



The Effects of Sleep Deprivation on the Exploration-Exploitation Tradeoff

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Introduction

- Sleep deprivation is thought to be more complex than an overall slowing of mental processes.
- Some tasks are impaired (e.g., integrative decision making) whereas others are not (e.g., rule-based) [1]
- Exploration-exploitation tradeoff not well understood under sleep deprivation.
 - Exploration – willingness to try new strategies
 - Exploitation – reliance on known successful strategies.
- Resource acquisition tasks are useful for examining the exploration-exploitation tradeoff [3,4]

➢ Locus coeruleus-norepinephrine system (LC-NE) may drive the exploration-exploitation tradeoff via frontal areas responsible for evaluating the effectiveness of currently employed strategies

Aim of Study

- To examine the effects of sleep deprivation on resource acquisition when exploration or exploitation is optimal
- To examine individual differences in vulnerability to sleep deprivation.

Participants

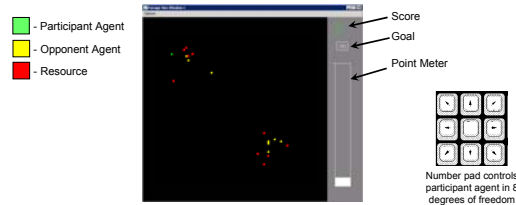
- 24 West Point cadets participated in the Sleepless group
- 24 UT students participated in the Control group

Procedure

Time 0		Time 24hr
Day 1	Sleepless: No Sleep Control: Sleep	Day 2
3 Exploit Tasks 3 Explore Tasks Interleaved		3 Exploit Tasks 3 Explore Tasks Interleaved

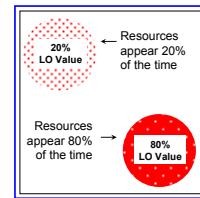
Task

- Exploitative and Exploratory Tasks developed through simulation (see Glass, et al. for details).



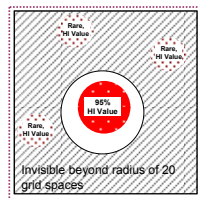
Exploitative Task

(Optimal Strategy = "Do not switch")



Exploratory Task

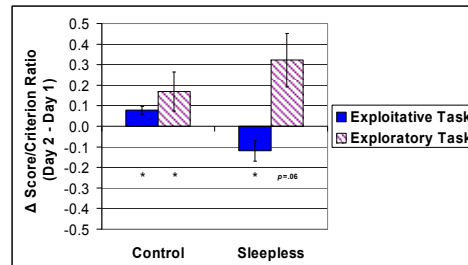
(Optimal Strategy = "Abandon Central Patch")



- Participants attempt to reach a Bonus Criterion

Performance

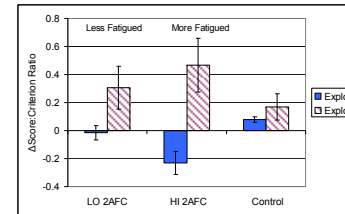
- Measure: Ratio of Score to Bonus Criterion
- 3-way Task x Day x Group interaction was significant ($F(1,44)=5.95, p=.02$)



- On Day 2, Sleep deprivation group performs worse on Exploitative Task and better on Exploratory Task

Individual Differences

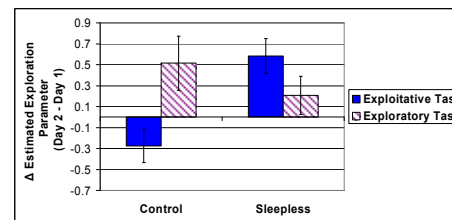
- Individual differences in vulnerability to sleeplessness correlated with task performance
- Performance change on Day 2 in a simple 2AFC used as measure of vulnerability to sleeplessness
- Non-sleepless perform at or near 100% accuracy
- Median split performed to compare task performance



- Higher vulnerability associated with worse exploitative performance and better exploratory performance

Model Comparison

- Subject profiles compared with Generalized Exploration Model (GEM).
- Model profile that best matches a subject's profile yields an Estimated Exploration Parameter



- On Day 2, Sleep deprivation group is exploratory in both the Exploitative Task and Exploratory Task

Conclusion

- Sleep Deprived participants impaired when exploitation is optimal, but not when exploration is optimal
- Pattern held for resources acquired, and was reflected in exploration parameter estimates from Generalized Exploration Model [3]
- Increased vulnerability to sleeplessness predicted greater impairment when exploitation was optimal, but was not predictive of exploration performance
- The LC-NE framework [7] suggests that low and high levels of tonic LC activity lead to exploration, whereas intermediate, phasic levels of LC activity lead to exploitation. Interpreted within the LC-NE framework, these data suggest that in fatigued individuals, the system may be in a state of high tonic discharge, possibly leading to exploration.

References

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Acknowledgments

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