



**Morad Kasmi**

<https://orcid.org/0000-0002-8927-8695>

Mohamed I University, Oujda, Morocco

[moradkasmi061@gmail.com](mailto:moradkasmi061@gmail.com)

## The impact of chronotype on second language vocabulary acquisition: Insights into timing and learning efficiency

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### **Keywords:**

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### **Abstract**

**Research objectives (aims) and problem(s):** This study examines the connection between second language vocabulary learning and chronotype (morningness–eveningness preference). Academia has paid little attention to how biological rhythms affect vocabulary learning effectiveness, despite the fact that individual variances are widely acknowledged as having an impact on language acquisition. As a result, this study seeks to examine whether learners' chronotype influences vocabulary acquisition outcomes and whether performance varied depending on the time of day.

**Research methods:** The study employed a sample of 102 people with a quantitative research approach. The Morningness-Eveningness Questionnaire was adopted to determine the learners' chronotypes, classifying them as either morning types ("larks") or evening types ("owls"). Both morning and afternoon sessions were used to gauge vocabulary acquisition performance. Data were analyzed using inferential statistics, including independent samples t-tests to compare vocabulary learning abilities between individuals with different chronotypes and the paired samples t-test to compare the means of each group in the morning and afternoon.

**Process of argumentation:** The study is based on the premise that people's circadian preferences can affect their cognitive function. The investigation evaluates whether alignment between learners' biological rhythms and instructional schedules improves vocabulary acquisition by comparing vocabulary learning results across chronotype groups and various times of day.

**Research findings and their impact on the development of educational sciences:** Based on chronotype, the results show statistically significant differences in vocabulary learning outcomes, with larks generally outperforming owls. While evening-type learners scored higher later in the day, morning-type learners performed noticeably better during morning sessions. Effect size analyses found medium to large effects, indicating the substantive importance of chronotype in second language vocabulary learning. These results contribute to educational sciences by emphasizing the role of chronobiological elements in shaping learning efficacy.

**Conclusions and/or recommendations:** In second language contexts, chronotype has a considerable impact on vocabulary learning performance. Aligning teaching times with students' biological rhythms may improve vocabulary acquisition and overall learning outcomes, so it is advised that language instructors and educational planners take learners' circadian preferences seriously when planning learning schedules and instructional activities. While SLA research emphasizes WHAT and HOW to teach, WHEN to teach is neglected, a matter this research tries to bring forth. The WHEN-TO-TEACH should be learner-centered; therefore, it transforms into WHEN-TO-LEARN. Learning is bound to WHEN it occurs, as each learner is open to learning in a specific biological time.

## Introduction

Chronotype is defined as an individual's preferred sleep-wake pattern, influenced by genetic, age-related, and environmental factors. It reflects the time of day when a person feels most alert and productive and when they naturally tend to fall asleep and wake up. Chronotypes are categorized into three main types: morningness, eveningness, and intermediate. Morningness, or "morning larks," describes individuals who thrive in the early morning hours, while eveningness, or "night owls," describes individuals who prefer the evening and night for peak productivity. Intermediate types fall in between these extremes. Identifying one's chronotype can help optimize daily routines by aligning activities with natural body rhythms to improve well-being, sleep quality, and overall performance (Adan & Almirall, 1991; Roenneberg et al., 2007; Sletten et al., 2019). However, only two studies have looked into the relationship between chronotype and second language vocabulary acquisition (De Bot, 2013; Deli,

2020). Notably, the findings of these two studies contradicted each other. Therefore, it remains unknown whether chronotype affects second language vocabulary acquisition.

This study aims to fill the gap in the literature by contributing to the existing body of research. Its main objectives are to categorize learners based on their chronotype, investigate the relationship between chronotype and vocabulary acquisition, examine the performance differences between morning learners (larks) and evening learners (owls), explore the effect of timing on vocabulary instruction, and analyze the statistical relationship between chronotype and second language vocabulary acquisition. We hypothesize that morning learners will exhibit superior vocabulary acquisition outcomes, especially when taught in the morning, while evening learners will excel with evening instruction. Additionally, we expect no significant correlation between chronotype and vocabulary acquisition. By employing various data collection methods and a robust study design, we aim to contribute valuable insights into the role of chronotype in second language vocabulary learning and individual differences in language acquisition.

## **Research questions and hypotheses**

### **Research questions**

This study tried to provide answers to the following questions:

- Q1: When learning new words, are morning learners really more successful in the morning?
- Q2: Do evening learners pick up new words and remember them better during the evening?
- Q3: Are morning learners better at learning and remembering vocabulary than evening learners?

## Research hypotheses

The research hypotheses of this study were as follows:

- H<sub>0</sub>: No relationship exists between the chronotype of the students and their vocabulary acquisition.
- H<sub>1</sub>: Language learners' chronotype positively correlates with their effectiveness in acquiring and retaining vocabulary, where "morning learners" perform better on vocabulary-related tasks during the morning and "evening learners" perform better during the evening.
- H<sub>2</sub>: Morning learners learn and retain vocabulary more effectively than evening learners.

## Previous studies

This subsection provides a brief overview of two relevant studies that explore the relationship between an individual's chronotype (circadian rhythm) and their language-related abilities. De Bot (2013) examined the impact of chronotype on language aptitude and word learning in university students, while Deli (2020) investigated the potential relationship between circadian rhythm and vocabulary learning. The findings from these studies have implications for language instruction and the development of personalized learning strategies. Further research is needed to deepen our understanding of this relationship and its practical applications.

De Bot (2013) investigated the influence of chronotype on language aptitude and word learning in university students. Using the Munich Chronotype Questionnaire, participants were categorized as "larks" or "owls" based on their preference for morning or evening activity. Language aptitude tests and word learning tasks were administered at both preferred and non-preferred times of day. The findings revealed that chronotype had a significant impact on performance in language aptitude tests, with participants performing better at their preferred time. However, no direct effect of chronotype on word learning ability was observed. Thus, individuals' morning or evening preferences may affect their perform-

ance in language-related tasks without directly influencing word learning abilities.

On the other hand, Deli (2020) suggests a potential connection between an individual's circadian rhythm and their vocabulary learning habits. His findings indicate that larks exhibit better performance in vocabulary learning tasks during the morning, while owls demonstrate improved performance in the evening. These findings are significant for language teaching and learning, as well as the development of individualized learning strategies. However, it is important to acknowledge that this study was conducted on a small scale, highlighting the need for further research to fully comprehend the relationship between circadian rhythm and vocabulary learning.

The studies reviewed in this section shed light on the potential influence of an individual's chronotype on their language-related abilities. De Bot (2013) found that chronotype may impact language aptitude but not direct word learning ability. On the other hand, Deli (2020) suggested a connection between circadian rhythm and vocabulary learning, with morning-type individuals performing better in the morning and evening-type individuals excelling in the evening. These findings have implications for language teaching and learning strategies. However, more research is needed to fully comprehend the relationship between circadian rhythm and language abilities. Future studies should consider larger sample sizes, more advanced statistical analyses, and explore learning and testing at different times of day to delve deeper into this relationship. A better understanding of this relationship could lead to more effective and personalized approaches to language instruction and learning.

### **Individual learner characteristics**

The influence of individual learner characteristics on second language acquisition (SLA) has long been acknowledged (Dörnyei, 2005; Skehan, 1998). Learners' aptitudes, motivations, learning styles, and cognitive processing preferences differ, which may have an effect on the results of their

language acquisition (Dörnyei, 2005; Ehrman & Oxford, 1989; Gardner, 1985). Recognizing these variations has sparked the development of learner-centered methodologies that seek to adapt to learners' particular needs and enhance their capacity for language acquisition (Ellis, 1994; Nunan, 1999).

Chronotype, an individual's preferred sleep-wake rhythm affected by genetic, age-related, and environmental variables (Adan & Almirall, 1991; Roenneberg et al., 2003), is a significant component of individual learner differences. According to Roenneberg et al. (2003) and Swaminathan et al. (2017), chronotype refers to the time of day when people are at their most awake and productive, as well as when they naturally sleep and wake up. According to Adan and Almirall (1991), chronotypes may be divided into three primary categories: morningness, eveningness, and intermediate. These individual variations in chronotype affect a variety of everyday activities, cognitive functioning, and general performance (Adan and Almirall, 1991; Roenneberg et al., 2003; and Swaminathan et al., 2017).

### **Chronotype and cognitive functioning**

Attention, memory, executive functioning, and learning have all been shown to be influenced by chronotype (Codoñer-Franch et al., 2023; Goldstein et al., 2007; Schmidt et al., 2007). Morning people, often known as "morning larks," are more awake and have greater cognitive functioning in the morning, which is when they operate cognitively at their best (Codoñer-Franch et al., 2023; Schmidt et al., 2007). Those who are "night owls," or evening personalities, perform better cognitively at night and throughout the evening hours because they are more aware and capable of higher-level thinking during these times (Codoñer-Franch et al., 2023; Schmidt et al., 2007).

The effects of chronotype on cognitive function may have an influence on vocabulary development and other language learning procedures. Learning new words requires cognitive processing, memory encoding and retrieval, and attention (Nation, 2001). As a result, a person's preferred cognitive functioning times, which are governed by their

chronotype, may affect how well they learn and remember language. While “owls” may perform better in the evening, “larks” may show improved vocabulary learning skills in the morning.

To optimize language training and account for each student’s particular learning variations, knowledge of the link between chronotype and cognitive functioning is crucial. In order to strategically design and arrange language learning activities to coincide with learners’ best cognitive periods, educators must take into account learners’ chronotypes and the cognitive functioning patterns that correspond to them. This information may aid in the development of individualized, effective teaching strategies that optimize vocabulary learning outcomes.

## **Participants and methods**

### **Study design**

This study used a correlational design to examine the relationship between the predictor variable (chronotype) and the outcome variables (second language vocabulary acquisition). The selection of the correlational design was due to the rarity of studies in this aspect, which made it difficult to control all the variables. In fact, studying the relationship between variables through testing hypotheses imposes the analytical nature of this study. In other words, the study used inferential statistics to explain the relationship between variables. What is more, the study is non-interventional, i.e., observational. There was no manipulation of the predictor variable. The study’s observational nature was due to the researcher’s inability to control all the variables. As the data were collected and analyzed at a single point in time, the study is cross-sectional.

### **Selection of participants**

#### **Selection criteria and methods**

The study took place in El Jadida Kassita High School in Driouch Province, Morocco, between May 15 and June 20, 2023. The recruitment

process started on May 18, following the Vice-Ministry of Education in Midar's authorization to start the study. The subjects were selected based on various criteria. First, the participants needed to be in the senior year of high school. In the context of second language learning, senior high school students are exposed to a large body of vocabulary input. Another reason for including senior high school students is that their ages are almost the same, with a low standard deviation.

The sampling method used was probabilistic, specifically simple random sampling. First, a list frame of the student population was obtained from the Vice-Ministry of Education in Midar. Then, Microsoft Excel was used to generate random participants from the list frame using the function =RANDBETWEEN([1],[1000]). The sample size was determined before the study began. Using R Studio, the effect size (Cohen's *d*) was 0.5, the significance level (*alpha*) was 0.05, and the power was 0.8. The desired sample size for each two groups was 52.

Finally, recruitment was conducted with the help of the school administration, which asked teachers to explain the study to the students beforehand. The participants were officially recruited after informed consent forms were distributed and collected. Surprisingly, all students who were given an informed consent form agreed to participate. The author is grateful to the teachers who advised their students on the importance of this study and on how its findings will help second language learners achieve better learning outcomes.

### **Ethical considerations**

The students were not asked to provide their names for the sake of privacy and anonymity. Instead, each student was assigned a unique identifying number throughout the whole research process. Furthermore, students were given an informed consent form at the recruitment stage to indicate whether they agreed to participate.

## Data collection

### Variables and instruments

The predictor variable is chronotype, a person's biological inclination to be productive at certain phases of the day and not at others. This variable had two values: larks and owls. Data for this variable were collected through the Morningness-Eveningness Questionnaire (MEQ). The outcome variable is second language vocabulary acquisition (SLVA), measured on a scale from 1 to 6. SLVA data were collected through a vocabulary test.

### Data analysis

To determine the participants' chronotypes, the study used the MEQ, a 19-item multiple-choice questionnaire. Participants receive a score between 16 and 86; scores below 41 indicate an inclination toward eveningness, while scores of 59 and above indicate a preference for morningness. Scores between 42 and 58 indicate individuals who fall into the intermediate category.

Descriptive statistics such as median, mean, and standard deviation were obtained. This study also used an independent samples t-test to compare vocabulary acquisition between the two groups (larks and owls). In addition, the paired samples t-test was used to compare each group's language acquisition in the morning and in the evening. Pearson's correlation coefficient was used to examine the relationship between chronotype and other variables, such as age and gender. For inferential statistics, the alpha value was set to 0.05 and the confidence level at 95%. The use of parametric tests is due to the normality of the data. No data were missing.

## Results

The results were analyzed to assess the impact of a particular time of day on the effectiveness of vocabulary learning for both morning type (MT) and evening type (ET) learners. An independent samples t-test com-

pared the two groups (MT & ET), while a paired samples t-test compared the outcomes for each group between the morning and evening. Statistical analyses were conducted using SPSS software.

### Descriptive statistics

Table 1 provides a comprehensive overview of the statistical results. The table presents the mean, median, and mode for each group at different times of the day. The standard deviation for each group is also included.

**Table 1. Overall morning and evening results**

	MT: MSLVA	MT: ESLVA	ET: MSLVA	ET: ESLVA
<b>N Valid</b>	52	52	50	50
<b>Missing</b>	0	0	0	0
<b>Mean</b>	5.33	3.96	3.76	5.04
<b>Median</b>	5	4	4	5.5
<b>Mode</b>	6	4	3	6
<b>Std. Deviation</b>	0.76	1.05	0.98	1.21

According to Table 1, MT learners' morning results were higher than those of ET learners: the mean MT morning result was 5.33, while the mean ET morning result was 3.76. On the other hand, the evening results of the ET learners were higher than those of the MT learners: the mean ET evening result was 5.04, while the mean MT evening result was 3.96. Tables 2, 3, 4, and 5 illustrate the vocabulary outcomes of different chronotypes at different times of the day.

**Table 2. Results of MT learners in the morning**

		Frequency	Percent	Valid Percent	Cumulative percent
<b>Valid</b>	3	1	1.9	1.9	1.9
	4	6	11.5	11.5	13.5
	5	20	38.5	38.5	51.9
	6	25	48.1	48.1	100
<b>Total</b>		52	100	100	

Table 2 shows that 25 MT learners acquired six words in the morning, while 20 acquired five. Only one MT learner acquired three words in the morning.

**Table 3. Results of ET learners in the morning**

		Frequency	Percent	Valid Percent	Cumulative percent
Valid	2	3	6	6	6
	3	20	40	40	46
	4	15	30	30	76
	5	10	20	20	96
	6	2	4	4	100
Total		50	100	100	

Table 3 shows that 20 ET learners acquired three words in the morning, while 15 acquired four. Only two ET learners acquired six words in the morning.

**Table 4. Results of ET learners in the evening**

		Frequency	Percent	Valid Percent	Cumulative percent
Valid	2	3	6	6	6
	3	3	6	6	12
	4	8	16	16	28
	5	11	22	22	50
	6	25	50	50	100
Total		50	100	100	

Table 4 shows that 25 ET learners acquired six words in the evening, while 11 acquired four. Only three ET learners acquired two words in the evening.

**Table 5. Results of MT learners in the evening**

		Frequency	Percent	Valid Percent	Cumulative percent
Valid	2	3	5.8	5.8	5.8
	3	16	30.8	30.8	36.5
	4	17	32.7	32.7	69.2
	5	12	23.1	23.1	92.3
	6	4	7.7	7.7	100
Total		52	100	100	

Table 5 shows that 12 MT learners acquired five words in the evening, while 17 acquired four words. Only four MT learners acquired six words in the evening.

### Inferential statistics

A paired samples t-test compared morning and evening types based on the paired differences in MSLVA and ESLVA. MT learners showed a mean difference of 1.365 (SD = 1.138, SE = 0.158), with a 95% confidence interval between 1.049 and 1.682. ET learners had a mean difference of -1.280 (SD = 1.715, SE = 0.243), with a 95% confidence interval between -1.767 and -0.793. Both differences were statistically significant ( $p < 0.001$ ) based on the t-test with degrees of freedom (df) of 51 and 49, respectively.

An independent samples t-test was conducted to compare the means of the two groups. The t-test yielded a significant difference ( $p < 0.001$ ), with a mean difference of 1.567 (SE = 0.173) and a 95% confidence interval ranging from 1.223 to 1.911.

A correlation test was carried out to discover if there was any correlation between the variables. Gender correlates with chronotype, with a correlation coefficient of 0.159. This correlation is positive but relatively weak. Age correlates with chronotype, with a correlation coefficient of 0.038. This correlation is positive but very weak. ESLVA correlates with chronotype, with a correlation coefficient of 0.434. This correlation is positive and moderate in strength. MSLVA correlates with chronotype, with a correlation coefficient of -0.671. This correlation is negative and relatively strong.

## Discussion

The results show a link between chronotype and vocabulary learning, with substantial differences in vocabulary acquisition across the two groups at different times of day. This is contrary to earlier research by De Bot (2013) and De Bot and Fang (2017), which did not discover statistically significant differences between the groups. However, the results do agree with Deli (2020), who found a substantial correlation between chronotype and vocabulary acquisition.

The results indicated that ET learners fared better in the evening, whereas MT learners did better on vocabulary-related activities in the morning. This demonstrates a favorable association between learners' chronotype and their success in learning and remembering language, which is consistent with the first study question and hypothesis. When it came to vocabulary acquisition, MT students performed better in the morning than ET students did in the evening. The association between chronotype (an independent variable) and second language vocabulary acquisition (a dependent variable) was further supported by the paired samples t-test and independent samples t-test. The second hypothesis, that MT learners acquire and retain vocabulary more efficiently, is supported by the data, which also showed that MT learners' vocabulary acquisition was superior to that of ET learners.

It is crucial to recognize that there may be a number of explanations for the discrepancies between the results of the present research and those of De Bot (2013) and De Bot and Fang (2017), including variations in sample characteristics, assessment methods, or educational environments. The motivation, aptitude, and learning techniques of each individual learner affect the multidimensional process of language acquisition. These elements may interact with chronotype to influence the results of language learning. The complex interactions between these variables and their overall impact on acquiring vocabulary in a second language call for further investigation.

The results of this study emphasize the practical value of language learning. Educators may maximize the results of vocabulary acquisition

by considering their students' chronotypes and coordinating instruction with their biological cycles. It may be more effective to adapt teaching methods to each learner's preferred alertness and productivity windows. Language instructors may also use these data to customize their lessons and improve the efficacy of their education.

This research adds to our understanding of the relationship between chronotype and the learning of vocabulary in a second language. The findings show that a student's chronotype affects how well they acquire and remember language, with MT students showing greater results in the morning and ET students showing improved performance in the evening. These results show the possibility for customized techniques to maximize vocabulary acquisition and emphasize the need to take individual learner variations, such as chronotype, into account when planning language education. Further study is required to better understand the intricate interactions among the factors affecting language learning outcomes and to develop comprehensive instructional techniques.

### **Conclusion**

The purpose of this research was to look at how chronotype relates to learning vocabulary in a second language. By addressing a gap in the literature about the influence of chronotype on language learning outcomes, the results add to the current body of knowledge. The study investigated timing effects on vocabulary training, performance variations between larks and owls, and the statistical link between chronotype and second language vocabulary learning.

This research has also shown that time is very important in vocabulary learning. When taught in the morning, morning learners performed better, whereas evening learners performed better when taught in the evening. These results highlight the importance of considering individual chronotypes when language instructors create instructional techniques and enhance language learning outcomes.

The findings lend credence to the idea that, in order to adapt to learners' specific needs and maximize their potential, individual variables should be taken into consideration. Teachers may better meet their students' requirements and preferences by adapting their lesson plans to incorporate knowledge of chronotypes, thereby helping students acquire more terminology.

It is important to highlight that earlier research in this area has produced inconsistent results. However, this study adds to the growing body of research that indicates a strong connection between chronotype and the learning of vocabulary in a second language. By using sound research techniques and statistical analysis, this work offers important insights into the role of chronotype in language acquisition.

In summary, the present findings support the hypothesis that second language vocabulary acquisition and chronotype are related. Learning vocabulary is more advantageous for morning learners, especially in the morning, whereas evening learners do best at night. It is advised that further research be conducted in this area to examine other variables and discover how chronotype affects other facets of language acquisition.

### **Implications and recommendations**

The results of this research have a number of significant ramifications for SLA theory and practice. First, the established link between chronotype and second language vocabulary acquisition emphasizes the need to consider individual variations when developing language learning curricula. The effectiveness and personalization of techniques may be improved by considering the learners' chronotypes, eventually improving language acquisition results.

While earlier studies recognized the importance of factors such as ability, motivation, and learning techniques on language learning results, the significance of chronotype has generally been disregarded. This study contributes to the growing body of data demonstrating the significance of individual chronotype as a variable in SLA research and instruction.

These results have practical ramifications for educators and language instructors. Education professionals may tailor their teaching strategies to students' peak hours of attentiveness and productivity by identifying and adapting to their chronotypes. For instance, early morning learners (larks) may benefit from vocabulary education, although late evening learners (owls) may do better. This specialized kind of training has the potential to improve students' motivation, engagement, and overall experience learning a language. Teachers should also strategically organize and schedule language-related activities and evaluations by knowing how chronotype affects vocabulary learning. By leveraging learners' cognitive resources and maximizing their vocabulary learning potential, judgments can be made about the sequencing and distribution of exercises throughout the day.

The results also have significance for the creation and development of tools and programs for technology-assisted language learning (TALL). TALL platforms can accommodate learners' chronotypes, offering vocabulary training materials and activities at the most suitable times depending on personal preferences. TALL systems can also provide customized and adaptive language learning experiences that suit learners' individual traits and enhance their vocabulary acquisition results by using technical developments and incorporating information about chronotypes.

It is important to note that the current research focused specifically on the relationship between chronotype and the acquisition of vocabulary in second languages. The consequences, however, go beyond acquiring vocabulary and may be applied to other facets of language learning, including grammar, phonetics, and pragmatics. Future research should examine how chronotype affects such linguistic elements to obtain a more thorough understanding of its significance in SLA.

Finally, the results have important ramifications for SLA theory and practice. Educators can achieve both the implementation of focused instructional techniques and the optimization of language learning outcomes by identifying the link between chronotype and the acquisition of second language vocabulary. This research adds to the body of knowledge about individual variations in SLA, highlighting the significance

of considering learners' chronotypes in language education and in the creation of individualized learning strategies. This study paves the way for future research on chronotype's impact on numerous facets of language learning, as well as the use of chronotype-aware technology in classroom settings.

## **Declarations**

### **Ethical Approval**

This study was approved by the Vice-Ministry of Education in Driouch Province, Morocco. An official document was provided to allow this study to take place in El Jadida Kassita High School. Students were also provided with informed consent forms, allowing them to choose whether to participate in the study. Students accepted that the results of this study would be published in a scholarly work.

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**Conflict of interest:** The author declares that there is no conflict of interest.

**Availability of data and materials:** Data, including raw data, questionnaires, pre-test data, and post-test data, will be available online.

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