

Using EEG for recording Sleep

Elaine Tham



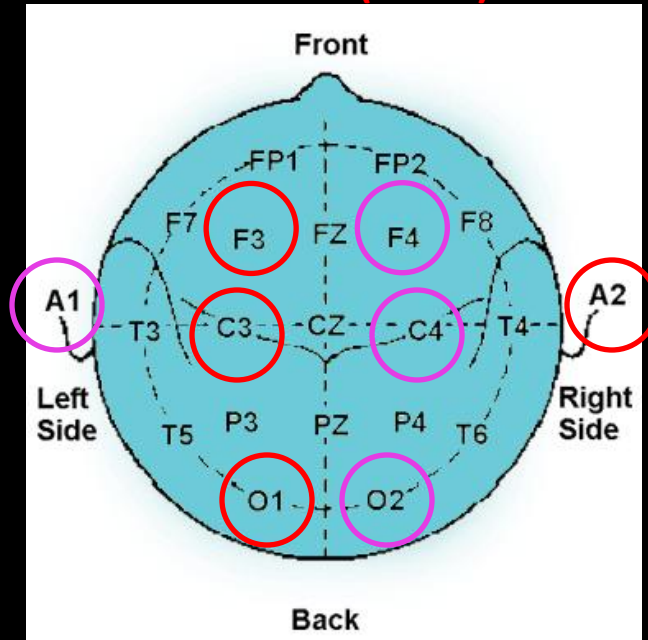
OVERVIEW

1. **What is sleep polysomnography or sleep EEG?**
2. **Sleep stages/scoring**
3. **Relating sleep EEG with behavioural data**

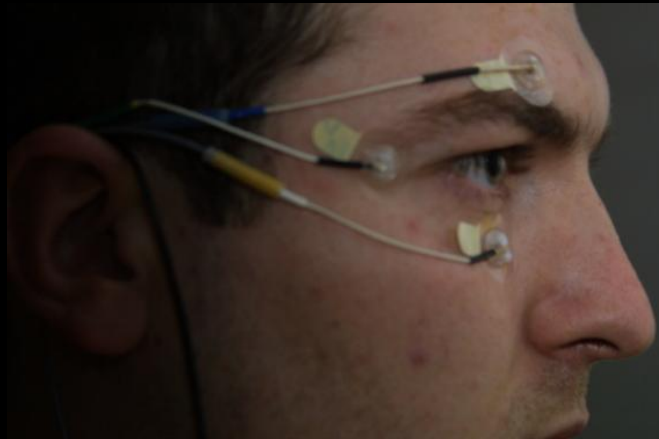
1. Sleep Polysomnography

Electrodes

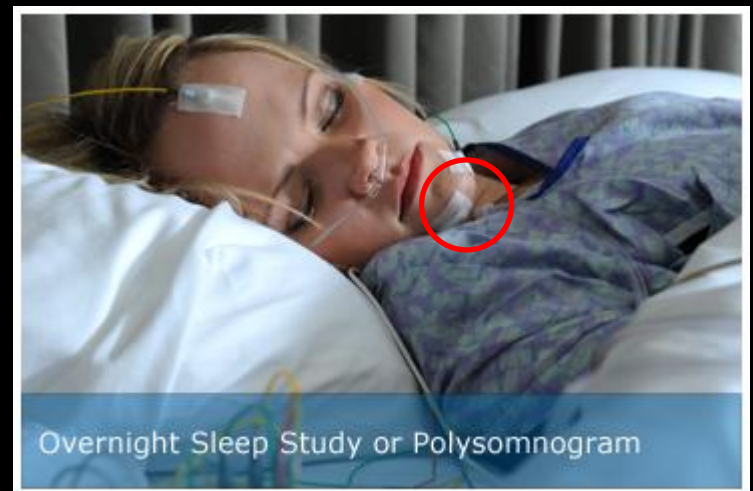
THE REST (Head)



EYES = EOG



CHIN = EMG



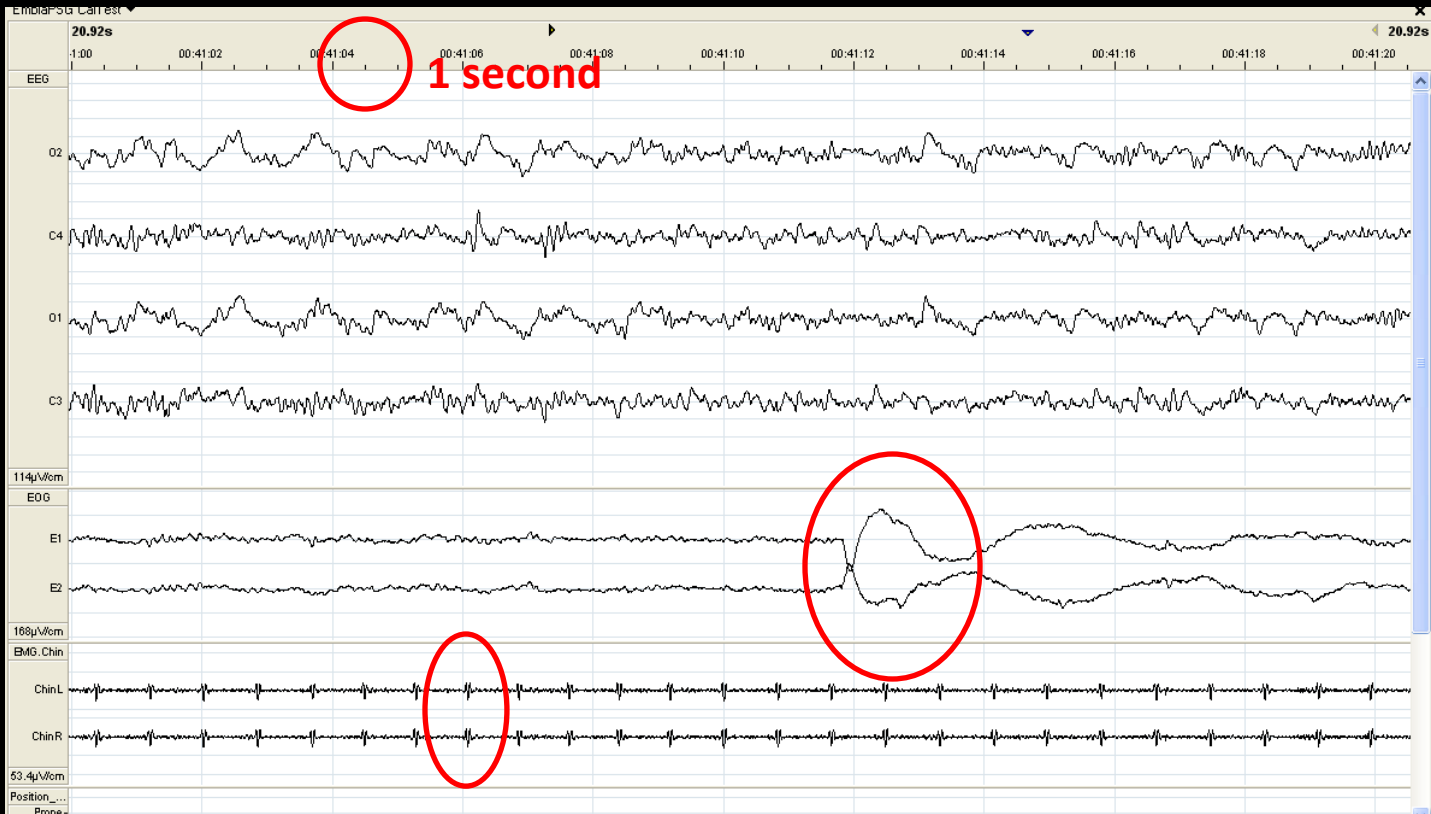
Overnight Sleep Study or Polysomnogram

REMlogic

30 seconds = 1 epoch



EEG

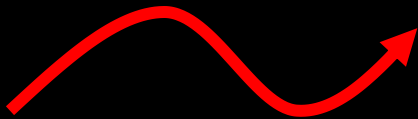


EOG

CHIN

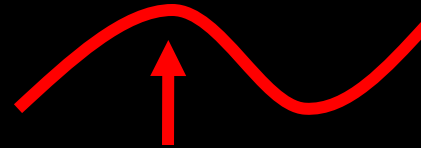
REMlogic

FREQUENCY

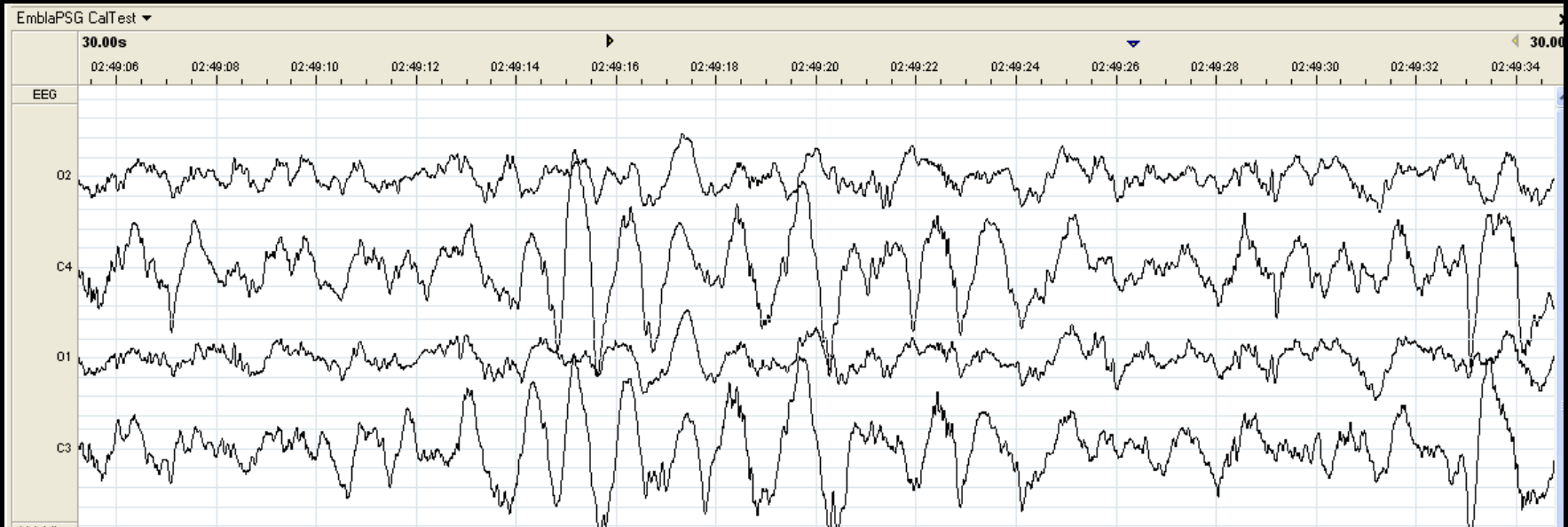


Hz = Cycles Per second

AMPLITUDE

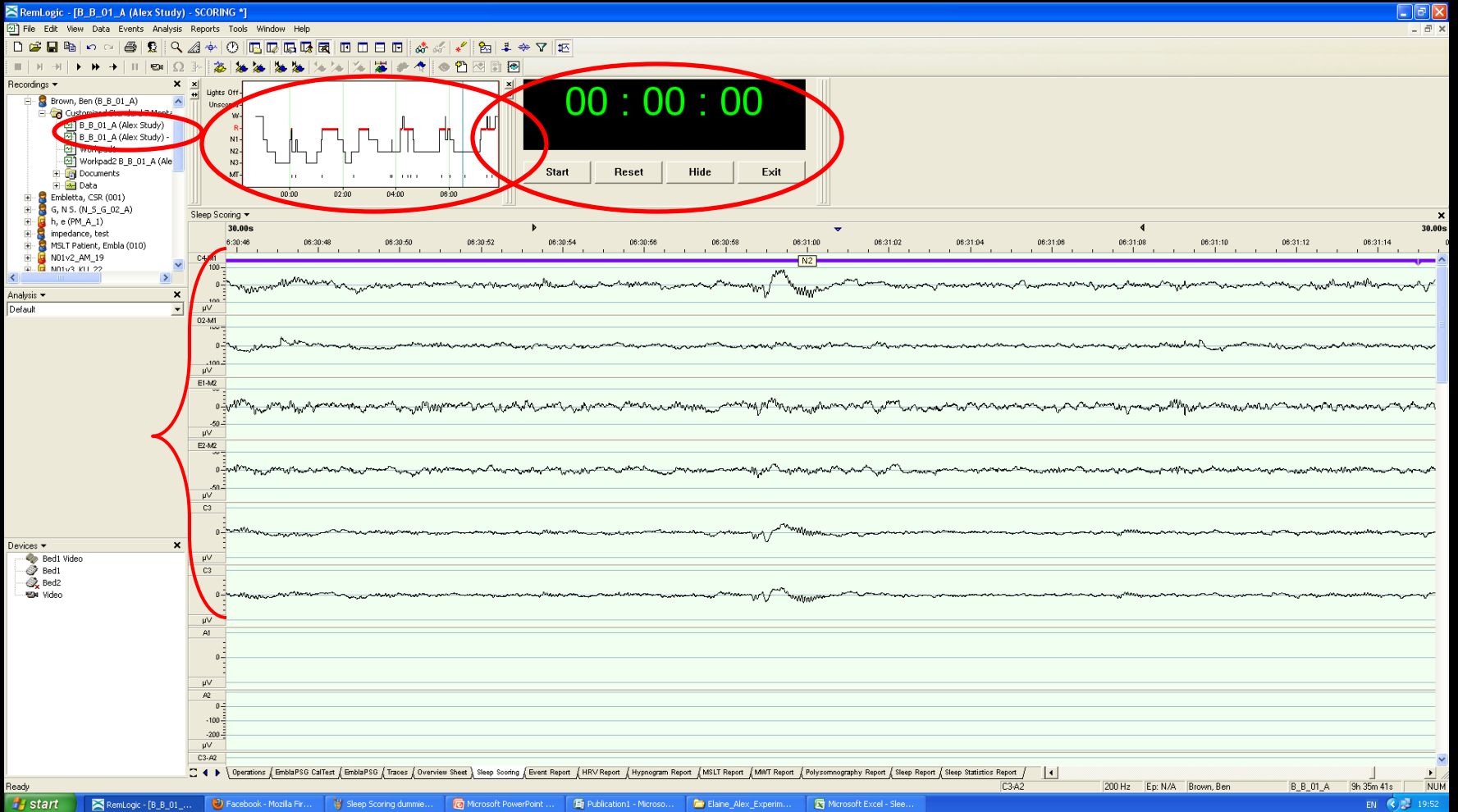


μV = Microvolts



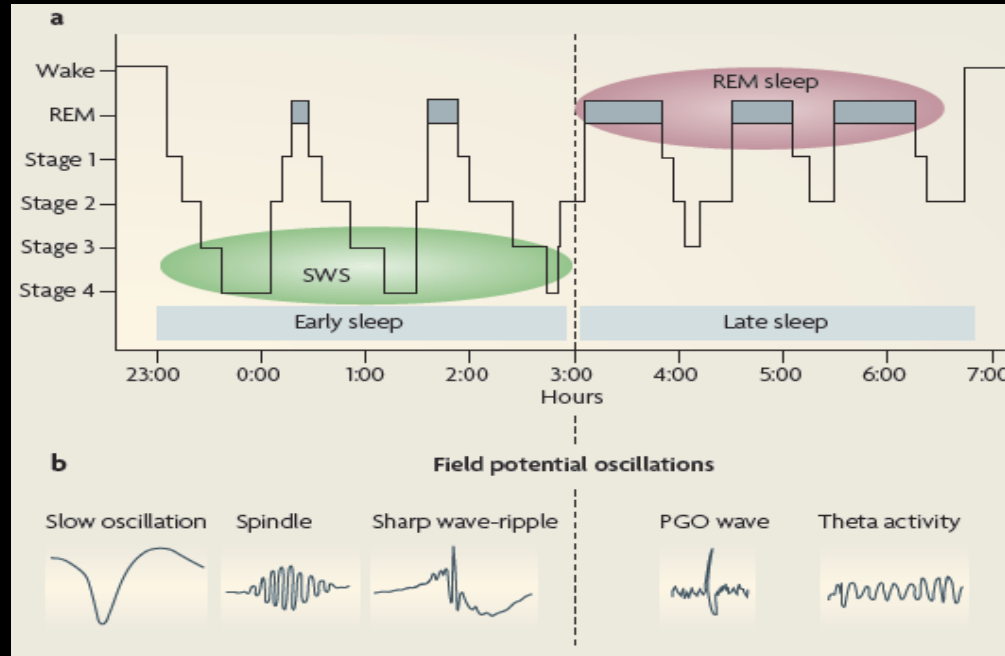
SLOW WAVE SLEEP N3

REMlogic



2. Sleep stages

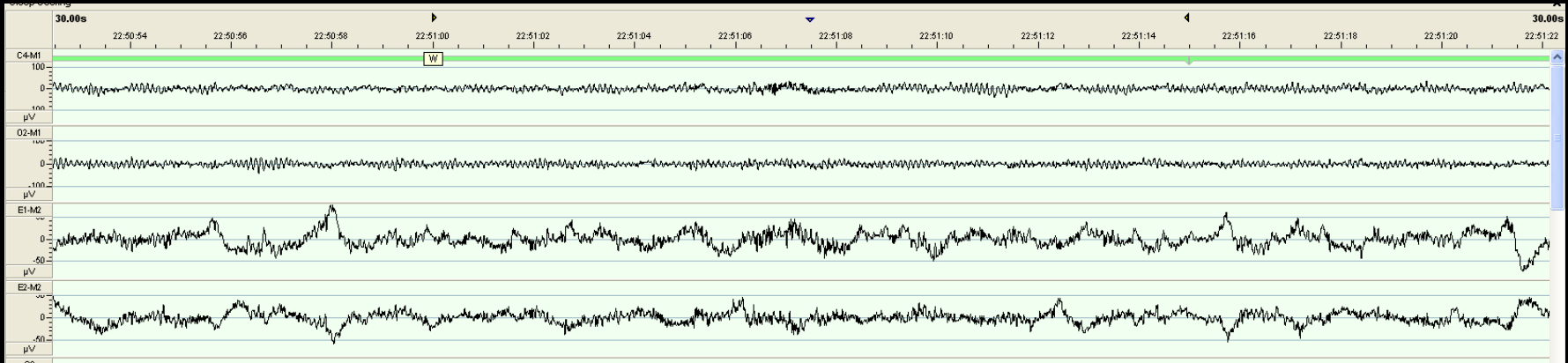
SLEEP STAGES



- Sleep occurs in natural cycles of about 90 minutes
- This is based on a normal overnight participant
- More SWS early in the night. More REM later.
- Nap studies may differ – more REM if the nap is early morning
- More SWS if later in the day

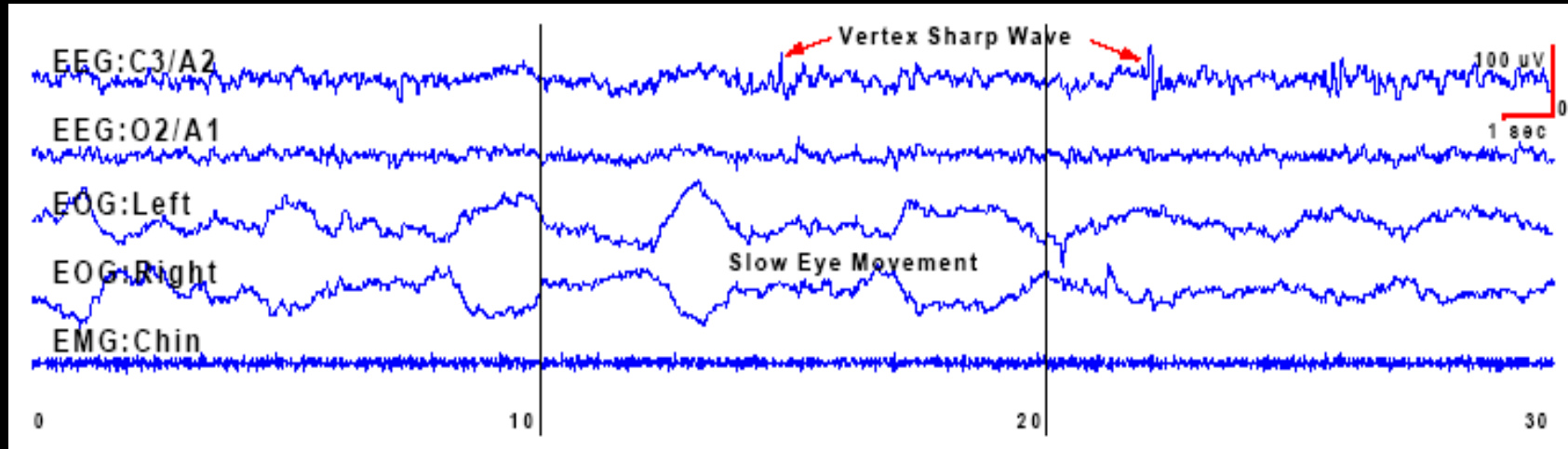
SLEEP STAGES

WAKEFULNESS



- Mixed frequency Alpha particularly in the Occipital (O1/O2) regions but NOT in all participants
- May have movement and blink artefacts.
- Natural, brief awakenings throughout the night.

Stage 1 (shallow sleep)

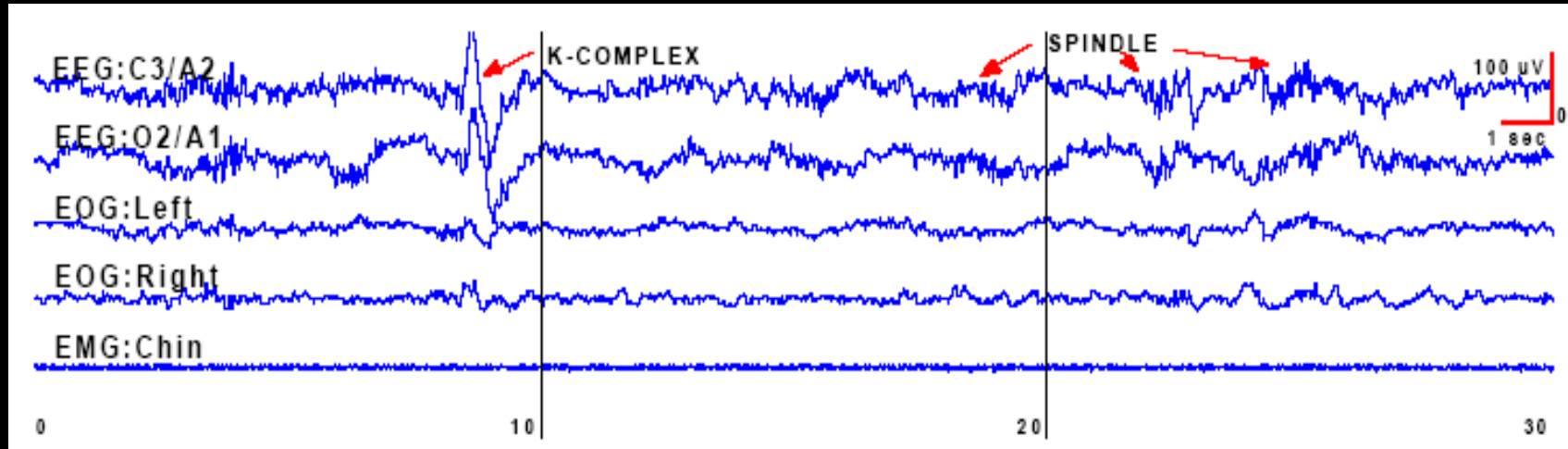


EEG: - the absence of alpha activity
- vertex sharp waves

EOG: - slow eye movement

EMG: - relatively low amplitude

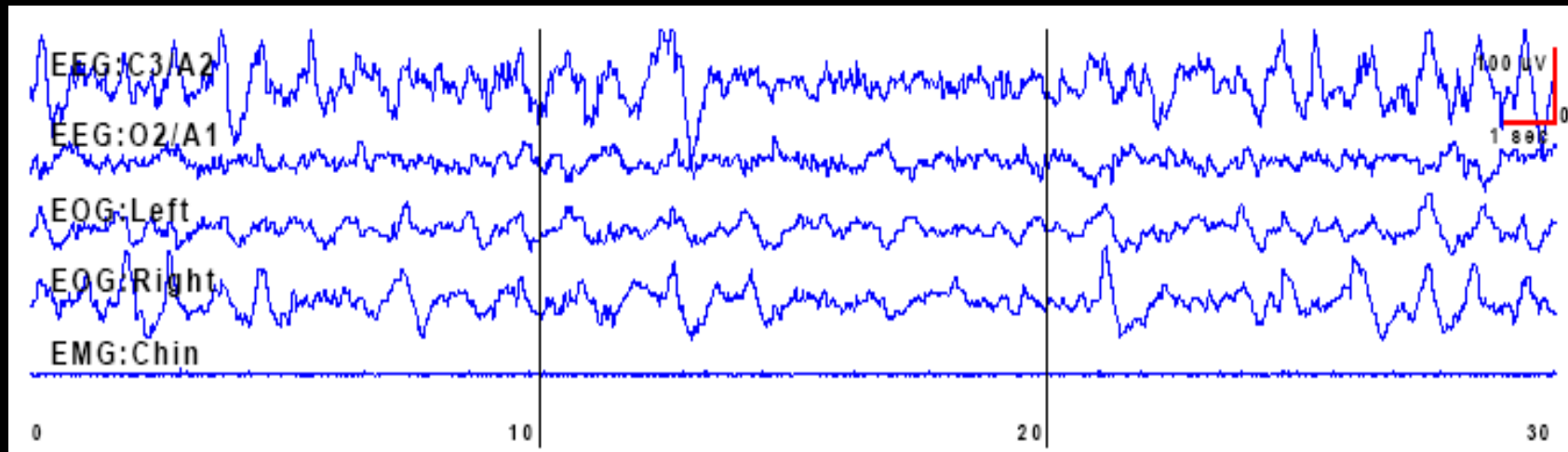
Stage 2



- EEG:
- sleep spindles (oscillating with frequency between 12-15 Hz) strongest in **central electrodes**
 - K-complexes (high voltage, sharp rising and falling wave) usually in **frontal electrodes**
 - relatively low voltage mixed frequency

- EOG:
- no eye movements

Stages 3-4 (Slow Wave Sleep)

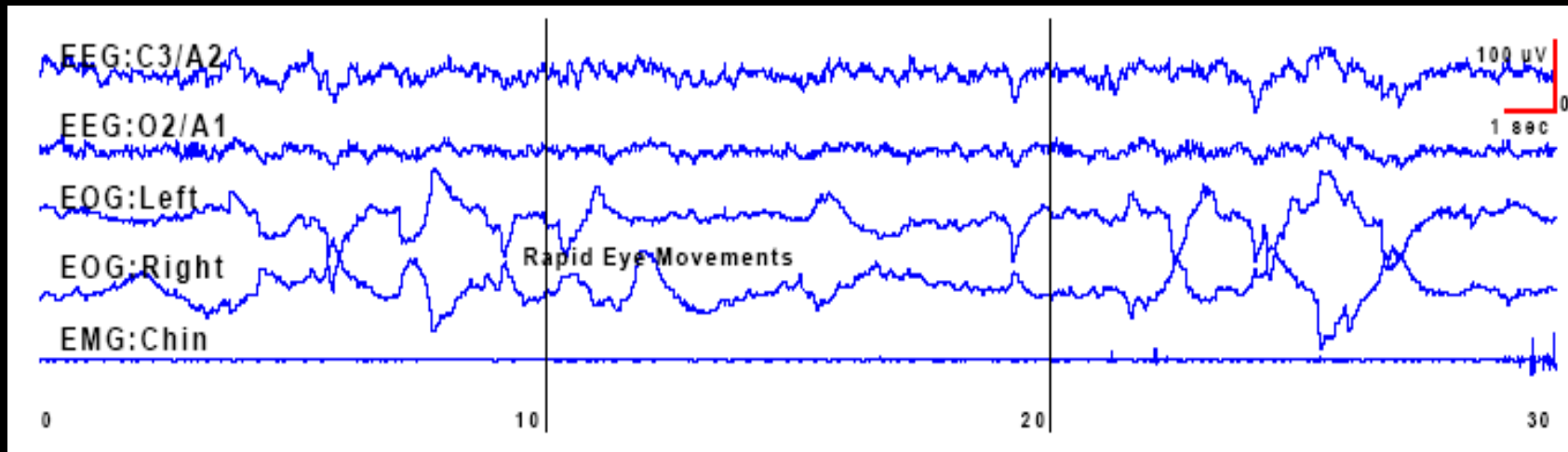


EEG: - slow waves: high-voltage ($\geq 75\mu\text{V}$) slow delta activity ($\leq 2\text{ Hz}$)

EOG: - no eye movement

EMG: - low tonic activities

REM sleep



EEG: - relatively low voltage, mixed frequency

EOG: - contains rapid eye movements

EMG: - tonically suppressed (Sleep Paralysis)

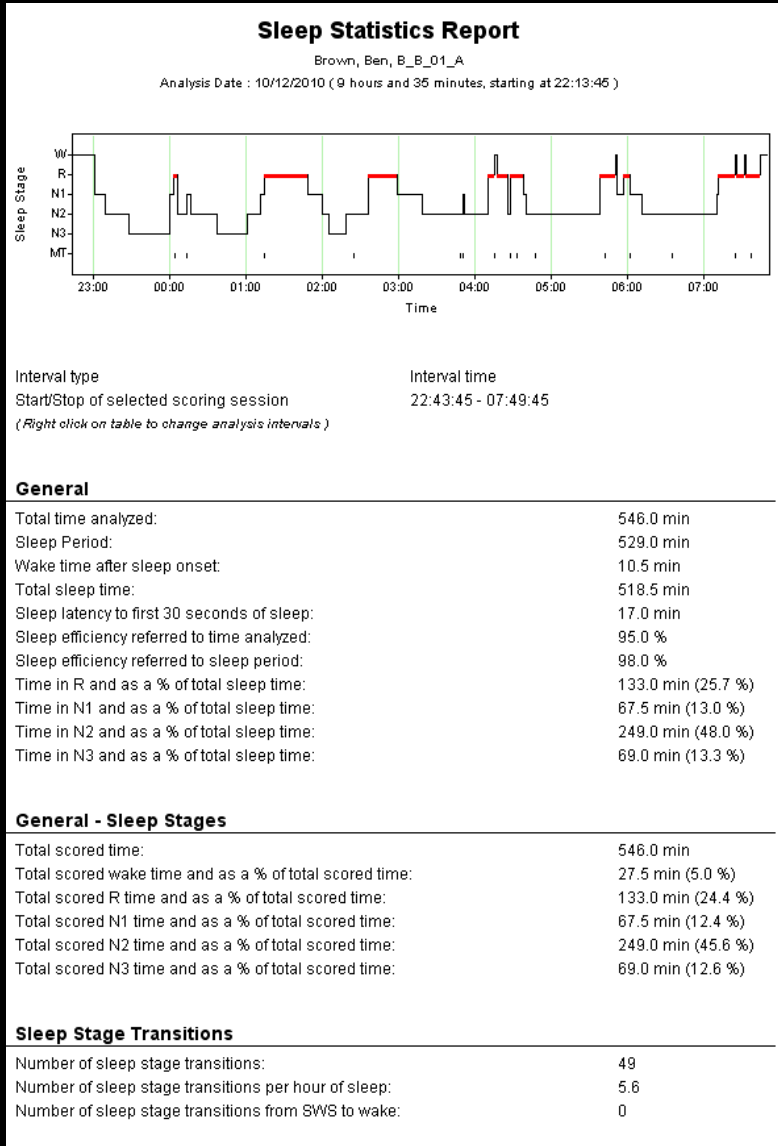
3. Relating sleep EEG with behavioural data

How?

- **Focus on methods using REMlogic**
 - Duration (e.g Total Sleep Time (TST))
 - Individual Sleep stages
- **Other software/programme**
 - **EEGLAB (Matlab)**
 - Frequency analysis
 - Spindle analysis

Sleep Statistics

Hypogram



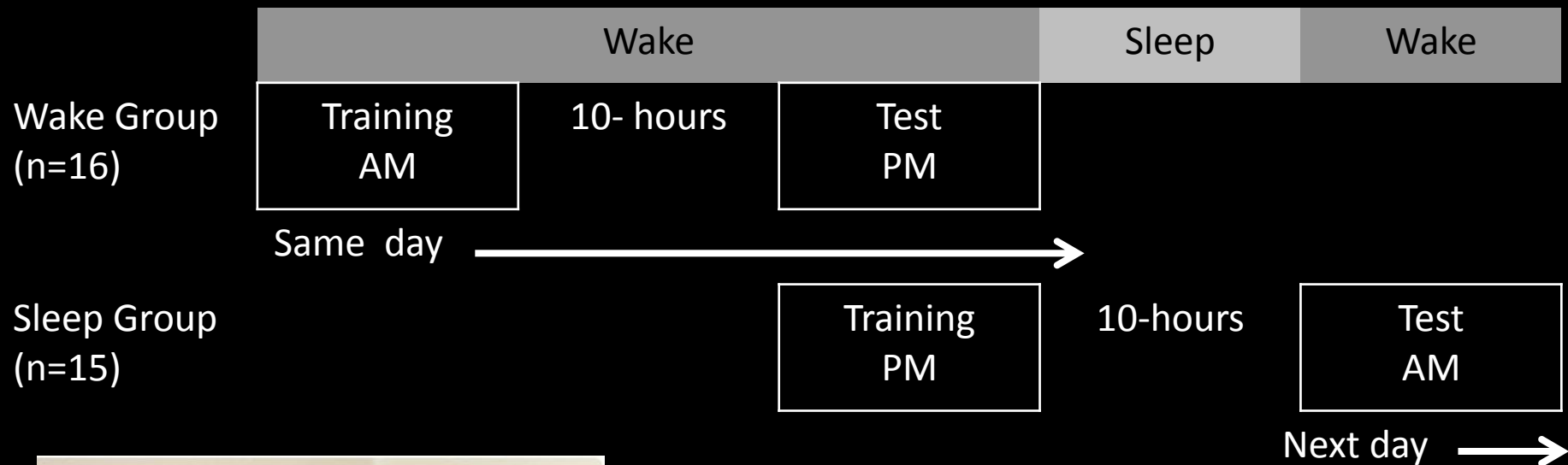
Total SLEEP
Time



Total SCORED
Time



Study 1: Overnight Sleep



Autonomous: Size Congruity Effect

- Select the (semantically) larger item out of each pair:

A) ANT COW congruent

B) ANT COW incongruent

- Size Congruity Effect: Reaction Time for A < B

Intentional: Semantic Distance Effect

- Select the larger animal out of each pair:

A)

CAT

COW

Small
distance

B)

ANT

COW

Large
distance

- Semantic Distance Effect: Reaction Time for $B < A$

Study 1

Task: Select the SEMANTICALLY larger item

Malay

Presentation of NEW
word-pairs differing in
both size congruity and
semantic distance

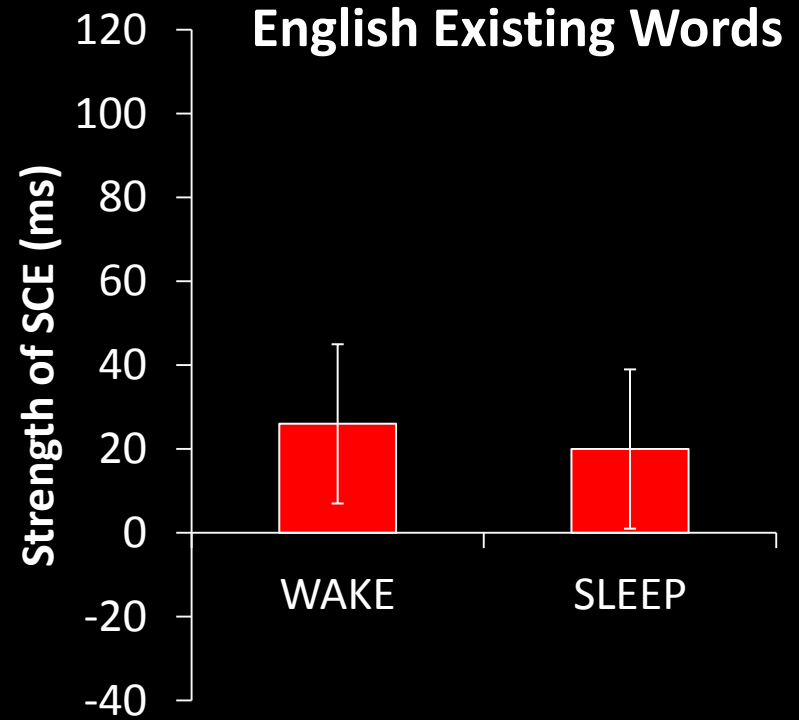
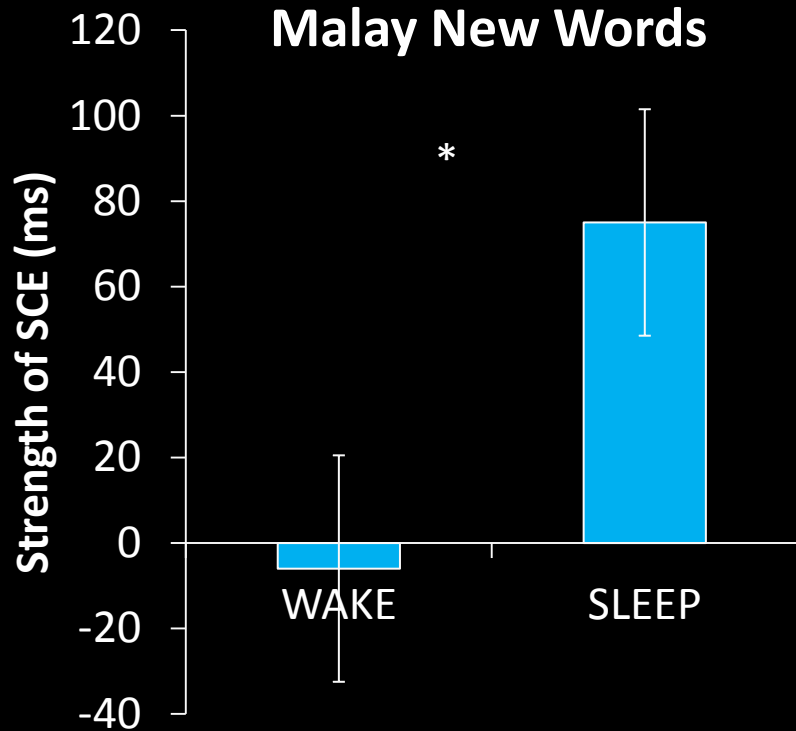
SEMUT KUCING

English

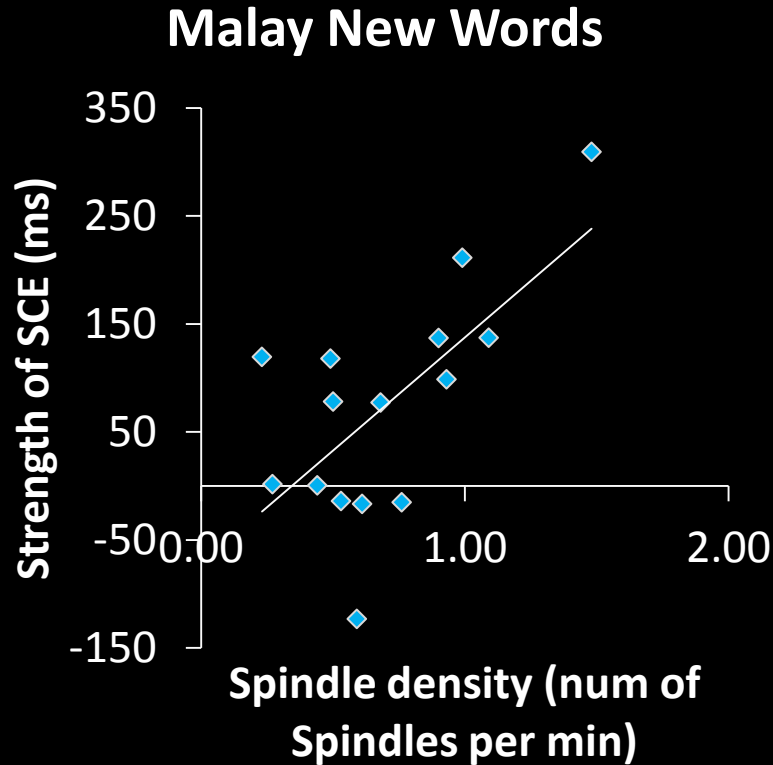
Presentation of similar
word-pairs in ENGLISH
(first language)

ANT CAT

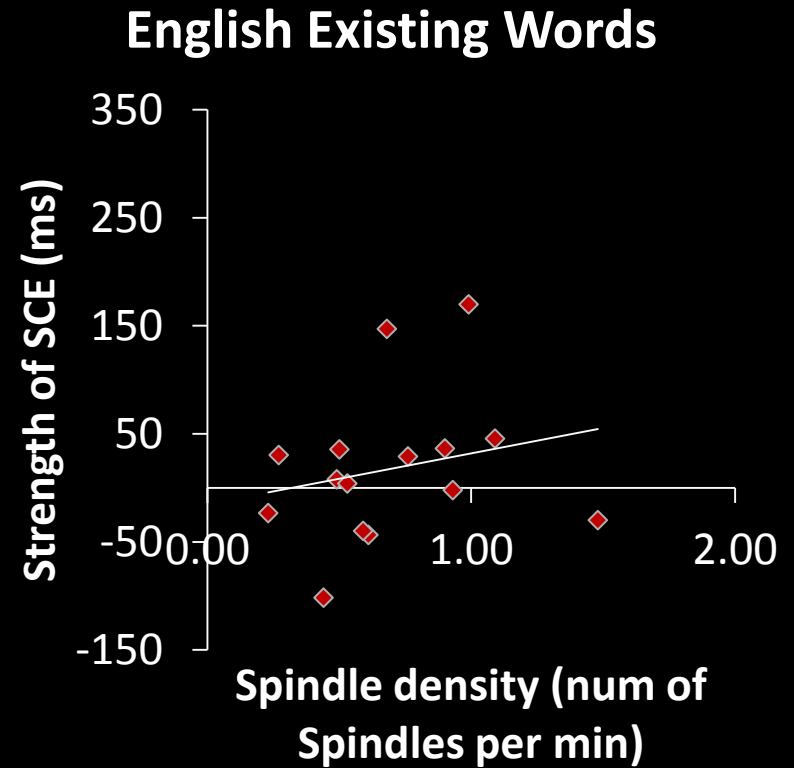
Size Congruity Effect (Most Salient Items: large dist & font diff)



Sleep Spindles (stage 2) and Size Congruity



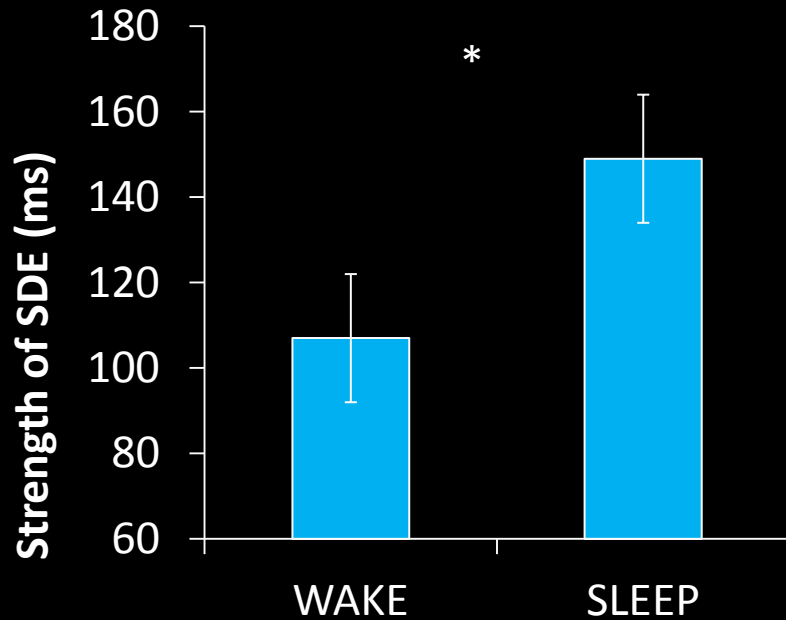
$r=.650, p<.05$; uncorrected $p=.009$



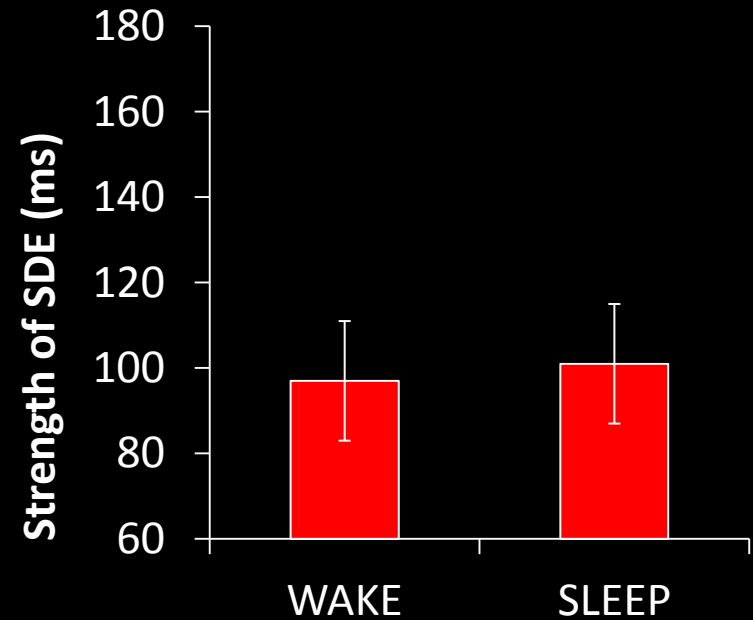
$r=.225, p>.05$

Semantic Distance Effect (Congruent trials)

Malay New Words

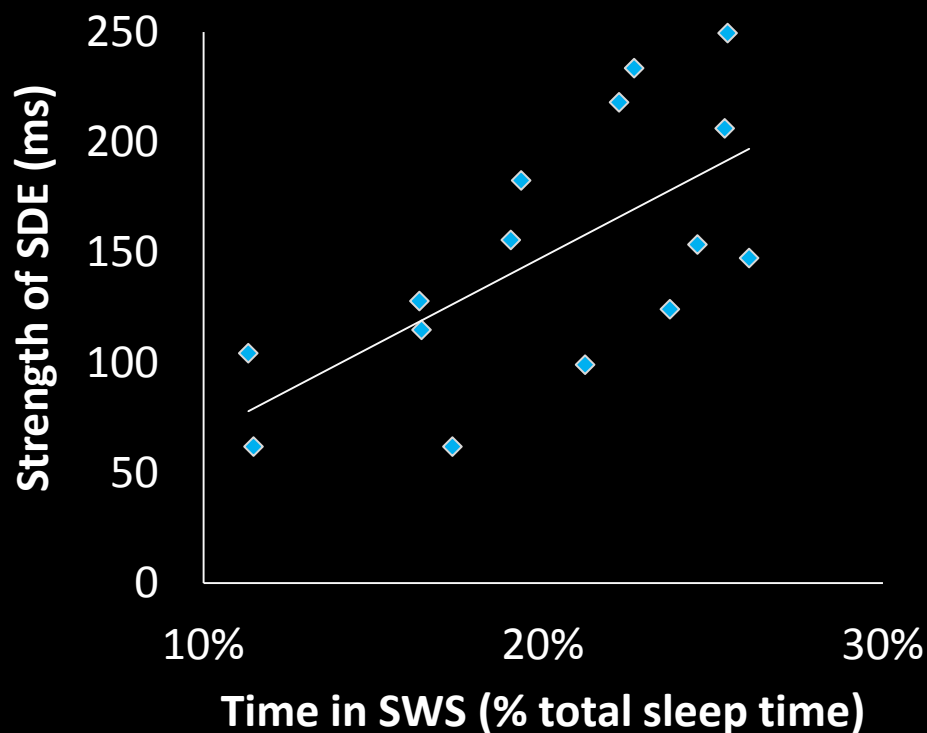


English Existing Words



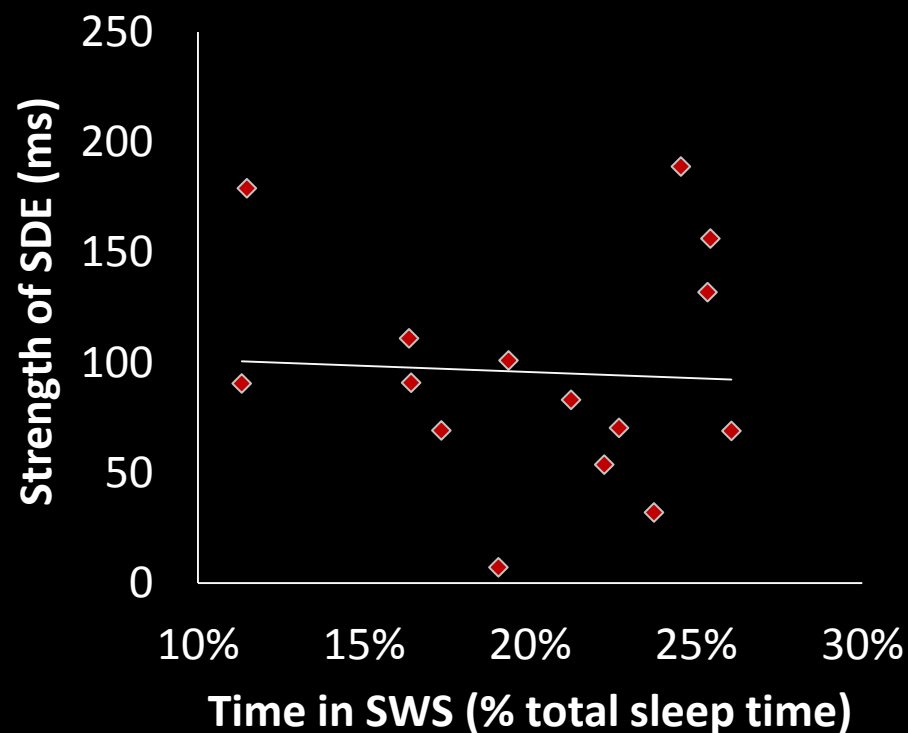
Slow-Wave Sleep and Semantic Distance (congruent trials)

Malay New Words



$r=.661$, $p<.05$; uncorrected $p=.007$

English Existing Words



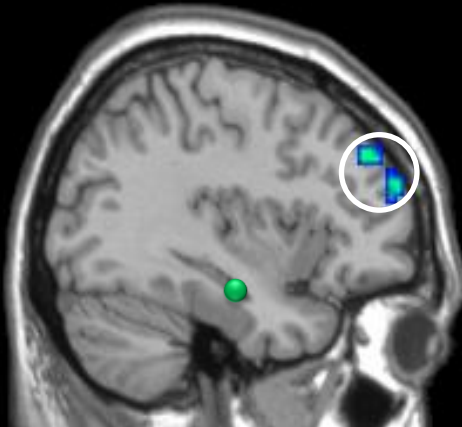
$r=-.053$, $p>.05$

Neural Reorganisation (PPI)

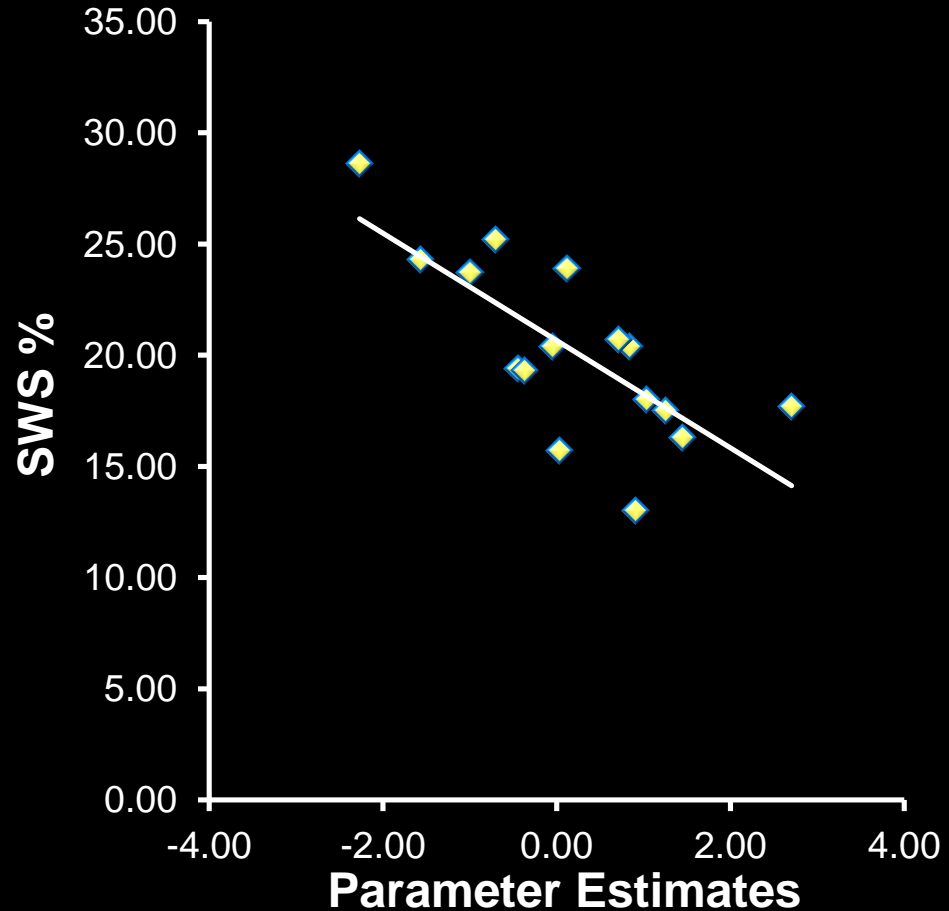
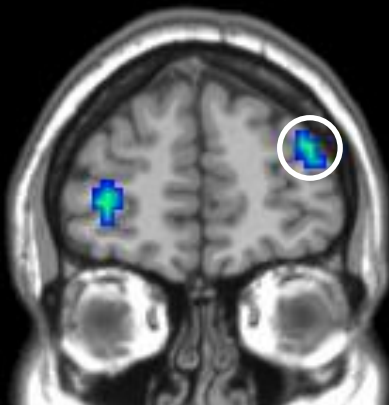
Seed placed in the right hippocampus (27, -10, -17)

Remote > Recent Recollection*SWS

x = 36



y = 53



$p = 0.001$ (uncorrected), minimum cluster extent threshold: $k = 10$ voxels

Nap Design

Second order constraints built into syllable list

Wake group

Syllable production (x48)

Video

Syllable production (x96)



12 pm

1 pm

2 pm

3 pm

4 pm

5 pm

Sleep group

Syllable production (x48)

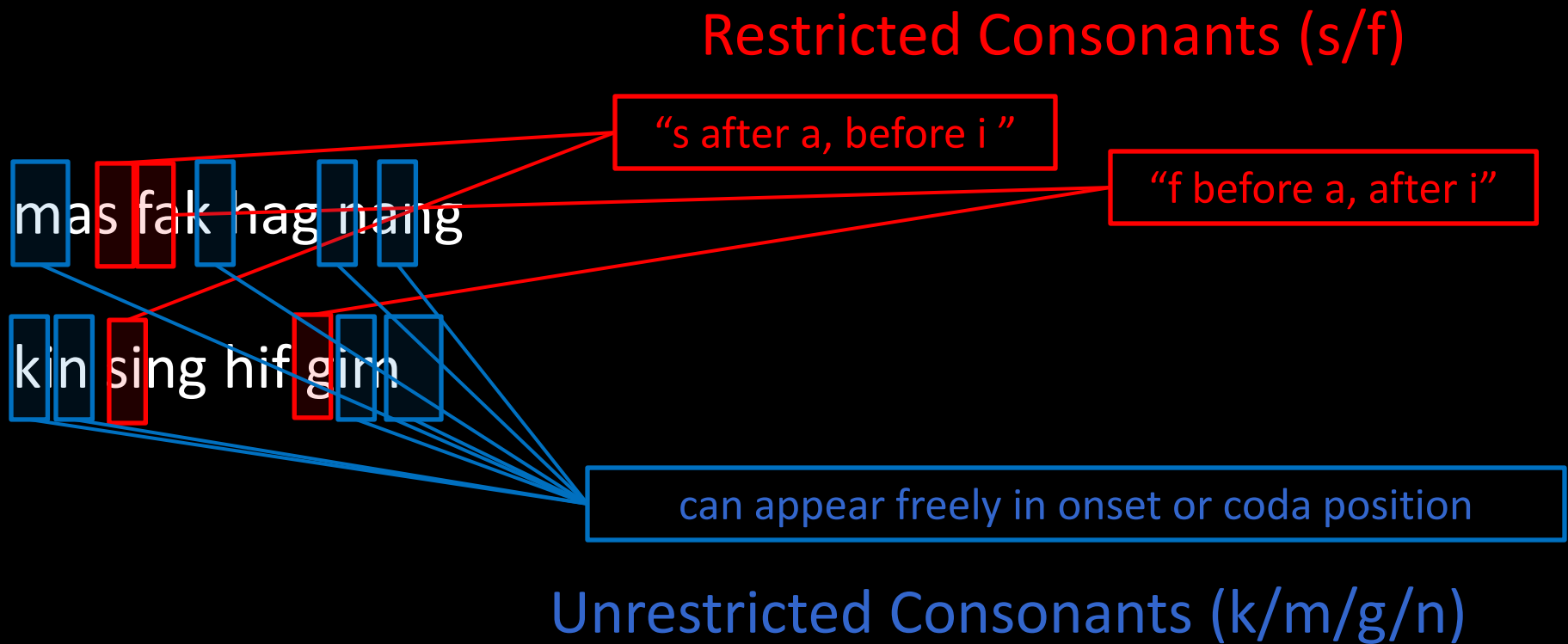
Sleep

Syllable production (x96)

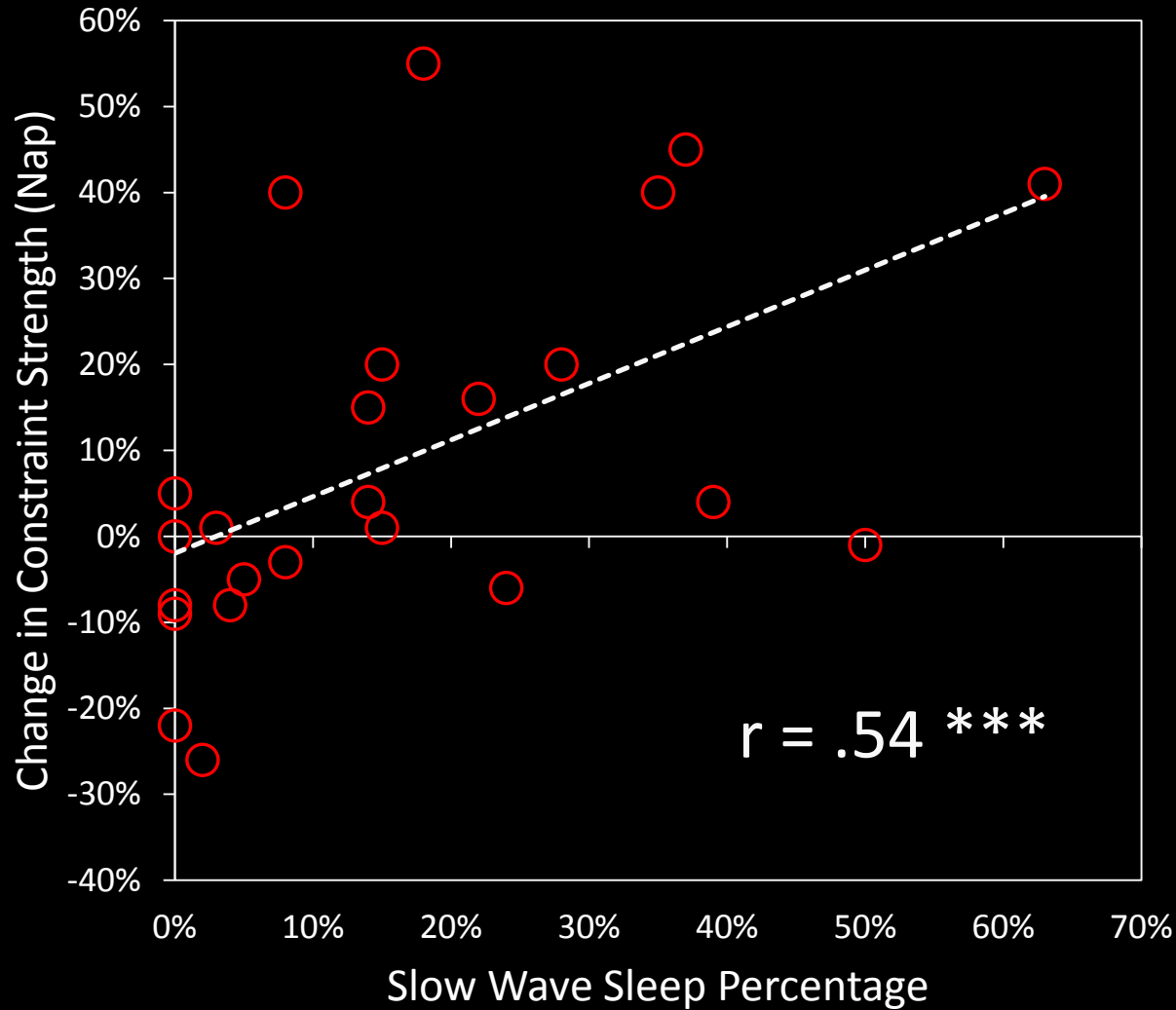
Implicit learning of second order constraints

(Warker & Dell, 2006; Warker et al, 2008; Warker, 2010)

- Speeded repetition of 4-syllable tongue twisters in time with metronome:



Correlation with SWS Proportion



Questions?



- Elaine Tham (PhD student): Ekht500@york.ac.uk
- Special thanks to Alex Reid for previous version of this talk
- Thanks to Gareth (nap data) and Scott (fMRI)

