The Role of Sleep and Knowledge in Motor Skill Learning

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INTRODUCTION

- Sleep is critical for motor learning and the consolidation of memories[1-4].
- Sleep may interact with other learning variables such as type of instruction.
  - Sleep preferentially benefits skill learning in neurologically intact people who are given explicit instruction prior to acquisition; Implicit motor learning is time dependent (i.e. the performance of people given no instruction prior to acquisition improves both following a period of sleep and a period of being awake)[5].
  - Consistent with work that demonstrates a preferential enhancement of explicit awareness and recognition following a period of sleep[6, 7].
- To date, no research has examined the effect of sleep on motor skill learning following stroke.

Purpose: To examine the role of sleep and instruction in consolidation of motor skill learning in neurologically intact individuals and individuals following stroke. Experiment 1 considered the interaction between sleep and type of instruction (implicit vs. explicit) during motor learning in neurologically intact subjects. Experiment 2 examined how sleep affects implicit motor skill learning following stroke.

METHODS

*Task:*Serial Reaction Time (SRT) task

Practice: For both experiment 1 and 2, participants practiced at 8:00 am or 8:00 pm and returned for a retention test at either 8:00 pm the same day (no-sleep group) or 8:00 am the following morning (sleep group).

Instruction: In experiment 1, half of the subjects in each the sleep and no-sleep group received no knowledge or instructions regarding the presence of a repeating sequence prior to practice (implicit condition) while the other half received explicit instruction (explicit condition) before practice. In experiment 2, practice conditions were implicit.

Hand Used: The participants in experiment 1 used their dominant hand; stroke participants in experiment 2 used the ipsilesional hand to reduce motor execution impairments.

Participants:

	Age (sd)	Sex	Fugl-Meyer* (sd)
Experiment 1 (n=56)	27.1 (4.9)	40 Female 16 Male	____
Experiment 2 (n=6)	64.2 (13.2)	2 Female 4 Male	37 (21.8)

*Motor, upper extremity portion of Fugl-Meyer Test

METHODS (cont'd)

Task Description: participants were seated before a computer with standard keyboard. The central four keys on the keyboard (V, B, N, M) were colored red, yellow, blue and green respectively. Participants practiced the SRT for 15 blocks during acquisition. The blocks consisted of a 10-element repeating sequence (repeated 10 times each block for 100 responses each block) except for block 1 and 14 which were comprised of 100 pseudo-random stimuli. The retention test consisted of 2 blocks; the first a random block followed by another repeating block. Simple RT was acquired using a 50 stimulus response test.

Instruction Provided:

Group by Information Provided		Session 1	Session 2
Explicit Condition	Information Provided	1. "There is a repeated segment" 2. Study pictorial representation	
	Explicit Knowledge Test	Recognition and recall test prior to practice	Recognition test following retention
Implicit Condition	Information Provided	None	
	Explicit Knowledge Test	None	Recognition test following retention

Data Analysis:

- RT faster than the participants' simple RT were removed from analysis
- Median RT was calculated for each 10-element sequence trial
- A mean of the median RT was then computed for each of the 10 sequence trials to represent each block
- A change score was calculated by subtracting each block from the second random block of session one
- Off-line learning was calculated for experiment 2 by subtracting the change score of the repeated sequence of retention from the last repeated sequence from practice to determine the effect of off-line learning (attributable to sleep or passage of time)

Statistical Analysis: For experiment 1, performance during acquisition was assessed using a two factor repeated measures ANOVA (Group (sleep, no-sleep) x Block (1 – 15)) with RT change score as the dependent variable. To assess off-line learning, paired t-tests were used to determine whether retention was significantly different than the last practice block. For experiment 2, effect size was calculated[8].

RESULTS

Experiment 1

Sixteen (7 implicit sleep condition; 9 implicit no-sleep condition) of the 28 participants (57%) in the implicit condition gained a better than chance amount of explicit awareness. Those subjects were removed from analysis.

Acquisition: All groups demonstrated faster RT for the repeated as compared to random sequence across acquisition practice.

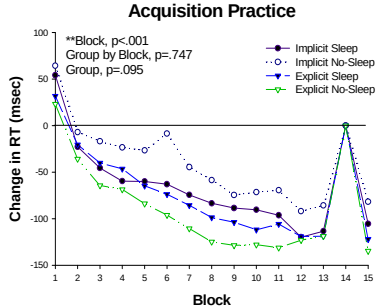

Figure 1. Change in response time across acquisition practice at Session 1. Random sequence RT is represented as the zero line; RT below this line indicate improved or faster responses.

Off-line Learning: Compared to the last practice block at Session 1, all groups (SS p=.033, SN p=0.01, SSE p<.001) except the explicit no-sleep (p=.081) showed significantly faster RT at Session 2 retention.

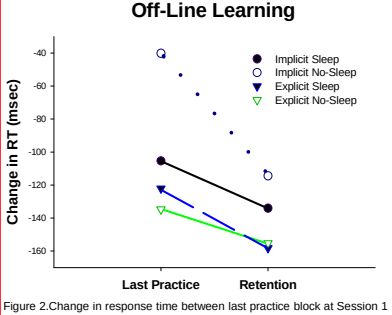

Figure 2.Change in response time between last practice block at Session 1 and retention at Session 2.

RESULTS (cont'd)

Experiment 2

None of the participants post-stroke gained a better than chance amount of explicit awareness. A large effect size of 1.46 indicates a real and meaningful difference between the two implicit groups[8].

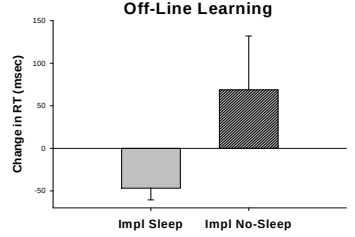

Figure 3. Response times associated with off-line learning for the implicit sleep stroke group compared to the implicit no-sleep stroke group.

DISCUSSION

The first experiment provides concurrent evidence that sleep preferentially enhances explicit skill learning in healthy young individuals but implicit skill learning is enhanced both following a period of sleep and a period of being awake. The second experiment suggests that people with stroke benefit from sleep differently than neurologically intact individuals; implicit motor memory is enhanced following a period of sleep compared with a similar period of being awake.

Understanding the role of sleep in memory consolidation and learning in the damaged brain has tremendous implications for rehabilitation. It may change the way therapists teach motor skills to patients who have suffered from a stroke, and may lead to an emphasis on the need for sleep between therapy sessions.

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