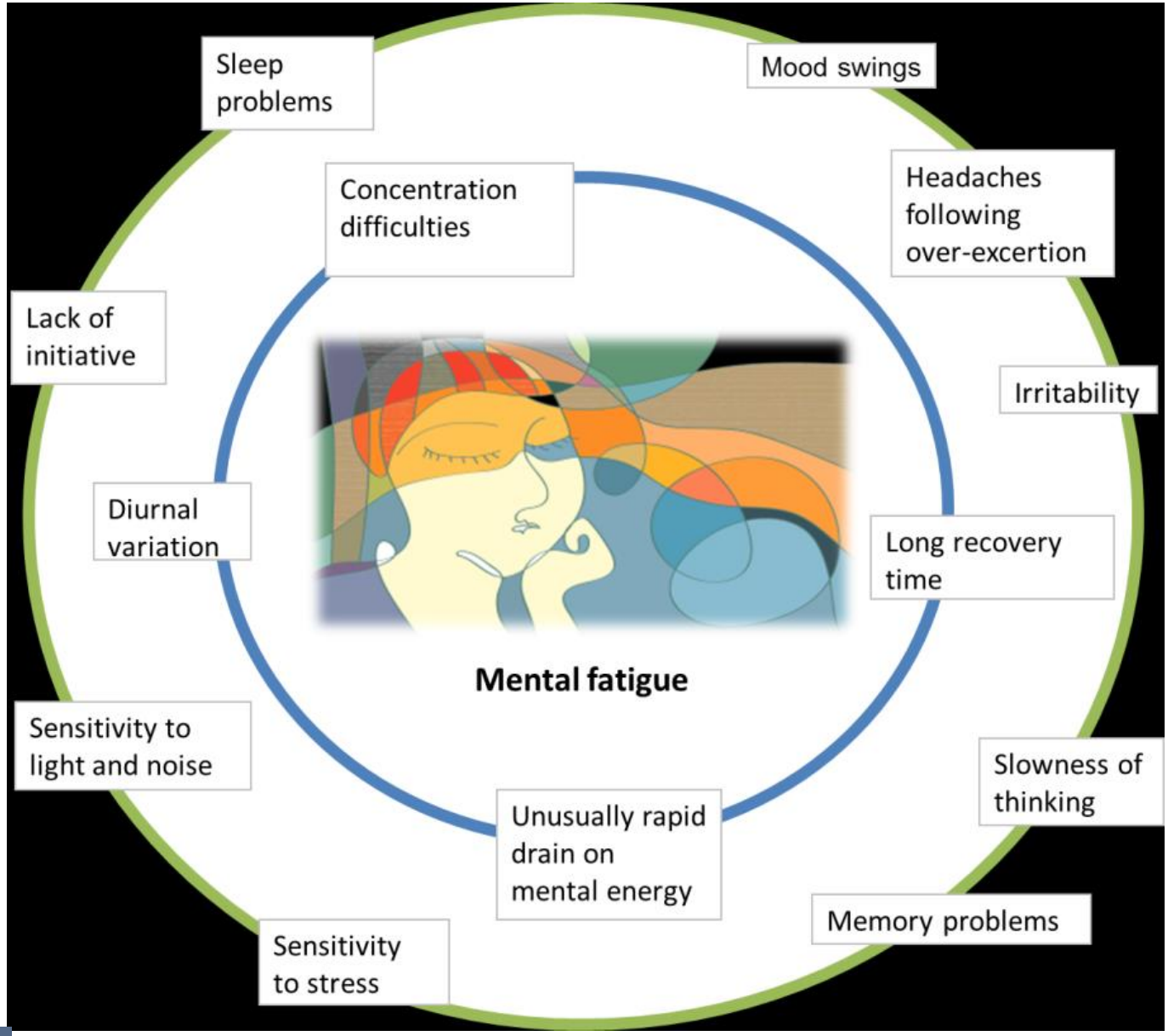
Concussions are multi-faceted



JAMA Network Open

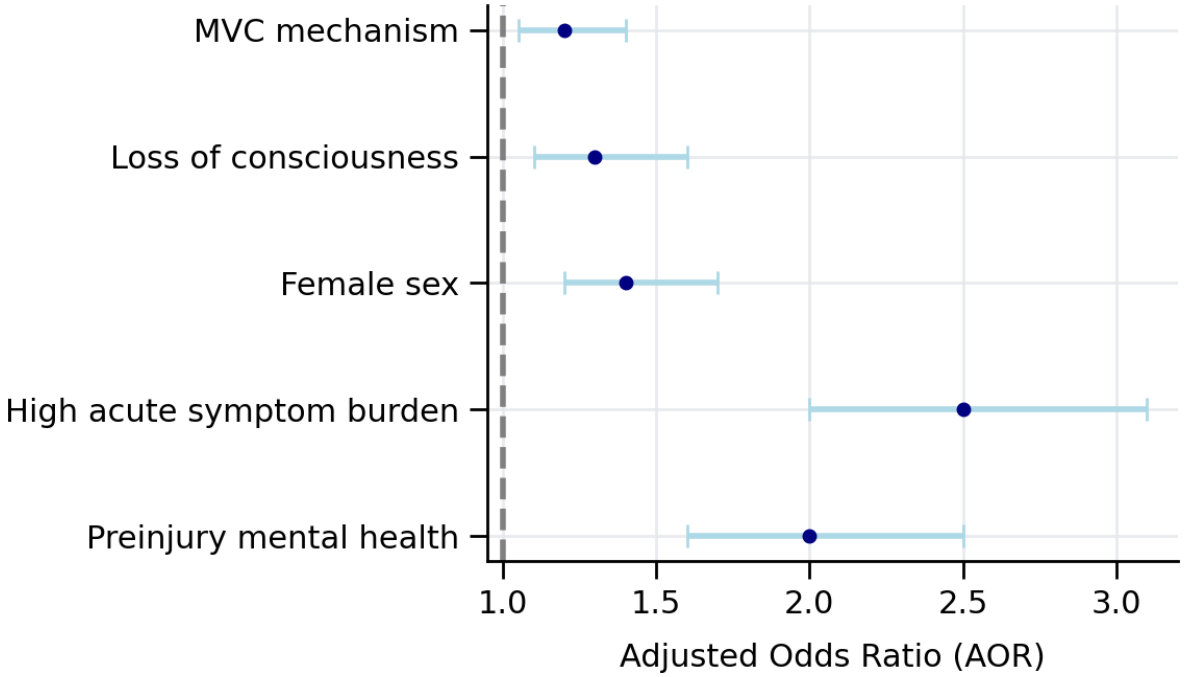
Original Investigation | Physical Medicine and Rehabilitation

Factors Associated With Persisting Symptoms After Concussion in Adults With Mild TBI

A Systematic Review and Meta-Analysis

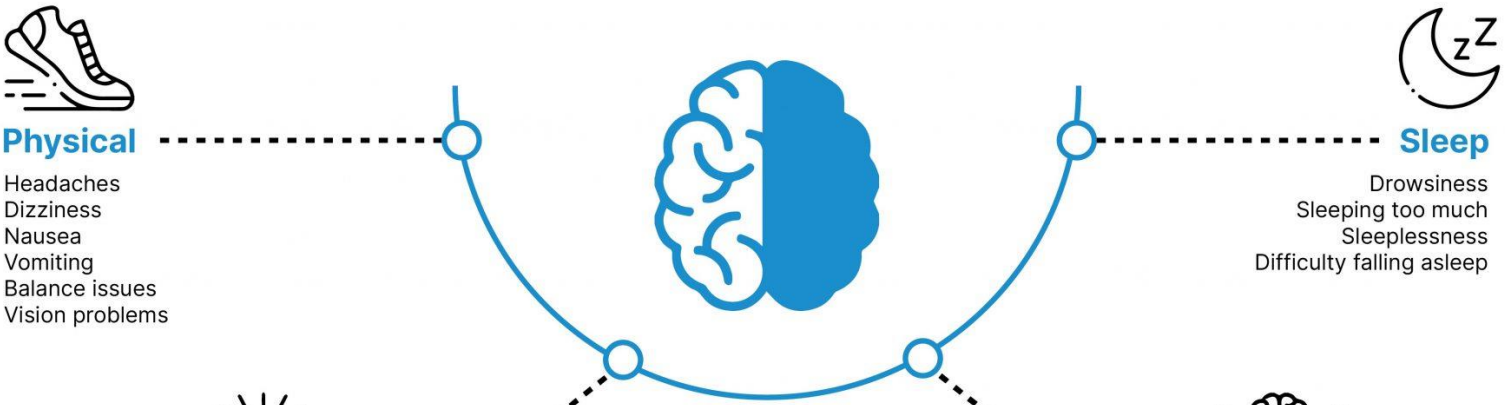
Samantha J. McIntosh, BHSc; Melanie H. Vergeer, MSc; Jean-Michel Galarneau, PhD; Paul H. Eliason, PhD; Chantel T. Debert, MD, MSc

Predictors of Persisting Symptoms After Concussion (illustrative)



Post-Concussion Syndrome Symptoms

Persistent post-concussive syndrome occurs when symptoms continue for three months or more after the injury.



Physical

Headaches
Dizziness
Nausea
Vomiting
Balance issues
Vision problems

Sleep

Drowsiness
Sleeping too much
Sleeplessness
Difficulty falling asleep

Cognitive

Brain fog
Slow thinking
Concentration issues
Memory lapses
Easily confused
Slowed responses

Emotional/ Psychological

Irritability
Apathy or malaise
Nervousness or anxiety
Depression
Mood swings

What type of thinking skills can be impacted?

Sustaining attention

Slowed thinking speed

Reduced cognitive stamina

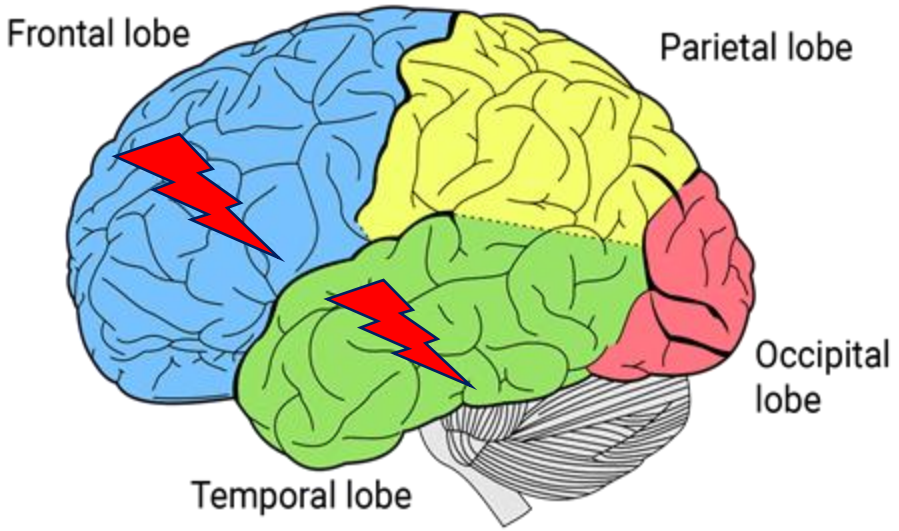
Learning new information

Multi-tasking

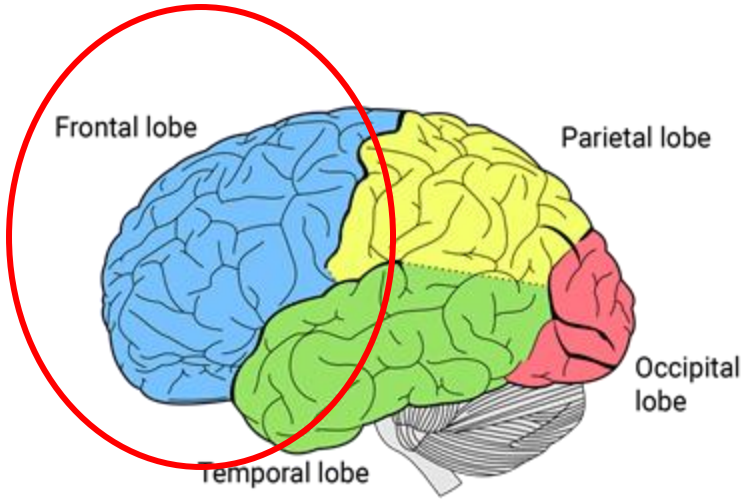
Word finding

Mental flexibility

+ other types of cognition

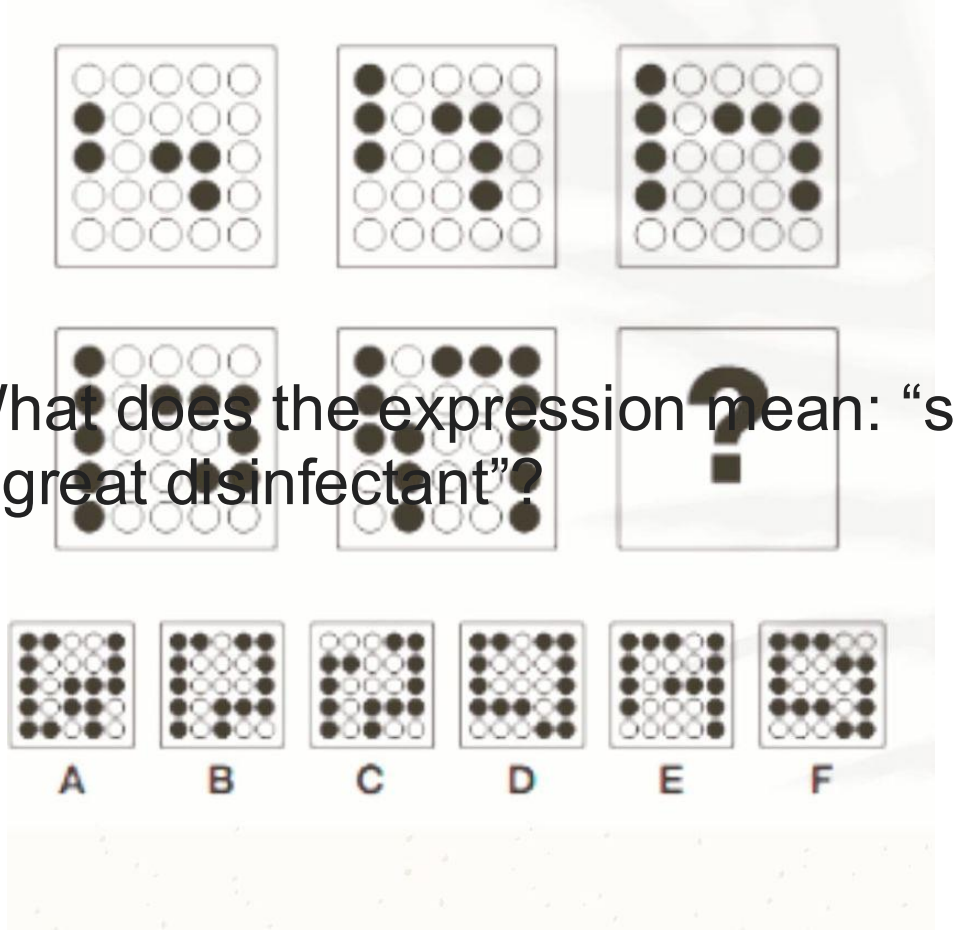


Executive Function



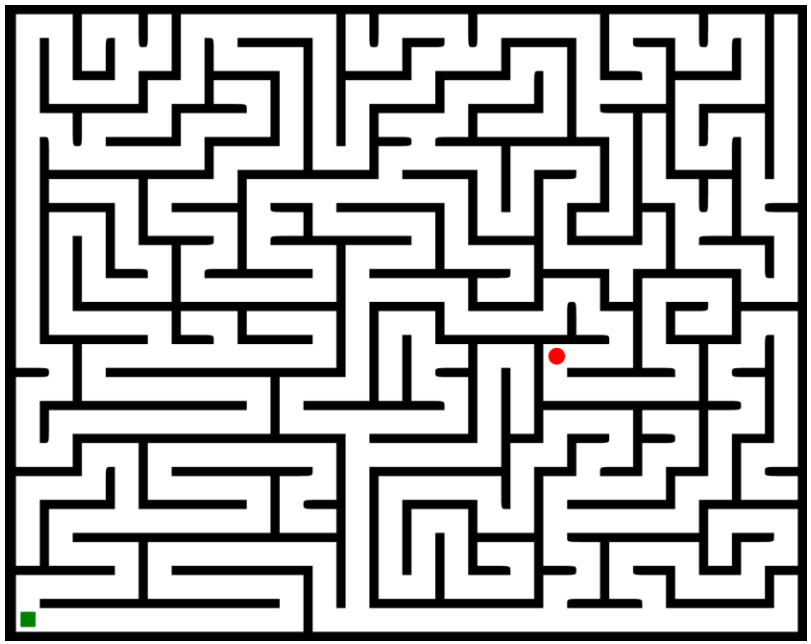
How do we assess thinking skills?

Reasoning and Problem Solving



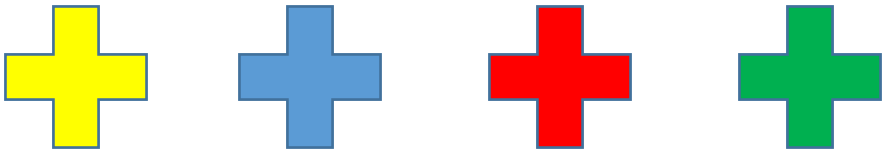
What does the expression mean: “sunlight is a great disinfectant”?

Reasoning and Problem Solving



If a train leaves at 7am from Oshawa traveling at 90 km/hr for 110 km to Mississauga, when will it arrive?

Attention span



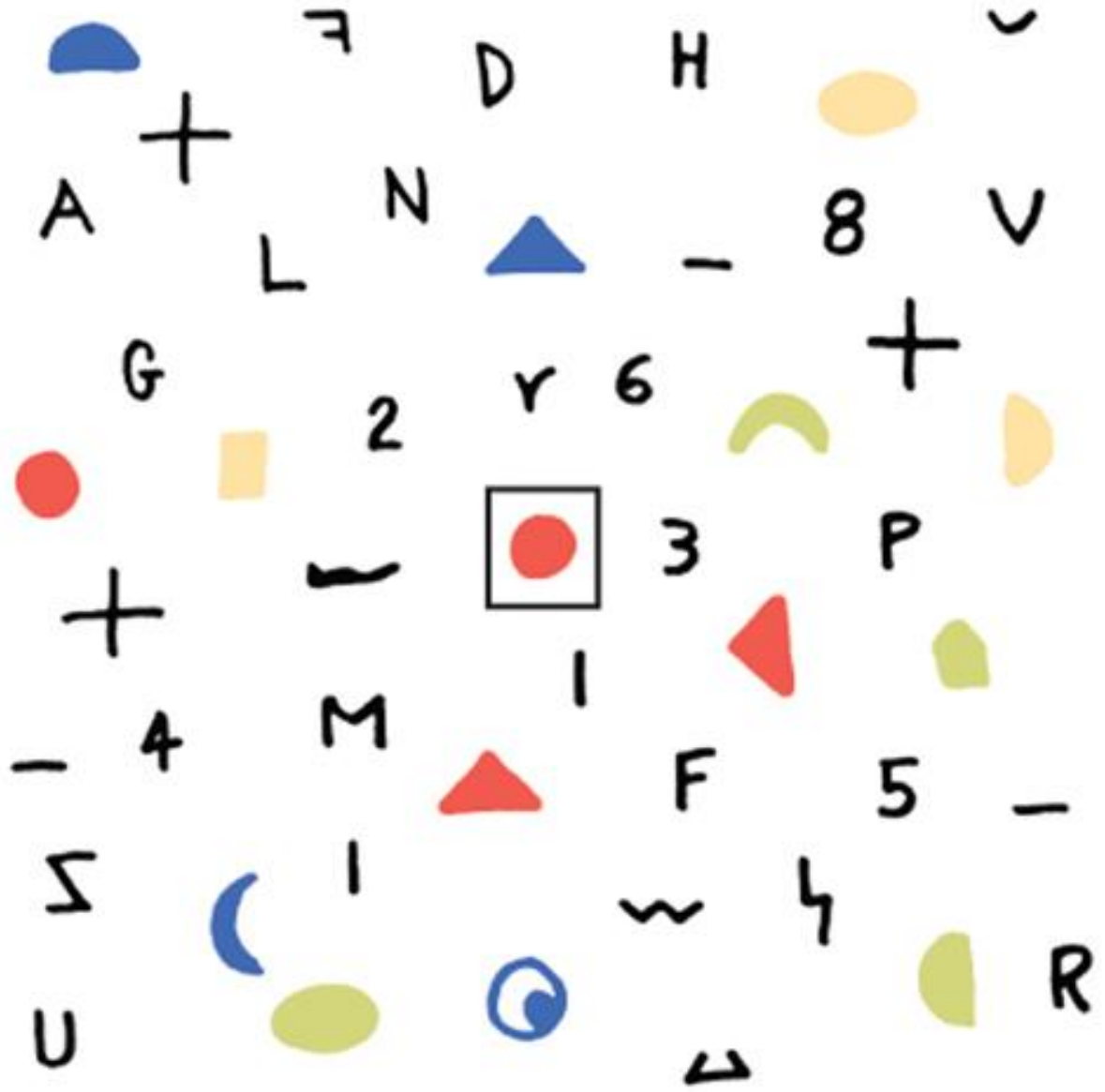
Attention Span

Working memory

27… 33… 49… 17…

Working memory

Multi-tasking



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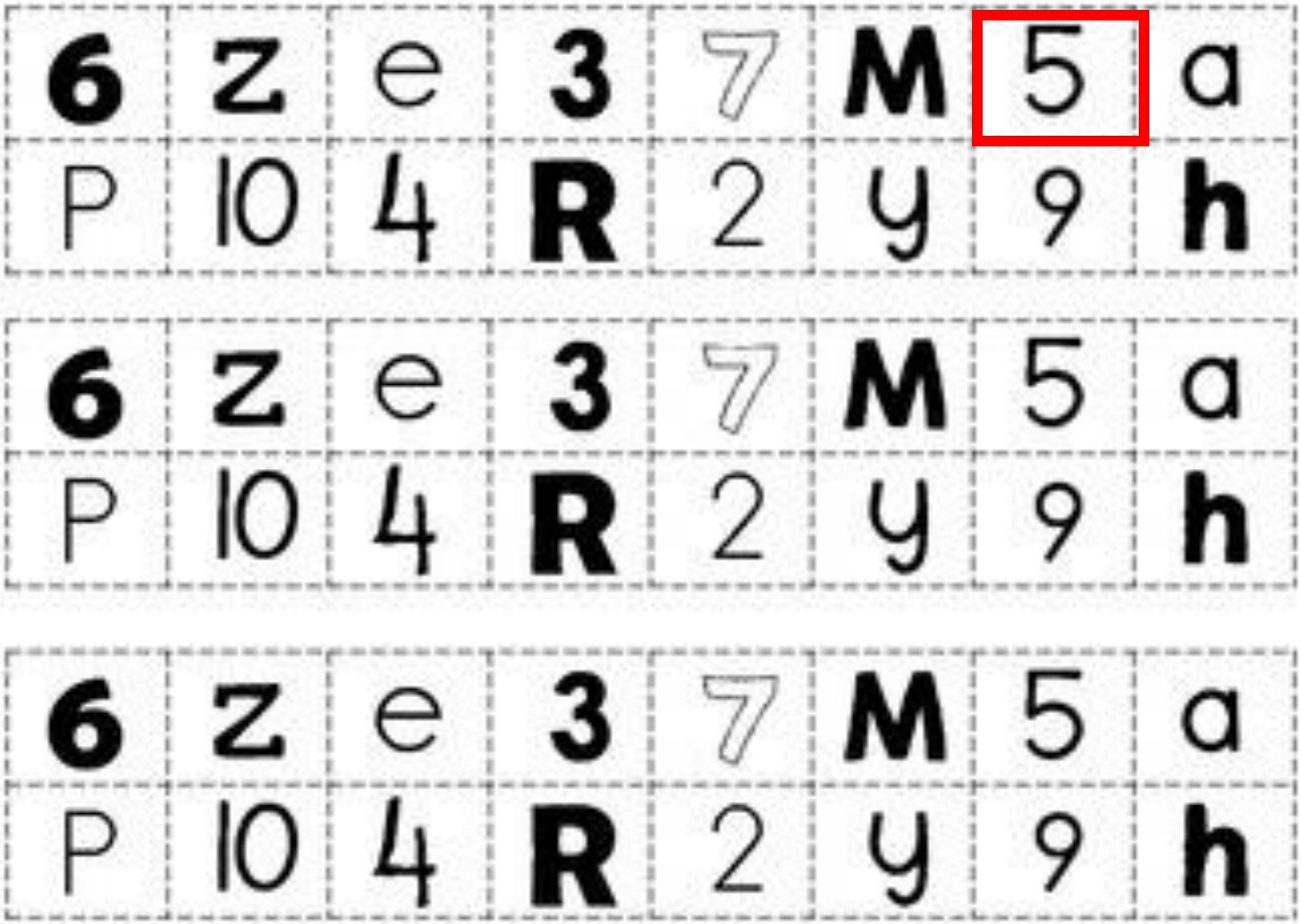
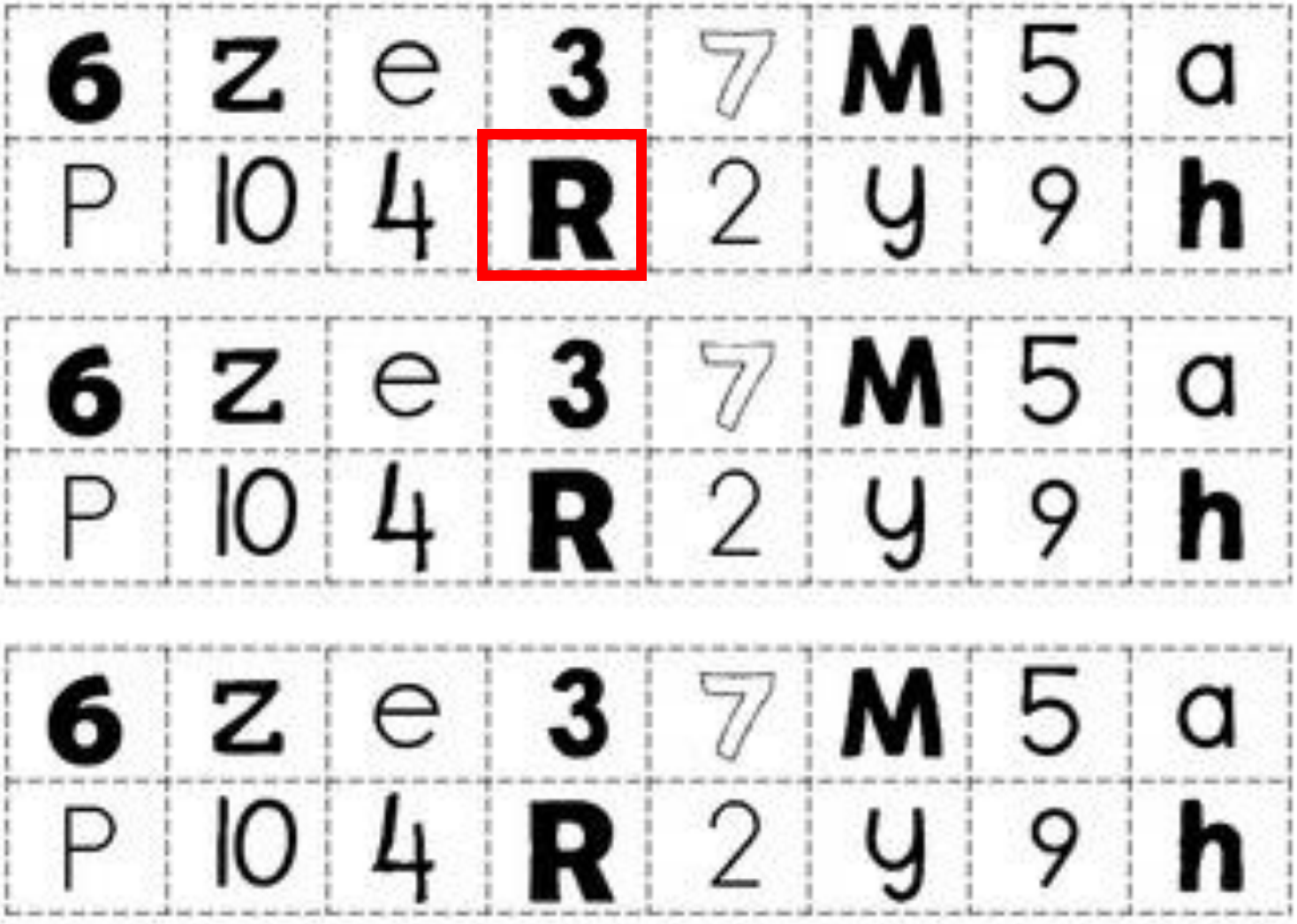
Complex Attention





Inhibition

Clapping Test

Processing Speed

Fast Reactions Test

How fast can you react?

Click here for instructions

Instructions:

When you see **GO!**
press the **SPACE BAR**
as quickly as you can.

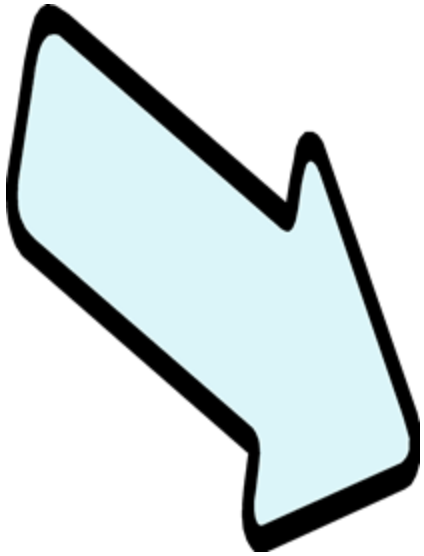
Use a finger on your writing hand.

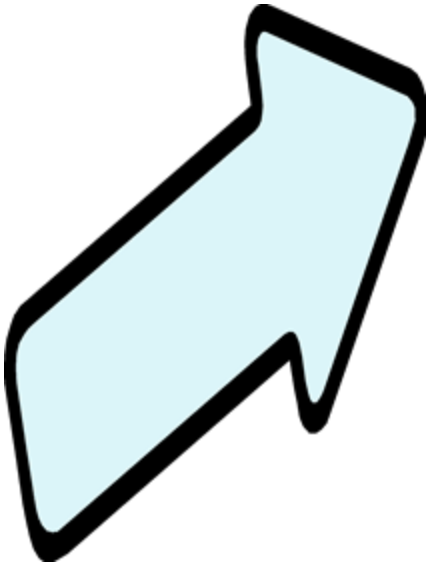
Click here to continue

WAIT

GO!

Memory processes





Encoding

Retrieval

Storage

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http://news.heart.org/memory-lapses-

Learning Test

horn
grass
bass
cement
cleats
boots

piano
loafers
mud
plastic
trombone
sandals

Recall Memory Test

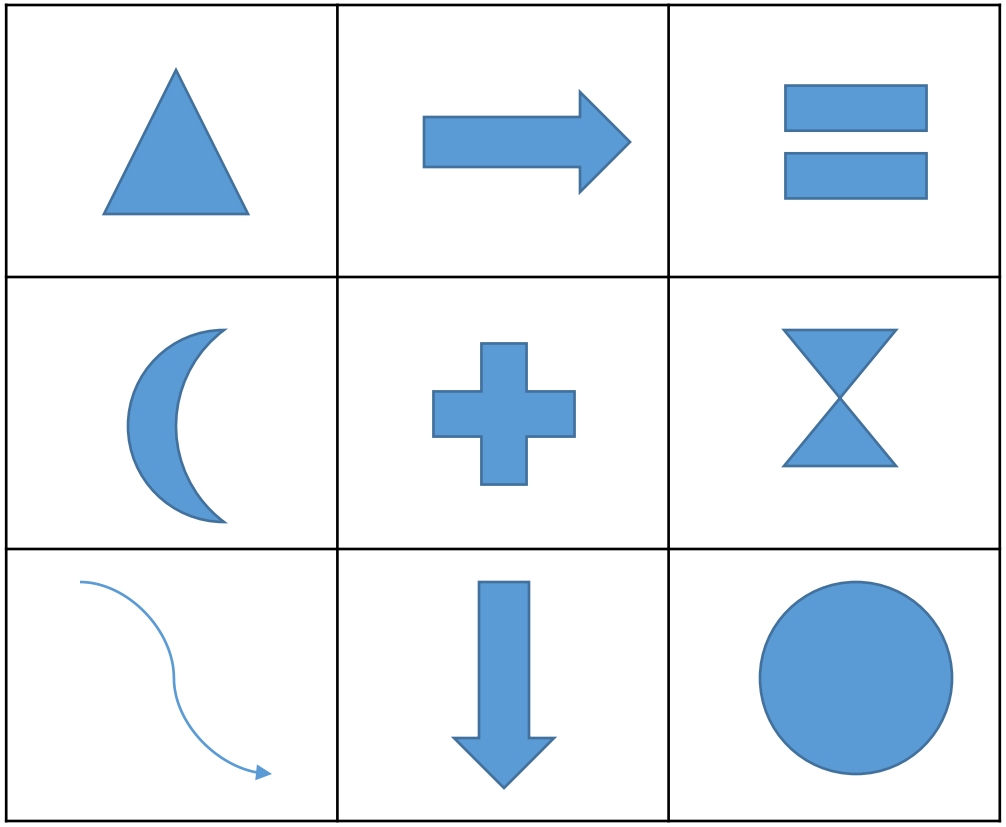
1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____

Recognition Memory Test

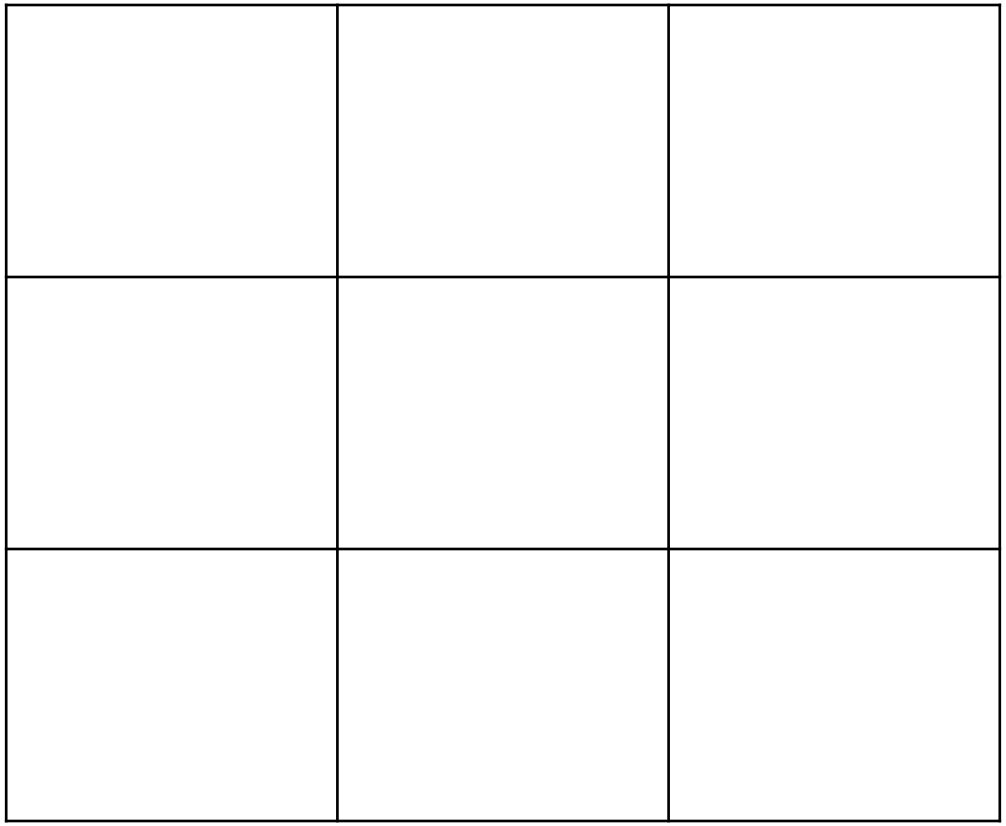
1. Was grass on the list? Yes or no?
2. Was accordion on the list? Yes or no?
3. Was sandals on the list? Yes or no?
4. Was trumpet on the list? Yes or no?

I.

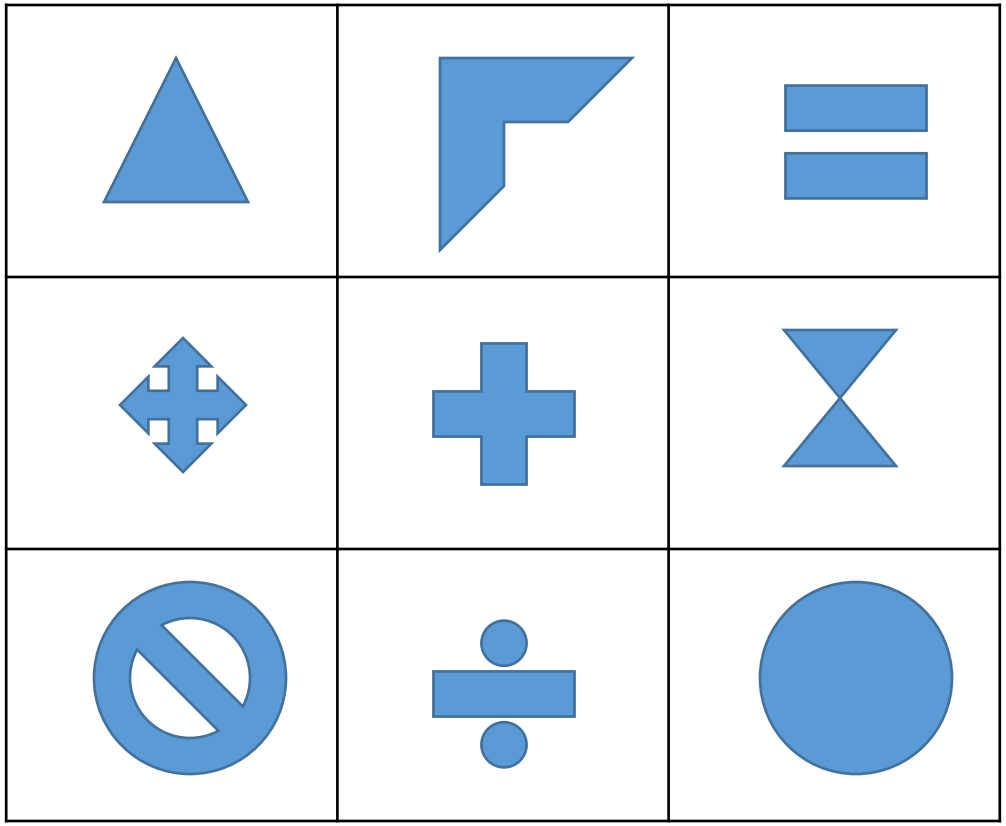
Visuospatial Learning



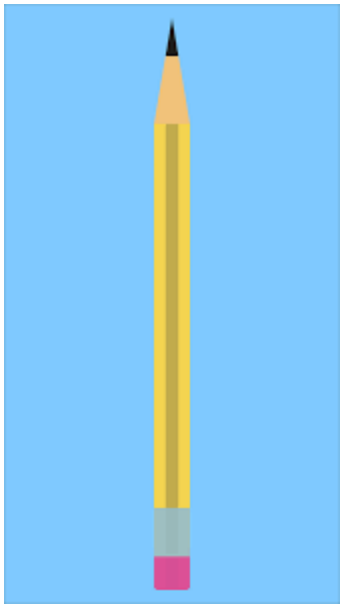
Visuospatial Recall



Visuospatial Recognition



What do you call it?



Nuts and Bolts of a Neuropsychological Assessment

- **Clinical Interview:** understanding your perspective

- **Neuropsychological Testing:** across cognitive domains

- **Feedback:** communication of strengths and weakness, implications for referral question, and strategies

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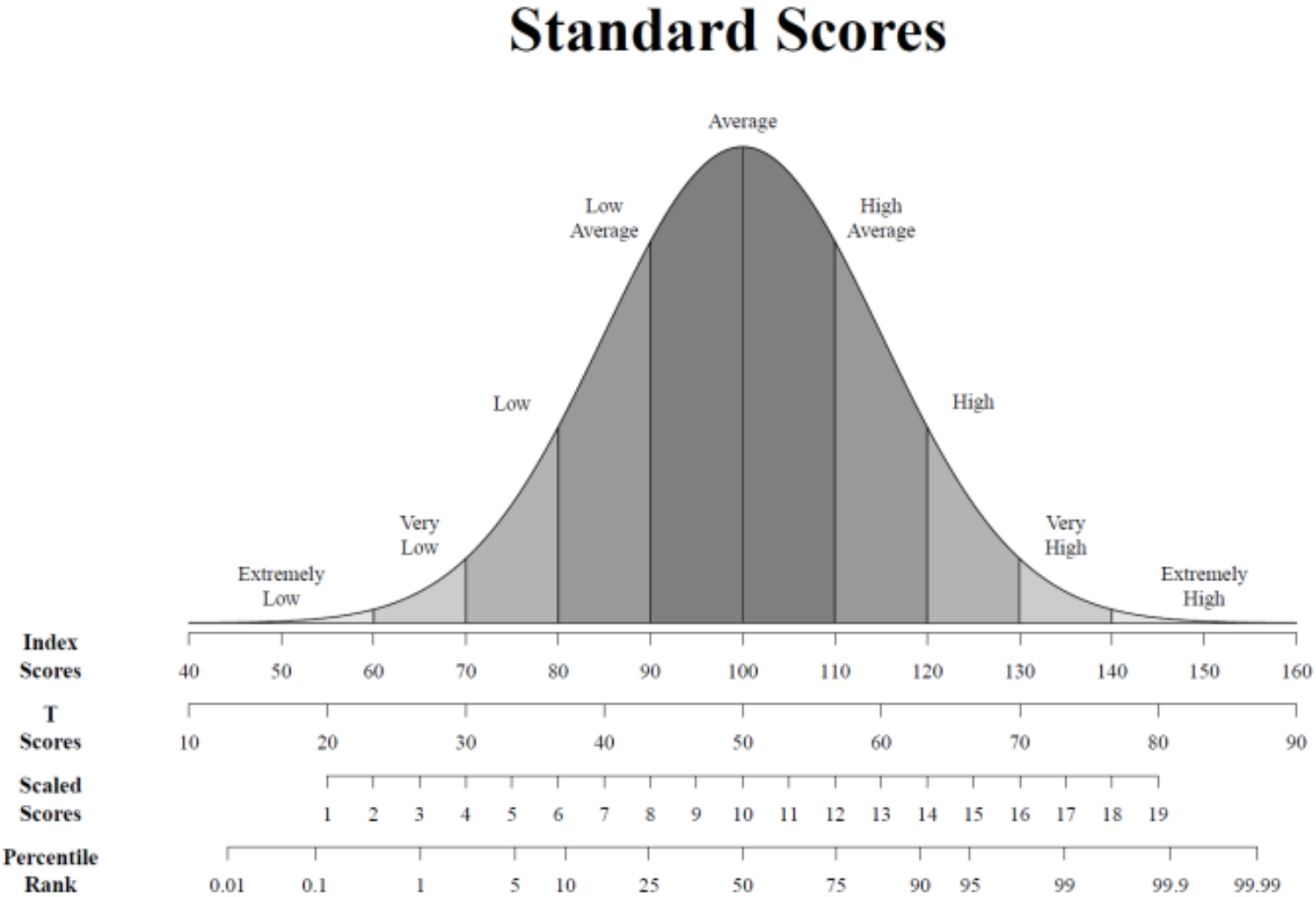
Comparing individuals to themselves & the population…



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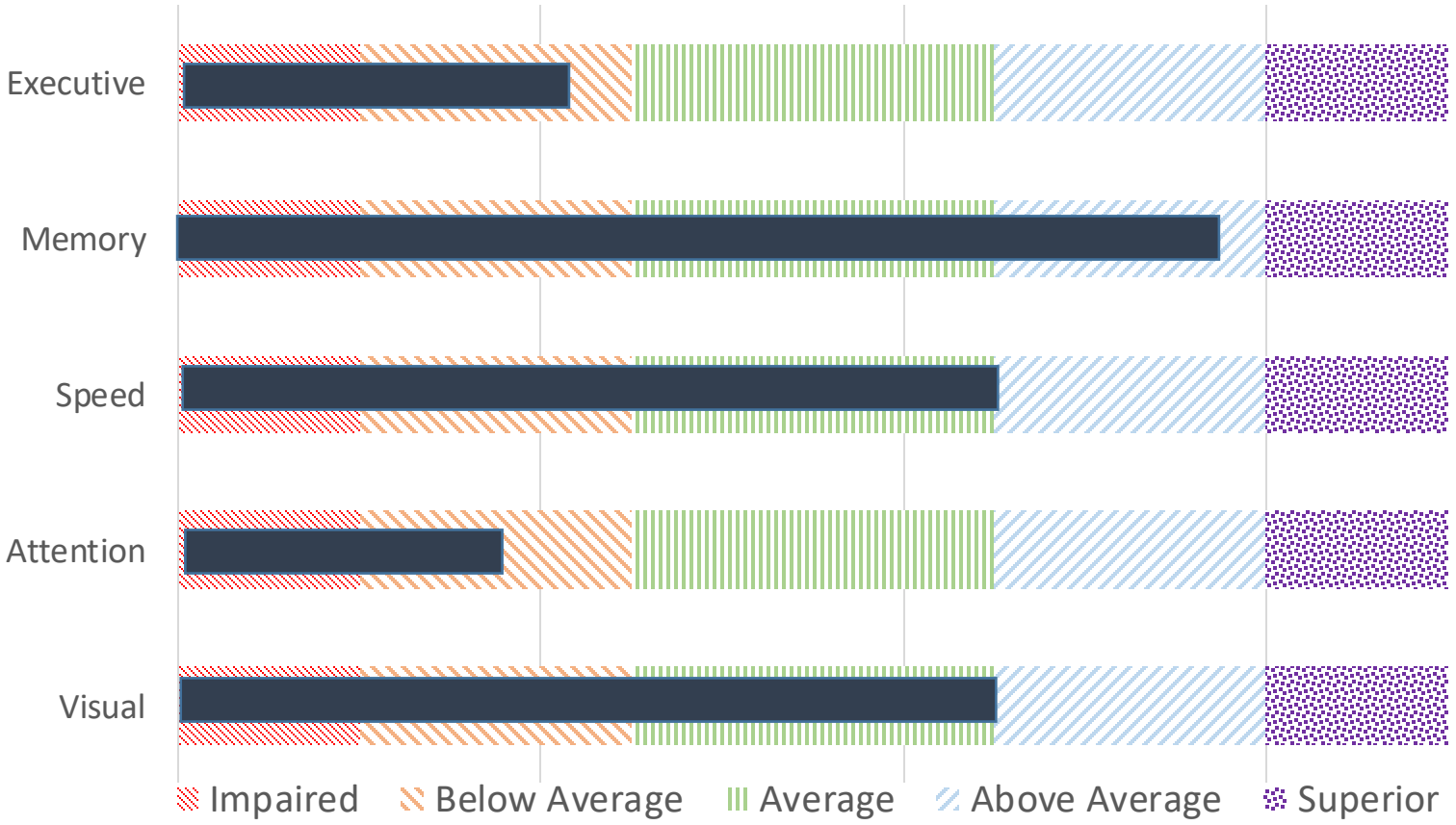
Profile of Cognitive Strengths and Weaknesses



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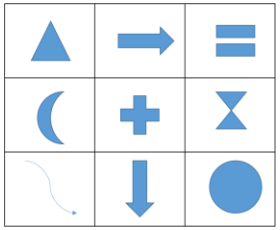
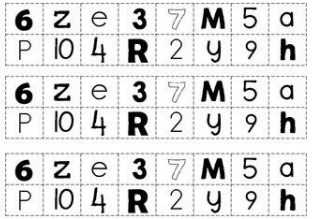
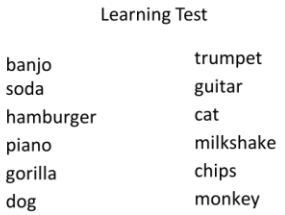
The Neuropsychological Approach

- Comprehensive interview

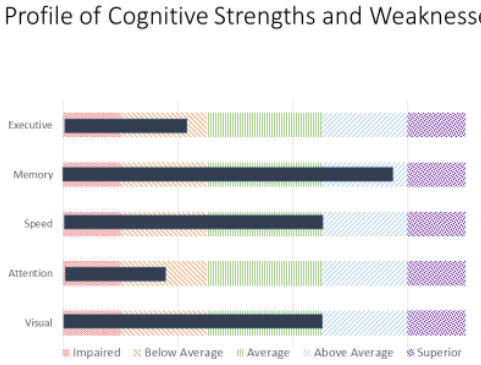
- Hypothesis-driven tests, comprehensively assess domains







- Cognitive profile integrated with medical investigations to inform diagnosis + prognosis



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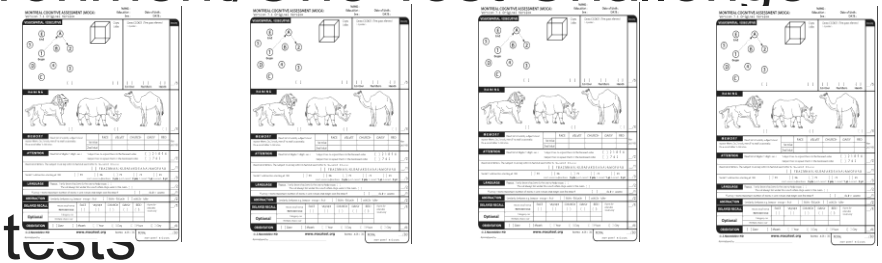
Common challenges

- Culture/Languag

- High Baseli

- The Testing Environment/One Test Challenge



- Serial screening tests

- The Role of Mood in Cognit

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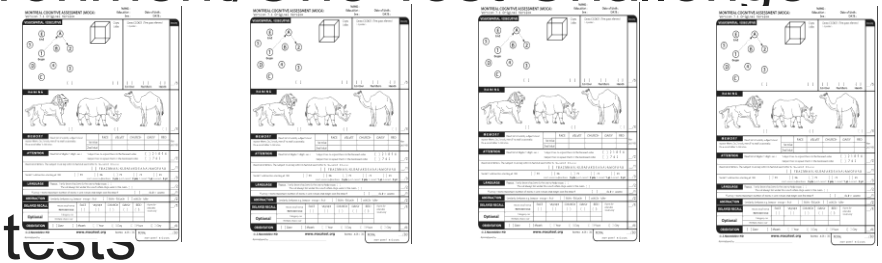
How do we handle the challenges?

- Culture/Languag

- High Baseli

- The Testing Environment/One Test Challenge



- Serial screening tests

- The Role of Mood in Cognit

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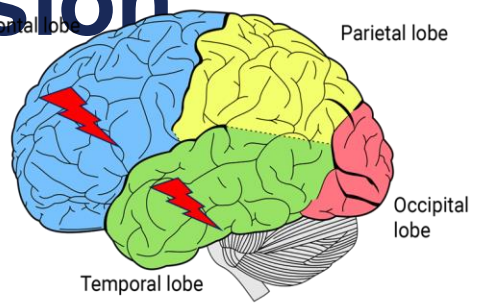
Purpose of neuropsychology assessment in persistent symptoms of post-concussion



- **Diagnosis**
  - Does pattern of cognitive strengths and weaknesses fit with other information (e.g., MRI, EEG, medical history)?
  - Are secondary factors impacting thinking skills?
    - e.g., mood, sleep disruption, fatigue, pain
  - Identifying modifiable targets
- **Prognosis**
  - ability to return to work/activity, track recovery, recommendations for optimization

Persistent Post Concussion Symptoms

- Up to 30% of individuals will experience persisting symptoms

- Why is a clinical interview and detailed history so important?

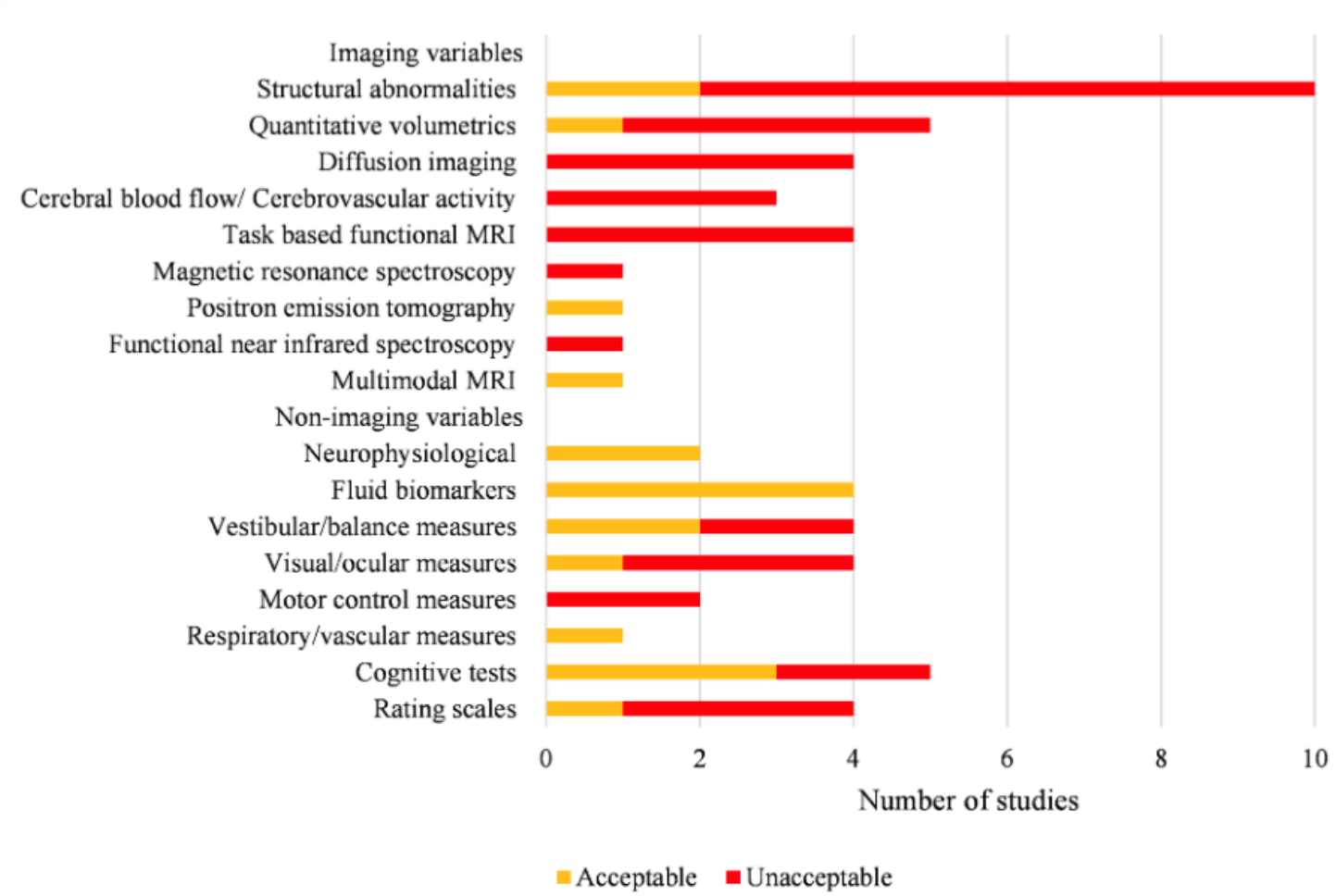


Figure 2 Risk of bias rating by outcome category. Studies could report outcomes in several categories. None of the included studies were assessed to be 'high quality'.

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Yeates KO, et al. Br J Sports Med 2023;**57**:780–788.

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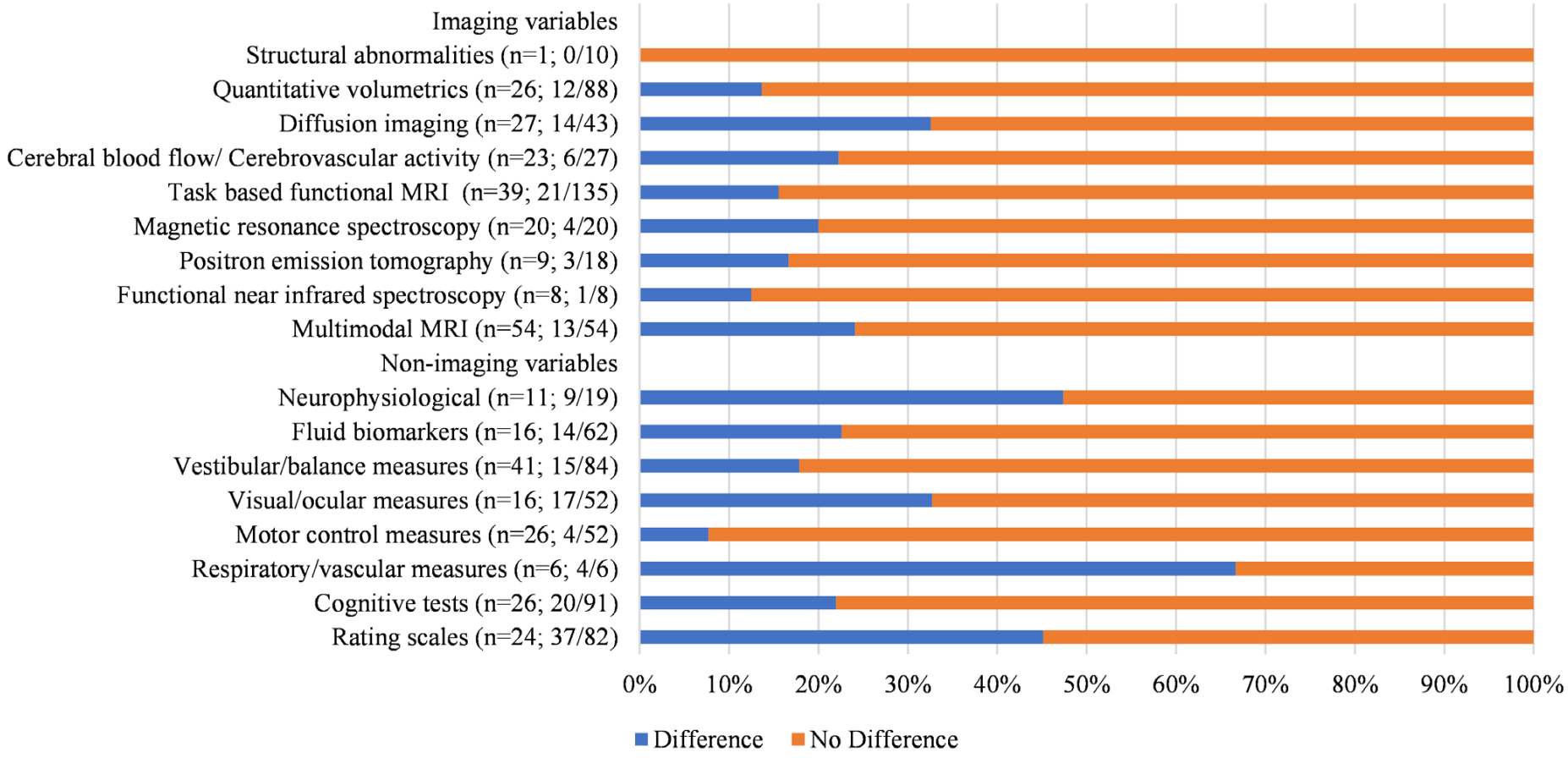

Yeates KO, et al. Br J Sports Med 2023;**57**:780–788.

Conclusions

Systematic review

Examining later-in-life health risks associated with sport-related concussion and repetitive head impacts: a systematic review of case-control and cohort studies

Grant L Iverson [1,2,3,4,5] Rudolph J Castellani,[6] J David Cassidy,[7] Geoff M Schneider,[8] Kathryn J Schneider [9] Ruben J Echemendia [10,11] Julian E Bailes,[12,13] K Alix Hayden,[14] Inga K Koerte [15,16,17] Geoffrey T Manley [18] Michael McNamee,[19,20] Jon S Patricios [21] Charles H Tator [22,23] Robert C Cantu,[24,25] Jiri Dvorak [26]

Iverson GL, Castellani RJ, Cassidy JD, *et al*
Examining later-in-life health risks associated with sport-r
concussion and repetitive head impacts: a systematic review of cas

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Table 2 Summary of findings from studies of former amateur athletes

Study	Country	N	Study group	Age (years)	Exposure	Topic/Outcome	Significant findings/risk
Bohr *et al*[71]	USA	10 951 (54.3% women)	High school sports	29.0 (1.7)	Sports participation	Football associated with reduced odds of lifetime history of depression, and it was not associated with worse cognitive functioning, current depression or suicidality in the past year.	Yes/Lesser for lifetime history of depression
Deshpande *et al*[72]	USA	2197; 521 (23.7%) football	High school sports	Football M=28.8 Controls M=29.1	Sports participation	Self-reported current depression; prior diagnosis of depression, anxiety or PTSD; suicidality.	No
Iverson *et al*[104]	USA	Wave IV=2218 Wave III=1856	High school football	Wave IV M=29.1, SD=1.8 Wave III M=21.8, SD=1.8	Football participation	Wave IV: lifetime diagnosis of depression, suicide ideation, current depression. Wave III: suicide ideation.	No
Iverson and Terry[36]	USA	1762 Football=369 No football=952	High school football	M=38.03, SD=1.95	Football participation	Lifetime diagnosis of depression, anxiety disorder or panic disorder; mental health treatment past year; suicidal ideation past year; current depression.	No
Deshpande *et al*[105]	USA	2 692; 834 (31.0%) played football	High school football	M=64.4, SD=0.8	Football participation	Former football players did not report greater symptoms of depression or perform worse on cognitive testing.	No
Savica *et al*[112]	USA	512 Football=438 Controls=140	High school football	Football: 68.4 (IQR=31.5–75.6); Controls: 59.1 (IQR=26.7–73.4)	Football participation	Neurological and neurodegenerative diseases.	No
Janssen *et al*[111]	USA	486 Football=296 Other sports=190	High school football	62–78	Football versus sports participation	Neurological and neurodegenerative diseases.	No
Valenti *et al*[113]	Italy	300 people with ALS (36% women) and 300 controls	ALS	ALS sample: males 59 (SD=8); females 60 (SD=8)	Sports participation, particularly soccer	No association between playing sports, and soccer in particular, and having ALS.	No
Porter *et al*[74]	USA	20 boxers 20 controls	Amateur boxers	16–25 at start	Boxing participation	Cognitive functioning over 9 years; neuropsychological test scores did not appear to change.	No
Weiss *et al*[117]	Sweden	668; 58.2% women	Amateur collision or contact sports	M=62.8, SD=7.9	Sports participation; n=77 men and n=1 woman	Cognitive impairment in older adulthood.	No

None of these studies examined concussions as the exposure variable of interest. All examined exposure to amateur (eg, high school) sports, but none of the studies quantified that exposure (eg, years of participation, position played or playing time).
ALS, amyotrophic lateral sclerosis; M, mean; n, sample size.

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view of cas

Table 3 Summary of findings from studies of former professional American football players

Study	Country	N	Group	Age	Exposure	Topic/Outcome	Significant findings/risk
Kerr *et al*[44]	USA	2001 cohort=3729 of which 2538 completed the survey; 1044 with complete data in 2010	Football (NFL)	NR	Concussions	Between 2001 and 2010, 10.2% reported a diagnosis of depression. Greater concussion history associated with greater risk for depression (eg, 3.0% in those with no prior concussions and 26.8% in those with 10+ prior concussions).	Yes/Greater
Brett *et al*[45]	USA	2001 cohort=3729 of which 2538 completed the survey; 333 had results in 2019	Football (NFL)	Age in 2001: M=48.95, SD=9.37; Approx. average age in 2019=67	Self-reported concussions and years of participation	Depression not greater than general population. Physical functioning rated worse than general population and decline in physical function associated with depression. Symptoms of depression associated with greater concussion history, but not years of participation.	Yes/Greater
Daneshvar *et al*[13]	USA	19 423; 38 ALS cases	Football (NFL)	Cohort range=25–79 ALS age of diagnosis M=51.0, SD=13.8	Sports participation	ALS more common in former NFL players than general population and associated with a longer career.	Yes/Greater
Kmush *et al*[14]	USA	14 388; 763 deaths	Football (NFL)	Age at death: M=53.3, SD=14.6	Repetitive head impacts derived from playing position and career duration	Repetitive head impacts (ie, player position) associated with greater all-cause mortality.	Yes/Greater
Nguyen *et al*[17]	USA	NFL=3419, 517 deaths; MLB=2708, 431 deaths	Football (NFL)	Age at death: NFL M=50.6, SD=13.2; MLB M=66.7, SD=12.3	Sports participation	Former NFL players had greater neurodegenerative disease mortality (7.5% of former NFL players (39/517) and 3.7% of former MLB players (16/431). Suicide was not significantly greater in former NFL players (11/517; 2.1%) compared with former MLB players (5/431; 1.2%).	Yes/Greater
Baron *et al*[18]	USA	3439, 334 deaths	Football (NFL)	At death: Md=54, Range=27–81	Sports participation	Lower risk of mortality from mental disorders and suicide in former NFL players compared with men in the general population. No difference in diseases of the nervous system and sense organs.	No Yes/Lesser
Lincoln *et al*[20]	USA	9778; 227 deaths	Football (NFL)	At death: Md=38, Range=23–61	Sports participation	Lower risk of mortality from mental disorders and suicide in retired NFL players; No difference in diseases of the nervous system and sense organs.	No Yes/Lesser
Lehman *et al*[19]	USA	3439; 537 deaths	Football (NFL)	NR	Sports participation	Former NFL players less likely to have suicide as manner of death than men from the general population.	Yes/Lesser
Lehman *et al*[19]	USA	3439; 334 deaths	Football (NFL)	Md=54 at death	Sports participation	Neurodegenerative disease mortality (17/334 deaths, 5.1%); primarily dementia and ALS, greater in former NFL players than the general population.	Yes/Greater

ALS, amyotrophic lateral sclerosis; M, mean; MCI, mild cognitive impairment; Md, median; MLB, Major League Baseball; NA, not available; NFL, National Football League; NR, not reported.

Risks Later in Life

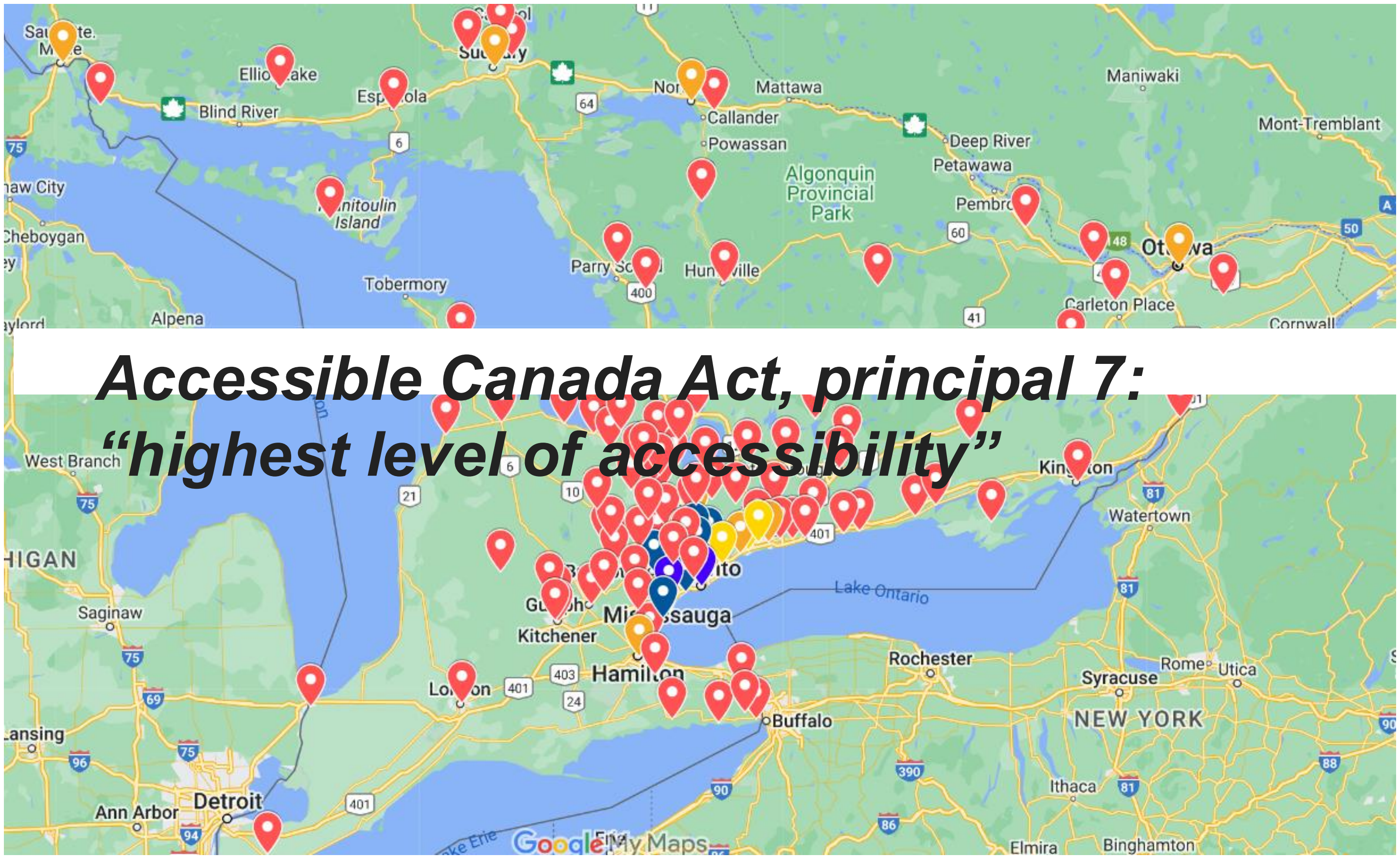
Iverson GL, Castellani RJ, Cassidy JD, *et al*

Expanding later-in-life health risks associated with sport-related concussion and repetitive head impacts: a systematic review of

Treatment

KITE TELENEUROREHAB CENTRE FOR (CHRONIC) ABI

Integrated treatment, research and training



Accessible Canada Act, principal 7:

"highest level of accessibility"

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Equity of Access

- No cost to

Scalability

- Reaching

Sustainability

- No travel location, costs mobility restrictions
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Referral (inclusion/exclusion)

REFERRAL CRITERIA

Inclusion	Exclusion
• **History of ABI** • **>6 months post-injury**. • **Insight** into diagnosis and symptoms. • **≥17 years** of age, fluent in **English**, basic computer literacy.	• Aphasia/dysarthria/**communication disorder** that would affect participation in an online group. • **Active psychosis or mania**.

EXAMPLES OF TREATMENT MODULES
Cognitive, Mental Health, Somatic Symptoms

Treatment	Description
Goal Management Training	• Executive function treatment (reducing attentional slips, improving planning and organization)
Cognitive Behaviour Therapy	• A psychological intervention focused on developing skills and strategies to manage emotions.
Mindfulness Skills Training	• Education and meditation practices that promote present-moment awareness and increased self-awareness.
Concussion Education and Symptom Management	• Novel module (synthesis of current guidelines) for individuals with a mild traumatic brain injury and persistent symptoms.
Relaxation Skills	• Education/psychotherapy for individuals with high tension, anxiety, and distress, and seeking strategies to help manage overwhelming emotions.

Group format (n=7 to 9 per group), facilitator-led; patients connect from home via secure video-conferencing; protocol adapted for remote delivery.

Questions

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UHN Toronto General Toronto Western Princess Margaret Toronto Rehab Michener Institute

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EXTRA SLIDES

Memory processes

Encoding

Retrieval

Storage

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http://news.heart.org/memory-lapses-among-highly-educated-may-signal-

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Memory Strategies

What do you do when you are trying to remember something?

Memory Strategies

1. Be strategic
2. Be creative
3. Be organized

Lovelace & Twohig (1990). *Bulletin of the Psychonomic*

Memory Strategies

Do an experiment with numbers.

9	**1**	**9**
6	3	6
4	1	6
3	1	4

?	?	?
?	?	?
?	?	?
?	?	?

9	**1**	**9**
6	3	6
4	1	6
3	1	4

Memory processes

Encoding

Retrieval

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Memory processes

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Memory Strategies

- Make new information meaningful!
  - elaborate and rich

- Use all of your senses

http://www.rediquest.com/ser

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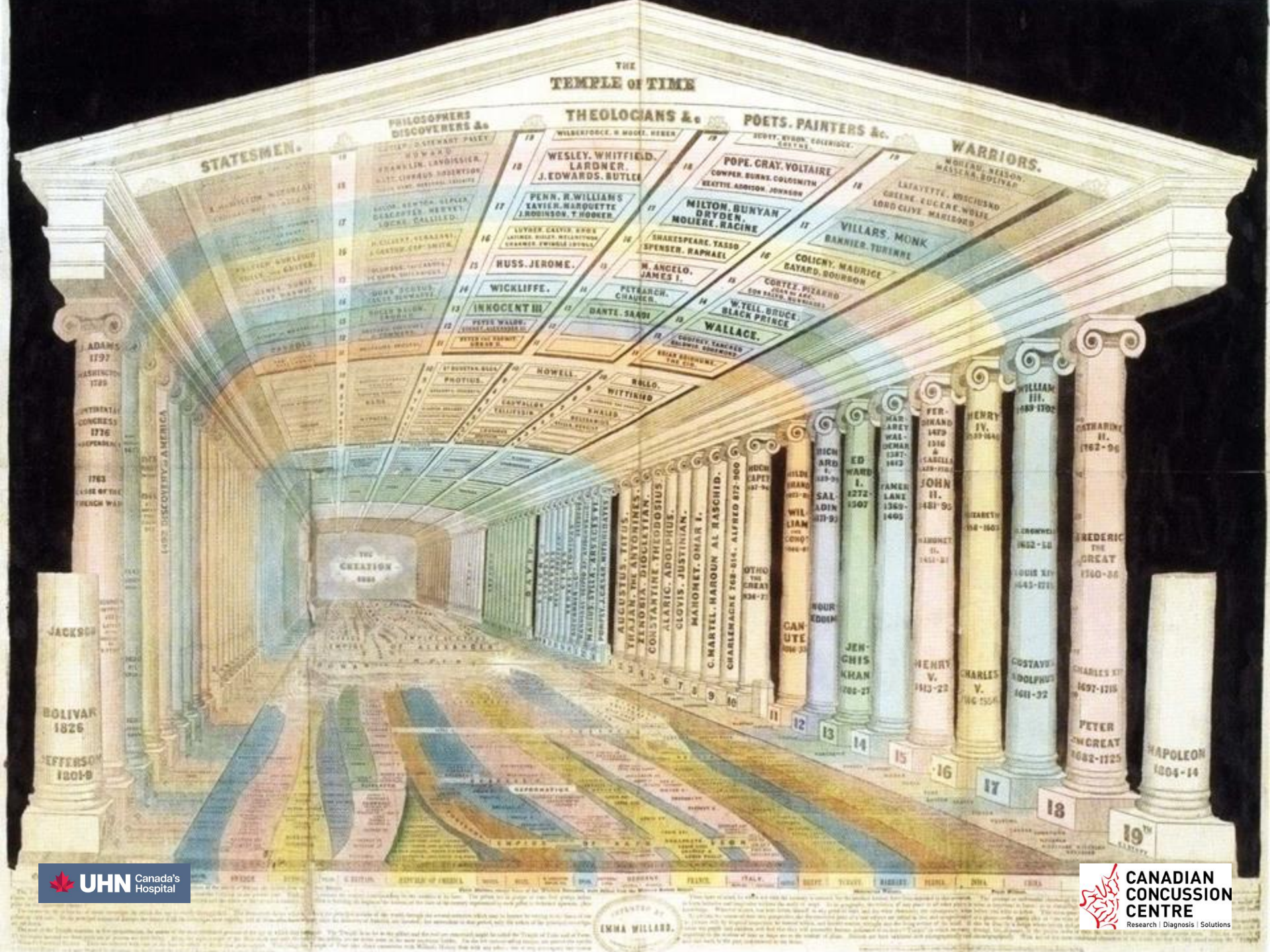
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STATESMEN.
PHILOSOPHERS
DISCOVERERS &c
THEOLOGIANS &c
POETS. PAINTERS &c.
WARRIORS.
WESLEY. WHITFIELD.
LARDNER.
J. EDWARDS. BUTLER
POPE. GRAY. VOLTAIRE.
COWPER. BURNS. GOLDSMITH
SEXTTIE. ADDISON. JOHNSON
PENN. R. WILLIAMS
XAVIER. MARQUETTE
J. ROBINSON. T. HOOKER
MILTON. BUNYAN
DRYDEN.
MOLIERE. RACINE
VILLARS. MONK
BANNIER. TURENNE
HUSS. JEROME.
SHAKESPEARE. TASSO
SPENSER. RAPHAEL
COLIGNY. MAURICE
BAYARD. BOURBON
WICKLIFFE.
M. ANGELO.
JAMES I.
CORTEZ. PIZARRO
INNOCENT III
PETRARCH.
CHAUCER.
W. TELL. BRUCE.
BLACK PRINCE
DANTE. SAADI
WALLACE.
HOWELL
ROLLO.
WITTIKIND
THE CREATION
AUGUSTUS. TITUS.
TRAJAN. THE ANTONINES.
ZENOBIA. DIOCLETIAN.
CONSTANTINE. THEODOSIUS
ALARIC. ADOLPHUS.
CLOVIS. JUSTINIAN.
MAHOMET. OMAR I.
C. MARTEL. HAROUN AL RASCHID.
CHARLEMAGNE 768-814. ALFRED 872-900
HUGH CAPET
OTHO THE GREAT
WILLIAM THE CONQ.
CANUTE
SALADIN
RICHARD I.
EDWARD I. 1272-1307
JENGHIS KHAN
MARGARET WALDEMAR
FAMERLANE
FERDINAND 1479
&
ISABELLA
JOHN II.
HENRY V.
CHARLES V.
HENRY IV.
ELIZABETH
WILLIAM III.
GUSTAVUS ADOLPHUS
CATHARINE II.
FREDERIC THE GREAT
PETER THE GREAT
NAPOLEON
1804-14
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BOLIVAR
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EMMA WILLARD.

Test Ourselves!

-banjo
-hamburger
-gorilla
-trumpet
-cat
-chips

-soda
-piano
-dog
-guitar
-milkshake
-monkey

Can we create our own memory palace?

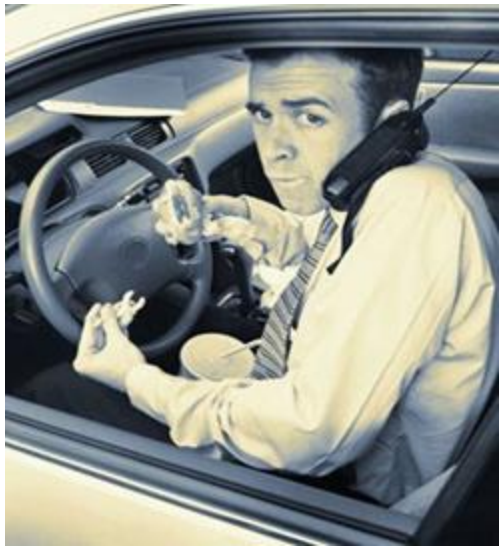
Test Ourselves!

-banjo
-hamburger
-gorilla
-trumpet
-cat
-chips

-soda
-piano
-dog
-guitar
-milkshake
-monkey

Memory Strategies

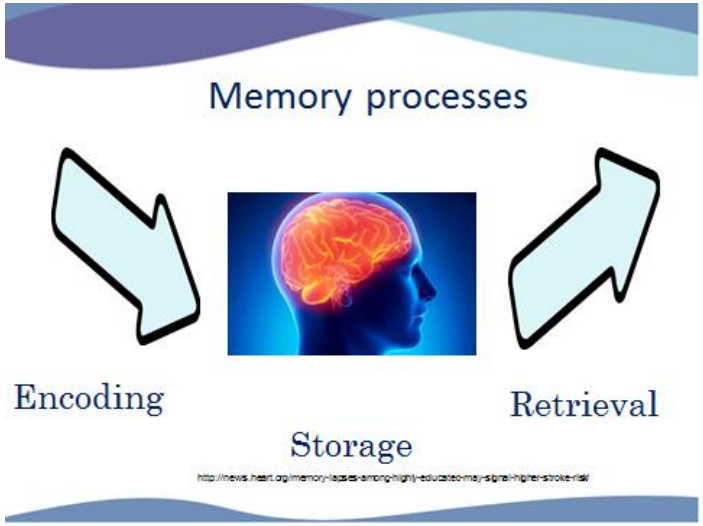
- The role of attention (Gold & Park, 2009)



- Write information down
- Practice good habits!

Retrieval Practice

- Powerful learning strategy



Memory Strategies

External memory aids

- Calendar / Lists / Notes

Internal strategies

- Attention “see it, and say it”
- Meaningful Encoding
  - Elaboration, personalization, acronyms, mnemonics (memory palaces), etc.

Goals of Strategies

- Increase knowledge about practical and effective memory strategies.
- Increase use of targeted strategies in everyday memory situations.
- These strategies take time to learn. But with practice, they can be incorporated into your life!

Factors Affecting Memory

- Medical disorders & diseases
- Medications
- Exercise
- Diet
- Stress and relaxation
- Thinking activities

Neuroplasticity

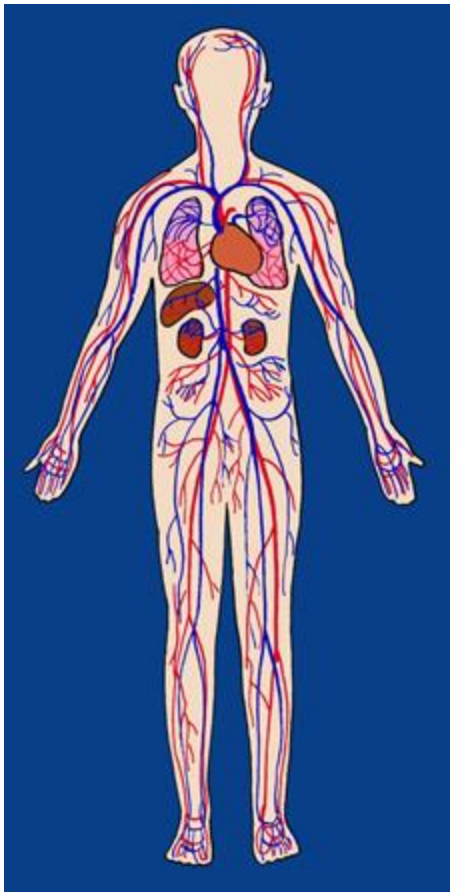
- Neuro = brain
- Plasticity = able to be remolded

- MAY EXPLAIN WHY THESE THINKING ACTIVITIES HELP US STAY SHARP AS WE AGE!!

Neuroplasticity

www.livestrong.com

Holistic Approach to Aging – The Mind & Body



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Lifestyle - Exercise

- **Acute effects**:
  - Immediately after exercising, learning and memory are enhanced.
  - This is a short-term effect.

- **Long-term effects**:
  - Exercise lowers risk of heart disease and stroke.
  - Neurogenesis, nerve health, reaction time, etc.

Lifestyle - Diet

- Adequate nutrition and vitamins

- High fat and cholesterol

Lifestyle - Stress

- Cortisol is released.
- This affects the brain and memory.
- This effect is reversible.

Lifestyle - Relaxation

- Relaxation techniques:
  - Deep breathing
  - Visualization
  - Progressive muscle relaxation
  - Meditation

http://www.busymeditator.com/blog/

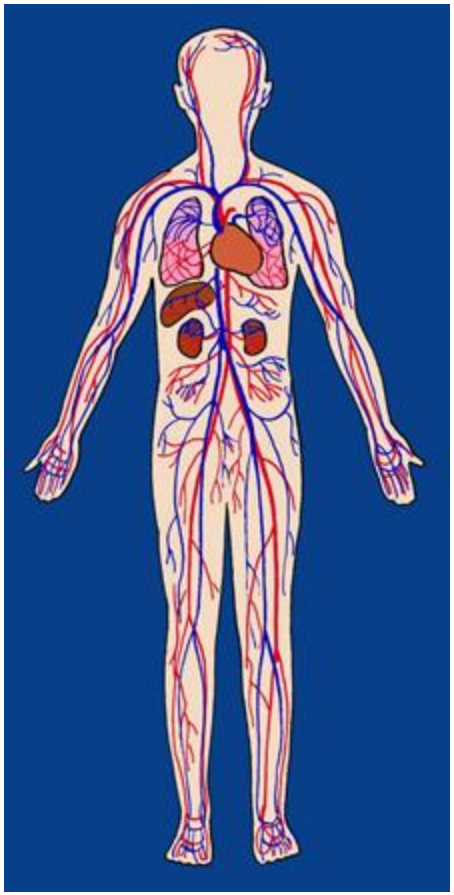
Lifestyle – Thinking Activities

- Involvement in intellectually-demanding activities correlates with:
  - better cognitive abilities
  - lower rates of dementias such as Alzheimer's disease

Lifestyle - Thinking Activities

- Working or volunteering
- Playing bridge or chess
- Doing crossword puzzles/ sudoku
- Reading books
- Learning a new language
- Traveling
- Playing a musical instrument
- Singing in a choir
- Attending theatre, symphony, lectures
- Visiting museums
- Socializing

Holistic Approach to Aging – The Mind & Body



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