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The Effect of Sleep Deprivation on Musical Auditory Performance

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Abstract

Sleep deprivation causes cognitive problems such as difficulty in establishing a cause-effect relationship, decreased problem-solving abilities, loss of concentration and attention. This study aims to determine the effect of sleep deprivation on interval, chord, rhythmic, melodic dictation skills and perception in students with Musical Hearing Reading and Writing (MHRW) activity, which has a high relationship with learning and memory. The experimental research was conducted with 18 students (14 men and 4 women) who volunteered to participate (Age: 22±2.1, Mean Body Mass Index: 24,6 ± 2.3). To determine the levels of effect of sleeplessness in the study group, the present experimental study made use of the pre-test – post-test model. Although the participants' pretest and post-test success levels were not statistically significant in intervals and chords (p> .05), a statistically significant decrease was found in rhythmic dictation and melodic dictation writing success levels (p < .05). These findings clearly show that sleep deprivation which negatively affected musical learning and memory consolidation significantly decreases the achievement levels of students in MHRW.

Keywords: *Sleep Physiology, Memory, Musical Hearing, Learning*

Öz

Uyku yoksunluğu neden-sonuç ilişkisi kurmada güçlük, problem çözme yeteneğinde azalma, konsantrasyon ve dikkat kaybı gibi bilişsel sorunlara neden olur. Bu çalışma, öğrenme ve hafıza ile yüksek ilişkisi olan Müzikal İşitme Okuma Yazma (MİOY) etkinliği ile öğrencilerde uykusuzluğun aralık, akor, ritmik, melodik dikte becerileri ve algı üzerindeki etkisini belirlemeyi amaçlamaktadır. Deneysel araştırma, katılmaya gönüllü olan 18 öğrenci (14 erkek ve 4 kadın) ile yürütülmüştür (Yaş: 22±2.1, Ortalama Vücut Kitle İndeksi: 24,6 ± 2.3). Çalışma grubundaki uykusuzluğun etki düzeylerini belirlemek için bu deneysel çalışmada ön test – son test modeli kullanılmıştır. Katılımcıların aralık ve akorlarda ön test ve son test başarı düzeyleri istatistiksel olarak anlamlı bulunmamakla birlikte (p> .05), ritmik dikte ve melodik dikte yazma başarı düzeylerinde istatistiksel olarak anlamlı bir düşüş bulunmuştur (p < .05). Bu bulgular, müziksel öğrenmeyi ve hafıza güçlendirmeyi olumsuz etkileyen uyku yoksunluğunun, öğrencilerin MHRW'deki başarı düzeylerini önemli ölçüde azalttığını açıkça göstermektedir.

Anahtar Kelimeler: *Uyku Fizyolojisi, Hafıza, Müziksel İşitme, Öğrenme*

Introduction

Sleep is a physiological and behavioral process that an individual requires to carry out their daily functions. The process of sleeping during which reflex responses decrease but brain functions actively is a vital brain activity in which body tissues are restored and memory is reinforced and protected and which plays a significant role in creative thinking and actions as well as learning. This physiological need, which should be met every night, is either postponed or underestimated by modern life-style humans (Kayabekir, 2019; 2020). Individuals with sleep deprivation more often report such cognitive issues as loss of attention, decrease in concentration and problem-solving abilities and difficulty in establishing cause and effect relationships (Zammit et al., 1999; Van Dort, 2016). A healthy young adult starts sleeping with NREM sleep and moves from NREM sleep to REM sleep and vice versa in 90-minute intervals. Body tissues and brain tissues are restored during NREM (Non-Rapid Eye Movement) sleep (calm, synchronized sleep, deep wave sleep) and REM (Rapid Eye Movement) sleep (moving, desynchronized, paradoxical sleep), respectively. On the other hand, motor integration takes place during REM sleep, and sensory network integration takes place during NREM sleep (Kayabekir, 2019; Jones, 2005; Stickgold, 2001; Rechtschaffen et al., 1989). It has been shown that while REM deprivation alone instead causes problems about the quality of life and learning, total sleep deprivation causes more effective physical and cognitive problems (Divac et al., 1987; Mc Namara & Bulkeley, 2015).

Cognitive functions of the brains, namely learning and memory (attention, concentration, and problem-solving abilities) are the essential duties of the brain cortex. The first encounter with a language in the brain is through hearing followed by the visual language via reading and the visual information conveyed with written words. Memory is defined as the ability to encode, store, memorize and recall information. The psychological processes in the memory consist of registration, short-term memory, rehearsal of memory, long-term memory, and recall (Fraize et al., 2016; Kryger at al., 2011; Turner at al., 2007). A significant amount of human sensory experiences is turned into their equivalents in one's language before they are stored in the memory areas in the brain and before being processed for other mental purposes. For example, when someone reads a book, words themselves or their meanings and associations are stored in their memory instead of visual images created by words. Wernicke's Area is the area which analyzes and interprets languages in the dominant hemisphere of the brain, and this area is in a close relationship with the auditory region of the temporal lobe. The reason for this close relationship is probably that the first encounter with a language is through hearing (Guyton & Hall, 2016; Stickgold &Walker, 2013, Mc Namara& Bulkeley, 2015). Memory processes that are involved in capturing and retaining acoustic information aggregate one's experience with spoken language into functional acoustic-phonetic units, speech sounds such as /d/ or /a/ (Sayako et al.; Joanisse et al.).

The first encounter of an individual with music is also through hearing. The individuals hear music actually starts to store the melodic and rhythmic images, that is, the meanings in the musical language and the thoughts provoked by them, in the memory area of the brain (Gracyk, 2007; Davidova, 2012). Musical Hearing Reading Writing (MHRW) can be deemed as the most crucial lesson in studying music, especially in establishing the connection between sounds and music and between sounds and images and in comprehending music. When the contents of MHRW classes are examined, it can be seen that their topics are pervasive (sound formation and perception and its fundamental characteristics, intervals, chords, tempos, meters, scales, modes, solfege, rhythmic dictation, melodic dictation, etc.) and their aim is to teach a vast number of theoretical and applied basic knowledge and abilities. It is also stated that the student's level of knowledge and dictation skills are the primary indicators of their ability to link sounds and symbols. (Özgür & Aydoğan, 2006; Şengül, 2006; Hacıev, 2007).

The development of cognitive processes in a musical activity has a special role for broadening

musical experience: perceptions of musical hearing are created and musical perception develops only by listening to music and participating in various musical activities (Davidova, 2012). A student who aims to acquire the ability to write intervals is first required to know sounds theoretically and to discern the intervals performed in various frets nominally. In other words, students are required to identify intervals with different hearings from each other. The teaching method used in interval studies is also used in chord studies. The only difference is that students are required to identify three notes. Rhythmic dictation is very different from both interval and chord writing abilities. A student who aims to acquire the ability to write rhythms first needs to learn the time values of notes and rests and their beats. Afterward, they are taught metric clefs. A student who aims to acquire the ability to write melodic dictation is required to write a melody's tone, metric clef, and rhythms as well as the notes, which make up the melody on the staff. The development of cognitive processes in a musical activity has a special role for broadening musical experience. Musical notions and perception are a process which tries to establish links between sounds of music (Karahan, 2016; Gracyk, 2007; Sağer et al., 2013; Ece & Kaplan, 2008).

As can be seen, MHRW courses cover very important topics related to professional music education. However, Karahan (2016:922) emphasizes that the main objectives of MHRW courses are to gain the knowledge and skills of being able to write the names and notes of intervals and chords, as well as to write the rhythmic dictation in various scales and melodic dictation in various tones and modes and to read solfege. These basic knowledge and skills, which are aimed to be gained in MHRW courses in all programs of professional music education (Department of Music Education, Conservatory, etc.), also affect the success levels of students in other courses. Ece and Kaplan (2008:294) found a positive, low-level significant relationship between the success levels of students in Musical Hearing, Instrument and Voice Courses. Sağer, Gürpınar and Zahal (2013: 313) also concluded that students' achievements in the MHRW course positively affected their achievement in other field courses in the first, second and third grades. For this reason, the success levels of students in MHRW courses affect their success both in the education-training process and in their professional lives.

When the related literature was reviewed, although many studies were conducted on MHRW lessons, no study was found in which the effects of sleep deprivation on the success levels of interval, chord, rhythmic and melodic dictation writing were examined. MRHW education during which various theoretical and applied knowledge and abilities offers an opportunity for researchers to understand the cortical functions. Knowing that sleep, especially REM sleep, has an important effect on memory, attention, hearing and thought creation motivated us to examine the impact of sleeplessness on musical hearing. The study aims to determine how much sleep deprivation affects students' skills and perception to write intervals, chords, rhythmic dictation and melodic dictation by comparing with the cognitive functions.

Problem Statement

Does sleep deprivation affect students' success levels in the MHRW examination?

Sub-Problems

1. Does sleep deprivation affect students' success levels in writing intervals?
2. Does sleep deprivation affect students' success levels in writing chords?
3. Does sleep deprivation affect students' success levels in writing rhythmic dictation?
4. Does sleep deprivation affect students' success levels in writing melodic dictation?

Materials and Methods

Participants

The study group consisted of second-year students in Music Teaching Undergraduate Program at Harran University in which the researcher himself works. The experimental research was conducted with 18 students (14 men and 4 women) who volunteered to participate (Age: 22±2.1, Mean Body Mass Index: 24,6 ± 2.3). To determine the

levels of effect of sleeplessness in the study group, the present experimental study made use of the pre-test – post-test model.

Experimental Design and Procedure

The study group was given a test, which consisted of questions about intervals, chords, rhythmic dictation and melodic dictation as the pre-test at 10:00 a.m. Afterward, the study group whose participants didn't sleep for 24 hours was given the post-test at 10:00 a.m. the day after. Thus, the study group was given the post-test 24 hours after the pre-test without any sleep and how much sleep deprivation affected the students' success levels was determined by examining the difference between the pre-test and post-test scores. The students were given equal opportunities to meet their physiological needs during the sleepless-24-hours in the experimental study (Why 24 hours? In this study, a -total -sleep deprivation was targeted. In this way, the restoration activities of both NREM and REM periods in the brain during sleep were experimentally prevented).

Inclusion criteria of participants: (a) Not having a systemic disease (individuals have undergone basic health checks by a medical doctor). (b) Not having sleep disorders (Sleep diaries reviewed by a physician working in the field of sleep disorders). (c) Not using drugs and other drugs that affect the Central Nervous System.

Precautions: Subjects rested overnight. Blood pressure was followed by heart rate measurements.

Pre-test-Post-test Exam Questions

In the selection of the pre-test and post-test questions, the success level of writing interval, chord, rhythmic and melodic dictation, which are the most basic knowledge and skills of MRHW lessons, were included in the scope of the research. In addition, 4 sub-problems were formed based on these basic topics. In determining the difficulty levels and numbers of the questions, the questions of interval, chord, 8-measure rhythmic dictation and melodic dictation, which are taught in MRHW courses, were created based on expert opinions.

The study group was given a total of 10 questions about intervals, ten questions about chords, eight questions about rhythmic dictation and eight questions about melodic dictation in the pretest. To decrease the possibility of students' remembering the questions given in the pretest, the order of the questions about intervals and chords asked in the pretest was switched and the same questions were given to the students as the posttest. The meters in the questions about rhythmic dictation asked in the pretest were changed using the same method and the same questions were given in the posttest. As for melodic dictation in the posttest, another melody was created using the same metric clef and tonal and rhythmic structures used in the questions about melodic dictation asked in the pretest. Moreover, expert opinions were obtained regarding the equality of the levels of the melodies asked in the pretest, and the posttest. Below is given some examples about the questions about intervals, chords, rhythmic dictation and melodic dictation asked in the pretest and the posttest (Figure 1,2,3,4).

The example questions about intervals and chords given in Figures 1 and 2 were played with the piano twice. For each question about intervals and chords, first, a la note was given, and then, students were asked to write the notes forming the intervals and chords on the staff.

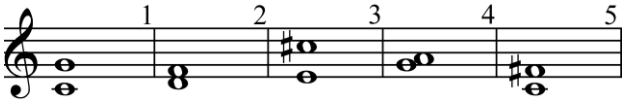

Figure 1. *Interval Questions*

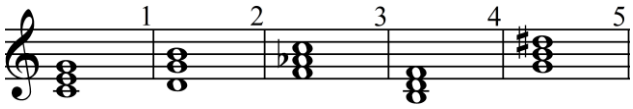

Figure 2. *Chord Questions*

The students were asked 1 rhythmic dictation which consisted of 8 meters. Rhythmic dictation was started with playing 1. and 2. meters and 1. and 2. meters were performed again after 30 seconds. 3. and 4. meters were played after 30 seconds, and the same procedure was used for the rest of the meters. In other words, the question about rhythmic dictation which consisted of 8 meters was applied with this method.

The students were asked one melodic dictation which consisted of 8 meters. The students were first given a la note. After providing the starting note of the melody, melodic dictation was started with playing 1. and 2. meters and 1. and 2. meters were played again after 30 seconds. 1., 2., 3. and 4. meters were played after 30 seconds, and 3. and 4. meters were played again after 30 seconds. The question about melodic dictation was applied which consisted of 8 meters with playing the rest of the meters using the same method.

The example meters about the questions about rhythmic dictation and melodic dictation are given in Figures 3 and 4.

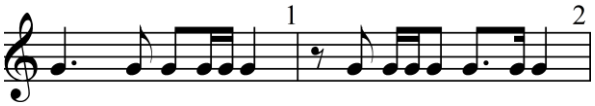

Figure 3: Rhythmic Dictation Question

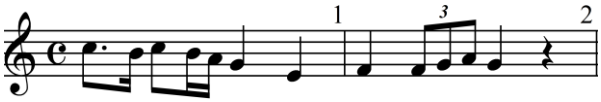

Figure 4: Melodic Dictation Question

Analysis

The research data were gathered with literature review and in the experimental environment created. Shapiro-Wilk test was used for the test of normality and the coefficients of skewness and kurtosis for the data gathered. The results showed that there were deviations from normality in only two dependent variables and their levels were acceptable. That's why it was decided to use parametric tests. The students' success levels in the experimental environment were determined with the pre-test and the post-test exams. The data gathered were analyzed with SPSS 24 and interpreted with paired samples t-test according to $p < .05$. The scoring table which was used to evaluate the hearing abilities of the study group is given in table 1.

Table 1. *Scoring Table*

Questions	Number of Questions	Points per Question	Total Points
Interval questions	10	1,5 points	15 points
Chord questions	10	1,5 points	15 points
Rhythmic Dictation	8	3,75 points	30 points
Melodic Dictation	8	5 points	40 points
Grand Total			100 points

The study group was evaluated according to the correct answers given to the questions about intervals, chords, rhythmic dictation and melodic dictation. It was decided in the evaluation that each interval question was 1.5 points, each chord question was 1.5 points, each meter of rhythmic dictation was 3.75 points and each meter of melodic dictation was 5 points.

Findings

The results related to the 4 sub-problems as part of the study are presented in a total of 5 tables.

Table 2. *Coefficients of Skewness and Kurtosis for Points and Results of Significance Level for Shapiro-Wilkinson Test*

				Shapiro Wilkinson (S-W)
	N	Skewness	Kurtosis	P
Interval Pretest Score	18	.32	-1.20	.15
Chord Pretest Score	18	-.14	-1.10	.44
Rhythm Pretest Score	18	.24	-1.36	.06
Melody Pretest Score	18	.25	-1.35	.06
Total Pretest Score	18	.24	-.77	.36
Interval Posttest Score	18	.41	-1.25	.10
Chord Posttest Score	18	-.84	.37	.10
Rhythm Posttest Score	18	.81	-.80	.00*
Melody Posttest Score	18	1.16	-.10	.00*
Total Posttest Score	18	.99	-.29	.01
Grand Total Score	18	.74	-.57	.07

When table 2 is examined, it can be observed that the scores the study group obtained in the pre-test and the post-test are normally distributed except for the score variables of Rhythm and Melody in

the post-test. The coefficients of skewness and kurtosis for these two score variables which present deviations from normality can be deemed as acceptable when 95% (acceptability -1.96 - +1.96) safe interval calculation is taken into consideration.

Table 3. *Results of Paired Samples t-Test for Interval Success Scores in Pre-test and Post-test*

Score	Groups	N	$\bar{x}$	ss	$Sh_{\bar{x}}$	t Test t	Sd	p
Interval	Pre-test	18	7.00	5.07	1.19	.94	17	.36
	Post-test	18	6.42	4.96	1.17			

When table 3 is examined, it can be seen that there is not a significant difference in paired sample T-test for interval score variable after sleeplessness. However, as can be observed in their average scores, when the average scores in the post-test are taken into consideration, there is an 8.3% decrease.

Table 4. *Results of Paired Samples t-Test for Chord Success Scores in Pre-test and Post-test*

Score	**Groups**	N	$\bar{x}$	ss	$Sh_{\bar{x}}$	t **Test** t	Sd	p
Chord	Pre-test	18	10.20	3.21	.76	1.29	17	.22
	Post-test	18	9.33	3.77	.89			

As the result of the analysis done in table 4, it is determined that there is not a significant difference in chord scores as in interval scores. However, as can be observed in their average scores, when the average scores in the posttest are taken into consideration, there is an 8.5% decrease.

Table 5. *Results of Paired Samples t-Test for Rhythmic Dictation Scores in Pretest and Posttest*

Score	**Groups**	N	$\bar{x}$	ss	$Sh_{\bar{x}}$	t **Test** t	Sd	p
Rhythm	Pre-test	18	13.33	10.78	2.54	3.96	17	**.00***
	Post-test	18	8.75	10.61	2.50			

In the analysis of the paired sample T-test for the rhythm scores which were the third score variable in the study in table 5, it can be seen that there is a significant difference (p=.00) between the pretest and the posttest scores.

Table 6. *Results of Paired Samples t-Test for Melodic Dictation Scores in Pretest and Posttest*

Score	**Groups**	N	$\bar{x}$	ss	$Sh_{\bar{x}}$	t **Test** t	Sd	p
Melodic Dictation	Pre-test	18	18.89	14.20	3.35	4.12	17	**.00***
	Post-test	18	10.76	14.74	3.47			

It can be seen that there is a significant decrease in the posttest scores in the analysis done for the melody variable in table 6.

Table *7. Results of Paired Samples t-Test for MHRW Total Success Scores in Pre-test and Post-test*

Score	**Groups**	N	$\bar{x}$	ss	$Sh_{\bar{x}}$	t **Test** t	Sd	p
Total	Pretest	18	49.42	23.62	5.57	5.69	17	**.00***
	Posttest	18	35.26	25.86	6.10			

In the analysis of MHRW total scores, there is an important deviation from significance (p=.00).

Discussion and Results

The study examined whether and how much sleep deprivation affects volunteer participants' interval, chord, rhythmic dictation and melodic dictation writing skills. As a result, when the total pretest and posttest success scores were examined, it was found that the success levels of the volunteer participants decreased significantly due to sleep deprivation.

As a result of the research, it was determined that there was no significant difference between the pre-test and post-test success levels of the students in interval writing, but there was a decrease of 8.3%, there was no significant difference between the pre-test and post-test success levels in chord writing, but there was a decrease of 8.5%, and there was a significant

difference between the pre-test and post-test success levels in rhythmic and melodic dictation writing, and also there was a significant difference between the pre-test and post-test success levels of the students in general. The results related to the problem and sub-problems of the research are discussed and presented below.

Does sleep deprivation affect students' success levels in writing interval?

Does sleep deprivation affect students' success levels in writing chords?

While the musical hearing is an important learning process, the brain should perform memory functions in order for learning to occur. Sensory memory as the first impression of a stimulant indicates consciousness. Storaged information either is treated as short-term memory or disappears rapidly (Kryger, vd., 2011; Kerstin, Dominik, Heib, Philippe, 2014). The students who volunteered for the study were asked to identify the interval which they had theoretically learned nominally when they were performed in various frets. However, the sensory memory which enables the first identification of a stimulant couldn't continue its function. Because the REM and NREM phases of sleep are especially essential factors in recalling the sensory memory, the volunteer participants who were deprived of REM-NREM sleep for 24 hours had difficulty in identifying sounds in the questions about interval and chords and their success levels decreased.

Does sleep deprivation affect students' success levels in writing rhythmic dictation?

Short-term or working memory is limited in its capacity. It stores information in several fragments and transforms it into direct behavior cooperating with the cognitive system. If these components of the memory fail to work appropriately, new information disappears immediately, and the memory capacity decreases. In other words, this memory provides information for immediate use and helps the repetitive cognitive processes or the rehearsal memory continue copying. When there is a problem in rehearsal, the learning activity decreases and new information starts to disappear (Kryger, Roth, Dement, 2011; Kerstin, Dominik, vd., 2014). The volunteer students who had rehearsed MHRW, who were known not to have experienced problems in sleep duration and quality up to that point in the study were asked questions about rhythmic dictation. The volunteers who were known to have learned about the time values and beats of notes and rests theoretically experienced a significant decrease in their success levels due to sleeplessness in this type of question which engages mental functions along with the short-term and long-term memories. The volunteers who couldn't remember the time values and beats of notes and rests had problems about consolidation of short and long-term memories. Moreover, the volunteers who experienced lack of attention and concentration while following the sensory and auditory stimulants were especially under the influence of REM deprivation.

Does sleep deprivation affect students' success levels in writing melodic dictation?

Long-term memory covers consolidation process or organizing information based on its meaning. Neurophysiological defects stemming from the loss of the ability to store data for a long-time result in inefficiency in the functions to learn, maintain or apply. Retrieval covers recalling information. If there is a defect in this function, spontaneous recalling will be lost (Turner, Drummond, Salamat, Brown, 2007; Kerstin, Dominik, Heib, Philippe, 2014). The statistically most significant failure in the current study due to sleeplessness took place in melodic dictation following rhythmic dictation. It is safe to say that this failure stemmed from the adverse effects of sleeplessness on music mental abilities which require follow-up and comparative mental performances, because musical phrasing and writing it down require procedural memory abilities. Similarly, it is possible to say that the significant difference in rhythm score was due to this reason as well.

The volunteer students were required to keep the sounds to form both the rhythms and the melody in their memory and to transform all this information into notes during melodic dictation writing. The current study attempted to involve not only the long-term memory and the consolidation of the brain but also the short-term memory, the ability to control and maintain attention and the mental focus against distracting factors. When the positive relationship between the long-term memory and memory consolidation

and REM sleep is taken into consideration, the volunteer students' success levels in melodic dictation writing decreased significantly especially due to REM deprivation.

Sleeping as a function of the brain has positive effects on long-term and short-term memories which are very important for learning. Postponing or losing this function effects listening, understanding and learning negatively and decreases the success of the lesson. The deep refreshing sleep called NREM greatly contributes to the declarative memory, and the brain waves which belong to the paradoxical sleep called REM contribute especially to the memory consolidation and the long-term memory (Kerstin, Dominik, Heib, Philippe, 2016).

In general, our study closely examined the cognitive functioning of individuals learning music through sleep deprivation and musical hearing model. Studies on music and sleep are limited in the literature. Our study has realized an original idea experimentally in this field. We accept the limited aspects of our study, for example, the number of samples and students being aware of the relationship between sleep deprivation and mental performance. Future studies will need to confirm the directionality of these findings and will need to examine physiological measures of sleep in larger sample sizes. Our experimental design allows to make a statement about the relationship between sleep deprivation and musical hearing skills. However, it does not allow to reach definitive conclusions about cognitive processing. In our future studies, we want to use polysomnography and multiple sleep latency tests (Kayabekir, 2019) including sleep EEG and reveal more electrophysiological findings.

In conclusion, it should be kept in mind that the cognitive activities needed during the MHRW training process have a strong connection with sleep duration and quality.

References

Davidova J. & Sersnova O. (2012). The Development of Coordination between Musical Hearing and Vocal Apparatus of 6–8-Year-Old Children during the Process of Singing. *Procedia - Social and Behavioral Sciences*, 45, 134 – 146.

Divac, I., Pettigrew, J.D., Hoist, M.C., McKenzie, J.S. (1987). Efferent connections of the prefrontal cortex of echidna (Tachyglossus acculeatus). *Brain Behav. Evol*., 30, 321-327.

Ece, S. Kaplan, S. (2008). Müziksel Algılama (Işitme, Okuma, Yazma) Ses Ve Çalgı Yeteneği Arasındaki İlişkilerin Farklı Değişkenler Açısından İncelenmesi. *Kastamonu Eğitim Dergisi* 16(1), 285-296.

Fraize, N., Carponcy, J., Joseph, M.A. (2016). et al. Levels of Interference in Long and Short-Term Memory Differentially Modulate Non-REM and REM Sleep. *Sleep*, 39(12), 2173-2188.

Gracyk, T. (2007). Listening to popular music, or How I learned to stop worrying and love Led Zeppelin. Michigan: University of Michigan Press.

Guyton, A.C., Hall, J.E. (2016). "Cerebral Cortex, Intellectual Functions of the Brain, Learning and Memory" Textbook of Medical Physiology, Thirteenth Edition Saunders Elsevier; Chapter, 59, 739-43.

Hacıev, P. (2007). Temel Müzik Teorisi. Pan yayıncılık. "Çeviri: Ahter Destan"

Joanisse, M.F., Manis F.R., Keating P., Seidenberg M.S. (2000). Language deficits in dyslexic children: Speech perception, phonology, and morphology. *Journal of experimental child psychology*. 77(1), 30–60.

Jones, B.E. (2005). "Basic Mechanisms of Sleep-Wake States" Kryger MH, Roth T, Dement WC Principles and practice of sleep medicine" 4th ed. Elsevier Saunders Philadelphia. 136-153.

Karahan, A. S. (2016). Müzik Öğretmenliği Programı Öğrencilerinin Müziksel İşitme Okuma Yazma Ders Dışı Çalışma Süreçlerinde Çoktan Seçmeli Testlerin Asenkron Uzaktan Eğitim Yöntemiyle Uygulanması ve Yöntemin Öğrencilerin Başarı Düzeylerine Etkisinin Belirlenmesi. *Akademik Bakış*: *13*, 920-934. ISSN: 1694-528X

Kayabekir, M. (2019). Sleep Physiology and Polysomnogram, Physiopathology and Symptomatology in Sleep Medicine. In: Fabian H. Rossi, (Ed.), *Updates in Sleep Neurology and Obstructive Sleep Apnea*. First ed. London Bridge Street: Intechopen, Press., 1-23. DOI. 10.5772/intechopen.82754.

Kayabekir, M. (2020). Diagnosis. In: Fabian H. Rossi, (Ed.), *Updates in Sleep Neurology and Obstructive Sleep Apnea.* First ed. London Bridge Street: Intechopen, Press., 1-13. DOI. 10.5772/intechopen.91368

Kerstin, H., Dominik, P.J., Heib, J.R., Philippe, P. (2014). et al. Slow Sleep Spindle Activity, Declarative Memory, and General Cognitive Abilities in Children. *Sleep*, 37(9), 1501-1512.

Kryger, M.H., Roth, T., Dement, W.C. (2011). "Memory Processing in Relation to Sleep" In: Kryger M. H., Roth T., William C. D., (Eds.), *Principles and Practice of Sleep Medicine*. 5th ed. Elsevier Saunders. Press.; 335-344.

Mc Namara, P., Bulkeley, K. (2015). Dreams as a source of supernatural agent concepts. *Front Psychol*, 19, 6, 283.

Özgür, Ü., Aydoğan, S. (2006). Müziksel İşitme Okuma Eğitimi ve Kuramı I. Sözkesen matbaası.

Rechtschaffen, A., Bergman, B.M., Everson, C.A., Kushida, C.A., Gilliland, M.A. (1989). Sleep deprivation in the rat. *Sleep*, 12, 68-87.

Sağer, T. Gürpınar, E. Zahal, O. (2013). Müziksel İşitme-Okuma-Yazma Dersi ile Diğer Alan Dersleri Arasindaki İlişkilerin Karşılaştırmalı Olarak İncelenmesi.

Sayako, F. E., Landi N., Myers E.B. (2017). Sleep duration predicts behavioral and neural differences in adult speech sound learning. *Neurosci Lett.*, 636, 77-82.

Stickgold R., Hobason J.A., Fosse R., Fosse M. (2001). Sleep, Learning, and Dreams: Off-line Memory Reprocessing. *Science*, Vol. 294, 1052-1057.

Stickgold, R., Walker, M.P. (2013) Sleep-dependent memory triage: evolving generalization through selective processing. *Nat Neurosci*, 16:139.

Şengül, C. (2006). Müzik Öğretmeni Yetiştiren Kurumlarda Müzik Teorisi ve İşitme Eğitimi Dersinde Kazanılan Bilgi ve Becerilerin Öğretmenlik Mesleğinde Kullanılma Düzeyleri. Ankara: Gazi Üniversitesi Eğitim Bilimleri Enstitüsü, yayımlanmamış doktora tezi.

Turner, T.H., Drummond, S.P.A., Salamat, J.S., Brown, C.G. (2007). Effects of 42 hours of total sleep deprivation on component processes of verbal working memory. *Neuropsychology.* 21, 787-795.

Van Dort, C. J. (2016). Locus Coeruleus Neural Fatigue: A Potential Mechanism for Cognitive Impairment during Sleep Deprivation. *Sleep*, 1;39 (12), 2173-2188.

Zammit, G., Weiner J., Damato, N. (1999) et al Quality of life in people with insomnia. *Sleep*, 22, 379-385.