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The Effects of Chronic Sleep Restriction on Multiple Object Tracking

Gregory Costedoat[1], Cary S. Feria, PhD[2], Sean Pradhan, PhD[1,3], Leland S. Stone, PhD[4], Erin E. Flynn-Evans, PhD, MPH[5]

[1]San José State University Research Foundation, Moffett Field, CA, [2]San José State University, San Jose, CA, [3]Menlo College, Atherton, CA
[4]Visuomotor Control Laboratory, NASA Ames Research Center, Moffett Field, CA, [5]Fatigue Countermeasures Laboratory, NASA Ames Research Center, Moffett Field, CA

INTRODUCTION

Chronic Sleep Restriction (CSR) has been associated with a variety of adverse neurocognitive affects

- Decreased functioning of the frontal and parietal regions of the brain (Cote et al., 2008)
- Reduced physiological measures of attention and behavioral performance deficits (Cote et al., 2008)
- Impaired ability to process and discriminate between targets in high-cognitive load conditions (Smith et al., 2019)

Multiple Object Tracking (MOT) is the ability to visually track a subset of moving objects among identical distractors

- Associated with increased activation of the frontal and parietal regions of the brain (Culham et al., 2001)
- Attentional resources are necessary for visually tracking multiple moving objects (Alvarez & Franconeri, 2007)

METHODS

Participants

- 12 participants (6 males, 6 females; M_{age} = 23.08 years old)
- Screened for medical disorders and sleep abnormalities

At-Home Procedures

- Participants maintained a sleep-wake schedule for 4 weeks in which wake time was held constant, actigraphy confirmed compliance
- *Satiation Weeks*: Weeks 1 and 3, 9-hour sleep-wake schedule, occurred prior to experimental weeks
- *Experimental Weeks*: Weeks 2 and 4, 5-hour and 9-hour sleep-wake schedules (randomized), lab visit took place after night 7

In-Lab Procedures

- 13-hour lab visit in dim lighting setting (< 15 lux), maintained a constant posture, provided with hourly isocaloric snacks
- MOT occurred 6 and 8 hours after waking

MULTIPLE OBJECT TRACKING (MOT)

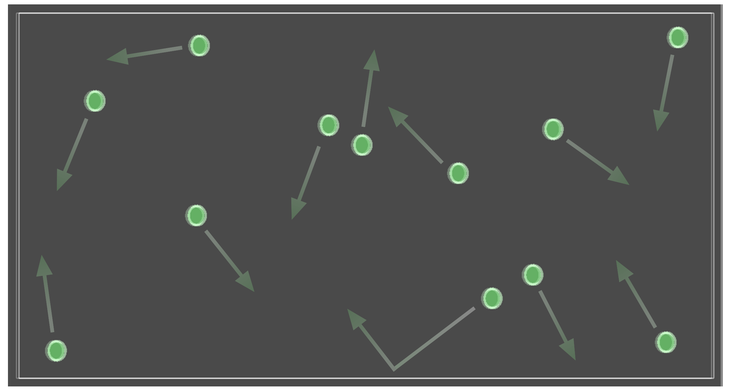
12 green disks were presented on a black background; viewed on a laptop monitor

45 trials (10 practice trials prior to experimental trials)

- 4, 5, or 6 targets; 15 trials of each

For each trial…

- Target disks flashed for 2 seconds
- All disks moved in a straight-line motion
- After movement stopped, one disk was highlighted in red
- Participant responded: Target or distractor



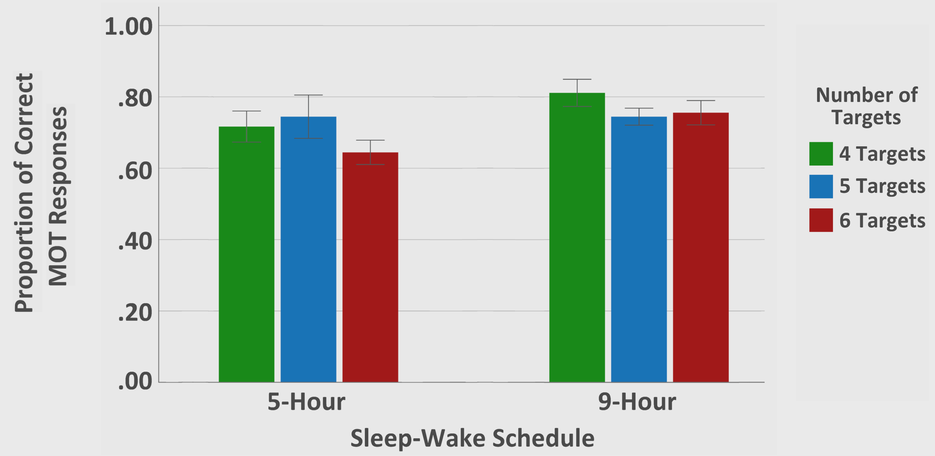
Sample MOT Display: *Arrows represent movement and were not visible to participants*

RESULTS

Participants slept significantly less when assigned 5 hours (M = 4.43 hrs, SD = 20.79 mins), compared to 9 hours of sleep (M = 7.42 hrs, SD = 26.21 mins), $F(1.94, 19.36) = 194.22$, $p < .001$

Proportion of overall correct MOT responses was not significantly different following the 5-hour (M = .70, SD = .15) compared to 9-hour sleep-wake schedule (M = .77, SD = .12), $F(1, 10) = 2.89$, $p > .05$

Additional analysis with only the 6 target condition found that the proportion of correct MOT responses was significantly lower following the 5-hour (M = .64, SD = .15) compared to the 9-hour sleep-wake schedule (M = .76, SD = .11), $F(1, 10) = 7.14$, $p < .05$



DISCUSSION

Overall MOT performance was no different following the week of CSR or the week of sleep satiation

Additional analysis examining only the 6 target condition found that MOT accuracy was reduced following the week of CSR compared to the week of sleep satiation

Supports previous research which found that CSR had an adverse impact on attention and performance (e.g., Cote et al., 2008)

Consistent with the findings that CSR reduced target discrimination in high-cognitive workload conditions (Smith et al., 2019)

REFERENCES

Alvarez, G. A., & Franconeri, S. L. (2007). How many objects can you track? Evidence for a resource-limited attentive tracking mechanism. *Journal of Vision*, *7*(13), 1-10.

Culham, J. C., Cavanagh, P., & Kanwisher, N. G. (2001). Attention response functions: Characterizing brain areas using fMRI activation during parametric variations of attentional load. *Neuron*, *32*, 737-745.

Cote, K. A., Milner, C. E., Osip, S. L., Baker, M. L., & Cuthbert, B. P. (2008). Physiological arousal and attention during a week of continuous sleep restriction. *Physiology & Behavior*, *95*(3), 353-364.

Smith, C. D., Cooper, A. D., Merullo, D. J., Cohen, B. S., Heaton, K. J., Claro, P. J., & Smith, T. (2019). Sleep restriction and cognitive load affect performance on a simulated marksmanship task. *Journal of Sleep Research*, *28*, 1-10.

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