# Nap Strategies for University Students During Exam Periods:
## Balancing Sleep Inertia and Memory Retention through Sleep Architecture

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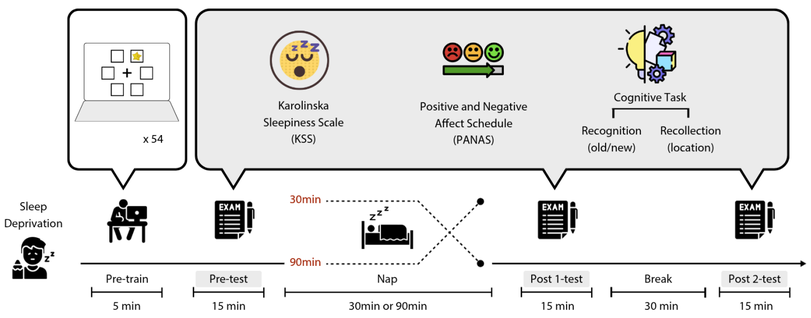
## Research Motivations & Hypothesis

Napping is a common compensatory strategy for sleep-deprived students, yet its **cognitive benefits rely on** the trade-off between **sleep stages** and **sleep inertia**, not just duration [1][2]. By analyzing **EEG-based sleep stages and microarchitecture** in relation to **memory consolidation**, this study provides a data-driven guideline for effective naps.

**H1**) "The 30-minute nap will result in superior immediate memory performance compared to the 90-minute nap, due to minimal sleep inertia costs.“
**H2**) "Once sleep inertia resolves, the 90-minute nap is expected to facilitate superior memory consolidation compared to the 30-minute nap."

## Study Design & Participants

- IRB: Approved by Hanyang University IRB (HYUIRB-202508-002-1)

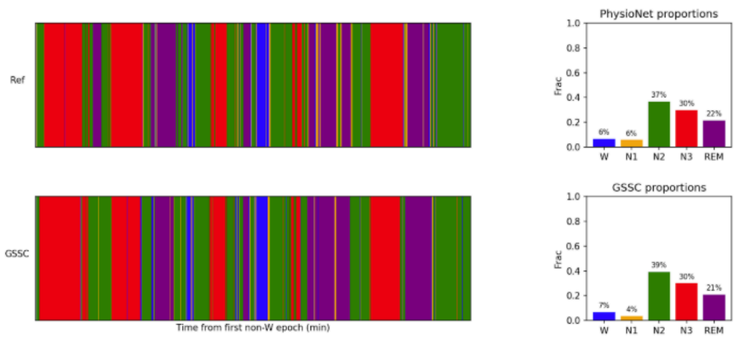



| Demographic | |
|---|---|
| N | 6 |
| Age | 24.8 (1.0) |
| Gender (M/F) | 3/3 |
| Average sleep | 6.5h |

- Within-subject crossover design

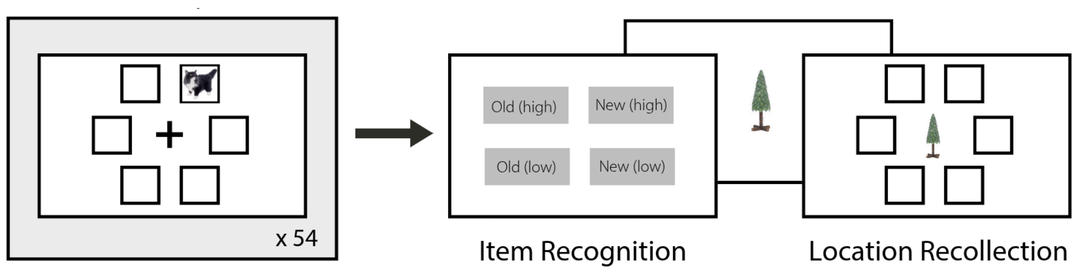
## Methodology

### GSSC : EEG-based Sleep Stage Classifier




- We validated the **GSSC** classifier [3] using the large-scale **PhysioNet Sleep-EDF dataset**, confirming that stage-wise error margins remained **within 3%**.

### Objective Measures



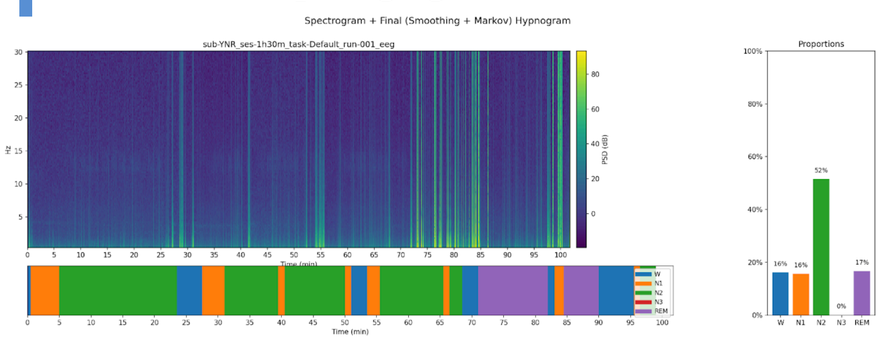

- Object-Location Association Task [4]
  - Encoding: **Memorization** of **objects** and their associated **locations**
  - Retrieval: Two-step process consisting of an **Old/New recognition** judgment followed by a **location recollection task for items**

### Subjective Measures

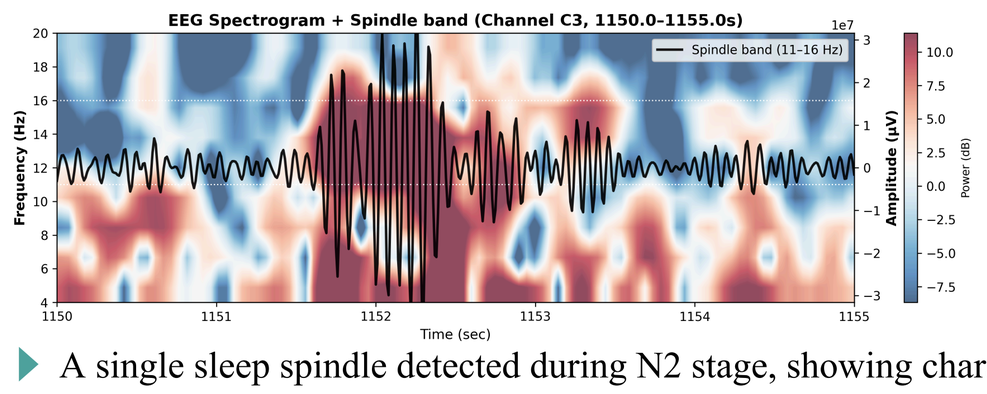
- Karolinska Sleepiness Scale (KSS): Measures subjective sleepiness
- Positive and Negative Affect Schedule (PANAS): Measures current mood

## Result

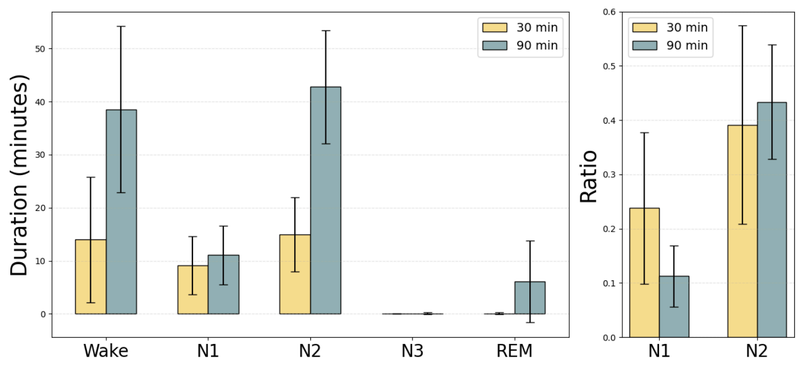
### EEG-based Sleep Staging




- Visualization example of sleep staging results from collected EEG data

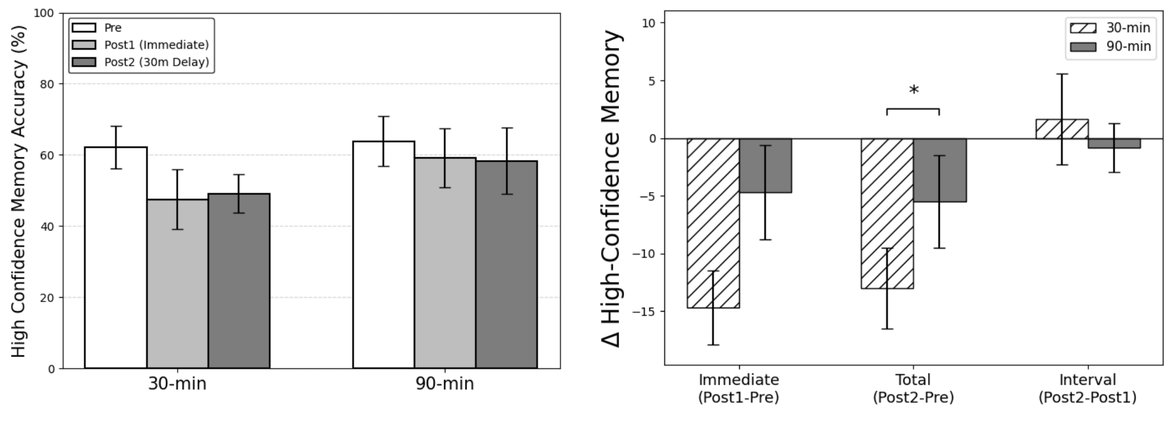



- A single sleep spindle detected during N2 stage, showing characteristic oscillation in the 11–16 Hz band lasting ~1 second.

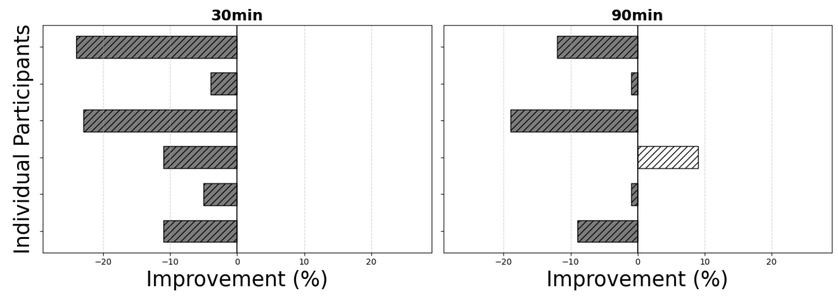



- The **90min-nap** contained significantly **more N2 sleep** ($M$ = 45.08, $SD$ = 12.49) , representing an approximately 2.8-fold increase compared to the 30min-nap ($p < 0.01$).

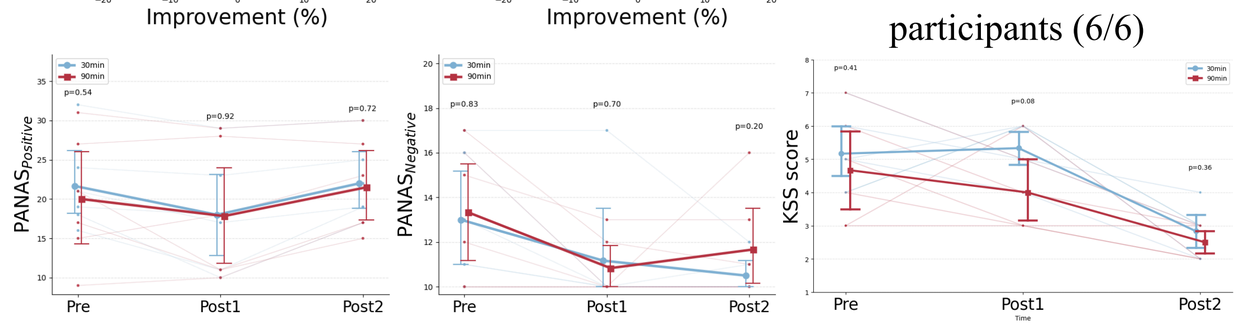
### Cognitive Task & Questionaire




- Friedman test: significant **decline in High-Confidence (HC) memory accuracy** in the 30-min, extending from immediate post-nap (Post1) to the 30m-delayed test (Post2) ($\chi 2 = 9.48$, $p < 0.01$).
- Wilcoxon signed-rank test: 90-min resulted in significantly **less HC-memory decay** ($\Delta M$ = -5.50) compared to the 30-min ($\Delta M$ = -13.00; $W = 0.0$, $p < 0.05$)




- Reduction in HC-Memory accuracy in the 30-min compared to the 90-min ($t_5$ = -2.59, $p$ = 0.049), across all participants (6/6)




- PANAS showed **no relationship** between subjective mood and consolidation.
- KSS showed a larger sleepiness reduction in the 90-min, though not significant → **N2 sleep and spindles** are the core mechanisms driving memory consolidation.

## Conclusion & Future Work

**The Critical Role of N2 Sleep:** Consolidation benefits associated with N2 sleep and spindles outweighed the temporary costs of sleep inertia, resulting in superior High-Confidence Memory retention during the 90-min nap.

**Optimal Strategy:** For sleep-restricted students, opting for a longer nap is advantageous, as securing N2 sleep provides net cognitive benefits.

Given the preliminary nature of this study, we plan to expand the participant pool to achieve more robust and valid results.

## Discussion

- It is highly likely that the detrimental effects of sleep inertia were not fully reflected in this study, as an insufficient number of participants entered N3 or REM sleep.

[1] Tietzel, A. J., & Lack, L. C. (2001). The short-term benefits of brief and long naps following nocturnal sleep restriction. Sleep, 24(3), 293-300.
[2] Boukhris, O., Trabelsi, K., Ammar, A., Abdessalem, R., Hsouna, H., Glenn, J. M., ... & Chtourou, H. (2020). A 90 min daytime nap opportunity is better than 40 min for cognitive and physical performance. International journal of environmental research and public health, 17(13), 4650.
[3] Hanna, J., & Flöel, A. (2023). An accessible and versatile deep learning-based sleep stage classifier. Frontiers in Neuroinformatics, 17, 1086634.
[4] Sungshin Kim et al. ,Selective and coherent activity increases due to stimulation indicate functional distinctions between episodic memory networks.Sci. Adv.4,eaar2768(2018).