Vol.1, No.4, 284-289 (2009)
doi:10.4236/health.2009.14046

Health

The effects of lunch time napping on habitual nappers' mental work efficiency in the afternoon and early evening: an empirical study from China

Guang-Jin Zhang[1], Fei-Fei Sun[2], Jian-Qiao Liao[3]

[1]Politics and Law School, China University of Geosciences, Wuhan, China; hbzgj@126.com
[2]Faculty of Foreign Languages, Jiangxi University of Finance and Economics, Nanchang, China
[3]Management School, Huazhong University of Science and Technology, Wuhan, China

Received 27 September 2009; revised 5 November 2009; accepted 11.November 2009.

ABSTRACT

30 college students who have the habit of lunch time napping (LTN) participated in experiments under two different conditions: Having lunch time napping and not having lunch time napping. They were asked to complete three tasks including vigilance reaction, short-term memory, addition arithmetic; their performance was recorded automatically by computer during 3 different periods in the afternoon and early evening. The analysis about the experimental data showed that: as for habitual nappers, midafternoon nap zone existed, LTN played a very important role in overcoming it, and did great help in enhancing their vigilance in the afternoon and early evening, however, LTN didn't bring significant positive effect to executing complex tasks (such as short-term memory and addition task) at the periods of time 16:30-17:30, 20:00-21:00. Finally, this article discussed the conclusions and its significance.

Keywords: Lunch Time Napping; Mental Work Efficiency

1. INTRODUCTION

Lunch time napping is very prevalent in China. The farmers often take LTN only in summer because they need avoid the hot sun's radiation at noon; however, more and more mental workers also take LTN, moreover, they usually take LTN all the year round, which can't be explained by the weather. An investigation in a university found that 71% teachers and 78% students are used to taking LTN more than 10 months a year; the respondents admitted that they won't perform well or work efficiently in the afternoon and evening without LTN. However, LTN also induced a lot of controversies, some people think that it leads to low work efficiency for that the continuity of eight hours work a day is interrupted by LTN. Besides, LTN extends the time between going to work and getting off work, especially for those whose home is far away from work site, such as the work time of not having HTL is often from 9:00 to 17:00, otherwise, it is usually from 8:00 to 17:30, which makes people feel more tired [1]. Dose not having LTN really lead to habitual nappers' mental work inefficiency?

To look for the answer from former researches, there were two difficulties. Firstly, Chinese literature usually only describes people's subjective feeling, few of them studies the effects of LTN based on the actual work performance. Secondly, in most of relative English literature, the napping time is often in the afternoon or in the evening, even in a few of researches about LTN, the duration of napping is very short, which is not consistent with the situation of China. For example, Macchi, Boulos and Ranney *et al*. studied the effects of afternoon nap on nighttime alertness and performance [2]. McEvoy & Lack studied the effects of nap (happens in the night shift) on work efficiency [3]. Mednick, Nakayama and Cantero *et al*. studied the restorative effects of afternoon naps on perceptual deterioration [4]. Backhaus & Junghanns studied effects of afternoon nap on memory ability [5]. Milner, Fogel and Cote studied the effects of afternoon nap on motor performance and the moderation effects of habitual napping between them [6]. Hayashi *et al*. studied the effects of both afternoon nap and lunch time nap on mood, performance and EEG activity [7-8]. Driskell and Mullen made A Meta-Analysis about the efficacy of naps as a fatigue countermeasure [9]. Almost all the naps studied mentioned above in the afternoon, which is the working time in China, the working time in the afternoon in China is often from 14:00 to 17:30 or 14:30-18:00. LTN is a common phenomenon in China, and the napping duration is usually as long as 1 hour to 1.5 hours (12:30-13:30 or 12:30-14:00). Therefore, the context about the western scholars' researches is far different from Chinese reality, the conclusions of those

researches can't be simply applied to practice in China. For the two pieces of reasons above, this research is to study the effects of LTN on habitual 'nappers' mental work efficiency in the afternoon and early evening through experiment.

2. METHOD

2.1. Subjects

30 college students (18 females and 12 males) participated in the experiment. These subjects have the habit of lunch time napping, they have lunch time napping at least 4 times a week, and more than thirty minutes each time, their night sleep is often from 23:00 to 7: 00, they are healthy and don't have the habits of smoking and heavy drinking. They did not take any drug during the experiment; meanwhile, all subjects are voluntary and given payment.

2.2. Procedure

The experiment is a balance intra-group design, that is, the 30 subjects were simple randomly divided into two groups with the same number. Each group participated once in two kinds of condition experiment（Having LTN and not having LTN), in order to eliminate the possible influence of the shift experimental condition on work efficiency in the next day, the two tests under different experimental condition which each group subjects participated in were conducted at one week interval. In particular, half of the subjects firstly participated in the experiment under the condition of having LTN, and then took the second test under condition of not having LTN one week later; the other half took the first test under not having LTN condition, and then took the second test under having LTN condition after a week.

In this study, the two kinds of experimental conditions are having LTN and not having LTN. The former is to let the subject have lunch time napping in dormitory from 12:30 to 14: 00, and arrive at the lab at 14:25. The later is to let the subjects arrive at the lab by 12:30, and they can do anything except taking naps until 14:25. In the week before the first experiment test and the week interval between the two experiment tests, the subjects were required to take normal night sleep and lunch time napping everyday, and to keep daily log so as to be checked. In order to let the subjects be familiar with and proficient at the experimental tasks, in the morning of the day before the first experiment test, all subjects participated in the instructions of the experiment and took 15 minutes practice for the three experimental tasks.

Each experiment includes three periods. The first period lasts from 14:30 to 15:30, the second period lasts from 16:30 to 17:30, and the third period is from 20:00 to 21:00. During the experiment, the subjects were not allowed to leave the laboratory except for having supper outside, they can read novel, play games or chat in the laboratory between the three periods. The reason for the first period design is that most organizations in China require their employees to start work at 14:30 in summer; the second period and the third period are to measure the effects of LTN on work efficiency before off duty in the afternoon and in the early evening.

In each period of the experiment, all subjects need accomplish three tasks: vigilance reaction, short-term memory, addition arithmetic, after each task there will be five-minute rest. As for the task of vigilance reaction, it needs the subjects response to 40 signals; as for the task of short-term memory, it needs the subjects recall 20 groups of English letters; as for the task of addition, it needs the subjects judge whether right or not about 30 equations of pairs of three-digit number addition. It will take about one hour to finish all the three tasks.

In order to motivate the subjects to participate in the experiment seriously, we had clarified that better performance and more payment.

2.3 Experimental Task

This study chose three typical mental workers as the experimental tasks.

One of the experimental tasks is vigilance reaction. This experimental task is completed on the computer. There is a clock designed by the researcher on computer screen, and the clock is the same as the one in our daily life. There is only one exception that its second hand occasionally walked 2 grids, and the requirement for subjects is to press the "Del" button in low right corner of the keyboard when the second hand walked 2 grids, then the computer would automatically record the subject's response. During the experimental task, the probability of second hand randomly walked 2 grids was 0.02, in other words, the second hand walked 2 grids once about on the average of 50 seconds, the probability is very appropriate, for if it is too small, signals appeared little, it would make subjects divert attention easily; if it is too large, signals appeared much, this would lead to the loss of the vigilance reaction characteristic. Since the second hand walked 2 grids is a random event, so within 30 minutes on each subject's computer screen, the number of signals was different, therefore, and the rate of wrong response was to evaluate the level of vigilance for the subjects. Here, the rate of wrong response refers to the total number which is the number of the second hand walked 2 grids but the subject didn't press the "Del" button adds the number of the second hand walked normally but the subject pressed "Del" button in the proportion of the total number of the second hand walked 2 grids.

The second experimental task is short-term memory. The earlier research has shown that human short-term

memory capacity is very limited and its storage time is short, it was considered as the bottleneck of human information procession. In this task, 20 groups of alphabet need the subjects recall one by one, and every group of alphabet consist of 10 letters, 10 letters showed on the computer screen in succession at a speed of one letter every two seconds, when the last letter of one group alphabet appeared, there were 10 seconds for the subjects to write the letters just showed on the computer screen from their memory, the computer will automatically compare the letters which the subjects wrote down with the alphabet, the number of the letters recalled correctly will be taken as the subjects' short-term memory performance, and the average number of the 20 groups of letters recalled correctly will be taken as the data to be analyzed in the following.

The third experimental task is addition arithmetic. The computer will display an equation of a pair of three-digit numbers addition on the screen every time, such equations in total up to 30, some of them are wrong, and some are right. The task required the subjects to judge them whether right or not as quickly and accurately as possible. Pressing the button "enter" on the low right keyboard when the equation is right, and pressing the button "ctrl" on the low left keyboard when the equation is wrong, the next equation appeared immediately when the subjects completed pressing key, the computer will automatically record the judging time and check whether the judge is right or not, the average judging time and the correct judging rate for the 30 equations will be analyzed.

3. RESULTS

3.1. Vigilance Reaction Analysis

The vigilance reaction performance under two kinds of experimental condition in each period was analyzed by paired-samples T test, in addition, the vigilance reaction performance under the same experimental condition in three periods was analyzed with ANOVA, and the result is shown in **Table 1**. The same analysis to short-term memory, addition arithmetic, and results are shown in **Table 2**, **Table 3**, and **Table 4.**

Table 1 shows that in three experimental periods, the subjects who took LTN have significantly higher vigilance than those without LTN, such situation especially obvious at 14:30-15:30, the napping subjects' rate of signals responded wrong is 10% lower than that of not napping ones, even at 16:30-17:30 and 20:00-21:00, the rate of signals responded wrong is also 4% lower, which proves that lunch time napping exert positive effect on vigilance for people no matter in the afternoon or in the early evening.

Table 1 also shows that for the LTN subjects, their vigilance hadn't changed significantly in the three experimental periods; however, as for the not having LTN subjects, their vigilance at 14:30-15:30 is significantly lower than that at 16:30-17:30 and 20:00-21:00, there wasn't significant difference between the second period and third period.

3.2. Short-term Memory Analysis

Table 2 lists the comparative analysis results of subjects' short-term memory capacity under two experimental conditions and in three experimental periods.

It can be seen from **Table 2** that only at 14:30-15:30, the subjects who took LTN have better short-term memory performance than those without LTN, at 16:30-17:30 and 20:00-21:00, there wasn't significant difference between them.

Table 2 shows that, as for the subjects who took LTN, the significant difference about short-term memory capacity wasn't found in three periods, however, as for the subjects who didn't take LTN, their short-term memory performance at 14:30-15:30 is worse than that at 16:30-17:30 and 20:00-21:00, and there wasn't significant difference between 16:30-17:30 and 20:00-21:00.

3.3. Addition Arithmetic Analysis

In order to analyze the effect of LTN on human arithmetic calculation performance, this research made the comparative analysis of calculation speed and calculation accuracy rate under two different experimental conditions and in three experimental periods, the results shown in **Table 3** and **Table 4.**

Table 3 lists the comparative analysis results of arithmetic calculation speed under two experimental conditions and in three experimental periods.

Table 3 shows that only at 14:30-15:30, the arithmetic calculation speed of the subjects who took LTN is significantly faster than that of those without LTN, while at 16:30-17:30 and 20:00-21:00, the significant difference wasn't found between them.

As can be seen from **Table 3**, for the subjects who took LTN, their arithmetic calculation speed is almost the same, but for the subjects who didn't take LTN, the arithmetic calculation speed at 14:30-15:30 is significantly slower than that at 16:30-17:30 and 20:00-21:00, and there wasn't significant difference between 16:30-17:30 and 20:00-21:00.

Table 4 lists the comparative analysis results of the calculation accuracy rate under two experimental conditions and in three experimental periods.

Table 4 shows that only at 14:30-15:30, the calculation accuracy rate of subjects who took LTN is significantly higher than that of those without LTN, while at 16:30-17:30 and 20:00-21:00, the significant difference couldn't be found between them.

As can be seen from **Table 4**, as for the subjects who took LTN, their arithmetic calculation accuracy rate is almost the same, but for the subjects who didn't take LTN,

Table 1. Vigilance reaction (the rate of signal responded wrong).

Experimental condition	the rate of signal responded wrong	experimental periods			F	LSD
		14:30-15:30	16:30-17:30	20:00-21:00		
Having lunch time napping	Mean	0.054 (NVR1)	0.063 (NVR2)	0.060 (NVR3)	0.309	NVR1≈NVR2 NVR1≈NVR3 NVR2≈NVR3
	Std.dev.	0.044	0.043	0.045		
Not Having lunch time napping	Mean	0.148 (NNVR1)	0.105 (NNVR2)	0.102 (NNVR3)	5.948**	NNVR1> NNVR2 NNVR1> NNVR3 NNVR2≈NNVR3
	Std.dev.	0.060	0.055	0.058		
T		20.828**	10.779**	9.069**		

Table 2. Short-term memory capacity (the number of letters recalled correctly).

Experimental condition	Short-term memory capacity	experimental periods			F	LSD
		14:30-15:30	16:30-17:30	20:00-21:00		
Having lunch time napping	Mean	8.05 (NSM1)	8.09 (NSM2)	8.01 (NSM3)	0.383	NSM1≈NSM2 NSM1≈NSM 3 NSM2≈NSM 3
	Std.dev.	0.340	0.373	0.412		
Not Having lunch time napping	Mean	7.30 (NNSM1)	7.96 (NNSM2)	7.92 (NNSM3)	20.588**	NNSM1< NNSM2 NNSM1< NNSM3 NNSM2≈NNSM3
	Std.dev.	0.390	0.582	0.334		
T		31.068**	1.145	1.665		

Table 3. Arithmetic calculation speed (seconds/one equation).

Experimental condition	arithmetic calculation speed	experimental periods			F	LSD
		14:30-15:30	16:30-17:30	20:00-21:00		
Having lunch time napping	Mean	5.06 (NCS1)	5.03 (NCS2)	4.99 (NCS3)	0.322	NCS1≈NCS2 NCS1≈NCS3 NCS2≈NCS3
	Std.dev.	0.339	0.338	0.402		
Not Having lunch time napping	Mean	5.49 (NNCS1)	5.01 (NNCS2)	5.04 (NNCS3)	14.980**	NNCS1< NNCS2 NNCS1< NNCS3 NNCS2≈NNCS3
	Std.dev.	0.402	0.405	0.337		
T		15.086**	0.813	1.708		

Table 4. The calculation accuracy rate.

Experimental condition	the calculation accuracy rate	experimental periods			F	LSD
		14:30-15:30	16:30-17:30	20:00-21:00		
Having lunch time napping	Mean	0.763 (NCAR1)	0.762 (NCAR2)	0.766 (NCAR3)	0.058	NCAR1≈NCAR2 NCAR1≈NCAR3 NCAR2≈NCAR3
	Std.dev.	0.041	0.042	0.040		
Not Having lunch time napping	Mean	0.701 (NNCAR1)	0.756 (NNCAR2)	0.752 (NNCAR3)	5.272**	NNCAR1< NNCAR2 NNCAR1< NNCAR3 NNCAR2≈NNCAR3
	Std.dev.	0.763	0.072	0.075		
T		7.423**	0.670	1.391		

the arithmetic calculation accuracy rate at 14:30-15:30 is significantly lower than that at 16:30-17:30 and 20:00-21:00, and there wasn't significant difference between 16:30-17:30 and 20:00-21:00.

4. DISCUSSION

4.1. Conclusions

This research showed that as for the subjects who didn't take LTN, their mental work performance at 14:30-15:30 is significantly worse than that at 16:30-17:30 and 20:00-21:00, while as for those who took LTN, their mental work performance almost is the same in three experimental periods, which indicated that midafternoon nap zone as Hayashi *et al*. [10], Broughton mentioned exists objectively for habitual nappers [11], this experiment provided the direct evidence for their standpoint. This research also showed that the subjects who took LTN have significantly better mental work performance than those without LTN at 14:30-15:30, which proved that LTN could overcome habitual nappers' "midafternoon nap zone".

It is interesting that as for mental work performance of such task as short-term memory and arithmetic calculation, there wasn't significant difference between the

subjects who took LTN and those who didn't take it at 16:30-17:30 and 20:00-21:00, however, as for vigilance reaction, the subjects who took LTN have significantly better performance than those who didn't take it at the periods as above, which may be caused by the different nature of the experimental tasks. In specification, the experimental task of vigilance reaction is relatively bald, such tasks may easily induce the subjects who didn't take LTN to desire sleep, and the result is that their performance is worse than the subjects who took LTN. Hayashi *et al*. also took for that nap could reduce human sleepiness and enhance vigilance [7,8,12]. However, as for short-term memory and arithmetic calculation, these tasks' mental workload are relatively overload, the subjects who didn't take LTN weren't easily to stimulate sleepiness, and the result is that their performance are the same as those who took LTN. Hayashi *et al*. have also gotten such conclusion [7]. This research results indicated that the effect of LTN on habitual nappers' mental work performance is moderated by the nature of mental work at 16:30-17:30 and 20:00-21:00.

It is worth noting that this research didn't deny the existence of sleep inertia. Hayashi *et al*. hold that sleep inertia is inevitable [7], and Taub [13], Dinges *et al*. believed that sleep inertia may last 15-35 minutes [14]. In this study, the measurement of mental work performance is carried out 30 minutes after LTN, as for the subjects who took LTN, their mental work performance has not changed significantly, which provides indirect evidence for that sleep inertia may last 15-35 minutes, because if sleep inertial exceeds 30 minutes, the mental work performance of the subjects who took LTN at 14:30-15:30 should be lower than that at 16:30-17:30 and 20:00-21:00, but this experiment result wasn't the case.

It should be noted that the above conclusions are got with the subjects who have LTN habit and took normal sleep at night and 1 hour and a half naps at noon, if experimental context was not the case, the conclusion of this study may be different, many scholars believed that the effects of naps depend on the duration of prior wakefulness, the time of day of the nap, and its duration [15,16].

Many people feel that they are sleepy and work inefficiently in the afternoon and evening without LTN; however as for the complex and over-workload task, such as short-term memory and arithmetic calculation, the conclusion of this study is contradict with it, it doesn't matter whether to take LTN or not, human work performance of such complex task at 16:30-17:30 and 20:00-21:00 is the same, the reason may due to the difference between experiment and reality. In the experiment, subjects' attention is highly focused, the pace of task is relatively fast, the experiment duration is short (each period about 1 hour), and also strong incentive provided. In reality, the pace of many tasks is slow, and the work duration is long, which easily induce people to be relaxed and stimulate sleepiness. Despite some difference between experimental context and reality, we think that this experiment proved that at least in theory, for complex and over-workload mental work, LTN is a phenomenon to be overcome temporarily in the later afternoon and in the early evening (16:30-17:30 and 20:00-21:00), not having LTN didn't exert significant negative effect to the performance of such task.

4.2. Recommendations

As for habitual nappers, because of LTN can ease such physical embarrassment as mid-afternoon nap zone, therefore, LTN is needed if conditions allow, especially for those whose home is near to their work site. For the task of vigilance reaction, LTN is particularly important because LTN can improve its performance in the afternoon and evening.

Whether having LTN or not has great influence on habitual nappers' mental work efficiency at 14:30-15:30 in order to eliminate the negative influence, on one hand, the government departments should try to avoid arranging important mental activities at this period of time, such as examinations, and so on. Unfortunately, Chinese government departments doesn't seem to notice it, for example, the most important college entrance examination, its examination time in the afternoon was always from 14:00 to17:00, as for some students who did not take LTN, their test score are likely to be lower than their real achievements, which is unfair for them to compete with students who have comfort LTN condition. On the other hand, many Chinese enterprises should adjust their shiftwork schedule, that is changing the present shiftwork timetable (8:00-16:00, 16:00-24:00, 24:00 -8:00) into the new one (6:00-14:00, 14:00-22:00, 22;00-6:00), which can let habitual nappers avoid not had HLT on duty yet at 14:30-15:30.

4.3. Limitations and Future Directions

All the subjects participated in this experiment have LTN habit, although it consists of the Chinese work and rest mode, we can't find out the effect of LTN on mental work efficiency of those who haven't LTN habit, there is no doubt that to study it is an interesting work, for example, if we find that LTN has no significant effect on mental work efficiency of those who haven't LTN habit, in addition, changing the LTN habit doesn't bring significant bad physical influence, then to reform Chinese public sectors' work and rest timetable is go without saying, because the timetable (9:00 -17:00) in many private sector is more reasonable than the timetable (8:00 -12:00 and 14:00-17:30) in public sectors obviously, which keeps the continuity of eight hours work a day and not require the public to wait out of the government

office at 12:00-14:00.

5. ACKNOWLEDGMENT

This study was supported by the Science and Technology Research Project of Hubei province under Grant B20080402, and also was supported by the Humanity Social Science Foundation of Hubei province under Grant 2008y054.

REFERENCES

[1] Liao, J.Q. (1996) The effects of napping on human performance of vigilance. *Ergonomics.*, **4**, 29-32.

[2] Macchi, M.M., Boulos, Z., Ranney, T., Simmons, L. and Campbell, S.S. (2002) Effects of an afternoon nap on nighttime alertness and performance in long-haul drivers. *Accident Analysis and Prevention.*, **34**, 825-834.

[3] McEvoy, R.D. and Lack, L.L. (2006) Medical staff working the night shift: can naps help? *Medical Journal of Australia*., **7**, 349-350.

[4] Mednick, S.C., Nakayama, K. and Cantero, J.L., *et al.* (2002) The restorative effect of naps on perceptual deterioration. *Nature Neuroscience*., **7**, 676-680.

[5] Backhaus, J. and Junghanns, K. (2006) Daytime naps improve procedural motor memory. *Sleep Medicine.*, **7**,508–512.

[6] Milner, C.E., Fogel, S.M. and Cote, K.A. (2006) Habitual napping moderates motor performance improvements following a short daytime nap. *Biological Psychology*., **73**, 141–156.

[7] Hayashi, M., Ito, S. and Hori, T. (1999) The effects of a 20-min nap at noon on sleepiness, performance and EEG activity. *International Journal of Psychophysiology*., **32**, 173-180.

[8] Hashi, M., Makiko, W. and Hori, T. (1999) The effects of a 20 min nap in the mid-afternoon on mood, performance and EEG activity. *Clini cal Neurophysiology*., **110**, 272–279.

[9] Driskell, J.E. and Mullen, B. (2005) The efficacy of naps as a fatigue countermeasure: a meta-analytic integration. *Human Factors*., **2**, 360-377.

[10] Hayashi, M., Morikawa, T. and Hori, T. (2002) Circasemidian 12-hour cycle of slow wave sleep under constant darkness. *Clinical Neurophysiology.*, **113**, 1505-1516.

[11] Broughton, R.J. (1998) SCN controlled circadian arousal and afternoon "nap zone". *Sleep Research Online*., **1**, 166-178.

[12] Hayashi, M., Fukushima, H. and Hori, T. (2003) The effects of short daytime naps for five consecutive days. *Sleep Research Online*., **5**, 13–17.

[13] Taub, J.M. (1979) Effects of habitual variations in napping on psychomotor performance, memory, and subjective states. *International Journal of Neuroscience*., **9**, 97-112.

[14] Dinges, D.F., Orne, E.C., Evans, F.J. and Orne, M.T. (1981) Performance after naps in sleep-conductive and altering environments. In Johnson, L.C., Tepas, D.I., Colquhon, W.P. & Colligan, M.J. (Eds.), Biological Rhythms, Sleep and Shift Work. *S. P. Medical and Scientific Books*., New York, 539-552.

[15] Lumley, M., Roehns, T., Zorick, F., Lamphere, J. and Roth, T. (1986) the alerting effects of naps in sleep-deprived subjects. *Psychophysiology*., **23**, 403-408.

[16] Naitoh, P. (1981) Circadian cycles and restorative power of naps. In Johnson, L.C., Tepas, D.I., Colquhon, W.P. & Colligan, M.J. (Eds.), Biological Rhythms, Sleep and Shift Work. *S. P. Medical and Scientific Books*., New York, 553-580.

