



**MOOVE & SNOOZE LAB**  
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# Sleep Measurement

Psychobiology of Human Performance SIG: Assessment  
Instruments for Psychobiological Variables – Theory, Validation,  
and Practical Implementation  
NEACSM Fall Meeting, October 17, 2024

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# Financial Disclosures

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No individuals involved in the planning or teaching of this activity have reported any relevant financial relationships with a non-eligible company (commercial interest).

# Why Do We Care About Sleep?



# My Perspectives



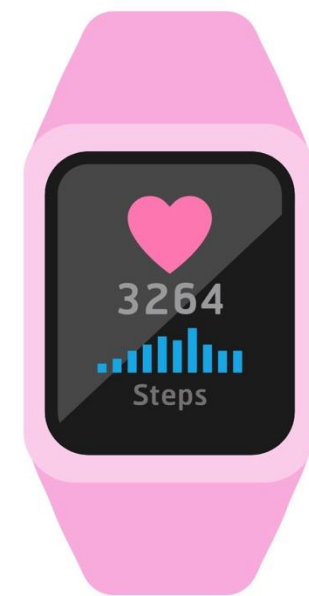
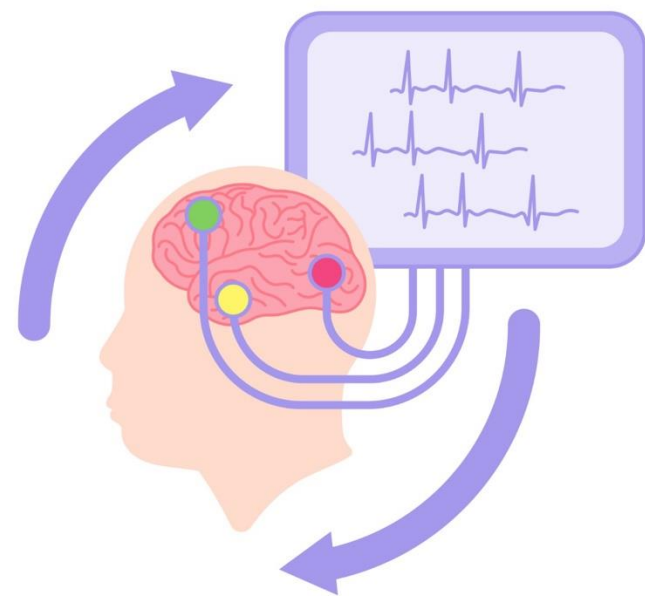
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# Common Sleep Measurement Tools

- Polysomnography (PSG)
- Actigraphy monitors & related wearable devices
- Self/proxy report: Diaries/logs, recall tools, questionnaires



# Common Sleep Variables

## Sleep Quantity

- Total sleep time
- Time in bed
- Wake after sleep onset
- Sleep onset latency
- REM latency

## Sleep Quality

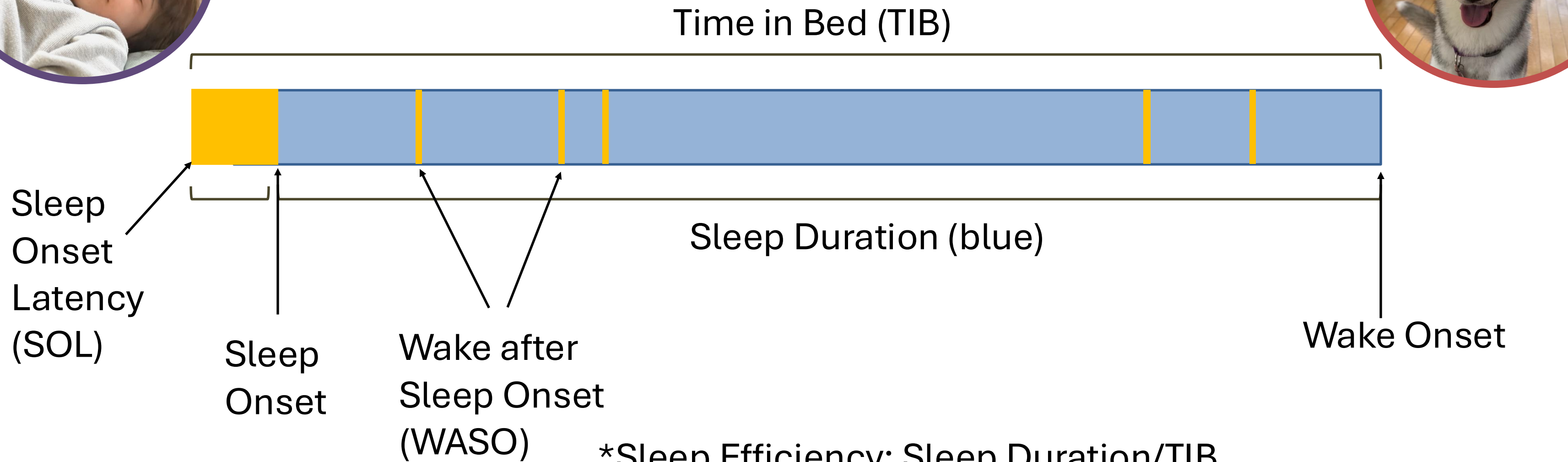
- Sleep efficiency
- Subjective quality
- Fragmentation
- Disturbances

## EEG

- Sleep staging
- Sleep spindles
- Slow wave activity
- Slow oscillations

Source: Depner, 2020

# Time-based Sleep Measures

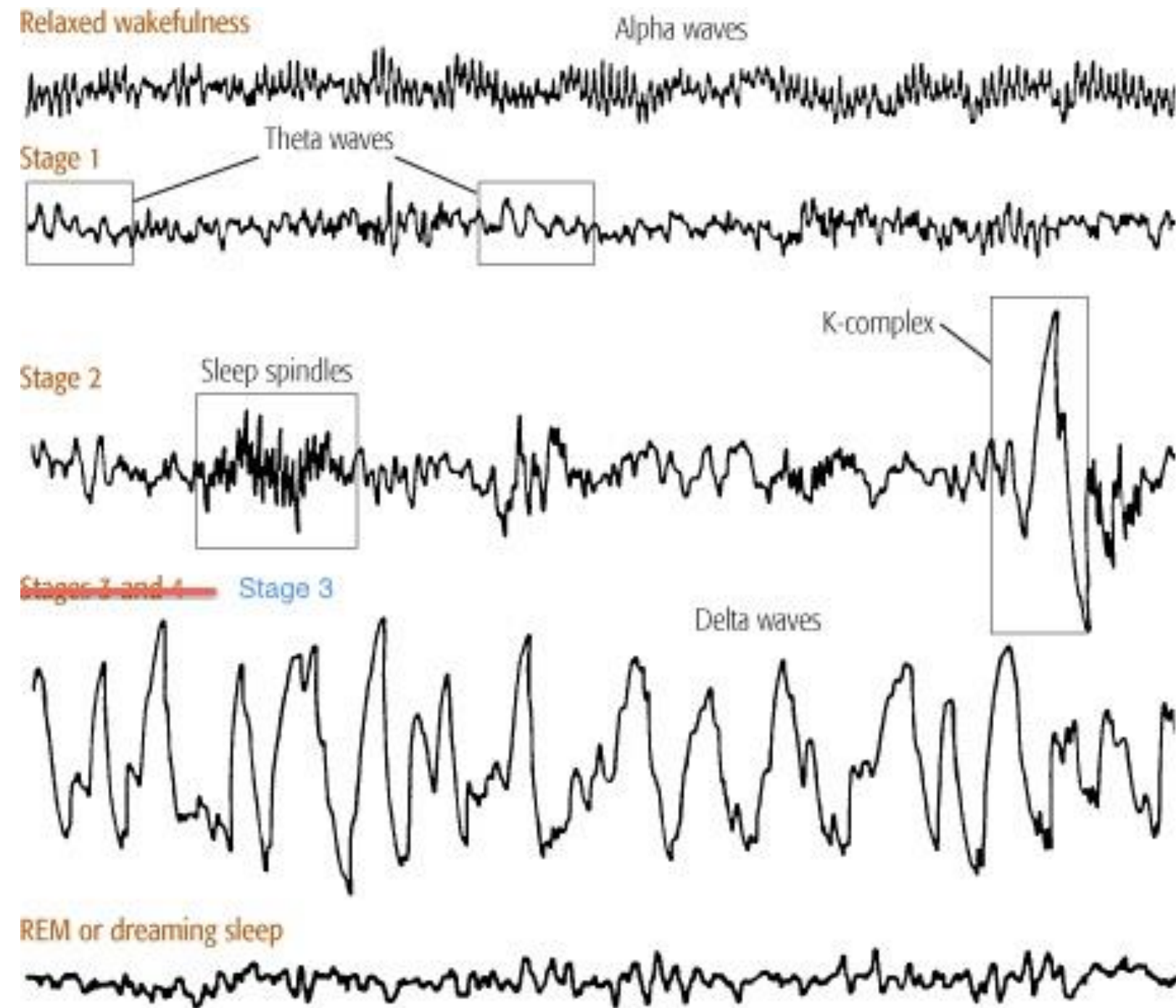


\*Sleep Efficiency:  $\text{Sleep Duration} / \text{TIB}$

\*\*Sleep midpoint: Midpoint between Sleep & Wake Onset

# Sleep Physiology

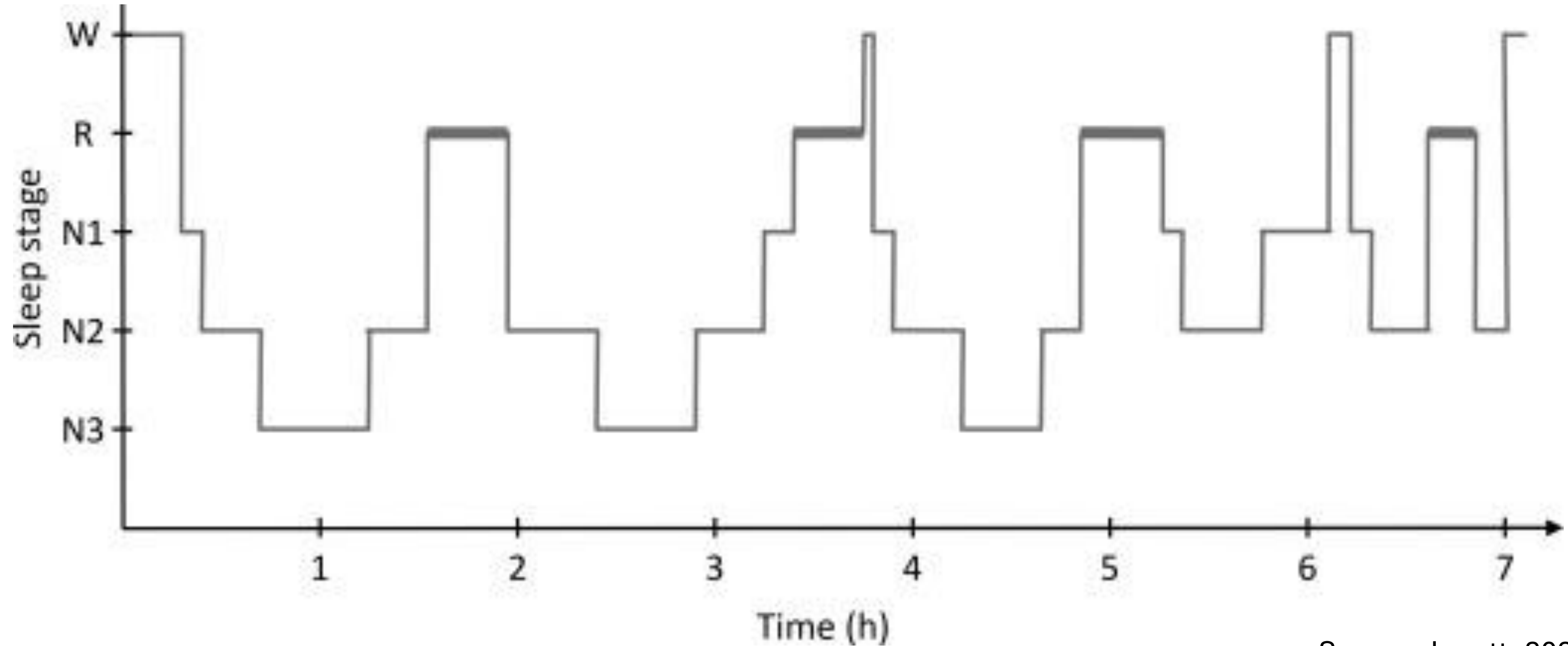
- Sleep Stages/Macrostructure
  - Rapid eye movement (REM or R)
  - Non-REM (NREM or N) 1
    - N2
    - N3
- Microstructure
  - Sleep spindles
  - K-complexes



Source: Berry, 2012



# Sleep Physiology: Somnogram



Source: Janott, 2020

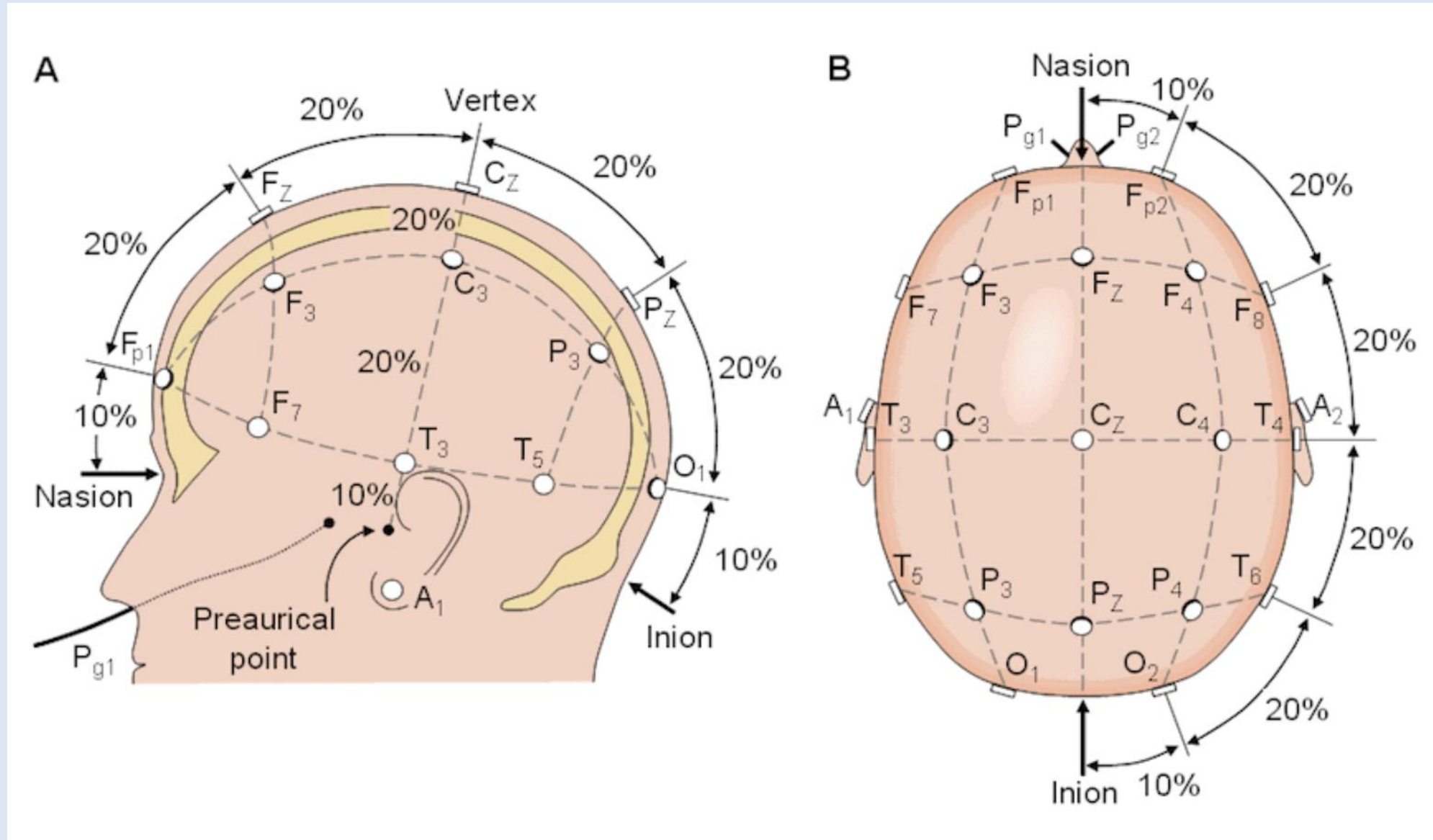
# What is PSG?

## **A full 'sleep study' can include:**

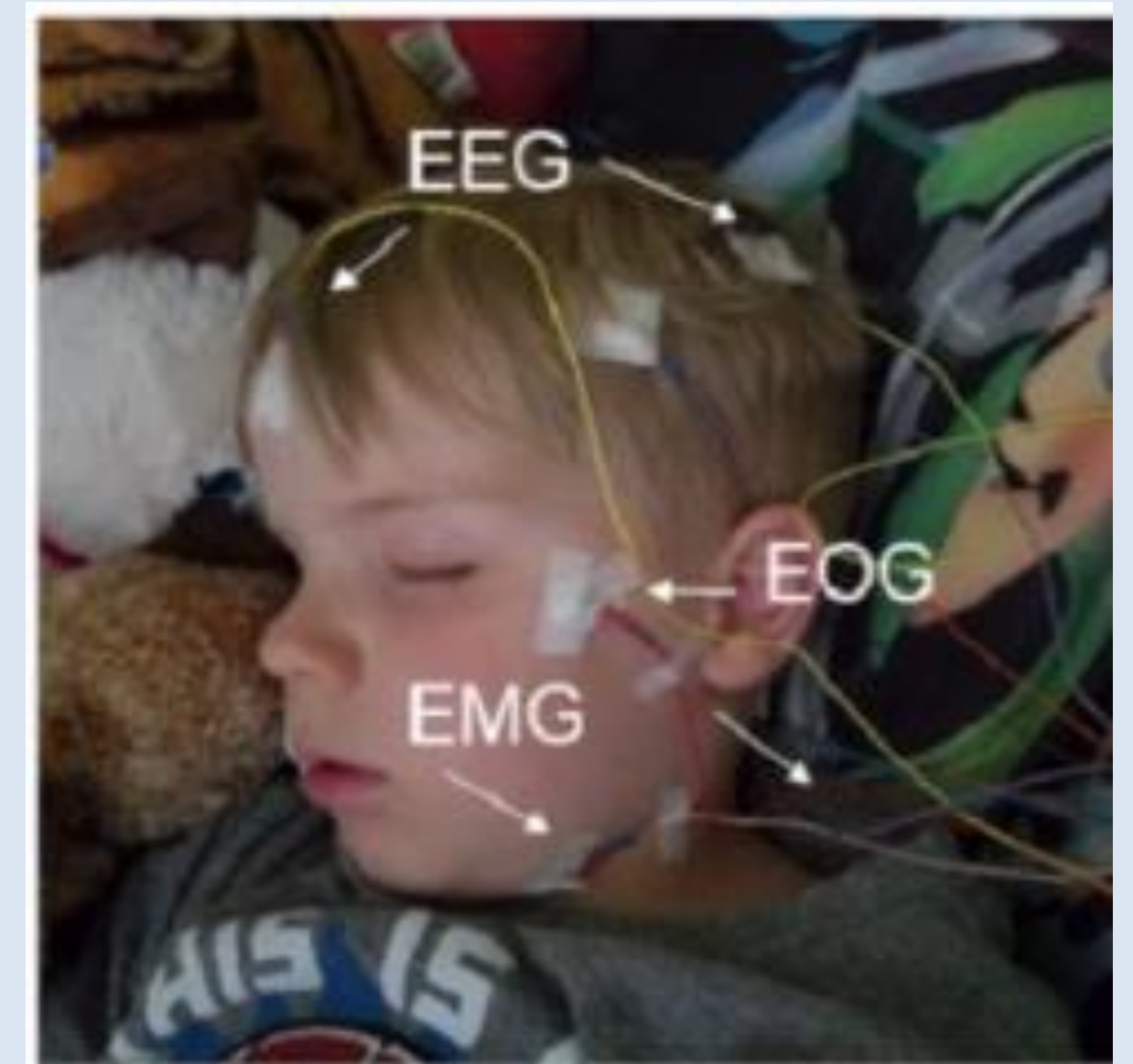
1. Bilateral frontal, central, & occipital EEG - brain waves
2. Bilateral eye electrooculogram (EOG) - Eye movements
3. Surface chin & leg electromyogram (EMG) - Muscle activity
4. Electrocardiogram lead (ECG) - heart rate/variability
5. Nasal pressure transducer & oronasal thermal flow sensor - Breathing patterns
6. Pulse oximeter - Oxygen levels (pulse oximetry)
7. Audio & video recordings - Snoring and body position

Source: Berry, 2012

# Traditional PSG Set-Up



Source: Carden, 2009



Source: Allard, 2021

# PSG: Lab-based

## PROS

- Considered gold standard
- Detailed sleep stage analysis
- Full system set-up to detect sleep apnea & disorders
- An 'objective' measure

## CONS

- Expensive
- Uncomfortable
- Not ideal for long-term use
- Lab environment
- Requires training
- Manual scoring
- Human error/system issues



# Ambulatory PSG

Dreem Headband



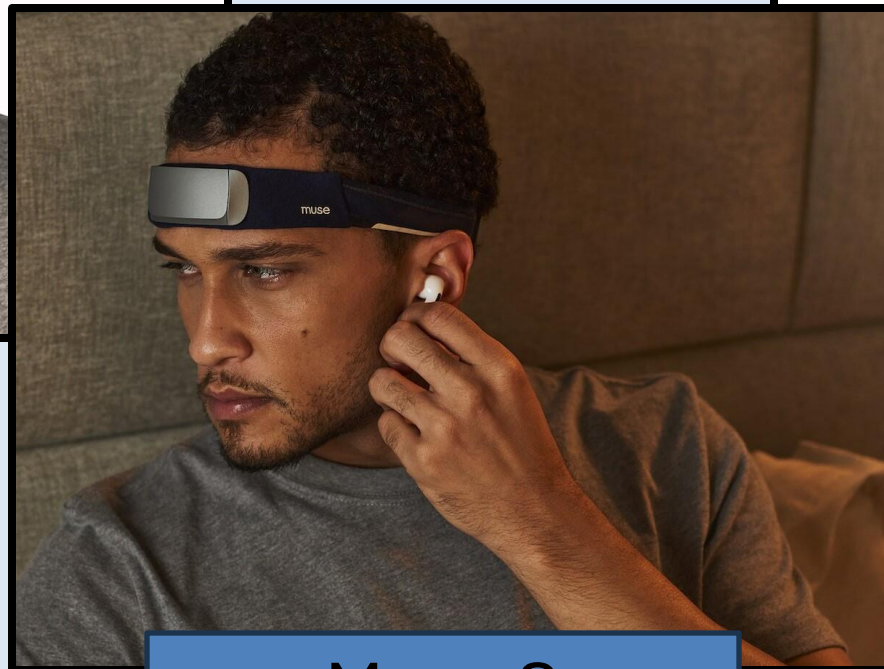
Somnotouch



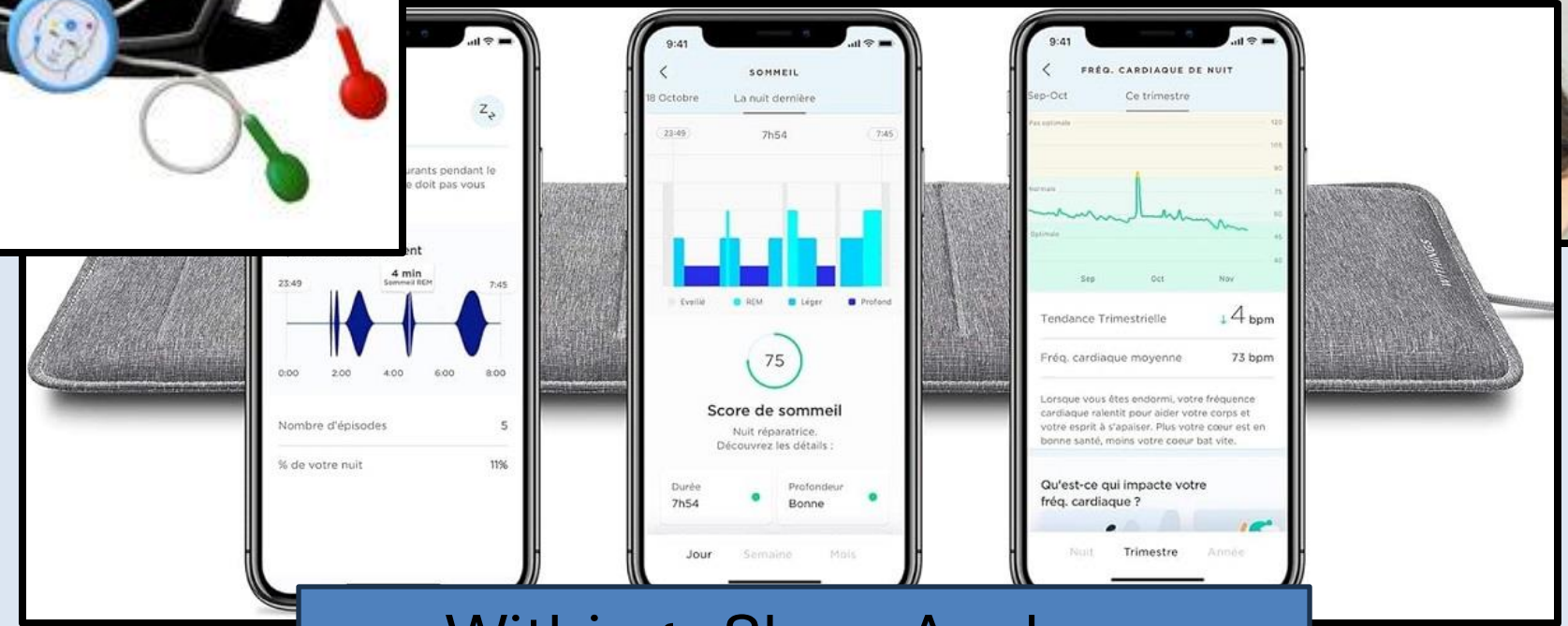
Mentalab



Muse S



Withings Sleep Analyzer



# PSG: Ambulatory

## PROS

- Often include EEG + other measures
- Portable
- Easier for repeated nights
- In-home measurement
- Less discomfort
- Some provide 'raw' data

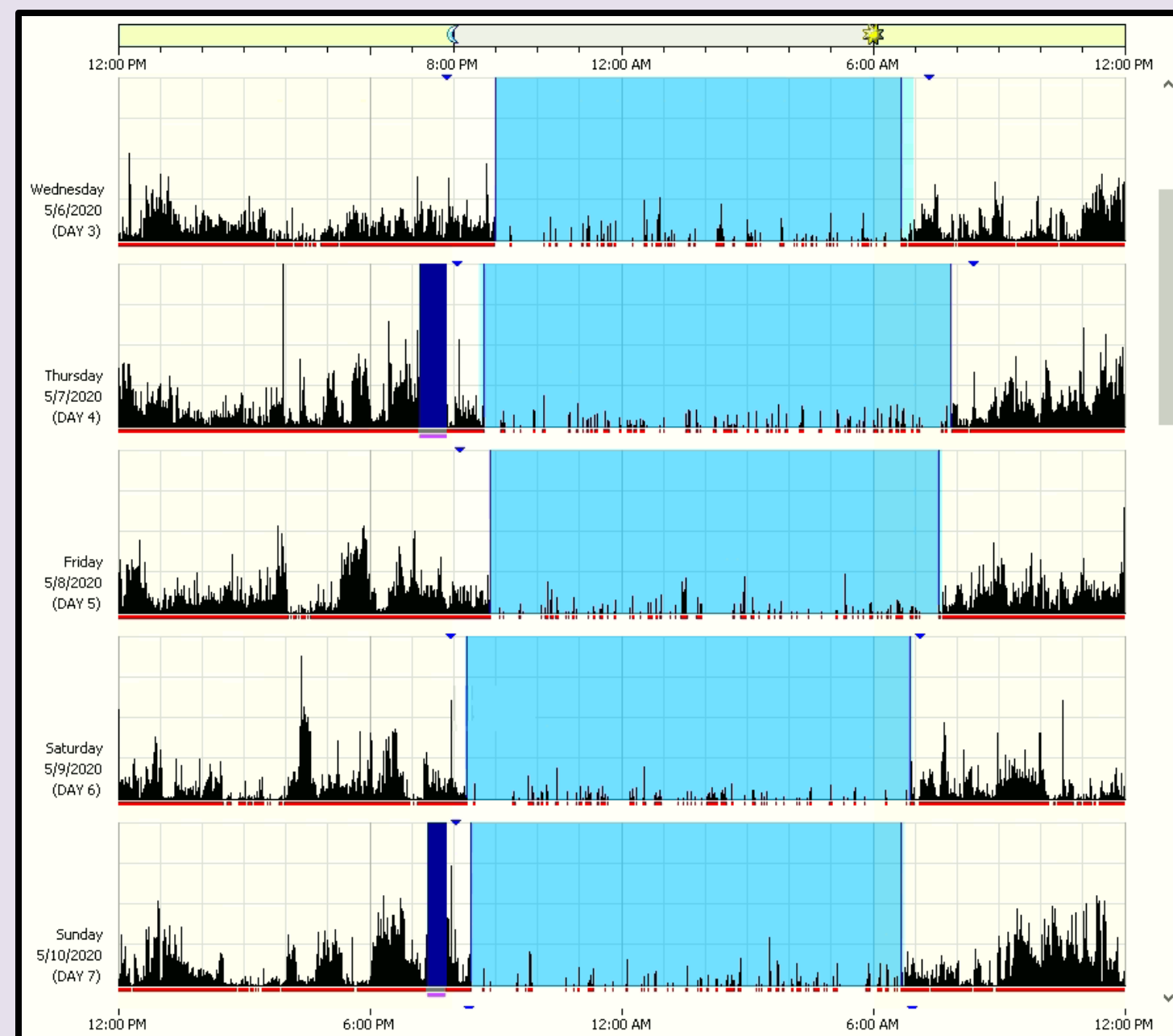
## CONS

- Can still be expensive
- Level of signals vary
- Varying levels of accuracy
- REM sleep often inaccurate
- Less control over data output
- May still require set-up

# What is Actigraphy?

- Wearable device
- Estimates sleep vs wake via an accelerometer
- Additional features may include light, temperature, event markers, heart rate, wear sensors
- Commonly worn on non-dominant wrist, hip, or ankle
- Many validation studies with PSG

Source: Ancoli-Israel, 2003 & 2015





# Actigraphy

## PROS

- Generally high agreement
- Reliable
- Appropriate for any age
- Small, user-friendly
- Good for sleep trends & circadian rhythms
- Some have user-friendly software

## CONS

- Some are expensive
- Data processing can be complex
- Not all provide 'raw' data
- No context of activity
- Can confuse sleep & sedentary activities
- Nap sleep & WASO are tricky!
- Diaries improve accuracy



# Actigraphy Considerations

## Device Selection

- Research-grade or consumer
- Water-resistant or waterproof
- Placement & materials
- Battery life (sampling rate & recording time)
- Can it be charged while recording?

## Device Set-Up

- Sampling rate
- Epoch length
- Other parameters

## Data Processing

- Epoch length
- What algorithms (wake/sleep, wear-time, etc.)?
- If using public code (e.g., GGIR) – adjust parameters to your protocol!





# So Many Choices!

There are two buttons  
I never like to hit:  
that's panic and  
snooze.

~Tad Lasso

ChatGPT. "Photocollage of Various Research and Consumer Sleep Trackers." 2024. OpenAI.



# Deciding What Works for You!

- What variables do you want?
- Why do you want them?
- Accuracy
- Data access
- Comfort and wearability
- Ease of use
- Measurement duration
- Population
- Privacy concerns
- Proprietary issues or app/device updates
- Performance evaluation research

**No one size fits all or 'best' measurement tool/method!**

Sources: Depner, 2020, de Zambotti, 2022, de Zambotti, 2020, & Lots of anecdotes!



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## Slides & Resources



[www.mooveandsnoozelab.com](http://www.mooveandsnoozelab.com)



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# Measuring Cognition

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# My Perspectives



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# What is Cognition?



“Collection of mental processes that allow an individual the ability to interact with the environment”

Source: Harvey, 2020

# Cognitive Domains

Sensation &  
perception

Motor skills &  
construction

Attention

Memory

Executive  
function

Processing speed

Language/verbal  
skills

Source: Harvey, 2020



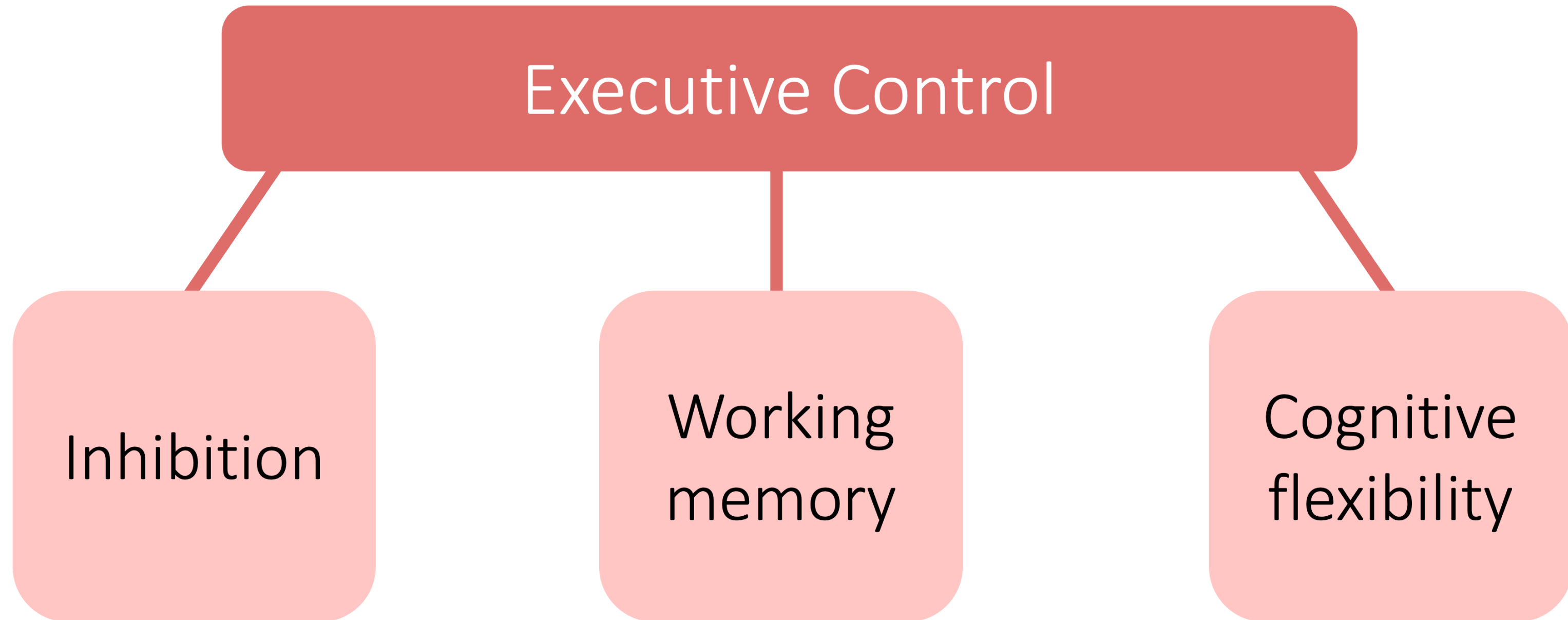
# Attention

- The “key to changes in human memory”
- Divided attention = ability to switch focus b/t tasks
- Selective attention = ability to focus on a single task
- Sustained attention = ability to stay on task for long periods



Source: Harvey, 2020

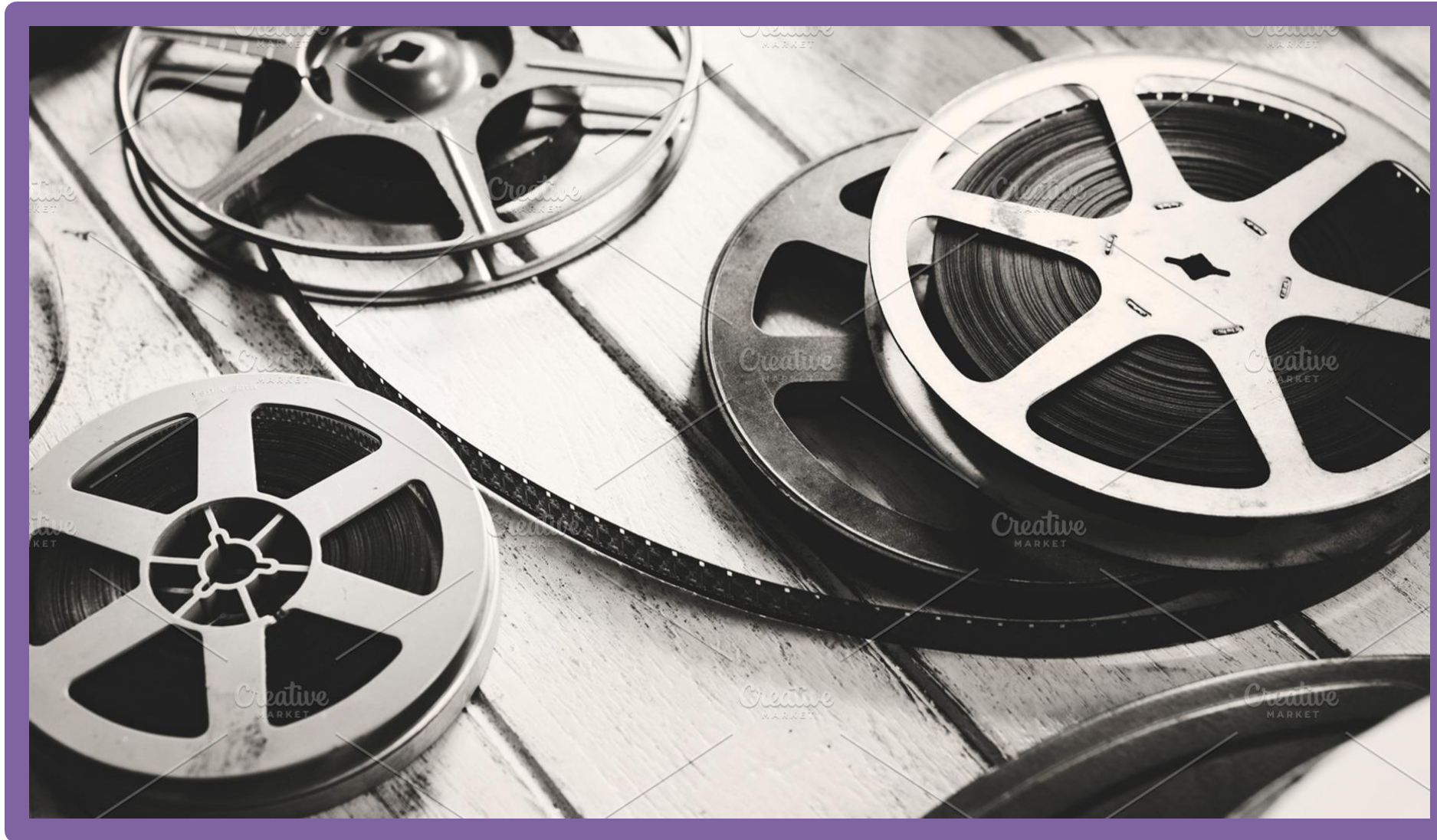
# Executive Function



Source: Harvey, 2020



# The Many Forms of Memory...



- Working
- Episodic/declarative
- Procedural
- Semantic
- Prospective

Source: Harvey, 2020



# Evaluation Tool Considerations

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- **Validity:** Does it measure what it claims to measure?
- **Construct Validity:** Does it effectively capture the intended cognitive domain?
- **Ecological Validity:** Does it resemble real-world cognitive tasks?
- **Reliability:** Does it provide consistent results over time?
- **Test-Retest Reliability:** Are scores consistent when administered multiple times?
- **Inter-Rater Reliability:** Are scores consistent between testers?

# Other Key Considerations

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- Population/age sensitivity
- Cultural bias
- Language differences
- Educational bias
- Scope/setting
- Context
- Delivery
- Technological & experience requirements
- Sensitivity/complexity
- Learning effects
- Comprehensive vs specific
- Duration

# Overall Cognition Function

- Montreal Cognitive Assessment (MoCA: targets mild cognitive impairment)
- Mini-Mental State Examination (MMSE)
- Cambridge Neuropsychological Test Automated Battery (CANTAB)
- Cognitive batteries (e.g., NIH Toolbox, Early Years Toolbox)
- Screening & diagnostic tools



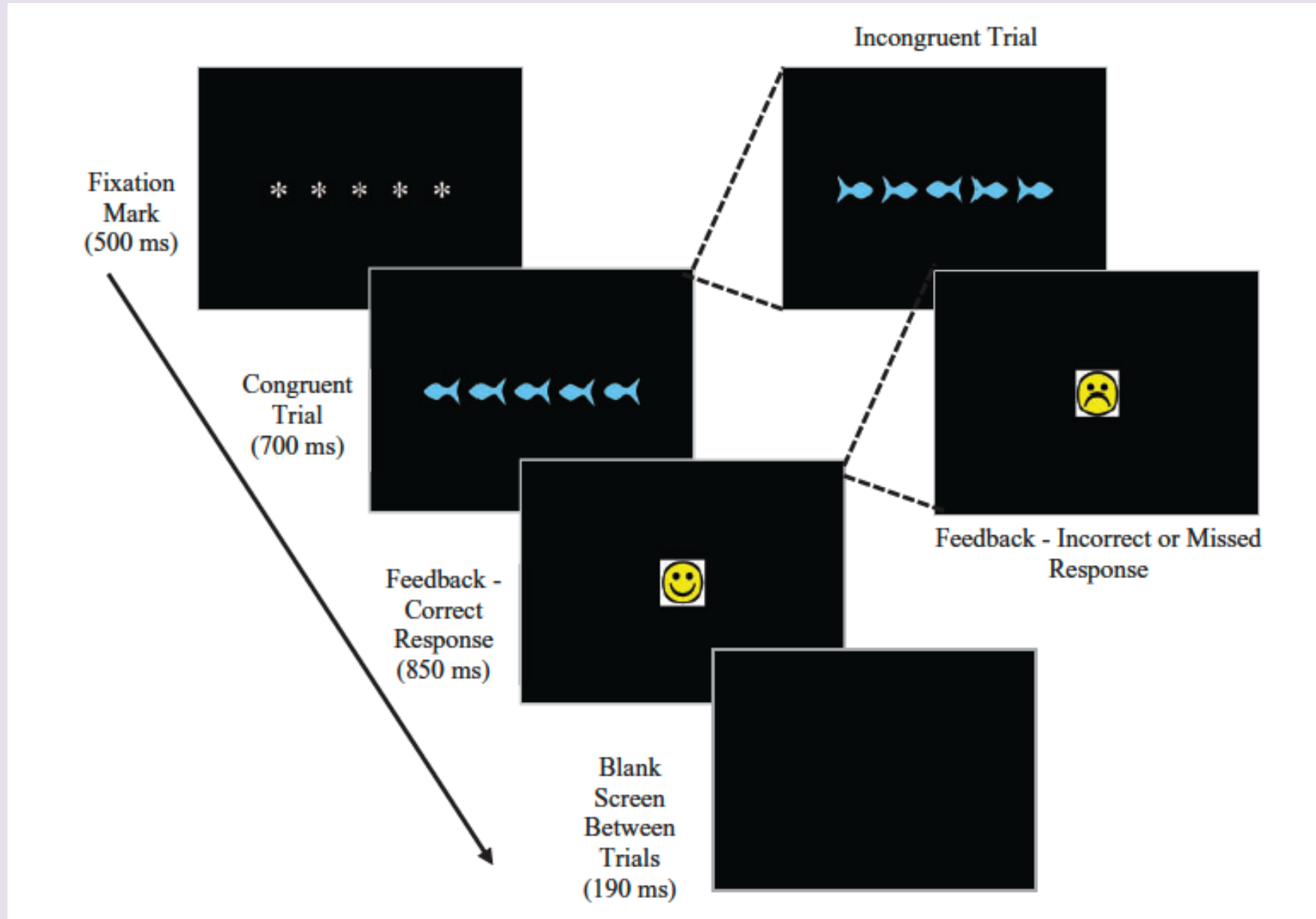


# Executive Function

- **Trail Making Test (TMT):** TMT-A: visual attention by asking participants to connect numbers in sequential order; TMT-B: Assesses executive function by alternating between numbers and letters in sequential order
- **Stroop Test:** Name the color of the ink used to print words, while the words themselves may represent conflicting colors
- **Wisconsin Card Sorting Test (WCST):** Match cards based on rules that change over time without explicit instruction, requiring adaptability and working memory
- **Digit Span Test (Forward and Backward):** Recall increasingly longer strings of numbers in the same order (forward) or reverse order (backward)
- **N-Back Task:** View a series of stimuli (numbers, letters, or shapes) > respond when the current stimulus matches the one presented "n" positions earlier in the sequence

Source: de Assis Faria, 2015

# Executive Function: Examples



Sources: Desroches, 2016; Howard, 2017

# Assessing Memory

- **Encoding** - taking information contained in working memory and processing it for longer-term storage.
- **Storage** - process of retention of information after encoding
- **Retrieval** – the remembering or ‘using’ the information part

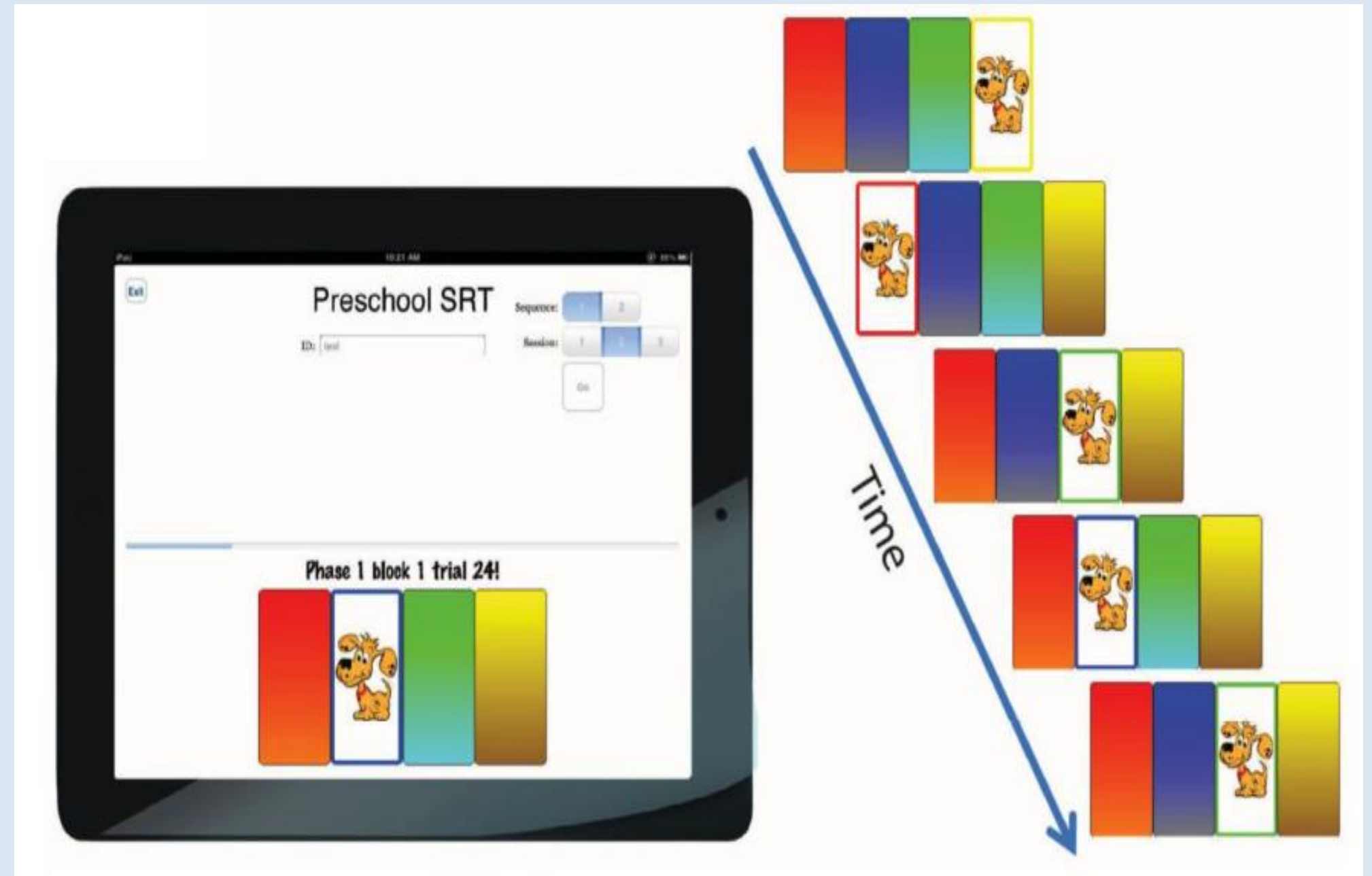
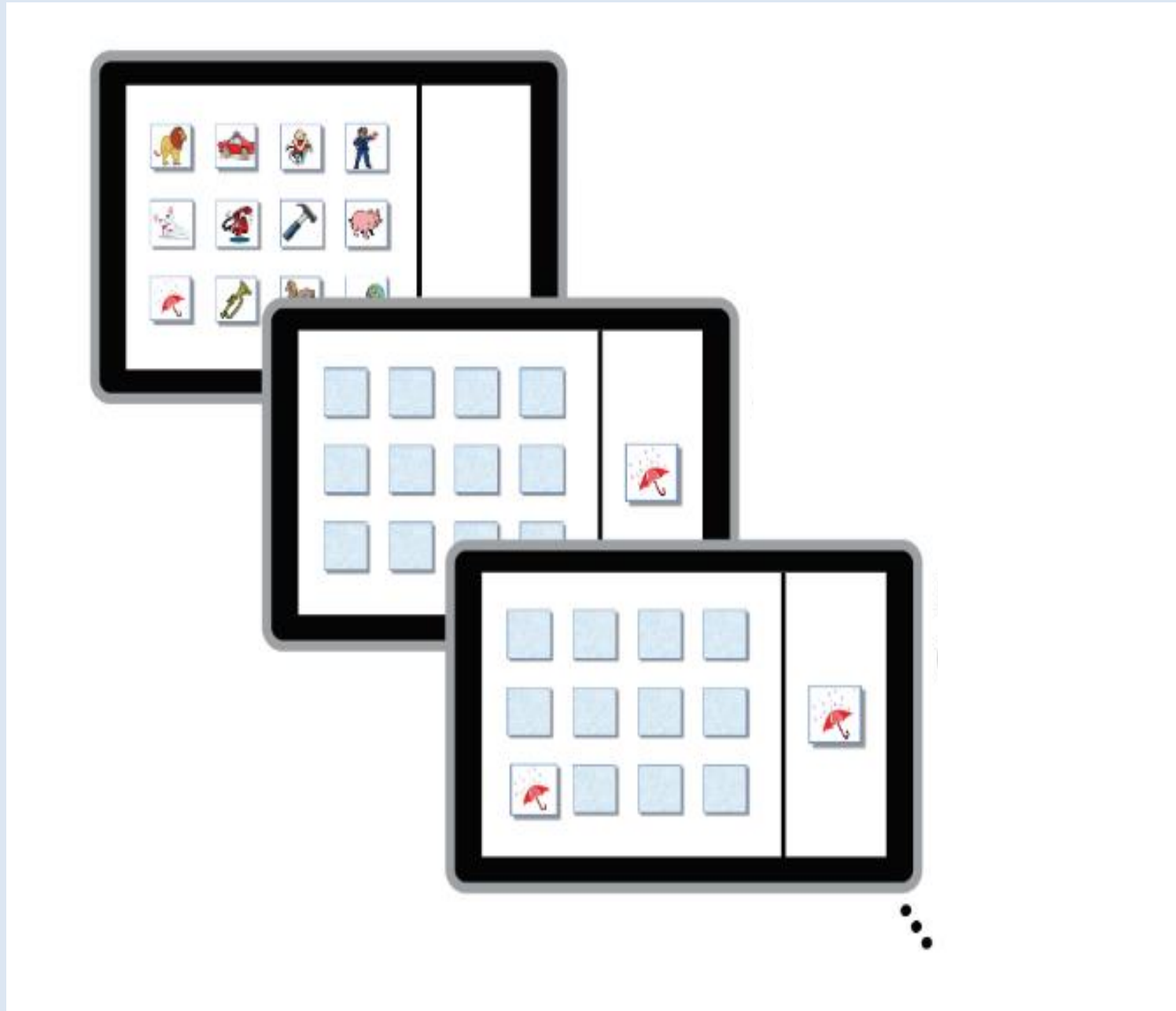
- **Free recall** – “recall what we showed you”
- **Cued recall** – providing prompts (e.g., “tell me all the animals”)
- **Recognition memory** – “did you see before?” (if not = ‘foil’)



# Memory Tasks

- **Word Recall Tasks** - recall as many words as possible from a list
- **Rey Auditory Verbal Learning Test (RAVLT)** - presented with a list of 15 unrelated words and asked to recall as many as possible, followed by several learning trials and a delayed recall trial
- **Paired Associates Learning (PAL) Task** - presenting participants with pairs of items and testing their ability to recall the second item when shown the first
- **Visuospatial Tasks** - presenting participants with pairs of items and testing their ability to recall the second item when shown the first
- **Mirror Drawing** - Traces a shape reflected in a mirror
- **Serial Reaction Time Task** - Learning sequences (e.g., on a keyboard)

# Memory Tasks: Examples



Sources: Kurdziel, 2013; Desroches, 2016

# Open Access Cognitive Testing Platforms

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- **PsyToolkit:** A free, web-based platform that allows researchers to design and run cognitive tasks like the n-back task and various working memory tasks
- **Gorilla Experiment Builder:** An online platform that enables researchers to create and run cognitive experiments, including memory tasks like visual memory tests, n-back, and prospective memory tasks
- **Cognition.run:** This platform offers a suite of cognitive tests including memory-related tasks that can be administered in real-world settings using mobile devices or computers



# Get Creative or Get Together!

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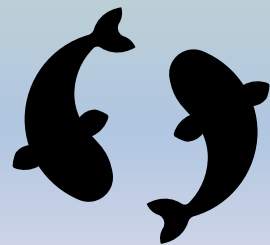
- Your university or collaborators may have access to licensed programs (e.g., E-Prime, Inquisit, or CANTAB)
- Work with collaborators (with the expertise) to code/create your own task(s)
- Consult with psychological test databases and publishers (e.g., Pearson, Cambridge Cognition, PAR, Inc.)
- Look into mobile/tablet options

Sources: Koo, 2019; McHenry, 2023

# References

“You know what the happiest animal on Earth is? It's a goldfish. It's got a 10-second memory. Be a goldfish, Sam.”

~Ted Lasso



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