EFECT OF MUSIC TRAINING ON AUDITORY PERCEPTUAL SKILLS

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A Dissertation submitted in part fulfillment for the
Final Year M.Sc. (Speech and Hearing),
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CERTIFICATE

This is to certify that this dissertation entitled ***"EFFECT OF MUSIC TRAINING ON AUDITORY PERCEPTUAL SKILLS"*** is a bonafide work in part fulfillment for the degree of Master of Science (Speech and Hearing) of the student with **Register No. MSHM0105.**

Mysore,
May, 2003

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CERTIFICATE

This is to certify that this dissertation entitled ***"EFFECT OF MUSIC TRAINING ON AUDITORY PERCEPTUAL SKILLS"****has* been prepared under my supervision and guidance. It is also certified that this dissertation has not been submitted earlier in any other University for the award of any diploma or degree.

Mysore
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DECLARATION

I hereby declare that this dissertation entitled ***"EFFECT OF MUSIC TRAINING ON AUDITORY PERCEPTUAL SKILLS"*** is the result of my own study under the guidance of **Dr. ASHA YATHIRAJ,** Reader and HOD, Department of Audiology, All India Institute of Speech and Hearing, Mysore and has not been submitted earlier at any other University for the award of any diploma or degree.

Mysore
May, 2003

Reg. No. MSHM0105

All the way, my saviour leads me,

What have I to as beside,

Can I doubt His tender mercy,

Who through life has been my guide?

Heavenly peace, divinest comfort

Here by faith in Him to dwell

For I know whate 'er befall me

Jesus doeth all things well.

- *Fanny Crosby(1820-1918)*

Dedicated to my wonderful Lord Jesus

&

My dear Amma, Appa & Anna

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My thanks and worship to the ***Almighty God,*** *who is my rock in times of trouble, who picks me up when I fall down and whose love is my anchor.*

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INTRODUCTION

"Music is a moral law. It gives a soul to the universe, wings to the mind, flight to the imagination, a charm to sadness, and life to everything".

- Plato

Music is an instrument for pleasure and enjoyment. It is also viewed as a therapeutic tool to enhance the cognitive, perceptual, intellectual processes and speech and language skills. Earlier it was thought that speech and music were encoded in different hemispheres. Later researches have shown that both right and left hemispheres are important for both linguistic and musical stimuli (Gates and Bradshaw, 1977).

According to Halperin, Nachshon and Carmon (1973), if the hemispheric specialization is determined by the kind or mode of processing, then speech and music which have superficially many similarities may also share some underlying processing requirements. Callaghan (2000) has given the relationship between speech and music which are as follows :

a) Both are semiotic systems using the medium of sound.

b) Structural similarity between music and linguistic features such as lines, rhyme and stanza that are present only in poetry.

c) Structural similarity between music and linguistic features found in language at large such as stress, length, tone and intonation.

According to Gates and Bradshaw (1977) there are many mental abilities that are common to both speech and music. They are temporal order; duration; simultaneity; rhythm; left hemisphere motor control; categorical perception. Since there are similarities between speech and music, both the hemispheres are activated during their perception. Wagner and Harmon (1981) has hypothesized that music education or experience produces a functionally more sophisticated brain that utilizes both rather just one hemisphere for information processing. Hence, music has been used with both normal arid emotionally and intellectually deviant children as a therapeutic tool.

Various authors have reported significant gains on different skills due to music training. These skills that are enhanced through music includes

a) Auditory skills (Rejto, 1973; Berard, 1993).

b) Speech and Language / Communication Skills (Rejto, 1973; Albert and Bear, 1974; Adler, 1982, cited in Zoller, 1991).

c) Reading, Writing and Arithmetic (Rejto, 1973, Hurwitz, Wolff, Bortnick and Kokas 1975; Wexler, 2002).

d) Memory (Rejto, 1973; Morris, 1991).

e) Cognition and perception (Rejto, 1973; Morris, 1991).

f) Emotional States (Aronoff, 1969, cited in Zoller, 1991; Bonny and Savary, 1973, cited in Morris, 1991).

The improvement of performance on these tasks have been attributed to brain plasticity. Brain plasticity is the phenomenon in which experiences excite individual neurons and influence connections between networks of neurons. The effect of prenatal auditory stimulation and stimulation during the first 12 months of an infant's life, with music is given by Callaghan (2000), Schoenberger (2002) and Pageais (n.d,). Proper stimulation of the baby will make their brain grow denser, their thought processes quicker and their perception better. This brain plasticity that is induced through auditory stimulation could be an explanation for the positive gain that is observed in individuals who have undergone music training.)

Based on these ideas, different therapy techniques have been developed to improve the auditory and speech and language skills of children. Some of the therapy techniques are Melodic Intonation Therapy (Albert, Sparks and Helm, 1973, cited in Helm-Estabrooks, 1983); Kodaly music training program (described by Hurwitz, Wolff, Bortnick and Kokas, 1975); Hemi-Sync (Monroe, 1982, cited in Mortis, 1991); Auditory Integration training (Berard, 1993). There are different methods to evaluate the performance an various auditory tasks after auditory training.

Traditionally, auditory processing has been investigated using behavioral tests of speech perception or auditory discrimination. The ability to understand speech depends on complex processing of the ascending neural signal within the central auditory pathways, particularly when the speech is degraded or presented in the presence of a background noise (Musiek, 1999; Purdy, Kelly and Thorne, 2001). The auditory ability that is utilized for this purpose is the auditory closure ability. Other auditory subskills such as auditory discrimination of frequency and auditory sequencing abilities are also measures of auditory learning (Wright, 2001 and Laughton and Hasenstab, 2000).

REVIEW OF LITE RATURE

Music is a universal language, transcending all language barriers. Rhythm and melody are innate forces at birth, placing them at the core of human expression and development (Nash, 1974, cited in Zoller, 1991). According to Birkenshaw (1982, cited in Zoller, 1991), melodic inflections and variations in speech and volume add color and make the speech more expressive. Rhythmic expression originates from bodily movement. Gaining an inner sense of rhythmic sureness is one of the most important tasks of the young child. It is a precondition to success in reading, writing or any other learning.

The reason why learning occurs fastest through music has been given by Zoller (1991). According to her, music is a natural, multi-faceted, novel, non-threatening and enjoyable stimulus for children. Hence, it allows active participation that promotes a variety of opportunities for integrating cognitive and affective growth.

The major areas covered in the following review are :

(i) Mental abilities common in perception of speech and music

(ii) Skills enhanced through music

(iii) Auditory cerebral plasticity

(iv) Measures of auditory plasticity

According to Halperin, Nachshon and Carmon (1973) if the hemispheric specialization is determined by the kind or mode of processing, then music and speech which have superficially many similarities may also share some underlying processing

Objectives of the Study

The main objective of the present study is to evaluate whether there is an enhancement of auditory perceptual processes in children who are trained in music using measures such as

a) Frequency Discrimination

b) Recognition of speech-in-noise

c) Word sequencing

Need for the study

Researches done on children trained in music indicate that music enhances perceptual processes (Rejto 1973; Hurwitz, Wolff, Bortnick and Kokas, 1975). Rejto (1973) had done the study on a single subject. Hence there is a need to examine whether similar findings would be obtained on a larger group.

Further these studies have not evaluated the auditory processing skills directly, but they have inferred that there is improvement in auditory perception from the results that is obtained in other speech, language and psychological measures. Hence, this study was undertaken to find out whether there is an enhancement in the auditory perceptual skills of children who are trained in music, by directly evaluating their auditory perceptual abilities.

Many teaching programs such as Kodaly music training program (described by Hurwitz, Wolff, Bortnick and Kokas, 1975); Melodic Intonation Therapy (Albert, Sparks and Helm, 1973, cited in Helm-Estabrooks, 1983) are reported to be beneficial in remediating the perceptual, cognitive, speech and language skills of children with learning disability, autism, central auditory processing disorders and adults with aphasia. This study can be used to infer the efficacy of these music training programs for individuals with speech and language problem due to auditory perceptual difficulties

The following chapter reviews studies that have been carried out to note the positive effects of music. The studies have been carried out on individuals having normal abilities as well as those having auditory or behavioural problems.

requirements. Thus the left hemisphere may be important for musical abilities which share some properties with speech, such as temporal order, duration, simultaneity and rhythm.

I) Role of Cerebral Hemispheres in the perception of mental abilities common in Speech and Music:

i) Temporal Order:

The importance of temporal ordering is evident in melodic recognition. Temporal ordering is as important in speech as in music, where grammatical relations and hence the meaning may be reflected in the order. The superior precision of the left hemisphere in coding temporal information is thought to be important for both verbal and musical stimuli (Bosshardt & Hormann, 1975, cited in Gates & Bradshaw, 1977). According to Efron (1963 a, b, c, cited in Gates & Bradshaw, 1977), the localization of this particular function in the left hemisphere may make it more efficient for other tasks (requiring accurate temporal analysis of incoming or outgoing data) to be similarly localized in the same or nearby regions.

ii) Duration:

Duration discrimination is a mental ability that is closely related to that of temporal ordering. According to Gates and Bradshaw (1977), perception of duration may demonstrate no invariant lateralization but may be mediated by the left hemisphere in some situations and by the right in others.

Hi) Simultaneity:

The perception of simultaneity, is a mental ability that is involved in both speech and music and is closely related to temporal order and duration discrimination. In music, perception of notes played simultaneously has been shown to differ from that of the same notes played successively (Doehring and Ling, 1971, cited in Gates & Bradshaw, 1977). The simultaneity is considered to be under left hemisphere control (Efron, 1963, cited in Gates & Bradshaw, 1977).

iv) Rhythm :

The importance of rhythm in speech perception suggests that left hemisphere has an important role in the perception of rhythm. In spite of the right ear superiority for recognition of rhythms, various authors such as Milner (1962, cited in Gates & Bradshaw, 1977) have reported the capability of both hemispheres in rhythmic perception.

v) Left Hemisphere Motor Control:

The motor theories which were utilized as explanation for speech perception have been used to explain music perception also. It has been suggested that any acoustic signal may become lateralized to the left hemisphere, if a difficult enough auditory task can be related to a complex vocal-tract movement (Berlin, Lowe-Bell, Cullen, Thompson & Loovis, 1973). Hemispheric control of such motor movements involved in music perception depend not only on the left hemisphere, which is usually involved if the articulation is controlled for playing instruments such as brass and wood wind instruments. The music perception also involves the right hemisphere if the left hand articulation of pitch is controlled for playing string instruments such as violin and cello.

vi) Categorical Perception :

This is a phenomenon that is utilized in both speech and music. This phenomenon, previously considered to be language specific by authors such as Liberman, Cooper, Shankweiler and Studdert-Kennedy (1967), was found to be not unique to language only, but also exists in music for the perception of single notes and intervals (Harris & Siegel 1975, cited in Gates & Bradshaw, 1977). According to Gates and Bradshaw (1977) the categorical perception task demands a perceptual acuity which training could further improve.

vii) Laterally effects :

There are also reports of differential laterality effects for musicians and non-musicians which is important since it shows that experience and practice with a particular kind of stimulus may affect the processing strategies of the listener. The processing strategies of the listener could be influenced such that one or other cerebral hemisphere is involved, while not necessarily affecting the cortical mediation of the stimulus (Gates & Bradshaw, 1977).

Thus the above literature shows that there are many mental abilities which are common to both speech and music being encoded in the same hemisphere. At the same time musicians and non-musicians differ in the processing strategies employed by them to perceive a stimulus. These findings may have an implication in understanding the various positive results that have been observed in children who have undergone music training.

II) Skills enhanced through music:

Using music is a mutisensory experience that enhances a number of other skills that have an impact on speech and language development, Auditory skills, linguistic skills, cognition, perception, memory, socialization and creativity are some of the skills enhanced by music. This enhancement is possible on account of cerebral plasticity. The following review covers the skills enhanced through music.

(i) Auditory skills :

According to Adler (1982, cited in Zoller, 1991), auditory attention is one of the skills that is improved through music training. Several studies have been carried out to investigate this aspect.

Rejto (1973) investigated the use of music as a therapeutic tool to aid a learning disabled child with poor visual and auditory perception. Weekly piano lessons of one hour duration was given for six months. The results of the study showed a strong relationship between the special music instruction and the child's improvement in perceptual areas and in sensory motor integration. Auditory decoding and auditory-vocal sequencing were some of the areas in which there were greater gains.

Rejto (1973) also added that auditory perception difficulties can be helped by the rhythmic training offered through music lessons. If the child's ability to detect rhythm is poor, this would affect his auditory memory and his ability to understand language. Hence rhythmic training through playing music could develop this ability and aid auditory decoding and auditory sequencing skills. The study of music with it's note reading, writing and transposing would seem a natural tool for remediation. The child learns to distinguish between notes of different rhythmical value of varying pitch and dynamic intensity. He learns to sequence the notes in relation to each other as in a melody or in a scale. He learns to perform logical operations with notes as in the building of intervals and chords and he learns to produce all these from memory.

Studies by Bever and Chiarello (1974) have shown that musically naïve subjects tend to treat melodies as an unanalyzable whole and focus on the overall musical contour or pattern. Experienced musicians, however treat a melody as an articulated set of relationships. They found a right ear (left hemisphere) superiority in musicians and a left ear (right hemisphere) superiority in naive listeners for melody recognition.

According to Wagner and Hannon (1981), it would seem that the strategies learned in musical training will produce a neurological shift in hemispheric preference for melody recognition. The music education or experience produces a functionally more sophisticated brain that utilizes both rather than just one hemisphere for information processing. The reason given by Davis and Schmidt (1971, cited in Wagner and Hannon, 1981) is that when the information is processed simultaneously in both hemispheres, the speed and accuracy of responses are increased.

Auditory Integration Training (AIT) developed by Berard (1993) is one of the methods utilizing music. According to him distortions in the auditory system (peaks and valleys in the audiogram) would produce problems in behavior and cognition. Threshold differences between adjacent frequencies of 5 dB was considered to be significant. The stimulus used in AIT (music modulated in a random, unpredictable way) stimulates an area of the reticular activating system (locus coeruleus and lateral tegmental area). The reticular activating system receives input from vestibular and auditory pathways. It contains neurotransmittors which have a role in arousal, alerting, motivation, emotion, memory and reorganization (Frick and Lawton- Shirley, 1994, cited in Madell, 1999). The AIT involves listening to music with those frequencies that results in hyperacquity filtered out. The auditory system reacts to this therapy by adjusting the totality of the frequencies heard. Thus, the audiometric curve tends to flatten and hearing is normalized maintaining the former frequency differentiations best, eliminating the hyperacute areas. AIT has been used in treating children with disorders such as learning disability, autism, central auditory processing disorder.

Another method of education that encorporates music is Montessori method. Montessori (n.d., cited in Pageais, n.d.) has embedded music in her teaching programme, which includes a singing approach with a variety of stimuli such as listening, playing and body expression. The materials which include bells and tone-bars were designed with the colloboration of Signorina-Macheroni with the purpose of responding to the child's sensitivities and tendencies, offering possibilities of auditory refinement and exploring sounds, rhythm and structure of music. The process of auditory refinement depends on concrete experiences with the materials and other stimuli received in dynamic interactions within the prepared Montessori environment. When a musical sound is played and sung it is absorbed, decoded by the brain and retained in the auditory memory as an abstract but precise musical note. A musical sound also exercise the ability to be attentive and therefore develops concentration.

The above studies and literature indicate that there can be improvement in auditory subskills such as auditory decoding, auditory sequencing, auditory memory through music training. There are other studies that report of better speech and language skills in children who are trained in music.

(ii) Speech & Language/ Communication skills :

According to Adler (1982, cited in Zoller, 1991), using music is a multisensory experience that enhances a number of other skills that have an impact on speech and language development. Vocabulary development is also enhanced through music.

In a single case study Rejto (1973), found that the speech and language skills were improved through music training. She postulated that the study of music either developed new channels of learning through which the language skills were utilized or the newly acquired abilities transferred themselves over to the language area. She also added that in a child with language problems, the symbolic thinking is affected and coding exercises are recommended for remedial training when symbolic thinking is disturbed (Frostig 1968, cited in Rejto, 1973). A whole new symbol code is learned through the music theory lessons. The higher associative processes are also used by the child, while learning to work with these symbols. Playing music with it's visual sequencing of the notes and fingerings, it's auditory sequencing of the sounds and kinesthetic sequence of the motor act, seems to be an ideal way to enhance perception with a multisensory approach.

One of the music training programs that is reported to have an impact on language learning is the Kodaly system. It uses techniques such as signs, games, clapping, reading musical notes, rhythmic notation and most centrally singing (Hurwitz, Wolff, Bortnick & Kokas, 1975). Exploratory research has indicated the potential impact of Kodaly music instruction on various skills inducing language learning (Kokas, 1969, cited in Hurwitz, Wolff, Bortnick & Kokas, 1975).

Music has been explored as a therapeutic means for increasing the use of speech and communication skills (Hollander and Juhrs, 1974, cited in Morris, 1991). Brain wave patterns change under different stimulus and learning conditions. Monroe (1982, cited in Morris, 1991) developed a clinical tool known as Hemi- sync which was based on previous research with binaural beats. Two different frequencies, presented to each ear, creates a difference tone as the brain puts together the two tones it actually hears. This electrical signal occurs with relatively equal frequency and strength in both hemispheres of the brain and creates a synchronization of the two sides of the brain. Music tapes containing Hemi-sync emphasize sound signals in the delta-theta range and thus create the ability to sustain this theta period of openness for learning (Morris, 1987, cited in Morris, 1991). Varney (1988, cited in Morris, 1991) studied six boys whose diagnoses included Down syndrome, neurological disorder and developmental delay. It was observed that playing metamusic with Hemi-sync during intervention improved many behaviours including communication.

Melodic intonation therapy (MIT) was developed to treat aphasic patients. It was first described by Albert, Sparks and Helm (1973, cited in Helm-Estabrooks, 1983). MIT is a hierarchically structured program which is divided into three levels or stages. In the first two levels, multisyllabic words and short, high probability phrases are intoned musically and tapped out in a syllable by syllable fashion. The third level introduces longer, phonologically complex phrases which are intoned first, then produced with exaggerated speech prosody and finally spoken normally. Albert and Bear (1974) hypothesized that after left hemisphere damage, the right hemisphere learns to process materials presented slowly. In MIT the patient not only listens to slowed auditory stimuli but slowed stimuli that are intoned musically. Theoretically this combination of variables should maximize the potential for right hemisphere comprehension.

Thus, the researches conducted by different authors have showed that, there is definite improvement in the speech and language skills through music. This can be either due to the development of new channels of learning or through the creation of a theta state, which is important for learning. Another aspect that music influences is the reading and writing abilities of children. This aspect is discussed in the following section.

(iii) Reading, Writing & Arithmetic:

Music is processed primarily in the right hemisphere and limbic system. Instrumental music can distract the more analytical left hemisphere and allow new information to be considered. Because of music's processing in the right hemisphere it's presence during the learning task may make it easier to integrate both analytical and intuitive processing system. Music invites the listener to create many images and to use these images for relaxation and learning.

There are various reports of better reading and writing skills in children who are undergoing music training. Kokas (1969, cited in Hurwitz, Wolff, Bortnick & Kokas, 1975) has reported that school teachers in Hungary have frequently noted better study habits and reading and arithmetic abilities in children who received Kodaly music instruction program. He also reported the potential impact of Kodaly music instruction on spelling and other skills.

The results of the study done by Hurwitz, Wolff, Bortnick and Kokas (1975) on twenty children showed that a program of music instruction involving a systematic presentation of rhythmic elements appeared related to the acceleration of reading skills. The transfer effect of the music program to spatial abilities and reading achievement was of particular interest because it suggested possible new avenues for helping children with disabilities in reading.

Rejto (1973) investigated the use of music as a therapeutic tool to aid a learning disabled child with poor visual and auditory perception. The music training was provided for six months. The results indicated that music as a skill subject can be adapted to a prescriptive teaching style in dealing with children who have learning disabilities.

Heausler (1987, cited in Zoller, 1991) used dance and movement activities to teach kindergarten and second grade students. She found that dance or movement activities were more effective in stimulating creativity and in facilitating learning of word analysis concepts over the short term than a lecture or worksheet approach. Over the long term however no differences were found.

According to Wexler (2002), there is also significant evidence that listening to music while studying improves reading and learning skills. Music that has sixty beats per minute relaxes and soothes the brain making learning and reading easier. When an individual is relaxed and in the best mood for learning, the heart beats at the rate of sixty per minute. Relaxation and a focussed brain helps to concentrate better and remember longer for about 10 to 15%.

The above studies indicate that better study habits, arithmetic abilities, acceleration of reading and increased focussed attention for learning can be achieved with music training.The contribution of music training in enhancing the learning abilities and memory has also been studied.

(v) Learning abilities and Memory :

According to Morris (1991), memory storage occurs in the limbic system and primarily in the hippocampal gyrus. Music is processed through the limbic system and has been shown to enhance memory storage and retrieval. Emotional and physical relaxation and increased memory abilities are associated with high receptivity for learning and high retention.

Receptivity for learning is related to specific states of consciousness. The theta state is important for learning This is the transition zone between wakefulness and sleep and this allows new information to be considered by the right hemisphere through bypassing the critical filters of the left hemisphere. Music tapes containing Hemi-sync emphasize sound signals in the delta-theta range and thus create the ability to sustain this theta period of openness for learning (Morris, 1991).

A pilot study was done by Edrington (1984, cited in Morris, 1991) exploring the utilization of Hemi-sync, a program that makes use of binaural beats as a background for classroom learning. It was found that the students were more focussed in attention, more enthusiastic about learning and able to learn more material in a given period of time. It was found that even when the background music was faded out, the students were able to achieve the same focussed attention for learning.

Hicks (1987, cited in Zoller, 1991) explored the effectiveness of rap music as a method of instruction for urban preschool children and found that forty 3 and 4 year old children were motivated to practice more and ultimately learned more names of unfamiliar body parts compared to a control group that received the same instruction without music.

In the Indian culture, shlokas have always been taught in a musical way. The probable reason for this might be to enhance learning by stimulating both hemispheres.

In the study by Rejto (1973) memory is one of the areas in which there was a positive gain due to music training. Music with a mathematically precise structure and rhythm and a tempo of fifty to seventy beats per minute has been associated with enhancement of learning and retention (Shuster and Mouzon, 1982, cited in Morris, 1991).

Adler (1982, cited in Zoller, 1991) also reported that music improves memory. Thus it would be used as a therapeutic procedure to enhance memory. Various reports have shown that even the cognitive and perceptual abilities of the children could be improved through music training.

(v) Cognition and Perception :

According to Aronoff (1969, cited in Zoller, 1991) music is a natural, novel and enjoyable stimulus which allows active participation that promotes a variety of opportunities for integrating the cognitive and affective growth. It has been reported by

Adler (1982, cited in Zoller, 1991) that perception, spatial relationships, motor planning, imagination and creativity are some of the skills improved through music training.

The use of music as a therapeutic tool to aid a learning disabled child with poor visual and auditory perception was investigated by Rejto (1973). According to her music seems an ideal avenue, since learning music involves the use of three sense modalities i.e. the visual, auditory and the tactual modalities. Playing music with its visual sequencing of the notes and fingerings, its auditory sequencing of the sounds and kinesthetic sequencing of the motor act seems an apt way to enhance perception with a multisensory approach. The results of her study showed a strong relationship between the special music instruction and the child's improvement in perceptual areas.

The study by Hurwitz, Wolff, Bortnick and Kokas (1975) utilizing the Kodaly music training program showed that a program of music instruction involving presentation of rhythmic elements improved the performance of normal children on various psychological measures such as the sequencing of verbal symbols, the solution of problems of perceptual restructuring and spatial abilities. This improvement was observed after the children were provided Kodaly instruction program for seven months with classes held five days a week for a duration of forty minutes per session.

According to Morris (1991), music invites the listener to create many images and to use these images for relaxation, learning and problem solving. Facilitation of cognitive learning has also been elicited through the auditory system with specific sounds or musical patterns which were designed to facilitate integration, organization and attention to sensory information which consequently enhanced learning.

Thus it can be noted that the various studies report of significant gains in cognitive and perception through learning music because of the multisensory involvement in music training. Individuals who have been trained in music also report of relaxation that is induced by music.

(vi) Emotional State:

Aronoff (1969, cited in Zoller, 1991) reported that music being a novel and enjoyable stimulus allows active participation which provides opportunities for affective growth. Music is a strong elicitor of emotions (Bonny & Savary 1973, cited in Morris, 1991). Major fibres connect the fronto cortical areas of the brain with the limbic system for the processing of music. Because music opens up the system to new information and engages the emotional system, it can help children process more positive feelings about themselves.

Subjective reports from thousands of normal adults who have experienced Hemi-sync described a feeling of inner calmness, emotional relaxation and pleasure (Monroe, 1990, cited in Morris, 1991). This could be due to the involvement of the limbic system which is responsible for both music processing and different emotional states. According to Pageais (n.d.), music is the language of feelings and has the power to communicate profound emotions. By it's nature and structure, music assists in the physical, intellectual and most importantly the emotional development of the individual. Playing any instrument requires self control and total coordination of mind and body which in turn develops intellectual and emotional balance.

From the above literature, it is evident that music has a positive effect on different aspects such as auditory skills, speech and language skills, learning abilities, memory, cognition and perception and the emotional state. There are various explanations offered by the researchers to reason out the positive impact of music training on the different aspects. This includes the concept of auditory plasticity which is explained in the following section.

III) Auditory cerebral plasticity:

Several studies have revealed that individuals can improve their performance on many perceptual tasks with practice. Wright (2001) has noted that such learning demonstrates that the perceptual systems are not rigid but further can be modified by experience. The systematic examinations of patterns of learning and generalization provides two types of information.

a) These patterns establish how learning progresses through the course of training on different trained tasks.

b) These patterns also reveal the properties of the mechanism underlying the improvement on the trained task. It explains how the mechanism organizes different stimuli and how it affects the performance on other tasks.

The mechanisms that underlie the improvement on trained task is the 'brain plasticity' that changes the cortex. The term 'brain plasticity' refers to the phenomenon in which experiences excite individual neurons and influence connections between networks of neurons. When multiple experiences occur over time, as happens during direct training, new neural groups can form, grow and strengthen (Merzenich et al., 1999, cited in Gillam, 1999).

with more higher quality synapses can process information more quickly and with less energy. Light, colour, sound and touch all create synapses.

There are critical periods when the brain must be stimulated in order for certain kinds of development to occur like sight, language, emotion and movement. Interaction and stimulation physically determine how intricately the neuro-circuitry of the brain is wired which ultimately determines how intelligent the person will be. Scientists have discovered that classical music is one of the best tools for increasing brain wave activity in children. Classical music has been proven to increase receptivity and retention and assist infants in learning (Schoenberger, 2002).These reports suggest that auditory exercise would induce neural reorganization resulting in auditory plasticity which could be evaluated through different tests.

IV) Measures for Auditory Plasticity :

The auditory perceptual abilities of human adults can be improved with practice. This demonstrates that the perceptual systems are not rigid but can be modified. Thus the auditory cortex is capable of reorganiztion due to experience which is called the auditory cerebral plasticity. The two methods that are used to study this are the behavioural measures and the objective tests.

(i) Behavioural Test *:*

It has been reported by Musiek (1999) that traditionally auditory processing and plasticity of auditory function is investigated using behavioural tests of speech perception or auditory discrimination. According to Wright (2001) systematic memory, cognition and perception and the emotional state. There are various explanations offered by the researchers to reason out the positive impact of music training on the different aspects. This includes the concept of auditory plasticity which is explained in the following section.

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Changes in the brains of adult monkeys during and after they were trained to process rapidly occuring tactile or acoustic stimuli was studied by Recanzone, Schreiner and Merzenich (1993, cited in Gillam, 1999) and Merzenich and Jenkins (1995, cited in Gillam, 1999). They found that the connections in monkey's brains could be reshaped through intensive practice that followed strict behavioral training processes.

The effect of prenatal stimulation on the developing brain has also been studied. According to Pageais (n.d.), before birth itself the fetus is surrounded by sounds, rhythm and movement. It is sensitive to the rhythmical impulse of the maternal organism. The embryo can hear music from the outside world, as research has proved. The auditory impressions received are of vital importance, since they remain as engrams in the nervous system, even if this is not yet completely organized.

It has been noted by Schoenberger (2002), that during the first twelve months of an infant's life, maximizing both the amount of stimulation as well as the kind of quality of stimulation, ensures a strong foundation for a child's future learning. The proper stimulation provided during this time has more impact on the child's brain growth and development than at any other time in his of her life. Proper stimulation of the baby will make their brain grow denser, their thought processes quicker and their perception keener, which ultimately results in a more competent and happier person.

Schoenberger (2002) also added that babies are born with hundred billion brain cells called neurons. During a child's formative years, trillions of connections called synapses form between the cells and establish the brain circuitry, which is the architecture that allows a person to see, feel, move and process information. A brain with more higher quality synapses can process information more quickly and with less energy. Light, colour, sound and touch all create synapses.

There are critical periods when the brain must be stimulated in order for certain kinds of development to occur like sight, language, emotion and movement. Interaction and stimulation physically determine how intricately the neuro-circuitry of the brain is wired which ultimately determines how intelligent the person will be. Scientists have discovered that classical music is one of the best tools for increasing brain wave activity in children. Classical music has been proven to increase receptivity and retention and assist infants in learning (Schoenberger, 2002).These reports suggest that auditory exercise would induce neural reorganization resulting in auditory plasticity which could be evaluated through different tests.

IV) Measures for Auditory Plasticity :

The auditory perceptual abilities of human adults can be improved with practice. This demonstrates that the perceptual systems are not rigid but can be modified. Thus the auditory cortex is capable of reorganiztion due to experience which is called the auditory cerebral plasticity. The two methods that are used to study this are the behavioural measures and the objective tests.

(i) Behavioural Test:

It has been reported by Musiek (1999) that traditionally auditory processing and plasticity of auditory function is investigated using behavioural tests of speech perception or auditory discrimination. According to Wright (2001) systematic examinations of patterns of learning and generalization following auditory stimuli simultaneously provide two related types of information. These are:

(i) The patterns establish the characteristics of learning itself, such as how learning progresses through the course of training on different trained tasks and with different training regimes.

(ii) The patterns also reveal properties of the mechanism underlying the improvement in performance on the trained tasks.

The auditory processing requires a complex series of behaviours. These behaviours have been described by Wood (1975, cited in Chermak, 1981) which includes the ability to do the following:

- Attend to the content and source of a message
- Detect and identify the message
- Transmit the message through the central nervous system for analysis
- Accurately sort the message on the appropriate perceptual and conceptual levels in order to store and retain the message
- Retrieve and restore the message for response purposes.

Some of the auditory subskills that are important for auditory processing include auditory vigilance, auditory closure, auditory discrimination, auditory memory, auditory sequencing, binaural integration. A few of the tests that are used to measure the different auditory perceptual abilities are listed in table 1.

Table 1 : Non-audiological tests used to assess the central auditory processes

Auditory Process	Tests (Non Audiological)
(i) Auditory Discrimination	1. Lindamood Auditory conceptualization Test (Lindamood & Lindamood, 1971, cited in Barr, 1976). 2. Goldman-Fristoe-Woodcock (GFW) Auditory Discrimination Test (Goldman, Fristoe & Woodcock, 1970, cited in Heasley, 1980). 3. GFW Diagnostic Auditory Discrimination Test (Goldman, Fristoe & Woodcock, 1974, cited in Heasley, 1980). 4. Composite Auditory Perceptual Test (Butler, Hedrick & Manning, 1973, cited in Willeford and Burleigh, 1985). 5. Auditory Discrimination Test (Wepman, 1958, cited in Willeford and Burleigh, 1985). 6. Differentiation of Auditory Perceptual skills (Reagan & Cunningham, 1976, cited in Bellis, 1996). 7. Test of Auditory Perceptual skills (Gardner, 1963, cited in Bellis, 1996). 8. Auditory Discrimination Test (Reynolds, 1987, cited in Bellis, 1996).

	9. Carrow Auditory Visual Abilities Test (Carrow-Woodfolk, 1981, cited in Bellis, 1996).
(ii)Auditory Vigilance (Sustained Attention)	1. Lindamood Auditory Conceptualisation Test (Lindamood & Lindamood, 1971, cited in Barr, 1976). 2. Composite Auditory Perceptual Test (Butler, Hedrick & Manning, 1973, cited in Willeford & Burleigh, 1985).
(iii) Auditory Memory	1. Illinois Test of Psycholinguistic Abilities (Kirk et al., 1968, cited in Barr, 1976). 2. Goldman-Fristoe-Woodcock Auditory Memory Test (Goldman, Fristoe & Woodcock, 1974, cited in Heasley, 1980). 3. Composite Auditory Perceptual Test (Butler, Hedrick & Manning, 1973, cited in Willeford & Burleigh, 1985). 4. Differentiation of Auditory Perceptual Test (Reagan & Cunningham, 1976, cited in Bellis, 1996). 5. Test of Auditory Perceptual skills (Gardner, 1985,, cited in Bellis, 1996).

	6. Carrow Auditory Visual Abilities Test (Carrow-Woodfolk, 1981, cited in Bellis, 1996). 7. Auditory Sequential Memory Test (Wepman & Morency, 1973, cited in Bellis, 1996).
(iii) Auditory Sequences	1. Illinois Test of Psycholinguistic Abilities (Kirk et al., 1968, cited in Barr, 1976). 2. Lindamood Auditory Conceptualization Test (Lindamood & Lindamood, 1971, cited in Barr, 1976). 3. Goldman-Fristoe-Woodcock Auditory Memory Test (Goldman, Fristoe & Woodcock, 1974, cited in Heasley, 1980). 4. Composite Auditory Perceptual Test (Butler, Hedrick & Manning, 1973, cited in Willeford & Burleigh, 1985). 5. Carrow Auditory Visual Abilities Test (Carrow-Woodfolk, 1981, cited in Bellis, 1996). 6. Auditory Sequential Memory Test (Wepman & Morency, 1973, cited in Bellis,1996).

(iv) Auditory Closure	1. Illinois Test of Psycholinguistic Abilities (Kirk et al., 1968, cited in Barr, 1976). 2. GFW Auditory Selective Attention Test (Goldman, Fristoe & Woodcock, 1974, cited in Heasley, 1980). 3. Flowers-Costello Test of Central Auditory Abilities (Flowers, Costello & Small, 1970, cited in Bellis,1996). 4. Composite Auditory Perceptual Test (Butler, Hedrick & Manning, 1973, cited in Willeford and Burleigh, 1985). 5. Differentiation of Auditory Perceptual skills (Reagan & Cunningham, 1976, cited in Bellis, 1996). 6. Carrow Auditory Visual Abilities Test (Carrow-Woodfolk, 1981, cited in Bellis, 1996).

(v) Fracturing Ability	1. GFW Sound Symbol Test (Goldman, Fristoe & Woodcock, 1974, cited in Heasley, 1980). 2. Composite Auditory Perceptual Test (Butler, Hedrick & Manning, 1973, cited in Willeford and Burleigh, 1985).
(vi) Auditory Contour Recognition	1. Differentiation of Auditory Perceptual skills (Reagan & Cunningham, 1976, cited in Bellis, 1996).

In the following section, the tests that are used in the present study (i.e. frequency discrimination, recognition of speech-in-noise and word sequencing) are reviewed.

(a) Frequency Discrimination/Auditory Discrimination of frequency:

Laughton and Hasenstab (2000) have noted that auditory discrimination has received much attention because it is necessary for differentiations within any auditory pattern. Different acoustic differentiations including frequency underlie a child's ability to understand, apply and code auditory aspects of his or her spoken language system. Acoustic differentiation is necessary for mastery of pragmatic role requirements for intent, discourse rules and meaning variations. The ability to determine acoustic differences underlies a listener's facility in recognizing modulations of acoustic cues in daily conversation. Acoustic differentiation is also the basis for interpreting and comprehending meaning beyond the literal definition of words.

The frequency discrimination abilities of the normal adults has been reported by Wier, Jesteadt and Green (1977). They reported the frequency discrimination using pulsed pure tones from 200 Hz to 8000 Hz at sensation levels between 5 and 80dB. The frequency difference limen becomes larger as frequency increases and frequency limen becomes smaller as sensation level increases. The difference limen was one Hz for low frequencies presented at 40 dB SL and 16 Hz at 4000 Hz.

(b) Recognition of Speech-in-noise:

In difficult listening situations, such as the presence of ambient noise or poor speech production habits of the speaker, one may not hear every word of the message. Words or phonemes may be audible, however they may be partially masked or distorted due to the presence of ambient noise. Auditory closure enables correct analysis of the signal and filling in when a portion of the message is not heard or perceived (Mencher, Gerber & Mc Combe, 1996). Closure may be accomplished through the use of selected acoustic cues to fill in the missing element. Nonauditory sensory cues (such as visual cues) might be utilized in conjunction with language knowledge to bring closure to incomplete input (Chermak, 1981).

Without closure skills, the sequencing of events becomes extremely difficult and auditory imagery will either be distorted or will be impossible to achieve. Relationships between ideas become irrational or nonexistent (Mencher, Gerber & McCombe, 1996).

Katz and Burge (1971, cited in Willeford & Burleigh, 1985) used the speech-in-noise test to compare the performance of a group of children in the age range of 5 to 14 years after eight 30 minute therapy sessions. A post therapy improvement was observed in selecting pictorial representations of monosyllabic words presented in the presence of speech noise. From this it is evident that the speech-in-noise is a sensitive test in determining the improvement following therapy.

(c) Auditory Sequencing :

Auditory sequencing ability is the ability to identify a series of sounds or words in correct and respective order. Any deficit in this ability will be manifested in terms of difficulty in re-picturing or rebuilding order of presentation, sequences of letters, or sounds or of units of movements (Chermak & Musiek, 1997).

According to Laughton and Hasenstab (2000), ordering or sequencing is an analysis of position within patterns and is critical to structuring elements as in phrase and sentence formation. It is basic to a child's ability to determine the semantic role or function of a word according to where it occurs. Auditory sequencing is an organization process that has received much attention as a skill necessary for mastery of reading, spelling and following directions.

The importance of auditory sequencing ability in the development of language is given by Bloom and Lahey (1978). Successful message formulation and resolution necessitates that the units of a message occur in their proper sequence if one is to decode the speaker's intended message. Increased memory span is also related to advanced language skills.

Huttenlocher and Burke (1976, cited in Chermak, 1981) suggest that the developmental increase in span of recall is associated with the speed with which subjects can identify incoming items, not with an increase in storage capacity. Clearly increased auditory memory span and sequential memory are related to advanced language skills. However a causal relationship is probably absent. Hence auditory memory, auditory sequencing and language ability could be related to some more general underlying language ability.

Estimates of the capacity of the short-term memory store vary according to the method by which they were obtained. Baddeley (1970, cited in Wetherick, 1975) arrived at a conclusion that two to four words could be recalled based on his free recall studies. Crannell and Parish (1957, cited in Wetherick, 1975) estimated the memory span for words at about five and they have concluded that semantic coding has no place at all or an insignificant place in short-term memory.

(ii) Objective Test:

A few of the different objective tests that can be used to investigate auditory plasticity are:

a) Magnetoencephalography

b) Electroencephalography

c) Auditory evoked potentials

Thus, the review of literature indicates that there are many mental abilities common to both speech and music and music training could improve skills such as auditory skills, speech and language skills, learning ability and memory. There are also reports of greater gains in cognition, perception and emotional balance. The results also indicate that the improvement due to auditory training is the result of brain plasticity that changes the cortex. The review has also covered the various tests that could reliably measure auditory cerebral plasticity. Tests such as frequency discrimination, speech-in-noise and auditory sequencing have been noted to be sensitive in detecting the improvement following auditory training.

METHOD

This study was done with the aim to evaluate whether there is an enhancement of auditory perceptual processes in children who are trained in music. To study this, different auditory skills such as auditory discrimination of frequency, speech recognition in noise and auditory sequencing skills were evaluated.

SUBJECT:

This study involved an experimental group and a control group. The experimental group comprised of fifteen normal hearing children in the age range of six to twelve years (mean age - 9.13 years).

The experimental group met the following criteria :

had undergone training in playing keyboard and in vocal music.

Ø the number of years of training varied from three years to nine years.

Ø the duration of instrumental music training was one hour per session and five sessions per week and duration of vocal music training was one hour per week.

Ø the training commenced when the children were three to six years old.

Ø they were proficient in Kannada.

Ø they had no history of ear discharge.

- Ø they had normal peripheral hearing (based on pure tone and immittance screening).
- Ø were right handed.
- Ø Academic performance was good (based on parent's report).

The control group consisted of fifteen age and sex matched children. The control group met the following criteria:

- Ø they had not undergone any formal training in vocal music or musical instruments.
- Ø they had normal hearing.
- Ø they were multilinguals (Since all the fifteen children in the experimental group were multilinguals, speaking three or more than three languages).
- Ø they were proficient in Kannada.
- Ø academic performance similar to the experimental group, based on their teacher's report.
- Ø were right handed.

ENVIRONMENT :

All the tests were carried out in a sound treated double room. Ambient noise levels were within permissible limits as recommended by ANSI (1991, cited in Wilber, 1994).

INSTRUMENTATION :

- Ø Screening pure tone audiometry and frequency discrimination were carried out using a two channel clinical audiometer Madsen OB922 Version 2.23, coupled to acoustically matched ear phones (TDH-39 with MX-41/AR ear cushions). The instrument was calibrated as per ANSI (1996, cited in Frank, 2000) standards.
- Ø Screening immittance audiometry was performed using GSI-Handtymp immittance meter.
- Ø The speech-in-noise was carried out using a Philips AZ2160V CD radio cassette tape recorder and Madsen OB922 clinical audiometer.
- Ø The word sequencing test was carried out using a Pentium IV computer with the AudioLab version II software.

TEST PROCEDURE:

Children who passed the screening tests were taken for the study. On both the experimental group and the control group pure tone audiometry (at 500 Hz, 1 kHz, 2 kHz and 4 kHz at 15 dB HL) and immittance screening (tympanogram and acoustic reflexes) were done to rule out hearing loss and middle ear pathology.

The tests that were done to evaluate their auditory perceptual processes were :

(i) Frequency Discrimination

(ii) Speech-in-noise test

(iii) Word sequencing

(i) Frequency Discrimination :

The frequency discrimination test was done using Madsen OB-922 clinical audiometer. The signals were presented through headphones (TDH-39 housed in MX-41R ear cushions). The test was done for four frequencies 500 Hz, 1 kHz, 2 kHz and 4 kHz. At each of the frequencies the subjects had to discriminate signals varied by 0.03%. Pairs of signals were presented for two seconds with a gap of 500 msec in between. The children were instructed to say whether the two tones which they heard were same or different. The responses of the children were recorded. If the subjects could discriminate the tones correctly, they were awarded a score of one and a score of zero if it was wrong.

(ii) Recognition of speech-in-noise:

The recognition of speech-in-noise was done using Madsen OB-922 (Version-1) audiometer. The speech material that was used for the test was from the 'Speech Identification test in Kannada for Children'(List-l) developed by Vandana (1998). The CD recorded version of the test was used. Speech-noise was presented in the same ear as the speech signal at 0 SN ratio. Both signals were presented at 40 dB SL through headphones. All children were tested only in the right ear. The instruction given to the children was that they would hear words through one headphone. Though the words would not be very clear, they should try to understand the words and repeat them.

The responses of the children were recorded in a sheet and were scored. The scoring was done based on whether they could identify the words correctly or not. Each correctly identified word was given a score of one and a wrongly identified word was given a score of zero.

(Hi) Word Sequencing:

The words from the second list of the 'Speech Identification test in Kannada for Children' (Vandana,1998) were used for the word sequencing test. The length of the word sequence increased from a three word sequence to an eight word sequence. The material was recorded in a computer and scaled for intensity using the Audiolab software. An inter stimulus interval of 500 msec was used between each word. A group of words was considered as a token. There were two tokens in the three and four word sequences and four tokens each in all the other sequences (i.e. five, six, seven and eight word sequences). Table 2 describes the details of the sequences and the number of tokens used in the word sequencing test.

Table 2 : Sequences, Number of tokens and examples of the word sequence test in Kannada

Sl. No.	Sequence Type	Number of Tokens	Example of a Sequence
1.	3 word sequence	2	Lari, Sebu, Chaku.
2.	4 word sequence	2	Mola, Biga, Eni, Bassu.
3.	5 word sequence	4	Kattu, Meke, Kage, Kannu,Huvu.
4.	6 word sequence	4	Kappe, Lari, Chaku, Kannu, Lota, Male.
5.	7 word sequence	4	Huvu, Kappe, Eni, Minu, Lari, Mola, Male.
6.	8 word sequence	4	Dara, Chila, Meke, Kappe, Chatri, Lota, Kannu, Kage.

The words for the sequence were selected from the list using a random table. The sequence was presented through a speaker in a sound treated room. The children were instructed to repeat all the words in the same sequence as presented to them. The response of the children were recorded and scored. A score of one was awarded for every correct word that was recalled. An additional score of one was awarded if the words were recalled in the correct sequence. The recall and the sequence scores were tabulated separately.

The data thus obtained from the experimental and control groups were tabulated and subjected to statistical analysis. The 'independent t test' was used to compare the scores of the two groups.

RESULTS AND DISCUSSION

The study was carried out to investigate the effect of music training on auditory perceptual skills of children who were trained in music. The auditory skills of the children in the experimental group and control group were compared using the independent 't' test on the following auditory skills :

i) Frequency Discrimination (at 500 Hz, 1 kHz, 2 kHz, and 4 kHz).

ii) Speech-in-noise (at 0 SN ratio)

iii) Word Sequencing (3 word sequences to 8 word sequences)

(i) Recall scores

(ii) Sequence scores

(i) Frequency Discrimination :

The frequency discrimination scores of the experimental and control group were obtained at 500 Hz, 1 kHz, 2 kHz, & 4 kHz. The mean, standard deviation and 'independent t values' were obtained and is tabulated in table 3.

(a) Recall:

The recall scores indicated the number of words that were correctly repeated from the word sequence that was presented immaterial of the order. The mean, standard deviation and independent't' values of the recall scores are given in table 5.

Table 5 : **Mean, Standard deviation and 't' values of word recall scores of Experimental and Control Group.**

Variable	Group	N	Maximum Scores	Mean	SD	t values
3 word sequence	Experimental Control	15 15	3	3.00 2.93	0.00 0.18	1.47 NS
4 word sequence	Experimental Control	15 15	4	4.00 3.60	0.00 0.51	3.06**
5 word sequence	Experimental Control	15 15	5	4.30 3.57	0.54 0.59	3.58**
6 word sequence	Experimental Control	15 15	6	4.88 3.75	0.67 0.42	5.52**
7 word sequence	Experimental Control	15 15	7	4.82 3.80	0.73 0.66	4.00**
8 word sequence	Experimental Control	15 15	8	5.00 4.40	0.93 0.49	2.22*

NS-Not significant; *Significant at 0.05 level; ** Significant at 0.01 level

Table 3 : Mean, standard deviation and 't' values between the experimental and control group in frequency discrimination task

Variable	Group	N	Mean	Standard deviation	t values
500 Hz	Experimental Control	15 15	0.53 0.00	0.52 0.00	4.00**
1 kHz	Experimental Control	15 15	0.33 0.00	0.49 0.00	2.65**
2 kHz	Experimental Control	15 15	0.60 0.00	0.51 0.00	4.58**
4 kHz	Experimental Control	15 15	0.67 0.00	0.49 0.00	5.29**

** Significant at 0.01 level ; Maximum score = 1

The results show that there is a significant difference in the frequency discrimination task at all the four frequencies (500 Hz, 1 kHz, 2 kHz and 4 kHz) between the experimental group and the control group. The mean and the standard deviation of the control group i.e. subjects who did not undergo any music training are zero, since they could not differentiate the frequencies that varied by 0.3%. In contrast, many of the children in the experiment group could differentiate these frequency differences.

A study by Wier, Jesteadt and Green (1977) showed that the just noticeable difference for frequency in adults was 1 Hz for low frequencies and 16 Hz in 4000 Hz. In contrast, the children who had not undergone music training could not differentiate the frequencies that varied by 0.3%. (A 0.3% in terms of Hertz would be 1.5, 3, 6 and 12 Hz for the frequencies 500 Hz, 1 kHz, 2 kHz and 4 kHz respectively). The possible reasons could be the age effect and also the difference between the frequencies used in the two studies. In their study the just noticeable difference was 16 Hz for the 4000 Hz tone. In the present study the subjects had to differentiate a 12 Hz difference at 4000 Hz. The experimental group in the present study, which consisted of children trained in music, could discriminate the frequencies that varied by 0.3%, which could be attributed to their training in discriminating and identifying pitch and rhythm.

(ii) Recognition of Speech-in-noise :

The mean and standard deviation of the speech-in-noise scores of the experimental and control group were obtained. The comparison between the experimental and control group was made using the 'independent t test'. Table 4 depicts the mean, standard deviation and the 't' values obtained.

Table 4 : Mean, Standard deviation (SD) and 't' values of speech-in-noise scores in the experimental and control group.

Group	N	Mean	SD	't' values
Experimental	15	14.73	2.28	2.44*
Control	15	13.13	1.13	

* Significant at 0.05 level

The results show that there was a significant difference in the speech-in-noise scores between the experimental and control groups at the 0.05 level. Katz and Burge (1971, cited in Willeford & Burleigh, 1985) also reported of an improvement in speech-in-noise scores after eight 30 minute therapy sessions. Their children were trained specifically in recognition of speech-in-noise, which could account for the improvement in speech-in-noise scores. However, in the present study the enhancement in speech-in-noise scores seen in musically trained children could be due to having to listen to the melody played, while a constant rhythm is played in the background. Though in music, both the signals are musical notes, the children are required to attend and separate the melody from the background rhythm.

***(iii) Word Sequencing*:**

Scores of recall and sequence were obtained by presenting word sequences of different length (3 word sequences to 8 word sequences) and asking the children to recall these words in the same order

(a) Recall:

The recall scores indicated the number of words that were correctly repeated from the word sequence that was presented immaterial of the order. The mean, standard deviation and independent't' values of the recall scores are given in table 5.

Table 5 : Mean, Standard deviation and 't' values of word recall scores of Experimental and Control Group.

Variable	Group	N	Maximum Scores	Mean	SD	t values
3 word sequence	Experimental Control	15 15	3	3.00 2.93	0.00 0.18	1.47 NS
4 word sequence	Experimental Control	15 15	4	4.00 3.60	0.00 0.51	3.06**
5 word sequence	Experimental Control	15 15	5	4.30 3.57	0.54 0.59	3.58**
6 word sequence	Experimental Control	15 15	6	4.88 3.75	0.67 0.42	5.52**
7 word sequence	Experimental Control	15 15	7	4.82 3.80	0.73 0.66	4.00**
8 word sequence	Experimental Control	15 15	8	5.00 4.40	0.93 0.49	2.22*

NS-Not significant; *Significant at 0.05 level; ** Significant at 0.01 level

The scores revealed that the experimental group obtained higher scores across all the word sequences (three to eight word sequences). The scores were significantly different at the 0.01 level in the recall of four, five, six and seven word sequences. While there was no significant difference in the recall of three word sequence, there was a significant difference at 0.05 level in the recall of eight word sequence. The reason why there was no significant difference in the recall of three word sequence between the two groups could be because the task was so easy, that it didn't require any special auditory abilities to carry out the task. Thus, even children who had not undergone music training could perform the task easily. In the recall of eight word sequences, even some of the musically trained children had difficulty and hence it was significant only at 0.05 level. This task was probably too difficult for some of the children in the experimental group and hence the difference was significant only at the 0.05 level.

The recall scores of the children who had not undergone musical training in the present study are similar to the scores obtained by Baddeley (1970, cited in Wetherick, 1975). His subjects, who had not undergone any formal music training, could recall two to four words on free recall studies. In contrast, most of the children who had undergone music training in the current study could recall six to seven words, which could be due to better short term memory. This is in accordance with the reports by various authors such as Rejto (1973), Morris (1991) and Adler (1982, cited in Zoller, 1991), who observed improvement in memory after music training.

Thus, it can be construed that music training does help children in improving their recall abilities. Though the children in the present study had primarily undergone training in playing the keyboard, they had also been trained on vocal music, once a week. It is possible that either one of these or both help the children in the experimental group obtain better auditory recall abilities.

(b) Sequence:

The sequence scores were given for the words recalled in the correct order. The mean, standard deviation and t values of the sequence scores for the experimental and control group obtained are tabulated in table 4.

Table 6 : Mean, Standard deviation and 't' values of word sequence scores of Experimental and control group

Variable	Group	N	Maximum Scores	Mean	SD	t values
3 word sequence	Experimental' Control	15 15	3	3.00 2.93	0.00 0.18	1.47 NS
4 word sequence	Experimental Control	15 15	4	3.95 3.52	0.19 0.67	2.40*
5 word sequence	Experimental Control	15 15	5	3.76 2.17	0.89 0.60	5.73**
6 word sequence	Experimental Control	15 15	6	3.48 1.28	1.05 0.69	6.73**
7 word sequence	Experimental Control	15 15	7	1.84 0.92	1.22 0.96	2.31*
8 word sequence	Experimental Control	15 15	8	1.62 0.53	1.13 0.61	3.26**

NS : Not significant; * Significant at 0.05 level; ** Significant at 0.01 level

From the results in table 6 it is evident that there is a significant difference in the sequencing of four to eight word sequences. While it was significant at the 0.01 level for the five, six and eight word sequences, the difference was significant at the 0.05 level for the four and seven word sequences.

The sequencing abilities of the musically trained children are better, which is in agreement with the finding of Rejto (1973), who reported of enhancement in auditory sequencing ability in his subject after undergoing training in piano for six months. The better sequencing abilities in the children who had undergone music training may be attributed to the need for these children to recall in the correct sequence the musical notes or tunes of the various pieces that they are taught.

Though in general it was observed that the experimental group outperformed the control group, two control subjects had recall and sequencing abilities similar to that of the experimental subjects. From this finding, it can be concluded that it is not essential for a child to have undergone music training to have good auditory recall and sequencing abilities. Other factors could be contributing to good auditory recall and sequencing abilities in some children.

In conclusion, the findings of the present study can be summarized as follows :

1) The frequency discrimination abilities of children who have undergone music training are better when compared to those children who have not undergone music training

2) The speech-in-noise scores of musically trained children are better. The enhancement in speech-in-noise scores seen in musically trained children could be due to the training to listen to the melody played while a constant rhythm is played in the background.

3) The children trained in music could recall more words than children who had not undergone training in music.

4) Musically trained children also had better sequencing ability.

5) A few control subjects also had good recall and sequencing scores indicating that it is not only music training that enables a child to have good auditory recall and sequencing abilities. Other factors could be contributing to higher auditory recall in some children.

SUMMARY AND CONCLUSION

Research carried out by several investigators have shown that there is improvement in various skills such as auditory skills, speech and language skills, reading and writing abilities, memory, cognition and perception (Rejto, 1973; Hurwitz, Wolff, Bortnick and Kokas, 1975; Adler, 1982, cited in Zoller, 1991) with music training.

The present study was carried out to compare the auditory perceptual skills of children who have undergone training in music with children who had not undergone any formal training in music. To study this, different auditory skills such as auditory discrimination of frequency, speech recognition in noise and auditory sequencing skills were evaluated in an experimental and a control group which consisted of fifteen children each in the age range of six to twelve years.

The data obtained from the experimental and control group were tabulated and subjected to statistical analysis. The 'independent t test' was used to compare the scores of the two groups. The findings of the present study can be summarized as follows:

1. The frequency discrimination abilities of children who have undergone music training are better when compared to those children who have not undergone music training

2. The speech-in-noise scores of musically trained children are better. The enhancement in speech-in-noise scores seen in musically trained children could be

due to the training to listen to the melody played while a constant rhythm is played in the background.

3. The children trained in music could recall more words than children who had not undergone training in music.

4. Musically trained children also had better sequencing ability.

5. A few control subjects also had good recall and sequencing scores indicating that it is not only music training that enables a child to have good auditory recall and sequencing abilities. Other factors could be contributing to higher auditory recall in some children.

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APPENDIX -1

WORD SEQUENCING TEST

3 Words

1. La:ri, Sebu, chaku
2. Hu:vu, Nalli, Mane

4 Words

1. Mola, bi:ga, E:ni, Bassu
2. Kappe, Hasu, Ka:ge, Kattu

5 Words

1. Kattu, Me:ke, Ka:ge, Kannu, Hu:vu
2. Nalli, Ko:li, Lo:ta, Hu:vu, Gu:be
3. Se:bu, Kattu, Bi:ga, Mola, Dara
4. Me:ke, Chatri, Mane, Chi:la, Mu:gu

6 Words

6. Kappe, La:ri, Cha:ku, Kannu, Lo:ta, Male
7. Mu:gu, Bi:ga, Kattu, Da:ra, Bassu, Kannu
8. Chi:la, Ko:li, Chatri, Ka:ge, Nalli, Se:bu
9. Hasu, Mane, Me:ke, Gu:be, Lo:ta, Mola

7 Words

1. Hu:vu, Kappe, E:ni, Mi:nu, La:ri, Mola, Male
2. Hasu, Se:bu, Kannu, Biga, Ka:ge, Kattu, Kappe
3. Mu:gu, Hu:vu, Chi.la, Kappe, Mane, Nalli, Bassu.
4. Lo:ta, Cha:ku, La:ri, Me:ke, Ko:li, Cha:tri, Da:ra

8 words

1. Da:ra, Chi.la, Me:ke, Kappe, Chatri, Lo:ta, Kannu, Ka:ge
2. Gu:be, Lota: Cha:ku, Kannu: Ka:ge, Mola, Mu:gu
3. Bi:ga, Mola: Ka:ge, Se:bu, Kannu, Hasu, Kappe, Nalli
4. E:ni, Nalli, Mi:nu, Male, Bassu, Kappe, Me:ke, Cha:ku.