

Heat environment increases mental workload even if learning efficiency is enhanced



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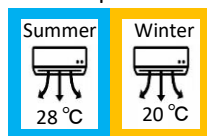
Introduction

Climate change is one of the most important issues for humanity (e.g., Haines and Ebi, 2019).

- Japanese government recommended a setting of air conditioner to 28 /20 °C in summer/winter.
- The aim of this setting was to save the energy by keeping the room temperature constant.

However, it is unclear whether this setting is an appropriate temperature for workers/students.

- This rooms' temperature setting is often criticized as offensive and inappropriate.
- Rooms' temperature influences cognitive performance, office work, and study (e.g., Taylor et al., 2016).



To save the energy

if this setting impairs
workers'/students' efficiency

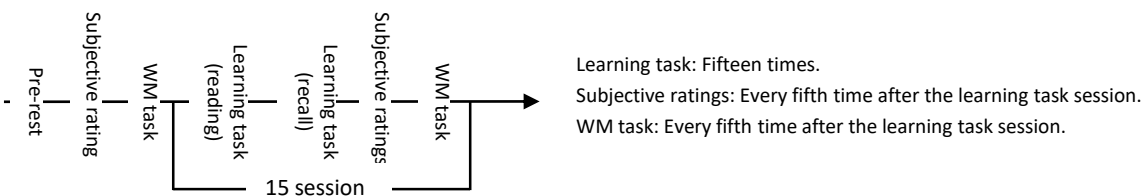


Work time/energy
consumption increase

We examined the influence of thermal environment for 1) the task performance varied with time.
2) the participant's psychological states.

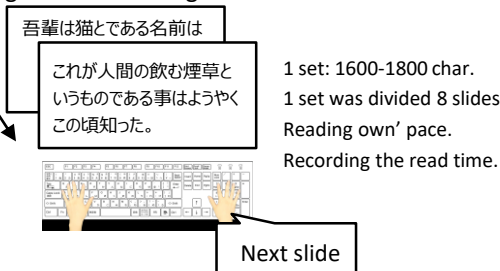
Method

- Twenty-four subject performed the taskset in the experimental room set by 18, 22, 25, or 29 °C.
- All subjects participated the all temperatures in two day, and their physiological data were recorded.
- **Taskset:** pre-rest, subjective ratings, working memory task, learning task (reading/recall)



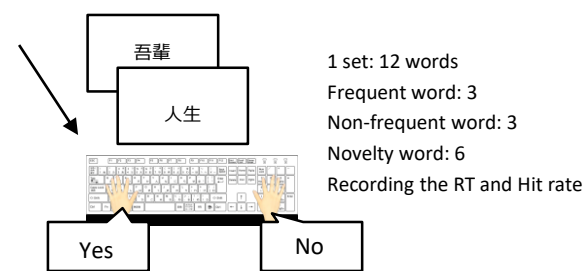
■ Learning task (reading):

Reading and memorizing the detail of text.



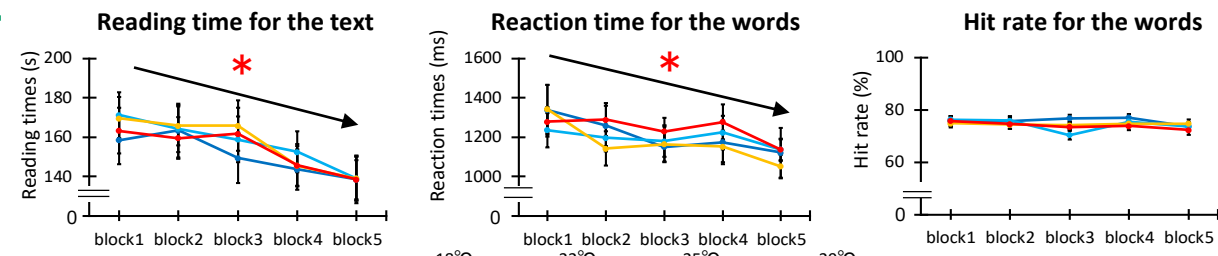
■ Learning task (recall):

This word existed in the text?



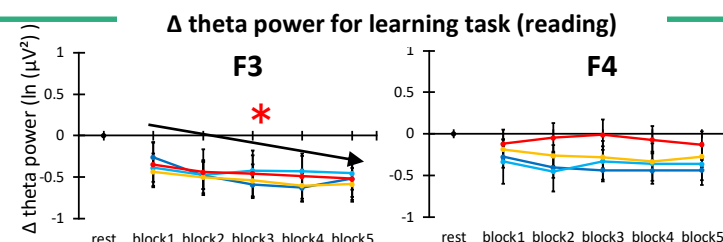
- **Subjective ratings:** NASA-TLX, arousal-valence, thermal sensation, and humidity sensation
- **EEG:** Recording at 8 sites (Fp1, Fp2, F7, F3, F4, F8, T7, T8), Ref: A1; Gnd: A2; Sampling rate: 500 Hz; Filter: DC (recording); 4-7 Hz (analyzing for theta power); Noise rejection: ICA
- **ECG:** Recording from the modified Lead II; Sampling rate: 500 Hz; Filter: 0.53-30 Hz; Analysis: HR and LF/HF
- **SCL:** Recording from the left index and middle finger; Sampling rate: 500 Hz; Filter: 0-15 Hz
- **Tympanum temperature:** Recording at right ear; Sampling rate: 500 Hz
- **Data analysis:** Each data were averaged across three sessions (i.e., five blocks per one taskset). ANOVA was conducted with four room temperature (18, 22, 25, 29°C) and five blocks.

Results & Discussion



The main effect of block: Reading times and Reaction times were facilitated over time.

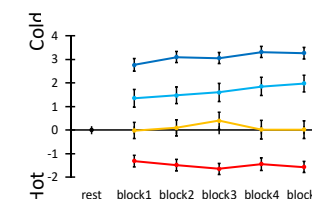
-Temporal learning efficiency was improved with progress on the task.



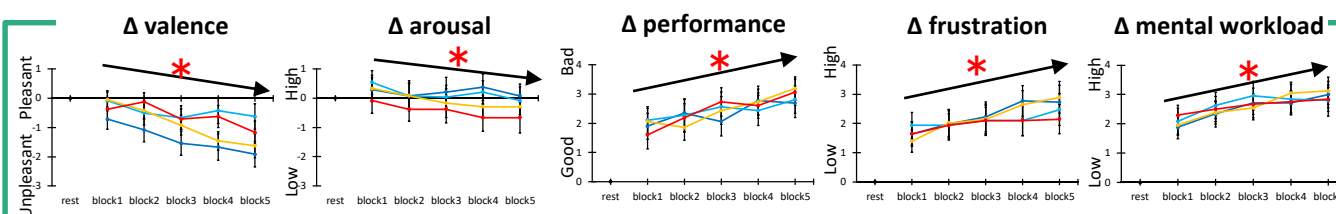
The main effect of block: the left frontal theta power decreased with time.

-The excessive cognitive resources were suppressed over time.

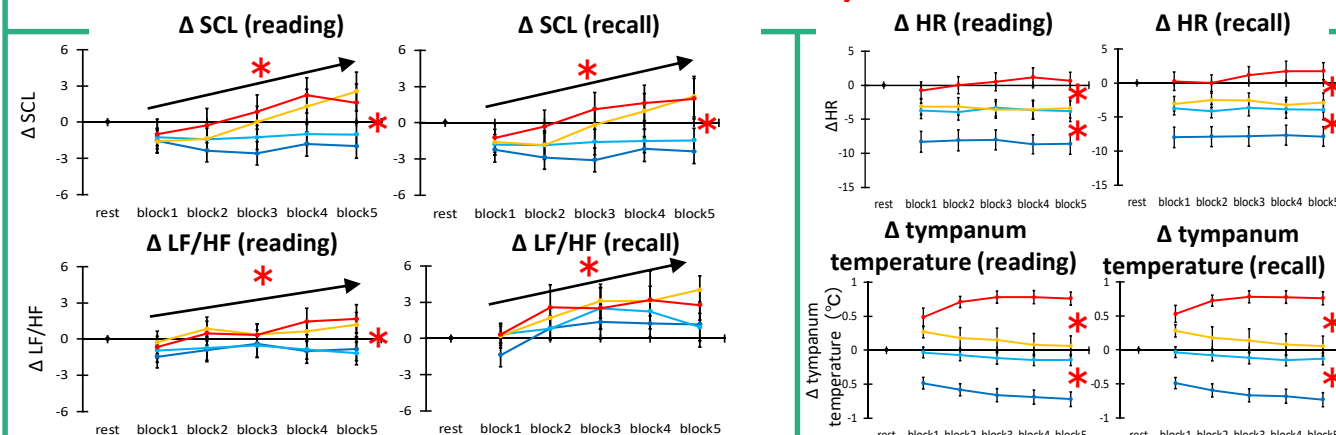
Δ thermal sensation



The main effect of room temperature
- Room temperature fit the desired.



The main effect of block: the mental workload increased with time. -The subjective mental workload increased with time.



Interaction: the SCL and LF/HF increased with time in the 25/29°C.

-The mental workload increases in the heat environment.

The main effect of room temperature

- Adaptation to room temperature was finished at the beginning of the task.

Conclusion

The mental workload increases in warmer environments, even if learning efficiency is facilitated.

Good learning/working environment requires both high efficiency and an appropriate level of mental workload.