The Effects of Music Presence on Auditory Verbal Working Memory

Ali Mohammadzadeh[1, *], Sona Matloubi[1] and Zahra Jafari[2]

[1]*Department of Audiology, School of Rehabilitation, Shahid Beheshti University of Medical Sciences, Tehran, Iran*

[2]*Department of Basic Sciences, School of Rehabilitation Sciences, Iran University of Medical Sciences, Tehran, Iran*

Abstract: *Background and Aim*: Music exists in all cultures; many scientists are seeking to understand how music affects cognitive development such as comprehension, memory, and reading skills. More recently, a considerable number of neuroscience studies on music have been developed. This study aimed to investigate the effects of null and positive background music in comparison with silence on auditory-verbal memory performance.

Methods: Forty young adults (male and female) with normal hearing, aged between 18 and 26, participated in this comparative-analysis study. An auditory and speech evaluation was conducted in order to investigate the effects of background music on working memory. Subsequently, the Rey auditory-verbal learning test was performed in three different conditions: silence, positive, and null music.

Results: The mean score of the Rey auditory-verbal learning test in silence condition was higher than the positive music condition (p=0. 003) and the null music condition (p=0. 01). The tests results did not reveal any between genders differences.

Conclusion: It seems that the presence of competitive music (positive and null music) and the orientation of auditory attention have negative effects on the performance of verbal working memory. It is possibly due to the intervention of music with verbal information processing in the brain.

Keywords: Rey learning test, background music, auditory verbal, working memory, normal hearing.

INTRODUCTION

Working memory involves the temporary storage and manipulation of information and functions to integrate incoming information with information in existing memory storages. Evidence suggests that rehearsal and storage of both tonal and verbal information involves the phonological loopand activates overlapping neural networks [1]. Background music refers to any music that is played while the listener's primary attention is focused on another task or activity [2]. Cognition is one of the most important aspects of brain functions which have been addressed by many researchers. Learning and memory are two of the most important functions of cognition. In fact memory is a key component in brain cognitive function that plays an important role in cognition and is rated in different types. There are three types of memory based on the retention time: a- Sensory memory, b- Long term memory, c- Short term memory. Short term memory is a short term storage system with a limited capacity through which information is transmitted to permanent storage systems [3]. Short term memory involves some sort of short lived memory called working memory. Working memory is used during an intellectual reasoning. Since working memory capacity predicts one's function in a vast area of cognitive skills such as making new strategies, calculation of math problems, reading comprehension and etc. it can be used in cognitive studies [4]. The growth of basic cognitive and auditory skills is affected by auditory environment around us. As the presence of background music is very common in today's life style in most societies the effects of background music can be studied in different cognitive aspects such as reading skills, math skills, learningmemory and so on. Some studies on the effect of background music on performance in cognitive tasks have shown improvements in episodic memory, IQ scores, verbal and visual processing speed, arithmetic skill, reading and second languages learning [5, 6]. Among the tools which are used to check the performance of memory is Ray's auditory – verbal learning test that is a well known neuropsychological test around the world that evaluates many different neural functions such as short term memory verbal memory, learning level, learning strategies and information recovery [7]. (Agha Mollaii *et al.*) It is quoted from Lazek *et al.* 2004 that use of auditory learning patterns for the evaluation of memory was first stablished by Edvard Clapareda (1919) but was

*Address correspondence to this author at the Department of Audiology, School of Rehabilitation Sciences, Shahid Beheshti University of Medical Sciences, Tehran, Iran; Tel: +9821 77561721; Fax: +9821 77561706;
E-mail: almedzade@gmail.com

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promoted after the introduction of auditory-verbal learning test by Andre-Ray. This test was provided in Persian language by Jafari *et al*. the validity and credibility of the test was confirmed. This test is composedof 8 stages. The first and the second prints consist of 4 lists of one syllable words (each list consists of 15 words) and the ability of each person in decoding, stabilizing and recovery of information in different stages of immediate memory is evaluated [8, 9]. On the other hand because of interrelation between music and various brain functions such as comprehension, cognition, emotions, behavior, memory and learning, it is an ideal tool to study cognition and other brain functions [7]. Evidences reveal that background music can affect cognitive functions [10]. Listening to music could indeed represent a relatively inexpensive and non-invasive method to enhance those cognitive abilities that are crucial to the daily living in elderly adults [11]. In the studies carried out on the effects of music in different aspects of cognitive functions some conflicting findings were acquired. Fewer resources have pointed out the remarkable effects of music on improving the cognitive functions. The study done by Mamarella *et al.* 2007 is an example at the same time there are also some sources that have mentioned an unrecognizable effect to non-effectiveness or even negative impact of the music on cognitive functions [12]. The impact of music on arousal and on the mood of listeners seems to be determined by the tempo (fast vs. slow) and the mode (major vs. minus) of the music itself, respectively [13]. In the review of the negative impact of music on cognitive functions includes the study performed by Dobbs *et al.* (2011) in which he has reviewed the effects of music and background noise on cognitive functions. Conversely, disturbing and interfering effects of background music have been reported for multimedia learning, surgeons learning of new procedures, mathematics, and reading. These negative findings could be explained by the “cognitive-capacity hypothesis”, assuming that a limited pool of resources is available for cognitive processing at any given moment, thus background music can disrupt cognitive tasks when there is a potential for interference due to an overtax of resources. It was determined in this study that all the participants showed weaker cognitive functions in the presence of background noise andmusic while comparing to the silent mode [14]. Among the reasons for conducting this research is the paradoxical & conflicting results obtained from already performed studies that indicates the need for further studies in this field. These findings have presumably direct relation with the nature of the background music. On the other hand the term background music implies that the listener’s brain performs two simultaneous functions at the same time so cognitive limits may apply and reduce the first function. It should be considered that many factors are involved in this area including the differences (in terms of character, music education music habits & etc) and the type of cognitive function and its contents and the type of background music played (in terms of pleasure mode, tempo, intensity and verbal being) [15]. Since at the present era, the amazing impact of music on human behavior and cognition is highly noticeable and most researchers often try to find guidelines to improve cognitive functions the study in the field of the interrelation of music and emotions and other cognitive functions can open a new window to arrange new strategies in the field of cognitive rehabilitation & also exposition of the importance of mutual communication between cognition and clinical neuroscience as much as possible. Considering the prevalence of background music in today’s societies and its ability to affect different aspects of cognition including reading skills, math skills, learning memory & etc, the effects of background music on verbal memory were investigated and studied in the current research.

METHODOLOGY

The present study was based on a comparative – analysis and was performed by a non random sampling method on 40 normal subjects (20 males & 20 females) between the ages of 18 to 26 years, in audiology clinic of Rehabilitation School of Shahid Beheshti University of medical sciences within a one month period. All subjects had academic education and none of them had previous formal music training with no history of medical illnesses or any kind of disorder that might affect the cognitive health, such as chronic neurological diseases Brain tumors, Brain Vascular problems, Epilepsy, mental disabilities, Trauma to the head, mental & emotional problems or pathologies and alsoany use of psychiatric drugs. The following issues were also taken into account among thesubjects entry measures to the study. Having enough and comfortable sleep in the week prior to the test. Being healthy enough & not suffering from any medical condition that might affect cognitive function (such as hearing defects). Being free from any type of speech disorders & having normal hearing. To ensure that all subjects have normal hearing, tympanic membrane were checked through otoscopy, type Atympanometry, the presence of contra-lateral & ipsilateral reflexes at 500-

2000Hz, frequencies and air and bone conduction thresholds less than 15 dB at 250 to 8000Hz in pure tone audiometry. Auditory evaluation was performed by Acoustic impedance device, Interacoustics model AT225h and audiometer device, Interacoustics model AD229 (Made in Denmark).

Phonetic and speech fluency test was performed for each participant by an expert Speech pathologist in a quiet place where background noise was less than 30dB SPL. In order to study the effects of background music on the working memory function Ray's Auditory-Verbal memory test was used. Ray's test has been standardized in Iran by two versions with 4 vocabulary lists. In the present study only stage 1 of the test was performed by using different word lists, because in the present study the goal was not evaluation of learning but comparing between immediate auditory-verbal memory in the subjects.

In this study we also used a piece of classical music to evoke positive feeling called Humoresque Composed by Devorak and a piece of neutral classical music called Orchestral Suites Composed by Bach. Positive music refers to a type of music that contains a positive emotional content and inspires a pleasant feeling and neutral music is a type of music that does not inspire neither a positive nor a negative feeling [16].

Each subject completed auditory verbal memory test once in silence and once in the presence of a positive classical music & once in the presence of neutral music. All subjects first did the test in silence to prevent from the effects of music on the results of the silence situation. For half of the subjects the test was continued at the presence of a positive piece of music followed by neutral music and for the other half, it was opposite, a neutral piece of music followed by positive music. In order to remove the effects of learning, 20 minutes resting time was considered, at the end of each stage, each participant was given a separate list of Ray's test. While performing Auditory-Verbal memory test, vocabulary list was run by pace of one word per second with a live sound and the subjects were asked to declare whatever they remembered. The number of words that every person remembered was considered as his/her score. It should be noted that one minute before the beginning of the test. The music was played and right at the end of the test it was stopped. Every subject was asked to stay silent one minute before the silent stage of the test. The piece of music was played through an Audiometer that was connected to a laptop (by windows media player software) in an audio field by a loadspeaker which was mounted at 45 degrees and at a 1 meter distance from the left ear of the subject at a constant 30dB SL level. The test was performed at a silent and quiet environment without any distractive factor for every individual. The mean score of audio-verbal memory test in 3 situations of silence-positive and neutral music. During data analysis, statistical indicators such as mean and standard deviation for dependent variables were used. Independent T test for the carry over effects of the test period and music type was used. Also, in order to compare mean scores of the 3 situations (silence – positive and neutral music) Variance repeated measurement analysis was done by using SPSS statistical software version 18 at the meaningful level of P=0. 05. Conducting the present research study was confirmed by vice chancellor of Shahid Beheshti University of medical sciences and all ethical considerations such as written consent of the participants and confidentiality of their information have been met.

FINDINGS

In the present study Ray's audio-verbal memory test was performed in three situations (silence – positive and neutral music) on 20 males (50%) and 20 females (50%) and in general 40 young subjects aged between 18 to 26 with the average age of 21 and 9 months and SD of 1 year and 8 months. The subjects had 4 to 6 years of academic education. According to the normal distribution of data in the studied variables, we used parametric statistical methods and the following results were obtained.

Chart 1: Statistical Parameters of Scores of Auditory Verbal Memory Test

Scores of Auditory Verbal Memory test			
Situation	**Mean, Std**	**Minimum**	**Maximum**
Positive Music	6. 25 ± 1. 83	3	11
Neutral Music	6. 52 ± 1. 79	4	11
Silence	7. 37 ± 1. 70	4	11

In comparison Ray's test score in silence was more than the two other situations. In statistical analysis by repeated measurement methods of ANOVA, there was a meaningful difference between Ray's test score at silence and it's score at the presence of positive classical music (P=0. 003). Also the difference with Ray's test score at the presence of neutral classical music was meaningful (P=0. 01). On the other hand

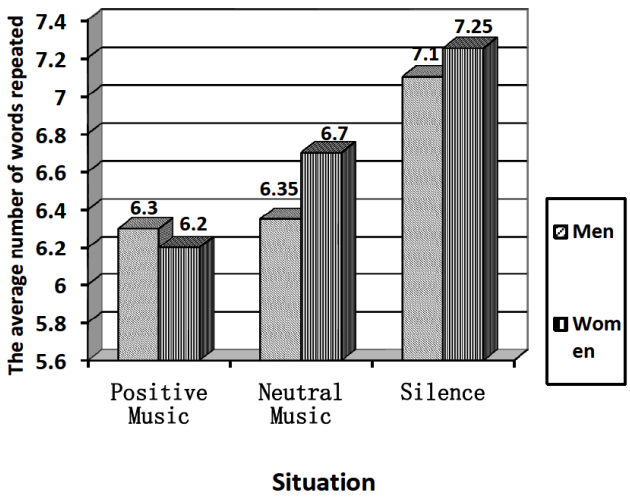

Diagram 1: Ray means score in silence, positive and neutral music.

there was no meaningful difference between Ray's test score at positive music and neutral music (P=0. 92). In the two musical situations (Neutral and Positive) the results of Ray's test was not meaningful (P=0. 96). Also the results of Ray's test indicates no meaningful difference between male and female (P=0. 56).

DISCUSSION

Development of basic Auditory and cognitive skills takes significant effects from the surrounding auditory environment. By considering the presence prevalence of background music in the surrounding auditory environment, in the present study, the effects of background music on the verbal memory has been taken in to consideration. The comparison of the test score of auditory-verbal memory in 3 different situations indicates that the score is higher at silence in comparison to the other 2 situations. It seems that music acts as a distinctive factor and reduced the function of the subjects. In fact music devotes part of person's memory and attention to itself which affects the amount of response to the verbal stimulator.

While reviewing the previous researches we can point out Iwanaqa and Ito's study (2002). This study has been done by the help of a verbal memory test, the results of that study is consistent with the findings in the present study [17].

Considering these findings we can conclude that music may probably intervene with the verbal processing in the brain and decreases the working memory and consequently the subject's score. But the results of the study done by Soto and Sirkim (2012) areinconsistent with our findings and shows that audio verbal functions improve at the presence of music [18].

One reason for inconsistency of the findings can be the effects of different factors such as the music identity, individual differences, the under study population and the type of cognitive task in the field of the effects of music on cognitive functions such as memory [15]. The present study was different from Sirkim and Soto (2012) in terms of studied population type. In their study subjects were suffering from a previous C. V. A and the results of their study indicated that music could improve the functional correlation between the attention and emotional areas of the brain and tends to positive structural changes in gray matter following C.V.A [18]. Also in a study done by Mammarella *et al* (2007) on a smaller group of elderly subjects [12] the findings showed better scores in the presence of music. But these differences between the findings can be addressed to the type of the music. In their study the piece 4 seasons (by Vivaldi) that is a very popular and known piece of music has been played for the participant subjects.

According to the study done by Schellenberg and Weiss (2000) whenever the music is the subject's favorite, it may evoke the brain and thus increases the performance of cognitive tasks [15]. In fact by listening to the music during the test, the subject hears two simultaneous stimuli that one of them must be ignored & the other one must receive more attention. In such conditions despite of selectionattention, the problem of cognitive limitation emerges. In other words by enhancing the listener's emotional state music may tend to improving cognitive functions. On the other hand it may occupy part of memory as a distractive factor and conflicts with the main stimulus [10].

In terms of the impact of gender on the neurological test results, there are different types of opinions. In astudy performed by Geer and Glone (2008), it was shown that there was no difference between male and female subjects in remembering the words that have no emotional loads. Since in the present study no word containing emotional load is used, so the present findings can be justified by the previously performed studyresults [19].

The lack of significant differences between auditory verbal memory test score in two situations of positive & neutral music was another finding which indicated that both positive & neutral musichas a similar role in reducing the subject'sperformances in the test. The

reason for these similarities is due to the western nature of both music types. In fact the Iranian classical music style is different from the western one, so an Iranian subject may probably be not able to differentiate between western classical music and the Iranian one, same as a non Iranian subject may not be able to differentiate Iranian classical music from the western one.

Taking into consideration the above mentioned facts an Iranian subject may have a similar performance in response to the two different music types (positive and neutral) regardless of their emotional load.

In a study performed by Hollan *et al* (2008), it has been observed that when music is gentle and relaxing, it has a positive Impact on the subject's performances and when the music has a provocative content it has a negative impact on the subjects performances [20].

On the other hand Jäncke and Sandmann (2010) did not find any substantial and consistent influence of background music on verbal learning. There was neither an enhancement nor a decrease in verbal learning performance during the background stimulation conditions. Verbal learning during the exposure to different background music varying in tempo and consonance did not influence learning of verbal material. Results of study ofJäncke and *et al* (2014), the exposure to vocal or instrumental background music during encoding did not influence verbal learning. They suggest that the participants are easily able to cope with this background stimulation by ignoring this information channel in order to focus on the verbal learning task [21].

The reason for these findingsamong the studies might have been due to the ability of native music to influence the subjects. With regard to the mentioned issues, even though we cannot talk with certainty about the impacts of background music on cognitive functions because of different factors that are involved, but according to the findings we can argue that music, regardless of it's positive or neutral content reduces attention.

In fact presence of a background stimulus such as background music affects the ability of learning, attention & Audio-verbal memory and reduces the subject's performance, however this area of research requires further attention and more studies.

In this present study we used a neuropsychological tool (Ray's Audio-verbal test) in order to check out the effects of music on learning and memory. In the future studies the application of other known behavioral tools combined with application of imaging techniques may provide more detailed information about the changes in brain functions in response to different types of music with emotional contents activity, this will make it possible to interpret the findings more precisely and accurately. The present study has been performed on a group of native Persian speakers that might have been affected by some cultural factors, so the result of this study is attributable with regards to the applied tools.

CONCLUSION

The results obtained from this study indicate that the auditory verbal memory test score in silence is better than the score in the presence of music. At the same time there is no difference between the impacts of positive or neutral music, both genders have almostgot similar scores that indicates subject gender has no influence on the results of Audio-Verbal memory.

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