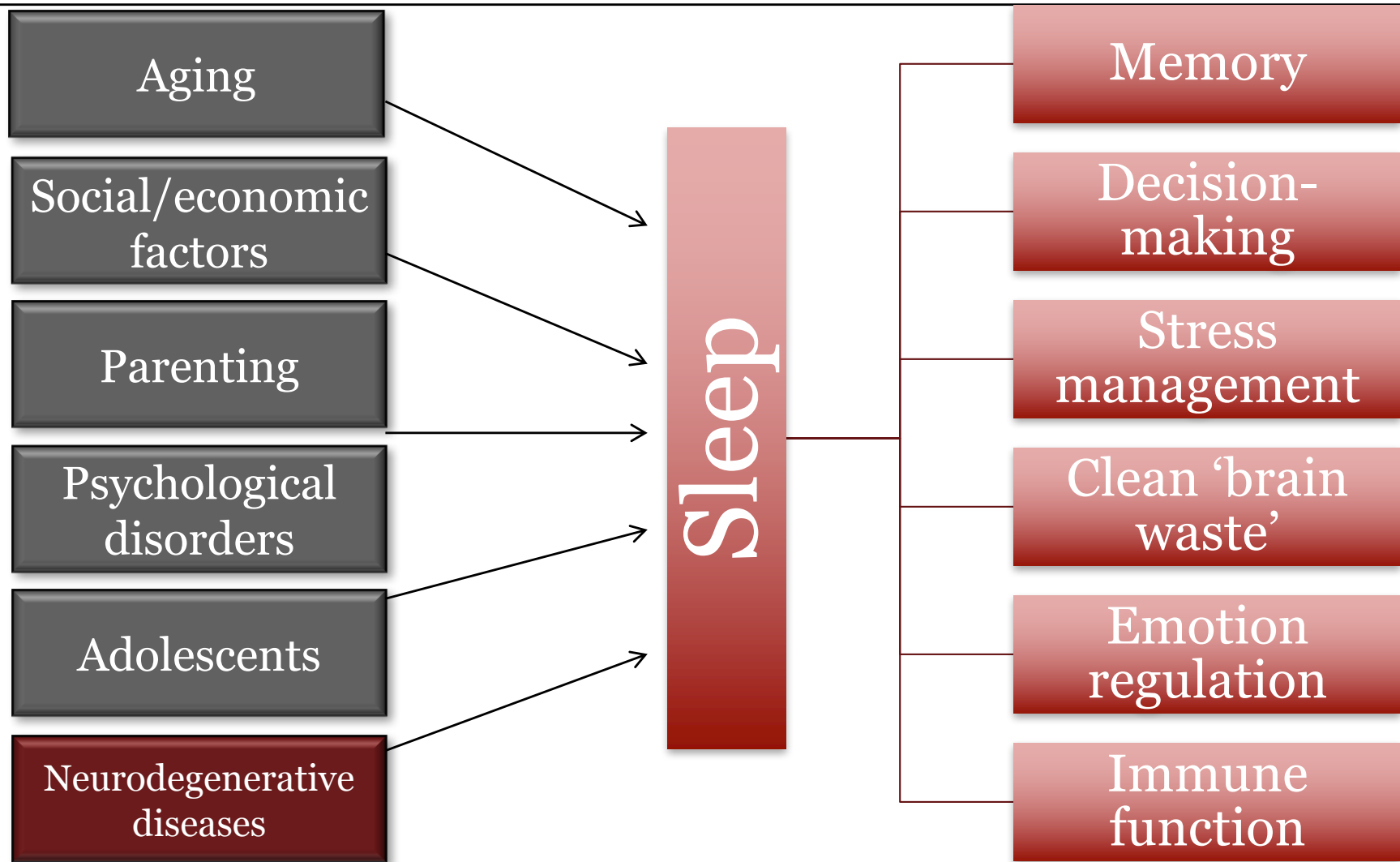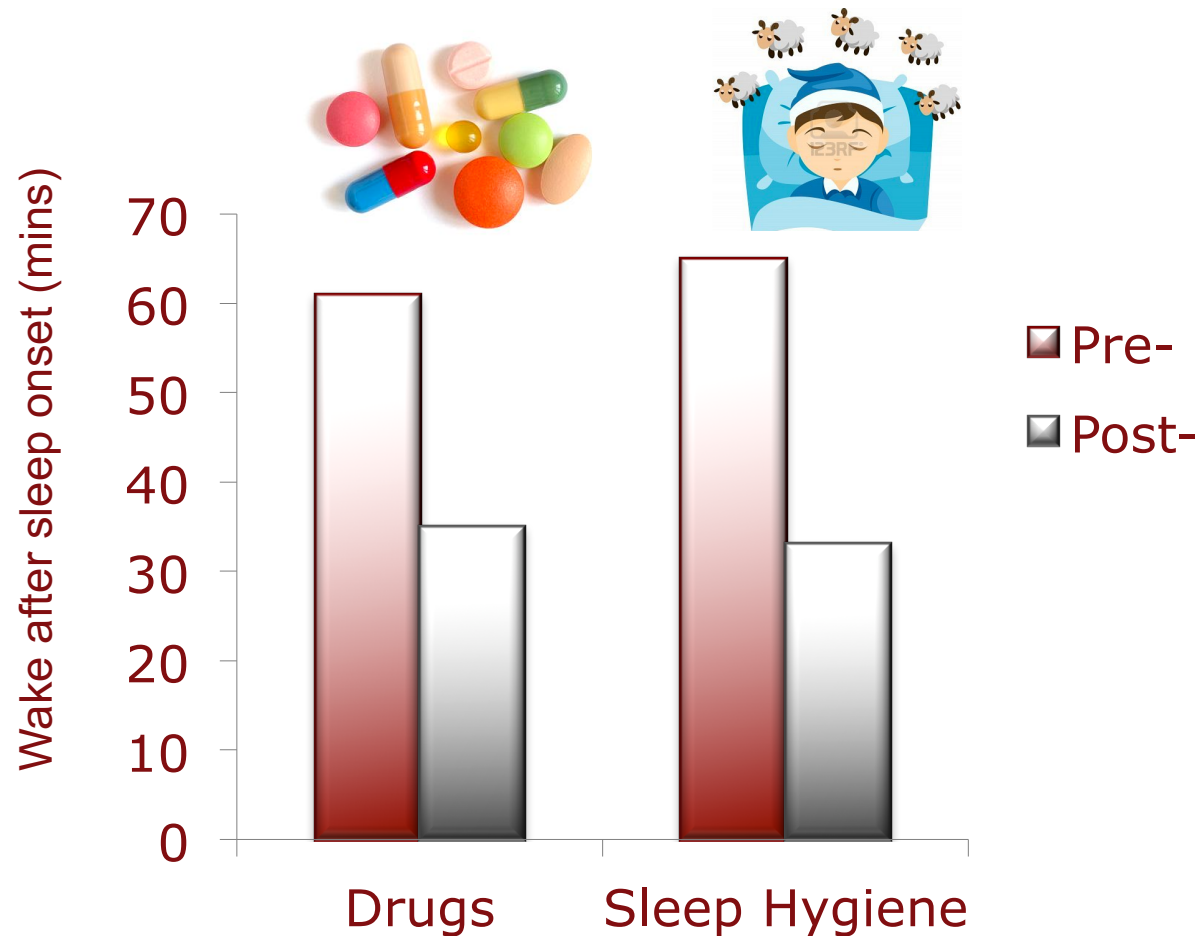# Measuring sleep and sleepiness with mobile devices

Rebecca M. C. Spencer, PhD
Center for Personal Health Monitoring
University of Massachusetts, Amherst
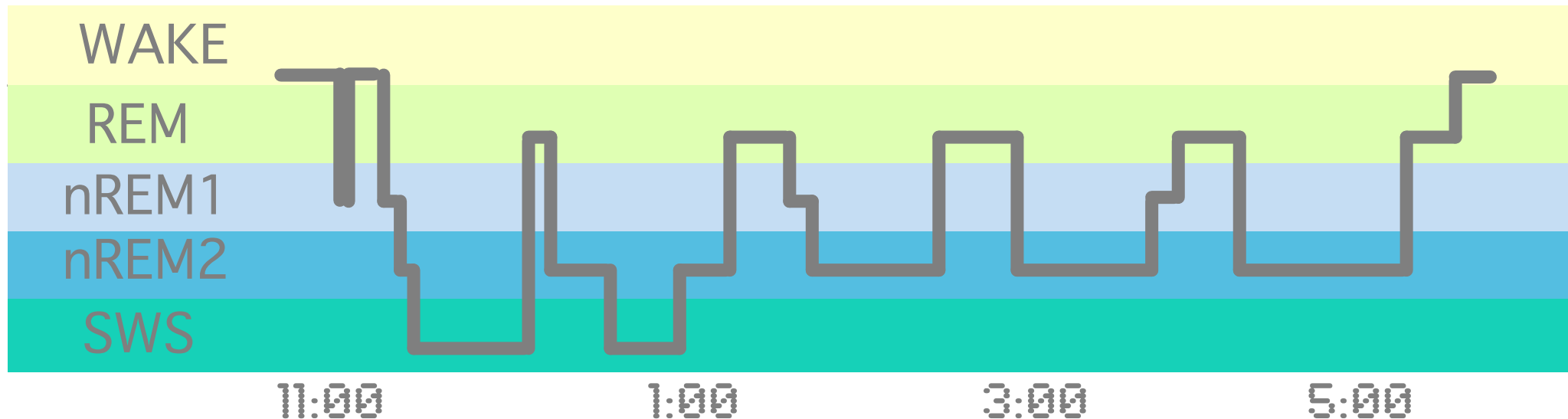
Why measure sleep?

```
Aging ───────────────┐
                     ▼
Social/economic ────► Sleep ──┬──► Memory
factors                       │
                              ├──► Decision-making
Parenting ────────────────►   │
                              ├──► Stress management
Psychological                 │
disorders ──────────────►     ├──► Clean 'brain waste'
                              │
Adolescents ──────────►       ├──► Emotion regulation
                              │
Neurodegenerative ────►       └──► Immune function
diseases
```

Sleep is treatable behaviorally

e.g., *Jacobs et al., Arch Int Med, 2004*
McClusky et al., Am J Psychiatry, 1991

Key points

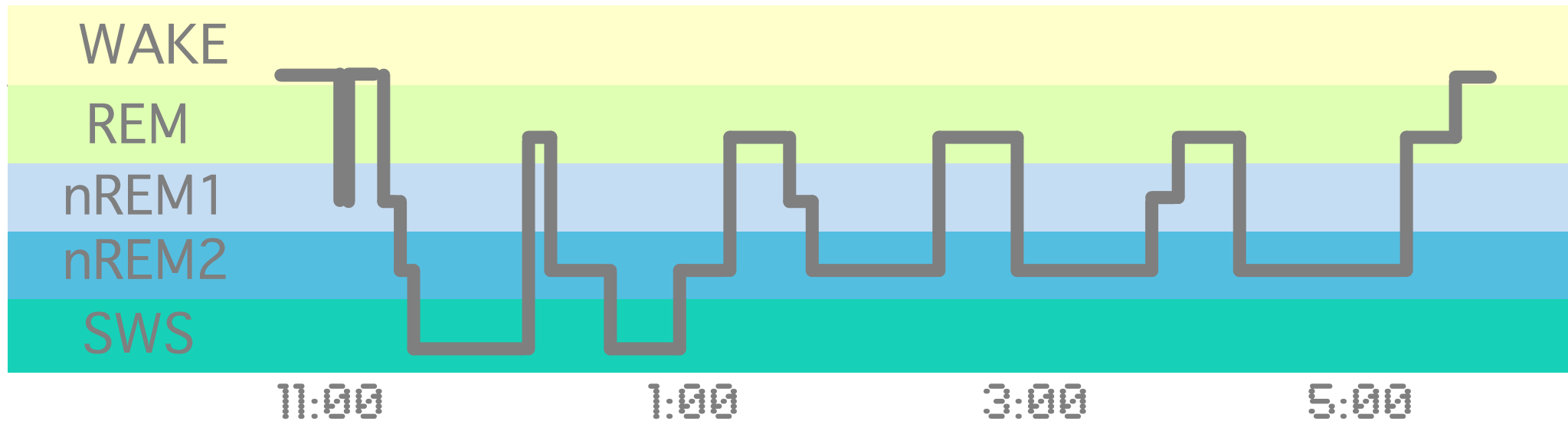- Sleep is not homogenous and all stages serve a unique function
- SWS may be particularly essential in neurodegenerative diseases given the role in glymphatic clearing

Key features of sleep that impact quality of life

Sleep quantity

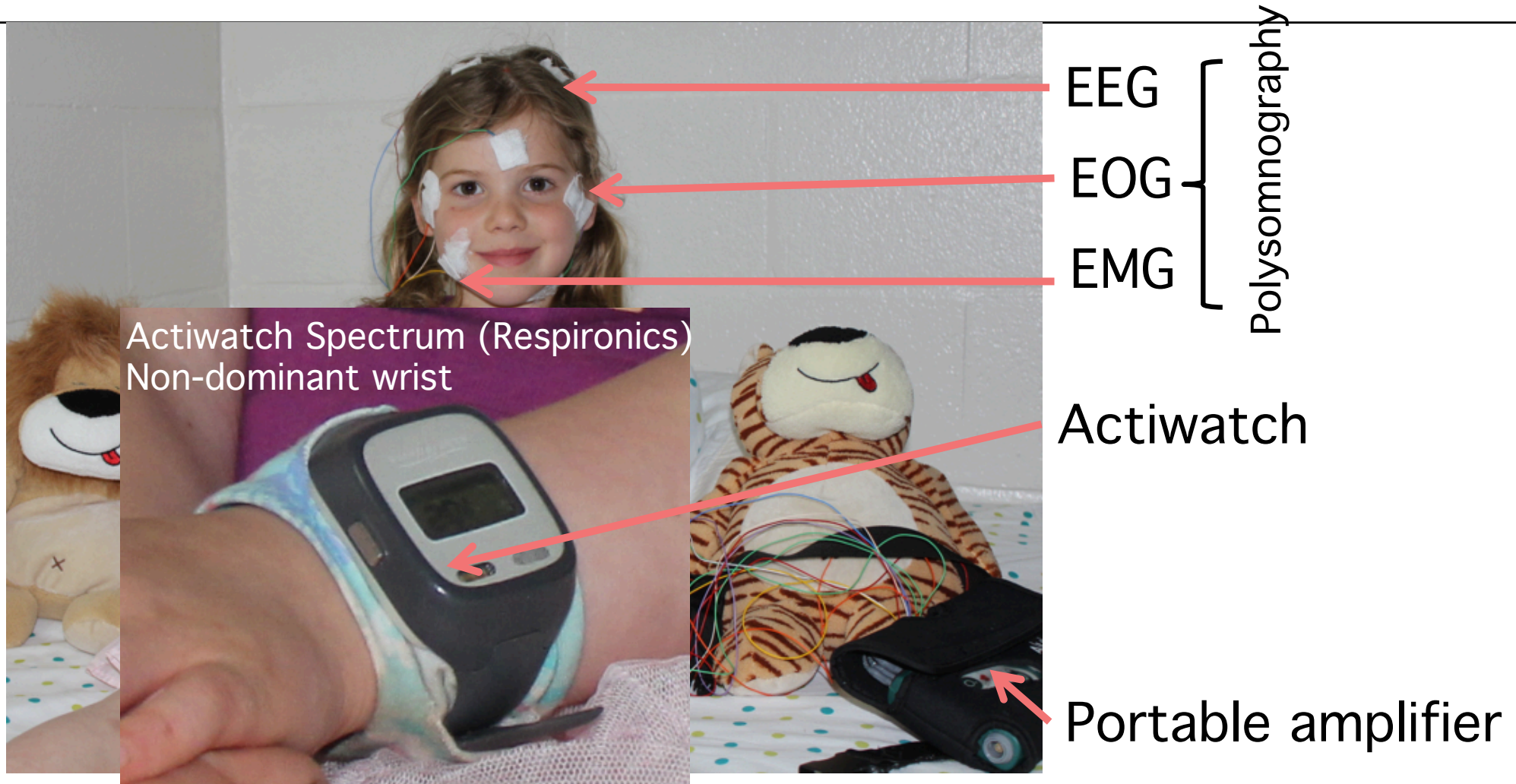more sleep, more of all of these functions

Sleep quality

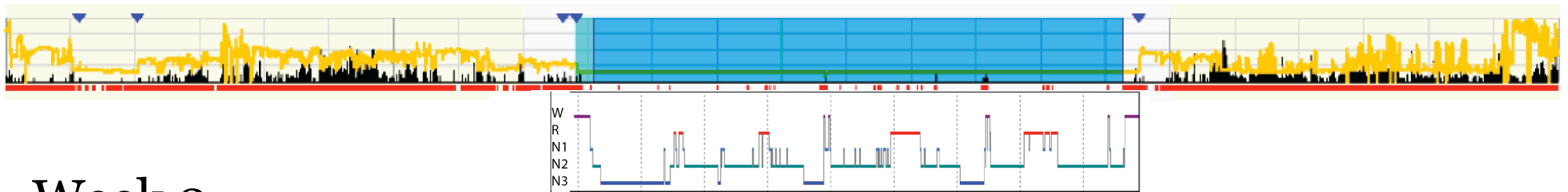less time wasted awake in bed improves function

Sleep sufficiency
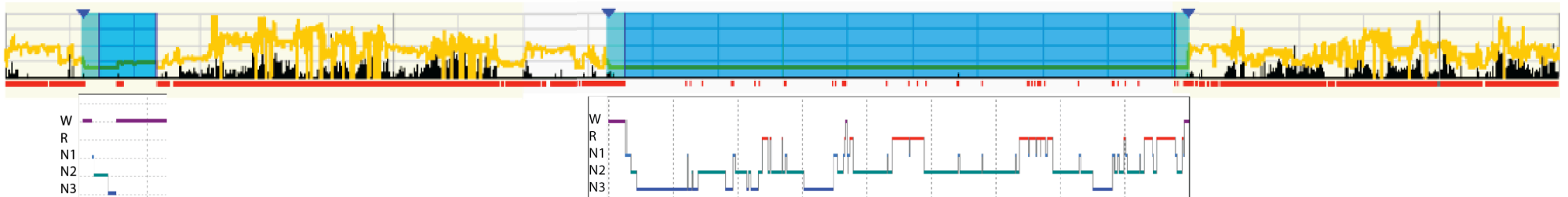
Does it meet sleep need?

Sleep measurement

EEG

EOG

EMG

Polysomnography

Actiwatch Spectrum (Respironics)
Non-dominant wrist

Actiwatch

Portable amplifier

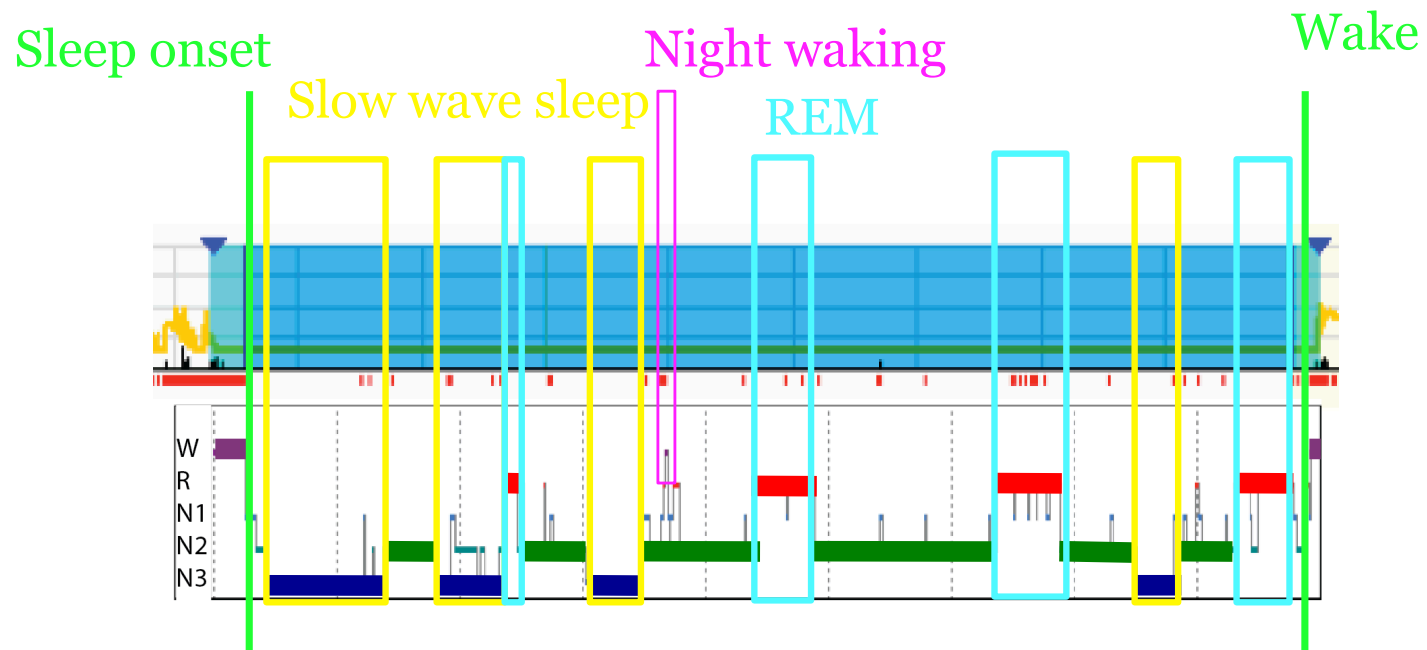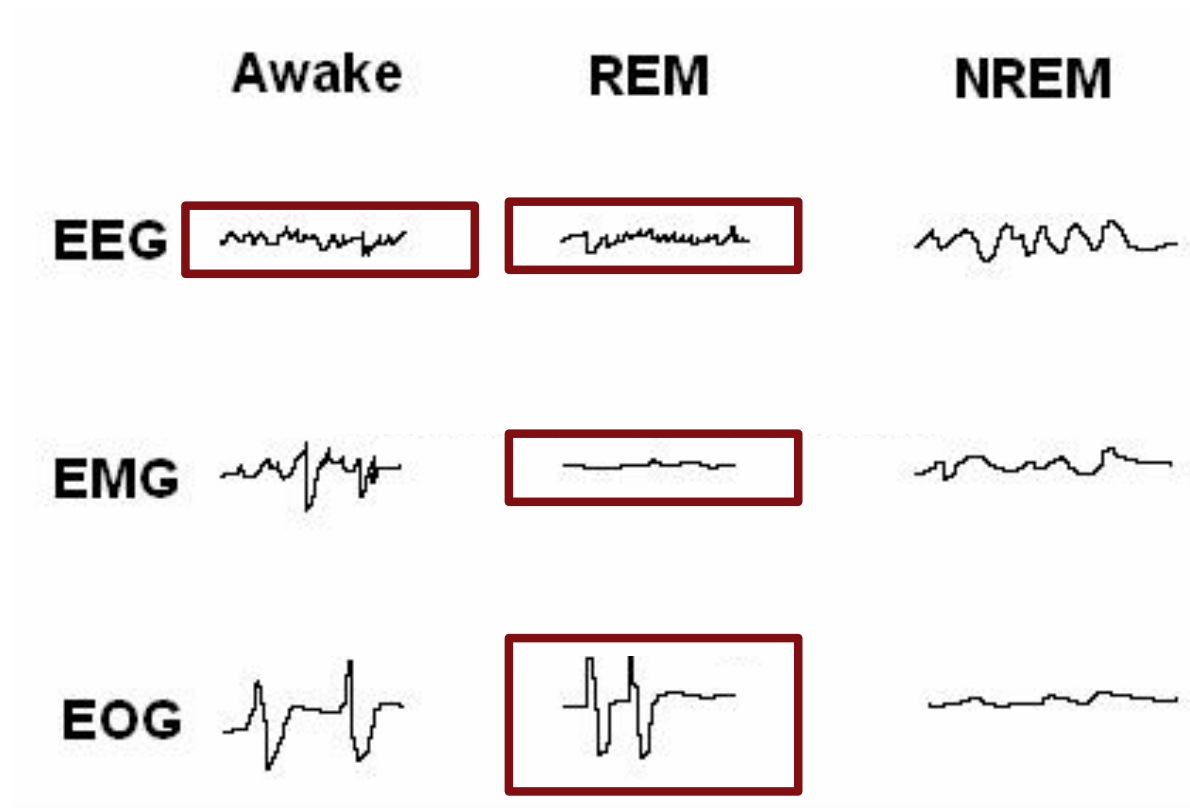# Sample recordings

Week 1

Week 2

Sample recordings

Polysomnography

Take home message:

- EEG is necessary to identify sleep
- EMG/EGO is necessary to identify sleep stages

Polysomnography

A montage:

- EEG (electroencephalography)
- EOG (electroculography)
- EMG (electromyography)

Can also have (for sleep disorder dx):

- Leg EMG
- Snore sensor
- ECG (electrocardiogram)
- Pulse oximetry
- Plethysmography

Key features of sleep that impact quality of life

BMD proxy for sleep <u>quantity</u>

Total Sleep Time (TST) = Sleep period*– (SOL+ WASO)

- SOL: Sleep onset latency
- WASO: Wake after sleep onset

BMD proxy for sleep <u>quality</u>

Sleep efficiency (SE) = TST/ Sleep period* x 100

Often called a 'sleep score'

*Sleep period=time 'in bed'

What is measured by devices?
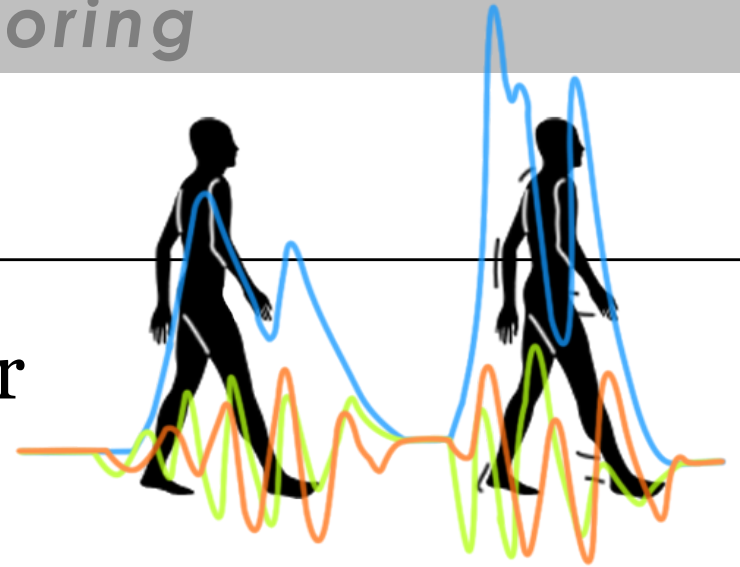
Research-based actigraphs

ActiWatch (Philips Respironics) ~$800

ActiGraph ~$200

Actigraphy

- Contains triaxial accelerometer

- Provides an **estimate** of the sleep/wake cycle via movement (or absence of). Based on many assumptions.

- Summarizes the frequency of motions into epochs of specified time duration and stores the summary in memory

Actigraphy

Actigraphy – research-based actigraphs

Advantages:

- Objective (compared to questionnaires, observation)
- Can be worn over multiple days/weeks
- Correlation between actigraphy- and PSG-defined sleep estimates

Disadvantages

- Accuracy is lower for some groups
- Cannot score sleep architecture
- **Scoring data is tedious**
- **Validated data requires simultaneous diary**
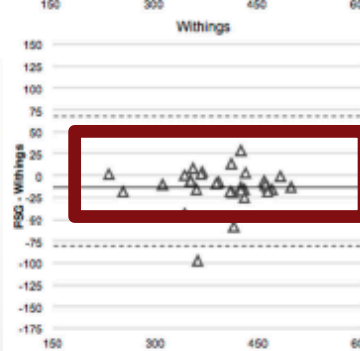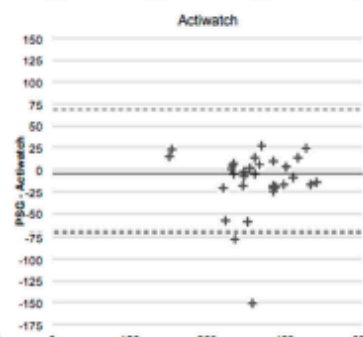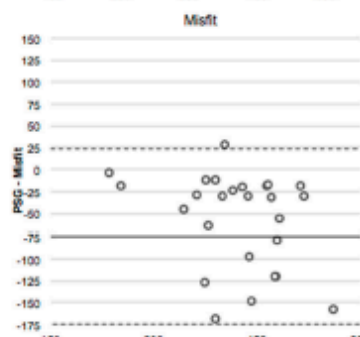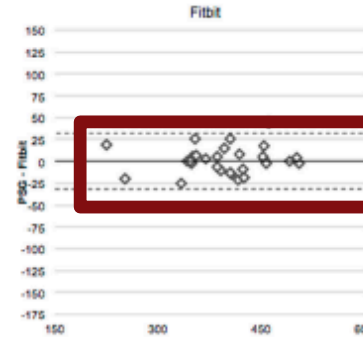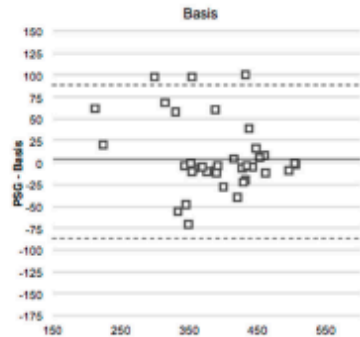
Comparison of commercial BMDs

Basis

Fitbit
(Flex)

Misfit

Research actigraph
(Spectrum)

Withings

Total Sleep Time

Sleep Efficiency (sleep score)
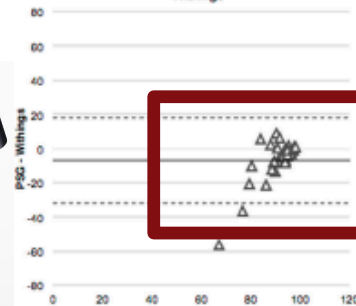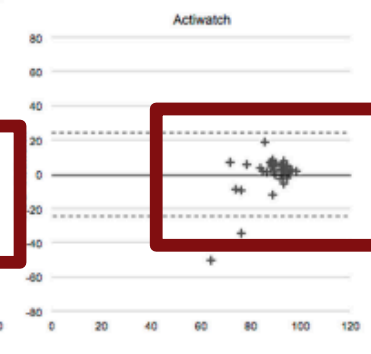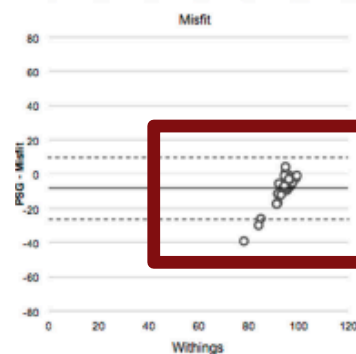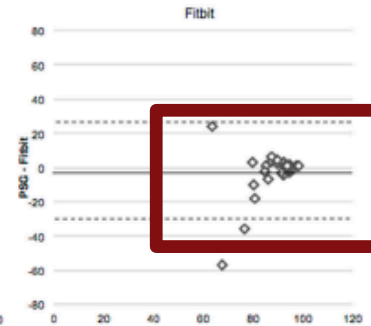
Deep & Light Sleep
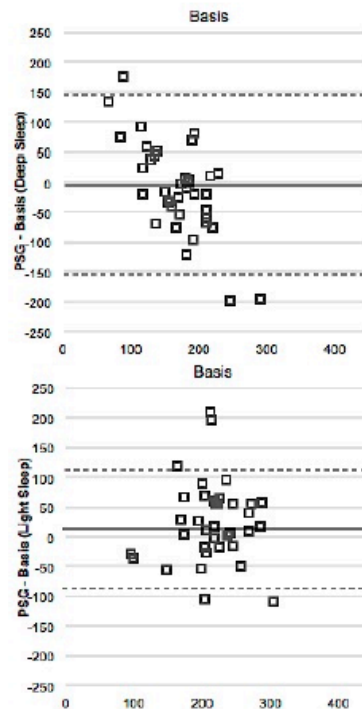
Other current devices

- ## Smartphone apps
  - Sleep Cycle, Sleep Time, SleepBot, MotionX

- ## Beddit

Challenges – part 1

- Actigraphy-based sleep measures are *generally* reliable for <u>total sleep time</u> and <u>sleep efficiency</u>

- However, most studies are
  - Limited to healthy young adults
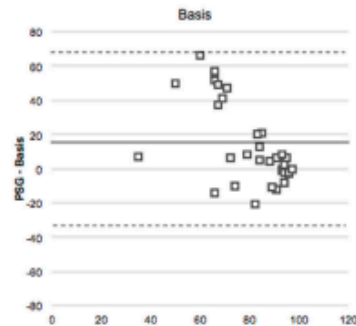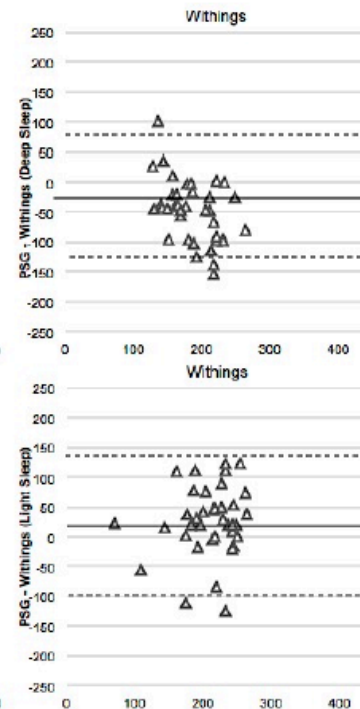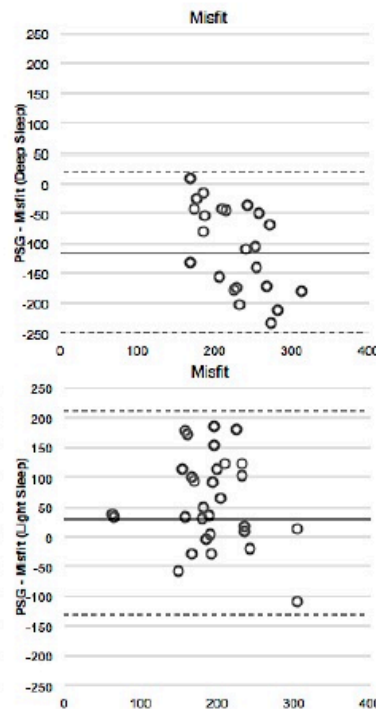 - Focused on night-time (supine) sleep
  - Inactivity v. napping v. sleepiness mid-day is indistinguishable

- BMDs do not capture sleep stages accurately. Given that SWS may be key and nREM1 of limited use, total sleep time may not be enough.

- How to improve:
  - Portable polysomnography?
  - Actigraphy + (EEG, EMG)

Commercial BMD usability

	Fitbit		Misfit			Moov	Withings
	Flex	Charge	Flash	Shine	Ray		Pulse
Battery length	2 weeks	5 days	**6 months**	**6 months**	**6 months**	**6 months**	2 weeks
Auto-detect sleep	No*	Yes	Yes	Yes	Yes	Yes	Yes
Bluetooth upload	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Waterproof?	Resistant?	Resistant?	**Up to 30 m**	**Up to 50 m**	**Up to 50 m**	3 meters	No
Face 'value'	2	**5**	3	3	1	1	**4**
Price	$80	$109	**$25**	**$37-56**	$100	$60	$76
iPhone compat?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Android compat?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Other					Can be word w/ watch	Extreme work out feedback	

Challenges – part 2

- Must limit opportunities to take it off
  - Battery life limits
  - Waterproof limitations

- Self-monitoring requires interpretable information
  - Is the 'sleep score' enough?

- What is the value of a sleep score without knowing how to change it?

Healthy sleep hygiene ABC's

ACTIVITY: Exercise!

BANS: Eliminate caffeine, evening light/stimulation

CONSISTENCY: Nap only if consistently; Bedtime +/- 1hr

D, MELATONIN & SUNLIGHT: Set your body clock

ENVIRONMENT: Quiet, cool, and dark room

Thanks.

Work by:
Nick Gravel
Janna Mantua

Thanks.

<u>Work by:</u>
Nick Gravel
Janna Mantua

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