Sleep States and Memory

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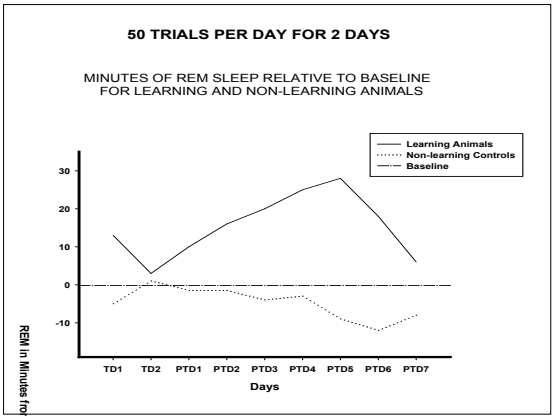
History and Background

- Two experimental designs have been used extensively to study the relationship of sleep to memory processes.
- 1) Learn Task - Observe Sleep - Retest
- 2) Learn Task - Deprive Sleep - Retest

Animal Studies

- Training was done with rats in a 2-way shuttle shock avoidance task.
- Animals were given 50 trials/day for two consecutive days.
- Sleep recording took place both before and for many days after the end of training



Early Human Work

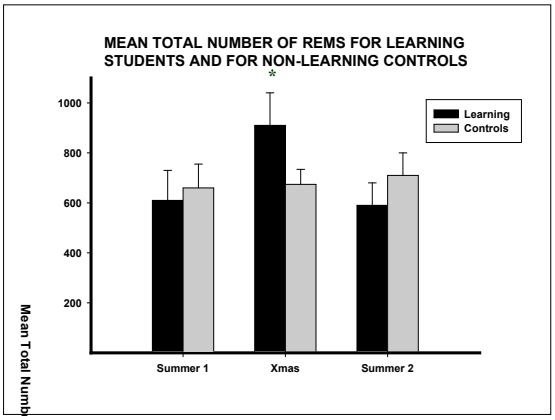
- In a study done in a practical setting, we examined the changes in sleep architecture that might occur after substantial learning in a real life situation.
- We examined the sleep of students before and after exams without typifying memory systems

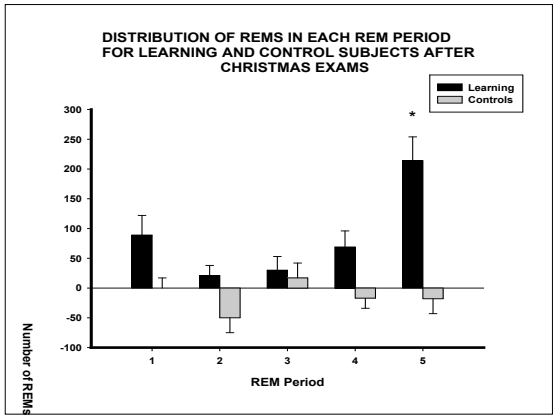
REM Sleep Changes After Exams

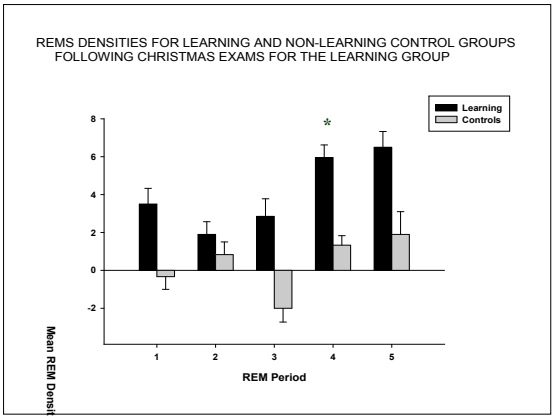
- We sleep recorded 4th year Honours Psychology students in the summer, when they were not taking classes of any kind.
- We recorded these same subjects 3-5 days after their last Christmas exam in Dec.
- We then recorded them again the next summer, when they again were not taking courses of any kind.

Exam Study Con't ....

- **Control subjects were same age individuals that had been in Honours, and were now in tech or teaching assistant positions.**
- **Their intent was eventually to go on to grad school, but they were consolidating debts, waiting for a partner to finish, etc.**
- **They were sleep recorded in Summer 1, at Christmas and during Summer 2 as well.**







Appetitive Bar Press Task

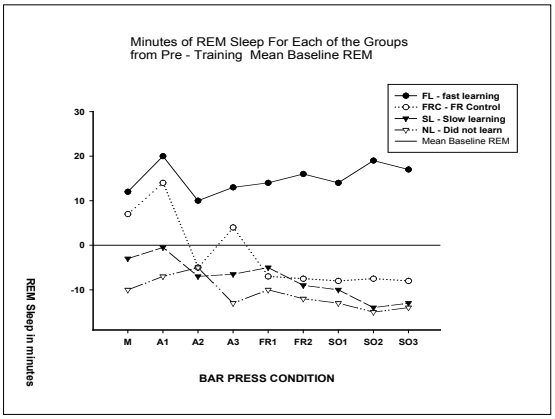
- We examined (Smith&Wong, 1991) changes in sleep after extended training in Skinner box with increasing levels of difficulty
- 1 Magazine (M), 3 Simple Bar press (A), FR -10 sched (2 days) and then 3 days with a difficult sequential operant (SO).

Con't...

- There were two bars to press.
- During the Sequential Operant, reward was only given when rats could "move" the light on a 3 x 3 matrix from upper left to lower right - after which they got a pellet
- This required alternate bar presses or 2 left bar, 2 right bar.
- Deviations reset the program.

Con't...

- Only some rats learned the task. We called them Fast Learning
- Some rats could not learn and extinguished. Called Slow Learners
- Non-learning rats were not trained.
- FRC controls pressed at the FR-10 level instead of changing to SO task

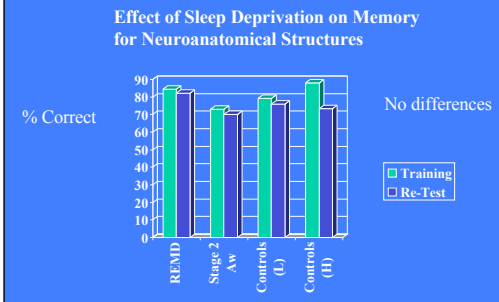


Human Studies

- **The progress in using human subjects has paralleled the progress in the understanding of memory itself.**
- **Different kinds of memory are now believed to exist.**
- **The two main types of memory are -**
  - **1) declarative - often explicit**
  - **2) procedural - often implicit**

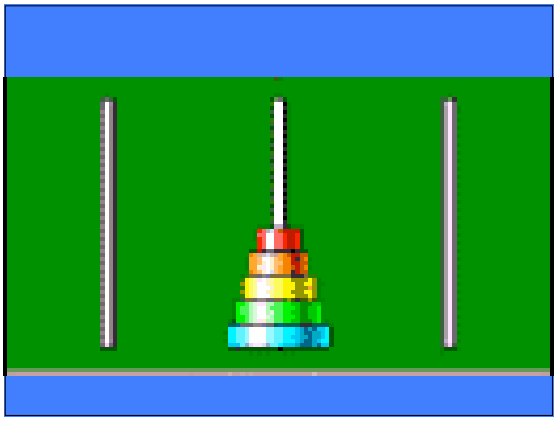
Declarative Memory and Sleep

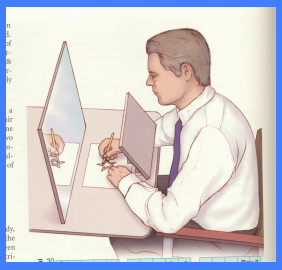
- **Declarative learning does not seem to be related to any stage of sleep.**
- **Sleep deprivation following acquisition of a paired associates task did not impair memory for this task 1 week later**
- **Sleep deprivation did not impair recall for of a set of memorized neuroanatomical structures.**

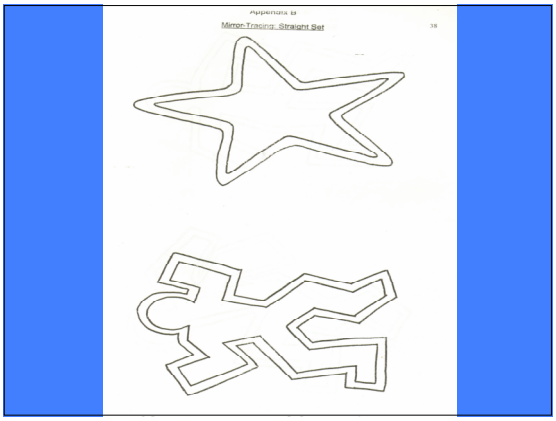


Cognitive Procedural Learning

- **Cognitive procedural learning is one type of procedural learning.**
- **This type of learning requires the learner to develop a new cognitive strategy in order to solve the problem (e.g. Tower of Hanoi).**

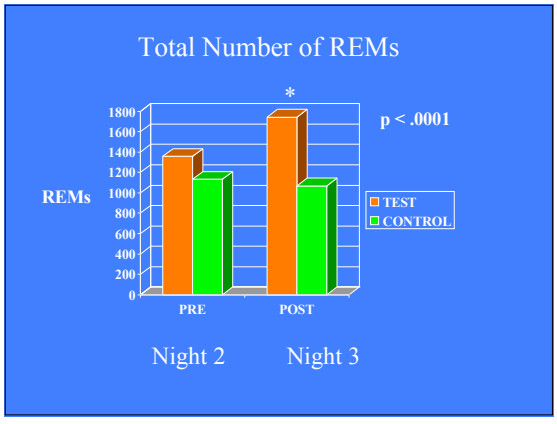


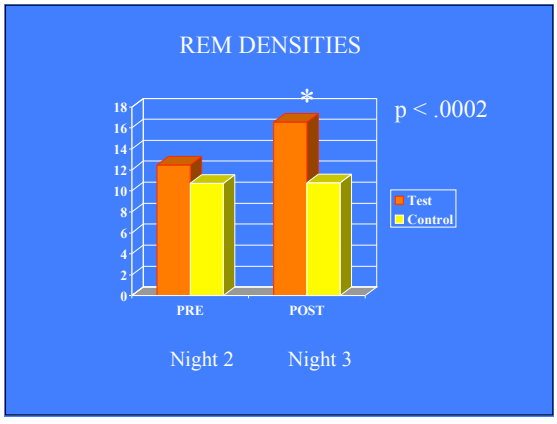




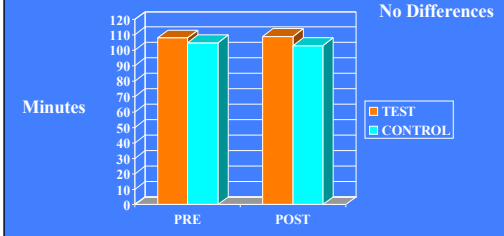
Cognitive Procedural Memory and Sleep

- Cognitive procedural tasks appear to require REM sleep for most efficient learning
- Sleep following acquisition of the Tower of Hanoi and Mirror Trace tasks shows a marked increase in number of REMs and REM density.
- There is no change in the amount of REM sleep (minutes) or any other stage.



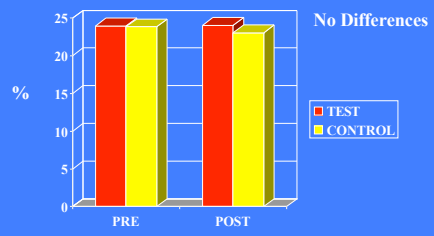


Total REM Sleep



Night 2 Night 3

% REM Sleep



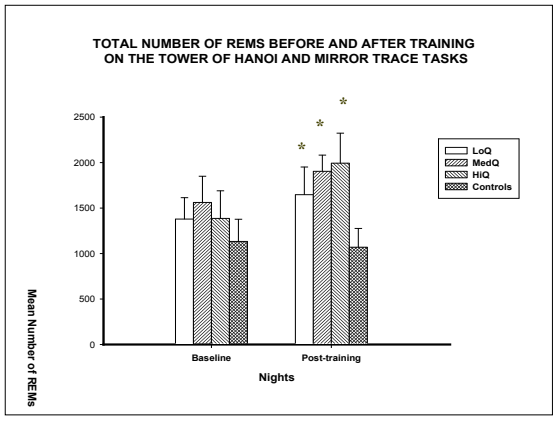
Night 2 Night 3

IQ Groups

- The test groups were separated in terms of High (HiQ; X=125.8), Medium (MedQ; X=114.7) and Low IQ (LoQ = 102.5).
- Controls were a mix of all levels @ X= 108.3 (n=6/group, N=24)
- The higher the IQ score, the better were the learning scores for the tasks.

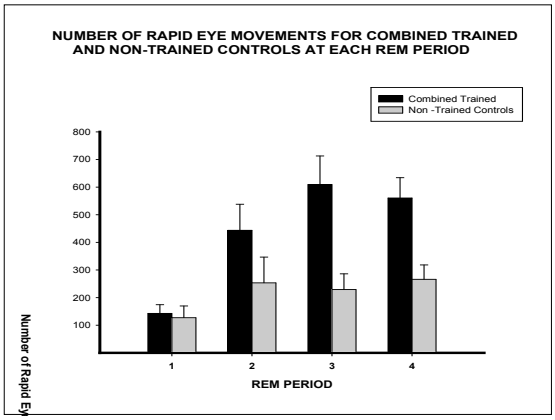
IQ Con't...

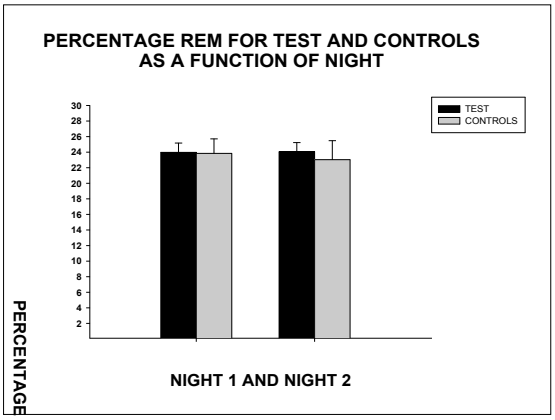
- The higher the IQ score, the greater was the number of post training REMs and the larger was the REM Density measure. (HiQ>MedQ>LoQ).
- The intensity of REM sleep was also correlated with success in task acquisition and re-test.



IQ Con't...

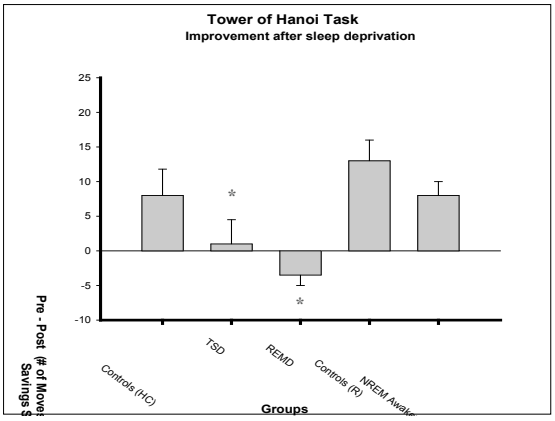
- There was no correlation between "native" REM intensity and IQ or task scores.
- The largest REM intensity responses were exhibited by Ss with the highest IQ and the highest acquisition and re-test scores.
- Post-training REM intensity may be a biological marker for learning potential





Selective REM Deprivaiton

- Selective REM sleep deprivation following acquisition of the Tower of Hanoi or a complex Logic Task results in marked memory loss on re-test one week later.
- NREM awakened controls were not impaired on these tasks.



Alcohol Ingestion

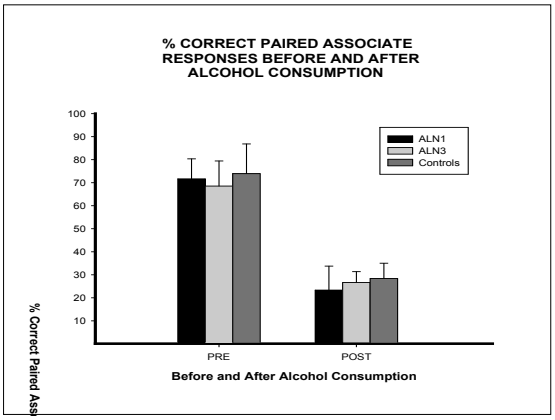
- One common type of behaviour on campus is to work hard during the day, drink hard in the evening and then fall into bed.
- Alcohol is know to induce a reduction in number and density of REMs when ingested in moderate amounts (as few as 3 drinks) just prior to bedtime.

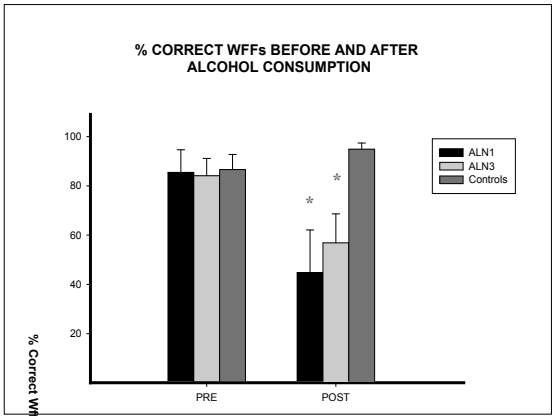
Alcohol Con't...

- After an acclimatization night in the sleep lab., we trained students in both a declarative (Paired Associates) and a cognitive procedural (Logic) task (Alcohol Night 1) .
- They then drank 3-5 drinks of vodka (1 1/4 oz/drink) and orange juice and then went to bed (0.7g/Kg.).

Alcohol con't...

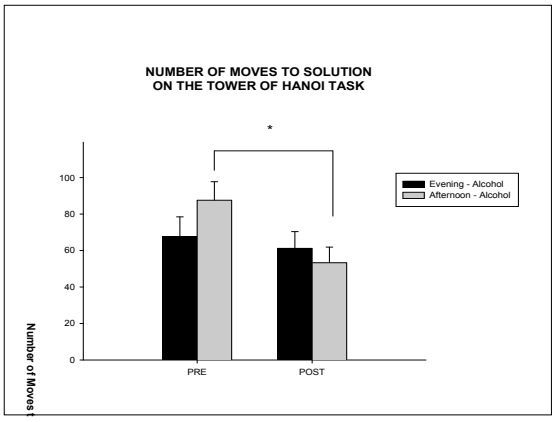
- Another group drank orange juice alone after learning (OJ Night 1)
- A third Control group drank nothing (C Night 1).
- All groups slept a second night with no drinking.
- On Night 3, the OJ group of Night 1 drank alcohol, while the alcohol group of Night 1 drank OJ.

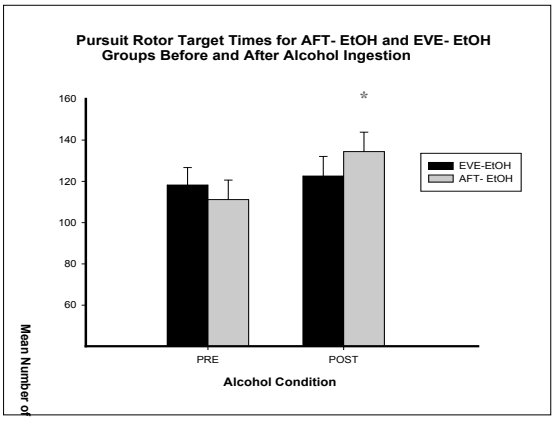




Experiment 2

- Was this an alcohol or a sleep effect?
- Trained subjects on Tower of Hanoi and Pursuit Rotor at 4 PM in the afternoon.
- One group (Aft - Alcohol) then drank immediately (0.9g/Kg) after learning and went to bed 5 hours later.
- One group drank just before bed (Eve - Alcohol).





Sleep Effects

- REM sleep was similarly modified in both experiments.
- Both number of minutes of REM sleep and number of REMs were reduced in the first half of the night in study 1.
- The density of REMs was reduced in the first half of the night in study 2.

Conclusions

- Even moderate alcohol ingestion prior to bedtime can modify sleep architecture, particularly REM sleep in the first half of the night.
- Moderate alcohol ingestion at bedtime can induce memory loss the night of learning AND/OR 2 nights after the original learning has taken place.

Conclusions con't...

- Interference with normal REM sleep either the same night, or two nights after acquisition of procedural material can result in memory deficits of 20-40%.
- Alcohol at bedtime can impair memory for both cognitive procedural and motor skills tasks.

Conclusions Con't ...

- The REMs results implicate the PGO system of the pons in efficient memory consolidation
- Animal studies (Datta et. al., 2000) support this theoretical position, since they have observed increases in P wave (PGO) activity in the rat following successful acquisition of the 2-way shuttle avoidance task