Global Journal of
Otolaryngology
ISSN 2474-7556

Juniper Publishers
key to the Researchers

Research Article
Volume 20 Issue 3 - June 2019
DOI: 10.19080/GJO.2019.20.556037

Glob J Otolaryngol

The Effect of Musical Training on Temporal Fine Structure Abilities of Normal Hearing Children

Nazeri Ahmad Reza[1]*, Mohammadzadeh Ali[1], Tazeen Saeed[1] Akbarzadeh bagheban Alireza[2] and Ahmadi Tayyebeh[4]

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

[2]*Department of Basic Sciences, School of rehabilitation, Shahid Beheshti Medical University, Tehran, Iran*

[3]*Department of Audiology, University of social welfare and rehabilitation sciences, Tehran, Iran*

Submission: June 08, 2019; **Published:** June 25, 2019

***Corresponding author:** Nazeri Ahmad Reza, Department of Audiology, School of rehabilitation, Shahid Beheshti Medical University, Tehran, Iran

Abstract

Introduction & Aim: The effect of music on different aspects of cognition & perception, especially language abilities and speech in noise recognition, has been attended by different researchers. In this present study the effect of musical training on temporal fine structure ability was investigated in normal hearing children (8-12 years).

Materials & Methods: This cross-sectional analytic study was performed on 50 normal hearing children (8-12 years) divided to with musical training and without musical training groups. After routine audiologic evaluation, temporal fine structure was performed by means of TFS-LF test.

Results: Significant difference was observed in temporal fine structure processing results at all tested frequencies (250,500,750 HZ), (P< 0.001). The musically trained children had better thresholds at all 3 frequencies in TFS-LF. There was no significant difference between male and female students.

Conclusion: The temporal fine structure processing ability was better in children who received musical training. As these children showed better speech understanding in noise in another studies temporal fine structure improving might be related to better speech in noise performance in musically trained students.

Keywords: Temporal Fine; Structure-Musical; Training- Auditory Processing

Introduction

Daily communications in acoustic environment surrounding us are rarely optimum and noiseless. Noise influences many auditory processing skills such as auditory streams segregation. Human auditory system consecutively detects target signals from different auditory inputs. The auditory system to detect target signal and understand the speech in noise, first segregates signals based on physical similarities, intervals, proximity, and spectral conjugations, and then, organizes the segregated signals over time [1,2]. To segregate auditory streams, perception features (including spectral and time features) are of great importance; hence, people with better auditory perception probably discover more fine aspects of complex sounds and are more capable of detecting and understanding the target signals of a noise [2]. Although understanding speech in noises is almost difficult, children are more vulnerable to the deleterious effects of background noise [3]. Speech understanding difficulties are associated with delay in neural timing and reduced codification of spectral features of speech [4]. In addition, increased level of noise interferes with learning; level of noise and echo usually exceed authorized limits in school classes and impedes effective communications, which in turn cause academic failure in children [5].

Different studies indicated that people who play music have better speech-understanding in noises [4,6-8,9]. People who play music have higher cognitive and sensory abilities and stronger cognitive-perceptional relationships and, in consequent, can better segregate speech signals in challenging environments [4,10]. In addition, children with music training have enhanced perceptional and cognitive performances in auditory working memory, auditory and visual attention, and speech-understanding, which are correlated with their music practices [8]. Music practice improves encoding temporal features of auditory stimuli sensitive to background noises as well as neural synchronization in background noises, which ultimately result in more specific temporal and spectral representation of the signal [7].

The binaural hearing is essential to segregate and process auditory streams. The binaural hearing system tuned to detect very small changes (in milliseconds) between the ears, which is necessary to hear in noisy environments (even when both ears have similar inputs; called diotic hearing). Better speech-understanding in noise in musicians is associated with more rapid neural timing and stronger responses in diotic hearing [11].

From psychoacoustic viewpoint, speech and music processing share different mechanisms. Auditory system should encode pitch, loudness, and other features of sound to extract perception from a part of a music or speech [12]. Pitch, timing, and timbre are the basic components of speech and music; hence, skill in music performance can assist better understanding of speech, which may be attributed to neural pathways and joint processes of both speech and music signals. In fact, long-time music practice improves cognitive and auditory skills as well as the process of lingual feature [6,13].

Different acoustic features are used in human auditory system to understand speech. These features categorized into spatial and temporal groups [14]. Complex signals, such as speech signals, are broken into the sequences of band-pass filtered signals (the cochlea acts tonotopically). In each part of the basilar membrane, the broken signal constitutes of 2 components: temporal envelop, which is observed over the time with moderately slow changes riding on a temporal fine structure (TFS) that are rapid oscillations in a rate near the central frequency of the band. Envelop information in auditory nerve is guided by variations in the number of nerve firing over time, while the information of TFS are guided in detail based on phase-lock patterns in the auditory nerve [15-17]. TFS features are necessary to understand speech in noise, particularly modular noises [14,15,18,19]. The auditory system uses TFS information for the perceptual segregation of a complex sound in the presence of background noise [17,20]. Detecting a signal in modular background noise is easier than the constant ones, particularly when the frequency of the signal is different from the masker center frequency; such hearing ability is called listen in the dips [17]. Based on the TFS information, the normal auditory system decides that the speech signal is in the depth of the target speech background sounds or only a part of background sounds. Variations in the phase-lock of the auditory nerve discharge, when a valley occurs, indicate that the signal is in a valley [21].

To evaluate the ability of using TFS information, first Moore and Sek (2009) designed a software sensitive to monaural TFS features; then, Moore and Hopkins (2010) designed another software sensitive to binaural TFS features. The basic for monaural TFS is the ability to understand pitch changes and the binaural TFS is designed to evaluate phase variations between ears [15,19,22]. Due to the significant effects of music training on children, it is investigated in many today studies. Behavioral and electrophysiological studies indicated the enhanced processing skills in children who benefit from regular musical trainings [8,23,24]. On the other hand, phase process in central nervous system (CNS) and TFS information are considered as a distinctive approach to evaluate the processing abilities of CNS. To the authors' best knowledge, no study evaluated the effect of musical education on the temporal TFS in children; hence, the current study aimed at investigating the development of speech processing skills though music education in children based on TFS and reminding the important role of systematic music education in childhood.

Methodology

The current analytical, cross sectional study was conducted on 50 children aged 8 to 12 years (19 females and 31 males) with normal hearing thresholds (≤20 dbHL in octave frequencies of 250-8000 Hz). All children had normative intelligence based on the Wechsler test (≥85 scores); they were Persian language monolingual and right-handed using the Edinburg questionnaire. Also, none of them had the history of attention deficit hyperactivity disorder (ADHD), head injury, epilepsy and seizure, as well as use of neurological drugs. Twenty-five children (11 females and 14 males) had continuous music trainings at least over the past 2 years [1]. Continuous musical training in the current study is referred to the regular two 30-minute sessions per week [8]; 25 children (8 females and 17 males) without any history of musical training were also recruited. In the beginning of the study before performing the test, a demographic questionnaire including personal characteristics and history of music education was completed by the examiner for each child. Then, all children underwent external and tympanic membrane otoscope examinations with a Heine autoscore. Then, air conduction (AC) audiometry was performed using AS-15 interacoustics audiometer and children with thresholds ≤20 bdHL at all octave frequencies were enrolled into the study. All experiments were performed by the same person in a completely quiet place.

To evaluate the effect of music education on the ability of using TFS information, the TFS-LF (LF stands for low-frequency) was used. TFS-LF is a rapid test to evaluate the sensitivity to TFS features in lower frequencies (<1000 Hz) without need for long-term training the subject. TFS-LF was developed in 2010 by Moore and Hopkins. The test focused on the measurement of threshold to detect interaural phase difference (IPD) of pure tone. Temporal envelopes of pure tones are synchronized between the ears. Hence, the listener can properly answer the test just in case he is sensitive to IPD; therefore, it is obvious that the results indicate the sensitivity of the subject to TFS. The TFS-LF contains 2 set of stimuli for each evaluating frequency (250, 500, and 700 Hz); 200 millisecond intervals are embedded between the sets and each one is presented with 4 tones and 20 milliseconds intervals. Also, 400 milliseconds delay is considered for each tone. One of the stimuli is given to both ears consecutively in 4 tones with frequency in similar phases, but in the other stimulus, 4 tones are given with f frequency in which the first and third tones are similar and the second and fourth tones have phase variations as $\Delta\Phi$ in TFS. The intensity of the

How to cite this article: Nazeri A R, Mohammadzadeh Ali, Tazeen S, A b A, Ahmadi T. The Effect of Musical Training on Temporal Fine Structure Abilities of Normal Hearing Children. Glob J Oto, 2019; 20(3): 556037. DOI: 10.19080/GJO.2019.20.556037

test was 30 dbHL; the 2-alternative forced-choice task method was used for this test.

The child was asked to choose a stimulus that seems the sound oscillates in it. In the beginning of the test, ∆Φ is in its maximum (180°), which is determined in follows using the adaptive method of 2-up 1-down, the thresholds matched with 71% correct answers in the psychometric function are determined with the software. In the software, if the subject only responds the maximum ∆Φ based on the adaptive method, then the non-adaptive method of ∆Φ should be replaced; ∆Φ should be given 40 times and the percentage of accurate answer should be calculated. In each of the method, the distinctive ability index is calculated based on specific tables and at the end, 2 comparable distinctive ability indexes result from the methods. The notebook Sony Vaio CS33G and headphone SH07205BK/10 O Neill Philips were used in the current study. Data analysis was conducted with SPSS version 20 using the Mann-Whitney test; P value <0.05 was considered the level of significance. The study protocol was approved by the Ethics Committee of Shahid Beheshti University of Medical Science, Tehran, Iran; confidentiality of participants' data was observed in the current study.

Results

Table 1: The age distribution of children in the study groups.

Group	Gender	Frequency	% Frequency	Age	
				Mean	SD
With music education	female	11	44%	10.2	1.13
	male	14	56%		
Without music education	female	8	32%	10.3	1.28
	male	17	68%		

Table 2: Mean and standard deviation of binaural phase change threshold index at 250, 500, and 750 Hz frequencies.

Group	Frequency (hz)	Minimum score	Maximum score	Mean	SD
With music education	250	2.5	20.1	7.83	5
	500	4.5	23.3	11.77	5.52
	750	8.2	35	18.58	7.92
With music education	250	5.1	37.7	17.78	10
	500	9.2	49	25.66	11.93
	750	16.7	82.4	37	18.29

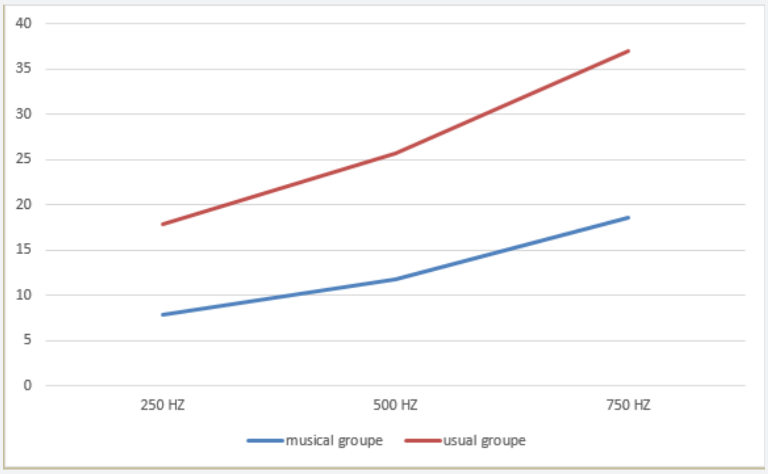

Figure 1: The mean binaural phase change threshold at 250, 500, and 750 Hz frequencies (the vertical axis indicate ∆Φ in degrees.

The sample size of the current study included 50 children assigned into 2 groups; first, children with regular musical training during the past 2 years, and the second, children who did not expose to musical practices; each group contained 25 subjects. The mean age of the children in the music and without music groups was 10.2±1.13 and 10.3±1.28 years, respectively (Table 1). At 250 Hz frequency, the mean binaural variation threshold was 7.83° and 17.78° in the music and without music groups, respectively. At 500 Hz frequency, the mean binaural variation threshold was 11.77° and 25.66° in the music and without music groups, respectively; while at 750 Hz frequency, the mean binaural variation threshold was 18.58° and 37° in the music and without music groups, respectively (Table 2). Based on Figure 1, in both the study groups, with increasing the frequency, the binaural phase change threshold increases, but in the music group the binaural phase change threshold is low from the beginning of the test and the slope change is also lower. Since data distribution was not normal in the study groups, non-parametric tests were used to analyze data. For this purpose, first the scale of data was changed from distance-based to rank-

How to cite this article: Nazeri A R, Mohammadzadeh Ali, Tazeen S, A b A, Ahmadi T. The Effect of Musical Training on Temporal Fine Structure Abilities of Normal Hearing Children. Glob J Oto, 2019; 20(3): 556037. DOI: 10.19080/GJO.2019.20.556037

based and the rank of subjects were compared between the groups using the Mann-Whitney test. Then, the subjects' ranks at each 3 frequencies were compared between the groups using the Freedman test.

Table 3: Comparison of binaural phase change threshold between the study groups at 250, 500, and 750 Hz frequencies.

Frequency	Group	Mean Rank	Total Ranks	Mann-Whitney Test Results	Error Level
250 Hz	With music education	16.98	424.5	99.5	0.001
	Without music education	34.02	850.5		
500 Hz	With music education	16.34	408.5	83.5	0.001
	Without music education	34.66	866.5		
750 Hz	With music education	16.88	422	97	0.001
	Without music education	34.12	853		

Table 4: Freedman test to compare binaural phase change threshold at 3 examined frequencies.

Group	Frequency (hz)	Mean rank	Mann-Whitney Test Results	Error level
With music education	250	2.1	1.08	0.58
	500	2.06		
	750	1.84		
Without music education	250	2.2	6.74	0.03
	500	2.2		
	750	1.6		

Table 5: Comparison of the ranks of binaural phase change threshold in both genders at 250, 500, and 750 Hz frequencies in the music group.

Group	Frequency (hz)	Gender	Mean rank	Total ranks	Mann-Whitney Test Results	Error level
With music education	250	female	10.88	87	51	0.34
		male	14	238		
	500	female	11.38	91	55	0.47
		male	13.76	234		
	750	female	10.75	86	50	0.31
		male	14.06	239		

Results of the Mann-Whitney test were significant in each of the examined frequency, which indicated a significant difference between the groups. Since the mean rank of the without music group was significantly higher in each of the examined frequencies than that of the music group, the scores of binaural phase change threshold were also higher in the without music group and the difference in this regard between the study groups was significant and the results can be generalized to the total population (P <0.01) (Table 3). Results of the Freedman test to compare the ranks of binaural phase change threshold in 3 different frequencies showed no significant changes in the music group, but the difference among the examined frequencies was significant in the without music group. Based on the mean rank of the frequencies, the lowest rank belonged to 750 Hz (1.6) and the 2 other frequencies had same ranks (Table 4). Results of the TFS-LF test in both genders at 250, 500, and 750 Hz frequencies in children with music education are provided in Table 5. The results of the Mann-Whitney test to compare the ranks of binaural phase change threshold in children with musical training showed no significant differences between the genders in this regard. Finally, results of the TFS-LF test in both genders at 250, 500, and 750 Hz frequencies in children without music education are provided in Table 6. The results of the Mann-Whitney test to compare the ranks of binaural phase change threshold in children without musical training showed no significant differences between the genders in this regard.

Table 6: Comparison of the ranks of binaural phase change threshold in both genders at 250, 500, and 750 Hz frequencies in the without music training group.

Group	Frequency (Hz)	Gender	Mean Rank	Total Ranks	Mann-Whitney Test Results	Error Level
	250	female	14	154	66	0.57
		male	12.21	171		
	500	female	13.68	150.5	69.5	0.68
		male	12.46	174.5		
	750	female	13.27	146	74	0.89
		male	12.79	179		

How to cite this article: Nazeri A R, Mohammadzadeh Ali, Tazeen S, A b A, Ahmadi T. The Effect of Musical Training on Temporal Fine Structure Abilities of Normal Hearing Children. Glob J Oto, 2019; 20(3): 556037. DOI: 10.19080/GJO.2019.20.556037

Discussion

Significant effects of musical training on children are reported in many studies; some other studies also claimed the development of processing skills in children with consecutive musical training [8,23,24]. For instance, Slater et al., in a randomized longitudinal study showed that 2 years music education or musical practices significantly enhances the ability of understanding speech in noise in children [1]. Now the question is that which aspects of the auditory processing skills are strengthened in people with musical training that improve their ability to understand speech in crowded environments? Different recently conducted literature indicated the important role of TFS in understanding speech in crowded environments, particularly modular noises [14,15,18,19]. The current study was designed to answer the above question. The current study evaluated the development of temporal processing skills through music education in children based on TFS. The current research compared TFS-LF scores at 250, 500, and 750 Hz frequencies between the music and without music groups and indicated a significant difference between the scores of the study groups in favor of children with musical trainings. It seems that music education, particularly in childhood, strengthens TFS processing ability. Results of the current study were in agreement with those indicating the development of temporal processing skills in the people exposed to music education [1,7,25]. In fact, music education in childhood strengthens auditory perception skills and probably these children can better detect fine acoustic features [2].

Mishra et al. (2015) conducted a similar study on 44 individuals (16 musicians within the age range of 18-31 years and 28 individuals without musical training within the age range of 18-32 years) with normal auditory system using the monaural TFS test and their results were consistent with those of the current study. Musicians were academically trained in Carnatic (South Indian classical) music and started their music practices from childhood before 10 years of age and had practiced regularly for the previous 3 years. Their results showed that the individuals who had musical training were more sensitive to TFS compared to the ones without such trainings, which indicated that the trained people can better encode TFS that is possibly attributed to the high accuracy of phase-lock patterns [25]. Mishra et al., used Indian classic music and indicated that the sensitivity to TFS was improved in musicians compared with the ordinary people; their results were in agreement with those of the studies conducted on Western music [25]. Hence, improved temporal encoding was observed in both the studied music types; these results are in line with those of the current study, although there are some differences between the current and Mishra et al. studies. They studied adults with the music practice experiment of 8-27 years (mean: 15.9 years); however, the music training experiment was 2 years in the current study. Hence, the Mishra's study participants had longer experience in musical practice compared with the children in the current study. Another point in the comparison between these 2 studies is the use of TFS1 by Mishra et al., and TFS-LF in the current study. Although both methods are reliable to assess TFS skills, there are some differences in the implementation procedures and measurements [15].

In a study by Moor and Hopkins et al., (2011), people with moderate cochlear hearing loss have limited ability to use TFS information in moderate and high frequencies. In fact, such explanations describe some speech understanding difficulties in the ones with hearing loss [26]. On the other hand, different studies indicated that people with educational trainings have better speech-understanding in noise and can better process speech signals in challenging noisy environments [4,6,8-10]. Hence, better speech-understanding in noise in people with musical practices can be attributed to their higher ability to use TFS information. In line with the findings of the study by Hopkins et al., (2010) [22], the current study also indicated that by increasing the frequency, TFS threshold also increases. In fact, in lower frequencies, better thresholds were recorded for both the study groups using the TFS-LF, which can be due to the stronger phase-lock in lower frequencies.

Significant effects of musical training on children are reported in different studies; some other studies also indicated the development of processing skills in children who benefited from regular musical training [8,23,24]. For instance, Slater et al., in a randomized longitudinal study showed that 2 years music education or musical practices significantly enhances the ability of understanding speech in noise in children [1]. It is important to find which aspects of the auditory processing skills are strengthened in people with music education, which improve their ability to understand speech in crowded environments. Different recently conducted studies indicated the important role of TFS in understanding speech in crowded environments, particularly modular noises [14,15,18,19]. It is important to find out if superiority in TFS in people with musical practices also leads to their superiority in real situations? Although the benefits of music education and practices did not particularly evaluate in real acoustic situations, as mentioned above, temporal TFS was used as a feature to understand speech in noise, particularly modular noises [14,17,21]. Hence, more accurate presentation of TFS in such people can indicate better speech-understanding in noise. Further studies on the possible effects of musical training and practices with temporal TFS processing tool as well as hearing in noise tests, such as Q-SIN and HINT, in different age ranges are recommended.

References

1. Slater J, Skoe E, Strait DL, O'Connell S, Thompson E, et al. (2015) Music training improves speech-in-noise perception: Longitudinal evidence from a community-based music program. Behavioural brain research 291: 244-252.

2. Parbery-Clark A, Skoe E, Lam C, Kraus N (2009) Musician enhancement for speech-in-noise. Ear and hearing 30(6): 653-661.

How to cite this article: Nazeri A R, Mohammadzadeh Ali, Tazeen S, A b A, Ahmadi T. The Effect of Musical Training on Temporal Fine Structure Abilities of Normal Hearing Children. Glob J Oto, 2019; 20(3): 556037. DOI: 10.19080/GJO.2019.20.556037

3. Klatte M, Lachmann T, Meis M (2010) Effects of noise and reverberation on speech perception and listening comprehension of children and adults in a classroom-like setting. Noise and Health 12(49): 270-282.
4. Kraus N, Chandrasekaran B (2010) Music training for the development of auditory skills. Nature Reviews Neuroscience 11(8): 599-605.
5. Anderson S, Skoe E, Chandrasekaran B, Zecker S, Kraus N (2010) Brainstem correlates of speech-in-noise perception in children. Hearing research 270(1): 151-157.
6. Jain C, Mohamed H, Kumar AU (2015) The effect of short-term musical training on speech perception in noise. Audiology research 5(1).
7. Parbery-Clark A, Skoe E, Kraus N (2009) Musical experience limits the degradative effects of background noise on the neural processing of sound. The Journal of Neuroscience 29(45): 14100-14107.
8. Strait DL, Parbery-Clark A, Hittner E, Kraus N (2012) Musical training during early childhood enhances the neural encoding of speech in noise. Brain and language 123(3): 191-201.
9. Kraus N (2013) Playing music to improve hearing in noise and tune the brain. ENT & Audiology News 22(3).
10. Strait DL, Kraus N, Parbery-Clark A, Ashley R (2010) Musical experience shapes top-down auditory mechanisms: evidence from masking and auditory attention performance. Hearing research 261(1): 22-29.
11. Parbery-Clark A, Strait DL, Hittner E, Kraus N (2013) Musical training enhances neural processing of binaural sounds. The Journal of Neuroscience 33(42): 16741-16747.
12. Shahin AJ (2010) Neurophysiological influence of musical training on speech perception. The relationship between music and language 209.
13. Anderson S, Kraus N (2010) Sensory-cognitive interaction in the neural encoding of speech in noise: a review. J Am Acad Audiol 21(9): 575-585.
14. Moon IJ, Hong SH (2014) What is temporal fine structure and why is it important? Korean journal of audiology 18(1): 1-7.
15. Sęk A, Moore BC (2012) Implementation of two tests for measuring sensitivity to temporal fine structure. International Journal of Audiology 51(1): 58-63.
16. Moore BC, Sęk A (2009) Sensitivity of the human auditory system to temporal fine structure at high frequencies. The Journal of the Acoustical Society of America 125(5): 3186-3193.
17. Moore BC (2008) The role of temporal fine structure processing in pitch perception, masking, and speech perception for normal-hearing and hearing-impaired people. J Assoc Res Otolaryngol 9(4): 399-406.
18. Hopkins K, Moore BC (2009) The contribution of temporal fine structure to the intelligibility of speech in steady and modulated noise. The Journal of the Acoustical Society of America 125(1): 442-446.
19. Moore BC, Sek A (2009) Development of a fast method for determining sensitivity to temporal fine structure. International journal of audiology 48(4): 161-171.
20. Strelcyk O, Dau T (2009) Relations between frequency selectivity, temporal fine-structure processing, and speech reception in impaired hearinga). J Acoust Soc Am 125(5): 3328-3345.
21. Lorenzi C, Gilbert G, Carn H, Garnier S, Moore BC (2006) Speech perception problems of the hearing impaired reflect inability to use temporal fine structure. Proceedings of the National Academy of Sciences 103(49): 18866-18869.
22. Hopkins K, Moore BC (2010) Development of a fast method for measuring sensitivity to temporal fine structure information at low frequencies. Int J Audiol 49(12): 940-946.
23. Chobert J, François C, Velay J-L, Besson M (2014) Twelve months of active musical training in 8-to 10-year-old children enhances the preattentive processing of syllabic duration and voice onset time. Cereb Cortex 24(4): 956-967.
24. Lorenzo O, Herrera L, Hernández-Candelas M, Badea M (2014) Influence of music training on language development. a longitudinal study. Procedia-Social and Behavioral Sciences 128: 527-530.
25. Mishra SK, Panda MR, Raj S (2015) Influence of musical training on sensitivity to temporal fine structure. International journal of audiology 54(4): 220-226.
26. Hopkins K, Moore BC (2011) The effects of age and cochlear hearing loss on temporal fine structure sensitivity, frequency selectivity, and speech reception in noise. J Acoust Soc Am 130(1): 334-349.

DOI: 10.19080/GJO.2019.20.556037

How to cite this article: Nazeri A R, Mohammadzadeh Ali, Tazeen S, A b A, Ahmadi T. The Effect of Musical Training on Temporal Fine Structure Abilities of Normal Hearing Children. Glob J Oto, 2019; 20(3): 556037. DOI: 10.19080/GJO.2019.20.556037