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A small scale circadian rhythm research on learning new vocabulary

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It is assumed that there is a more or less optimal time during the day for learning new school material, which can vary for different people. It is known that circadian rhythm and certain physiological functions in the human body are closely interconnected. Similarly, according to earlier research, morning and evening personality types can be correlated with certain personality factors. The purpose of the study is to investigate the optimal vocabulary learning habits of two different groups of learners, the early risers or the larks (L) and those who normally get up late and work late, the owls (O). A small scale experiment was conducted to investigate and analyze the best optimal time and the least optimal time that can potentially influence success at learning new vocabulary items. The research questions were aimed at discovering the most effective learning hours for both the owls and the larks. A shorter version of the Munich Chrono Type Questionnaire (MCTQ) was administered to potential participants. Then learning sessions were organized for both groups with the memorization of new vocabulary items followed by tests. It is a small-scale research, and long term implications cannot be drawn without further research. Since the results are somewhat contradictory to earlier findings; more emphasis should be given to this area of research. The results are promising for developing learning strategies; however, further research is needed to acquire more reliable findings. Examining the circadian rhythm of learners has important future implications in foreign language learning and teaching.

Keywords: *chronotypes, circadian rhythm, larks, owls, vocabulary learning*

Introduction

In recent years, there has been an increasing interest in researching the phenomenon of human circadian rhythm, and the amount of literature on the subject reflects this attention. The importance of the topic is mirrored in the fact that the Nobel Prize in Physiology or Medicine in 2017 was given to Jeffrey C. Hall, Michael Rosbash and Michael W. Young for their findings on how the various molecular mechanisms govern circadian rhythm (The Nobel Prize in Physiology or Medicine, 2017). It is now known how the biological rhythm works in plants, animals and human beings in intricate harmony with the revolution of the Earth (for a general overview see Kreitzman and Foster, 2009, 2011, 2017). The essence of the theory is that

living organisms, including humans, have an inner, biological clock that functions with great precision adjusting itself to the radically diverse phases of the day. This clock has a profound effect on diverse physiological levels such as our hormone levels involving practically all related systems such as sleep patterns, body temperature, metabolic processes, the nervous system, sleep-wake cycles and our behavioral patterns and learning habits.

In addition, on the cognitive level, a number of other factors are similarly influenced by it, such as memory tasks, verbal tasks and arithmetic calculations (Valdez et al., 2012). Regarding our general well-being, with regard to chronotype personalities, it has conclusively been shown in earlier studies that morning-type individuals are usually healthier than evening-type individuals (Díaz-Morales, 2007). Unfortunately, few studies have been carried out on how this biological clock, inherent in all of us, is related to learning processes, previous studies having primarily concentrated on how circadian rhythm affects the human body in general. In the next section some of the systems affected will be outlined in more detail in light of current literature, involving physiological functions, individual differences, and cognitive functions.

Background

Physiological functions

A number of studies have confirmed the importance of circadian rhythm as it is associated with physiological functions. It has been long known that circadian rhythm and certain physiological functions in the human body are closely interconnected. For example, Olds ed. (2015) investigated the relationship between circadian rhythm and metabolic processes. How metabolism works at night or in the morning and how it is connected to obesity, affecting the hypothalamic-pituitary-adrenal axis are only some of the manifestations of this interrelated network. One such important system is the Hypothalamic-Pituitary-Adrenal (HPA) axis which affects physiological functions in the human body such as the variations between daily and nocturnal metabolic processes.

The pathogenesis of circadian rhythm sleep disorders is well mapped by scientists. It is proven that sleep and cellular energetics in the brain are linked. Sleep disruption may cause metabolic disorders in the body, including problems connected to brain metabolism. Rique et al. (2014) state that evening chronotype personalities are related to deprived quality of sleep, common among university students, with probable deficiency in their academic performance, resulting in a lower quality of life. Valdez et al. (2008)

also claim that mental performance is affected by sleep deprivation in a negative way, and trying to catch up with lack of sleep during the week has its drawbacks, too. According to Valdez et al. (2008), taking a short nap might be beneficial; however, Taylor et al. (2008) warn that sleeping-in during the weekend does not solve the problem; on the contrary, it only delays circadian rhythm, resulting in more daytime sleepiness and fatigue during the following week, especially on Monday and Tuesday. In addition, it simultaneously decreases alertness and mental functioning, and it may also cause mood changes. It has manifestations on the biochemical level, too: not getting enough sleep can be related to factors negatively affecting cellular energy-related chemical processes of brain disorders as well as developing obesity (Olds ed., 2015).

Other manifestations of physiological functions include shift work. Shift work has serious health related consequences, and considering the fact that the number of shift workers increases globally, the issue seems even more relevant. Even though extensive research is still missing in the field, both acute and chronic effects are detectable in people, and it is assumed that chronotype factors may contribute in a crucial way to coping with shift work (Kantermann et al., 2010).

Finally, the widespread phenomenon of jet lag for travelers (Olds ed., 2015) is also connected with circadian rhythm. We might be accustomed to a one-hour change in time on two occasions annually, called daylight saving time, which change can still be quite easily handled by the human body (Kantermann et al., 2007); however, jetlag can alter the body's circadian rhythm in a dramatic way caused by rapid, long-distance trans-meridian travel (Olds ed., 2015), and it is something that places a substantial burden on our system since daylight itself plays a significant role in the synchronization of light in any living organism (Kantermann et al., 2007).

Individual differences

According to Díaz-Morales (2007), people prefer certain times during the day for various activities, which fact can indicate the personality types of morningness and eveningness. Therefore, differences in chronotypes show great individual differences, and larks can be characterized as the early risers, who normally go to bed early as well, while owls are the people who normally get up late and work until later in the evening. The differences between these chronotypes may have a significant effect on our lifestyles, our daily routine activities, work performance and personality traits. Different people have different learning habits for more or less optimal hours during the day for learning (de Bot, 2013).

It is also known that individual differences such as learner characteristics, age, aptitude, attitude, motivation and intelligence play a key role in the process of second language acquisition. Intraindividual or within-subject variability is related to the consolidation of new learning, and we know that non-optimal testing times and the age of people are influencing factors in the outcome of new learning (Hogan et al., 2009). Variability may also be connected to learning styles and strategies, together with gender and personality traits (de Bot et al., 2005); therefore, Dörnyei (2005) proposes that chronotype characteristics should be regarded as an important contributing factor to successful learning.

Cognitive factors

As it was mentioned earlier, previous studies have primarily concentrated on the general bodily manifestations of circadian rhythm, and the connection between circadian rhythm and second language learning has been barely studied to date. Nevertheless, if it has such a profound impact on living organisms and the human body, it also needs to be explored how circadian rhythm can be related to cognitive factors such as learning abilities and performance. As a result of that, it has raised the interest of some linguists in this respect (De Bot – Fang, 2017). According to earlier research, morning and evening personality types can be correlated with certain personality factors such as emotional stability, trustworthiness, creativity, originality and so on (Giampietro – Cavallera, 2007a).

Furthermore, Giampietro and Cavallera (2007b) studied the relationship between morning and evening type personalities and creative thinking. It is assumed that people do not show stable cognitive performance throughout the whole day and that they have a preferred time during the day for certain activities. De Bot and Fang (2017) conducted research on the effect of early-rising and late personalities on cognitive functioning and found that cognitive stability changes throughout the day, and early risers are expected to perform better earlier in the day while people going to bed late are expected to perform better cognitively later in the evening than their counterparts. Nevertheless, the result of their study showed that there was not a significant correlation between the two groups under investigation in terms of vocabulary learning.

Besides, a wide range of additional cognitive functions are regulated by circadian rhythm such as attention and memory (Schmidt et al., 2007). For example, Smarr et al. (2014) demonstrate that circadian rhythm has a profound and definite effect on learning and memory, which affects not only the process of memory acquisition, but also memory recall. In other words,

there are certain forms of learning and memory that show circadian modulation in terms of when they can be activated in the most effective way.

The purpose of the study

The main objective of the present study is to explore the most effective vocabulary learning times of two different groups of learners, the early risers or the larks (L) and the owls, those who normally get up late and work late (O). The study is intended to test the hypothesis presented below in the form of a small scale experiment with the intention to examine how the habit of learning at the best optimal time and the least optimal time influences success at learning new vocabulary items. The result of the experiment is expected to point to the direction of how chronotypes of individuals may contribute to forming more efficient learning habits and strategies.

Research questions and hypothesis

Research questions

1. Do larks learn words more effectively earlier in the day?
2. Do owls learn words more effectively later in the day?

Hypothesis

It is hypothesized that owls learn words more effectively later in the day and that larks learn words more effectively earlier in the day.

Participants and method

The experiment took place in Vári Szabó István Vocational and Secondary School Kiskunhalas – during the spring of 2019, with the preliminary consent of the participating students. The experiment involved twenty (N=20) participants who were divided into two equal-size groups of ten early risers or larks (L) and ten owls (O), those who normally get up and work late. Subsequently, the quantitative data were analyzed. In order to test the hypothesis, the following procedure was followed throughout the experiment. Before the research, it had been decided which participants would belong to which group (Larks or Owls) in their chronotime patterns. Therefore, a shorter version of the *Munich Chrono Type Questionnaire* (MCTQ) was administered to the participants. The questionnaire is designed in a way that is suitable for tracing typical sleep behavior patterns.

The participants were divided into two groups: Larks -10 (L) and Owls -10 (O). The task involved a learning phase for both groups in order to have the opportunity to memorize new vocabulary items on two different occasions, once in the morning hours and once later in the evening. Two different sets of new words were administered to them at these two phases. Both sets of words consisted of 10 words.

Subsequently, tests were administered to both the larks (L) and the owls (O) at an early day time in the morning hours, and the same procedure was repeated for both groups (L) and (O), respectively, later in the evening to define the most and least optimal learning time of the day for the two groups.

Results and discussion

This section discusses the findings about the larks (L) and the owls (O), and the results are analyzed in terms of what effect a certain period of time during the day has on the effectiveness of vocabulary learning on the larks (L) and on the owls (O), respectively. The statistical tool SPSS (*Statistical Package for the Social Sciences*) was used in a simple statistical analysis to demonstrate the outcome of the research.

The overall statistical findings can be seen in *Table 1*, broken down into the two groups for the two phases of the day under investigation. It includes the mean scores for each group and time of day. Similarly, the same table represents the median scores for each group, together with the mode values.

Table 1. Owls and Larks for overall morning and evening results

	Owls evening	**Owls morning**	**Larks morning**	**Larks evening**
N Valid	10	10	10	10
Missing	0	0	0	0
Mean	5,5000	4,5000	8,4000	6,4000
Median	5,0000	5,0000	8,5000	6,5000
Mode	4,00	5,00	10,00	6,00a

a= Multiple modes exist. The smallest value is shown.

The statistical results of the study reveal regarding the morning performance for the larks and the owls that the larks (L) are more effective in learning words in the morning hours. For example, there were four participants in the group of larks (L), who reached the score of ten words in the morning, while the maximum number of words by the owls (O) were only six, and only two participants reached that score. The results as shown in *Table 2* and *Table 3* illustrate these findings.

Table 2. Performance of larks in the morning

		Frequency	Percent	Valid percent	Cumulative percent
Valid	5,00	1	10,0	10,0	10,0
	7,00	2	20,0	20,0	30,0
	8,00	2	20,0	20,0	50,0
	9,00	1	10,0	10,0	60,0
	10,00	4	40,0	40,0	100,0
Total		10	100,0	100,0	

N=10, SD=1,713

Table 3. Performance of owls in the morning

		Frequency	Percent	Valid percent	Cumulative percent
Valid	2,00	1	10,0	10,0	10,0
	3,00	1	10,0	10,0	20,0
	4,00	2	20,0	10,0	40,0
	5,00	4	40,0	40,0	80,0
	6,00	2	20,0	20,0	100,0
Total		10	100,0	100,0	

N=10, SD=1,269

When we look at the results for the data obtained in the evening, we can see that during this testing time only two larks (L) reached the score of nine words, which was the best score in the evening phase (*Table 4*).

Table 4. Performance of larks in the evening

		Frequency	Percent	Valid percent	Cumulative percent
Valid	2,00	1	10,0	10,0	10,0
	5,00	1	10,0	10,0	20,0
	6,00	3	30,0	30,0	50,0
	7,00	3	30,0	30,0	80,0
	9,00	2	20,0	20,0	100,0
Total		10	100,0	100,0	

N=10, SD=2,011

Regarding the evening performance of the owls (O), the results are not so convincingly different than they are with the larks (L), and the median value for the evening is the same as the median value in the morning (*Table 1*), showing a quite even outcome. For instance, the maximum number of words remembered is nine, and only one participant was successful at it. The most words remembered were four, and three participants could deliver that result (*Table* 5).

Table 5. Performance of owls in the evening

		Frequency	Percent	Valid percent	Cumulative percent
Valid	3,00	1	10,0	10,0	10,0
	4,00	3	30,0	30,0	40,0
	5,00	2	20,0	20,0	60,0
	6,00	1	10,0	10,0	70,0
	7,00	1	10,0	10,0	80,0
	8,00	1	10,0	10,0	90,0
	9,00	1	10,0	10,0	100,0
Total		10	100,0	100,0	

N=10, SD=1,958

As can be seen from *Table 6*, the larks (L) performed 24% better in the morning on average; however, a 19% better performance of the owls is recorded for the evening hours on average as shown in *Table 7*.

Table 6. Larks' morning results in %

	%	(+/-)
Mean	24 %	+
Median	23,5 %	+
Mode	35%	+

Table 7. Owls' evening results

	%	(+/-)
Mean	19 %	+
Median	0 %	=
Mode	20 %	-

The results of this small scale research obtained from the analysis show that there are differences between the two groups; nevertheless, these finding are not consistent with previous results by De Bot (2013) and De Bot and Fang (2017), whose studies indicated that the difference between the tested groups did not prove to be significant. In the present study, the findings support the hypothesis of this research, namely, that owls learn words more effectively later in the day and that larks learn words more effectively earlier in the day, indicating a documentable difference between the performance of the larks or the owls at different times of the day.

Concerning the interpretations of the results, it should be noted that careful consideration and caution are needed, since it is hard to tell to what extent individual ways of life affect and form learning habits, and whether personality traits are the manifestations of pre-existing genetically conditioned circadian rhythm patterns. At this stage, it is difficult to explain

what the underlying causes are, predominantly responsible for the driving mechanism in determining our chronotypes (De Bot, 2013), and how chronotypes affect personality characteristics. Are early risers better performers in the morning only because they go to bed earlier, and they are more rested in the morning, and people going to bed later perform somewhat better in the afternoon or evening hours because they get up later and they are more rested until later in the afternoon or the evening hours? These are all complex questions to answer, and they call for more sophisticated research designs in order to eliminate confounding research factors such as tiredness, or the unavoidable pressure of working-hour patterns enforced on us. Therefore, cause and effect relationships seem to be rather interconnected in this case.

Conclusion and future implications

The current study was designed to determine the optimal vocabulary learning habits of two different groups of learners, referred to as the larks (L) and the owls (O). The results of this investigation show that larks perform better in the morning and owls perform better in the evening, although the difference is more salient in the group of larks. These findings confirm the hypothesis, although certain cautions and limitations should be taken into consideration regarding the present study. For example, it is a small scale study, the implication of which is that it can bring up the question of credibility, and generalizations should be handled carefully. However, the findings can still provide us with some insights and serve with useful information regarding the connection between the circadian rhythm of individuals and the efficiency of their vocabulary learning habits.

Consequently, more research involving a larger number of participants, together with a more elaborate statistical analysis, is needed which can yield more reliable and consistent research results in the future. Further investigation and experimentation into this field may provide us with a better understanding on how circadian rhythm influences human physiology and mental processes. In addition, with the incorporation of alternative research designs such as implementing learning in the morning and testing in the evening, and learning in the evening and testing in the morning can illuminate insights not incorporated into the present study.

Studying the circadian rhythm of people in connection with their learning habits and strategies has important future implications and applications in Second Language Acquisition (SLA) research in general, and in language teaching and individual learning strategies in particular. According to De Bot and Fang (2017), the pedagogical applications of

chronotypes of individuals may contribute to creating more flexible study schedules in order for students to perform efficiently in their academic life. The application of the most advantageous times during the day both in teaching and learning, with the optimization of school learning hours (Blatter and Cajochen, 2007) is desirable, and designing forthcoming learning material and curricula can also have beneficial educational effects. For example, the administration of new vocabulary items at certain hours of the day to learners with individual circadian rhythms may be helpful. Similarly, increasing learners' self-knowledge and reflection on their learning habits may prove to be a useful contributing factor in independent learning. A conscious approach in language teaching, which vocabulary development is part of, has its clear implications.

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