Music evoked P300 in individuals with and without musical abilities

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CERTIFICATE

This is to certify that this dissertation entitled **"Music evoked P300 in individuals with and without musical abilities**" is a bonafide work in part fulfillment of the degree of Master of Science (Audiology) of the student (Registration No. 15AUD036). This has been carried out under the guidance of a faculty of this institute and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

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DECLARATION

This is to certify that this dissertation entitled **"Music evoked P300 in individuals with and without musical abilities"** is the results of my own study under the guidance of Dr. N Devi Lecturer in Audiology, Department of Audiology, All India Institute of Speech and Hearing, Mysuru and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

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Abstract

Music is regarded as one of the skills that involve most parts of the brain. Research till date has proved the advantage of musical skills in enhancing the neural mechanisms and underlying cognitive skills. The effect of music training on auditory perception is being researched extensively in the recent past. In similar line, the present study aims to find out the amplitude and latency for P300 using Carnatic musical stimulus vocal and violin stimulus in musicians and non-musicians. The study examines the active auditory discrimination skills using musical stimulus in musicians and non-musicians using P300 potential. The P300 potential was recorded in two groups of 20 participants each with an age range of 18-40 years. A group of musicians served as experimental and non-musicians as control group. The P300 was recorded using musical stimuli consist of vocal and violin/instrumental stimuli. The latency and amplitude of P300 was measured in participants of both the groups. Results showed that musicians had shorter latency and higher amplitude than non-musician group for the both vocal and instrumental stimuli. The present study concluded that musicians acquire better attentive and active auditory discrimination skills which in turn enhance the auditory perception abilities.

Keywords: Vocal music, instrumental music, P300

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CHAPTER 1

Introduction

Music is the medicine of the mind – John A. Logan

"Where words fall, music speaks". Music is found to activate many parts of the brain than any other activities. Music is a demanding cognitive and neural task which requires very accurate timing of multiple actions, precise control of pitch intervals not involved in language, and multiple ways of producing sound. Musicians are often considered as the envy of working world in terms of the entertainment and also health benefits. With respect to the present forum, it is proved that musicians pursue an added advantage of a wide array of cognitive abilities. Scherer and Zentner (2001) showed that enhancement in the skills of musicians depends on the type and years of exposure to music. Enhanced auditory perception in musicians is likely to result from auditory perceptual learning over several years of training. Auditory perceptual learning is a term referring to improvements in the auditory system's ability to discriminate differences in certain attributes of a stimulus.

Musical training enhances the subtle auditory processing skills. The evidences include behavioral changes in discriminating fine auditory cues, enhancement in coding the incoming stimuli (studied through electrophysiological methods) and the anatomical differences in the cortical regions. The functional and structural changes have shown that certain brain regions are directly related to effects of music training. Instrumental musicians differ from vocal musicians since their task is more complex such as, independent fine motor movements in both hands and auditory discrimination (Schlaug, Norton, Overy, & Winner, 2005). Instrumental training requires more than one sensory motor system activations. Performing an instrument is a highly skilled activity. As well as reading complex musical notes and converting into sequential, bimodal motor activates depend on the multi sensory response; learning fine motor skills with metric accuracy; remembering long musical passage; and developing with given musical parameters (Zatorre, Chen, & Penhune,2007**).** Musical activation, different from most other motor performance, requires accurate time for numerous hierarchically structured performance and control on pitch interval production (Zatorreet al., 2007). These anatomical differences have been responsible for superior auditory processing of complex stimuli structures like pitch in musicians and non-musicians (Bainchi, Santurette, Wendt, & Dau, 2016). Both instrumental and vocal musical practice gives significant difference in auditory processing to determine timber changes, pitch, and timing of both musical notes and their higher syntactic association into melody (Butera, 2015). The musician's brain is presumed to be a good and appropriate model to investigate neuroplastic changes (Munte, Altenmuller & Jancke, 2002). Professional musicians have fine-tuned auditory skills which are achieved by aural training that they receive during their musical training. It is considered as an important component of their vocational formation (Herdener et al., 2010). Hannon and Trainor (2007), opine that musical structure is complex, consisting of a small set of elements that combine to form hierarchical levels of pitch and temporal structure according to grammatical rules.

The musicians and non-musicians perform differently for different stimulus such as auditory and tactile stimuli along with musical performance. A Magnetic Resonance Imaging (MRI) study was conducted in this regard by (Schlaug, Jancke, Huang,

&Steinmetz, 1995). Results reveal that an enlargement of the anterior region of the corpus callosum in musician who started music training at an early age, and a larger posterior region of the auditory cortex in left-sided planum temporal thought to be significant in the processing of absolute pitch and complex sounds in musicians than non-musicians. Study done on comparison between musician and non-musicians, measured with (fMRI) recorded resting-state activity in the brain and results found that musicians have larger functional links between multi-sensory and motor areas improved. And also shows that long-standing musical practice influences functional brain connectivity (Luo, Guo, Lai, Liao, Liu, Kendrick, & Li, 2012).

A study done using Evoked Response Potentials (ERP) showed an extension of Heschl's gyrus in musicians with enhanced N19m-P30m (Schneider, Eschman, & Zuccolotto, 2002). Instrumental musical practice may improve in the enlargement of neurofilament in upper cortical layers that present in children's between 6 and 12 years, with synchronized firing of neurons (Moore & Guan, 2001; Hannon & Trainor, 2007). Swaminathan, Mason, Streeter, Best, Kidd, & Patel (2015) studied cocktail party effect on musician and non-musician. The tasks were to recognize target sentences masked by other sentences presented from different spatial locations in speech in noise. The results showed that musicians scores were better by 6 dB than non-musicians. Many researchers have used electrophysiological studies to assess the difference in coding of the musical stimuli in musicians and non-musicians. Those studies have found that shorter neural onset latency and more robust cortical (Schon, Magne, & Besson, 2004) and sub cortical (Wong, 2007) encoding of speech in musicians than in non-musician peers. This holds true for both the groups instrumental and vocal musicians, and suggests that neuralplasciticity mechanism linked to musical training and may benefits from speech and language processing through their auditory processing skills (Palmer & Krumhansl, 1990).

Event-related potential (ERP) and Electroencephalography (EEG) measurement result in number of advantages when studying temporal information processing and temporally driven expectancies. ERPs to unexpected stimuli typically show a large positive wave approximately 300 ms after the onset of the unexpected stimulus, the so-called P300. However, studying information processing by comparing endogenous ERP components like the P300 from different experimental designs is difficult because the interaction between exogenous and endogenous components results in complex waveforms (Gaillard, 1988). Musicians are generally found to be both more accurate and consistent in their responses compared to non-musicians (Aschersleben, 2002; Jongsma, Quian, Quiroga, & Van Rijn, 2004). Because musical training makes it easier to predict an upcoming stimulus. The hypothesis is that musicians will have consistent and better /larger amplitude than non-musician.

1.1 Need for the study

Musicians have different perceptual and cortical structure than non-musicians. Auditory evoked potentials involves different neural structure for processing of the musical stimuli it not only involve sensory skills but also require good cognitive and motor skills to process and exhibit the response. Musicians will perform better than non-musician because of the experience. Okhrei, Kutsenko, and Makarchouk (2012) investigated P300 in 7 musicians and 10 non-musicians using tonal stimuli which showed that the peak latency of P3 component in the left hemisphere was significantly shorter in musicians than non-musicians. These reveal that there is a superior attentive auditory discrimination skill in musicians than in non-musicians. There is also significant difference in latency between the left and the right hemispheres.

Ungan, Berki, Erbil, Yagcioglu, Yuksel, & Utkucal (2013) found a dissimilarity among musicians and non-musicians in their skills to identify changes in rhythm. The stimuli used were three equally spaced and consecutive drum beats. The results showed that P300 evoked via rhythm change was significantly enhanced in amplitude and smaller in latency in musicians than in non-musicians. The above literature shows musicians have enhanced attentive auditory discrimination skills compared to non-musicians with respect to P300 latencies are shorter (better) and amplitudes larger (better). However, the stimuli that are used to evoke these P300 responses were using tonal stimuli, speech stimuli, violin strings, and drum beat and contra lateral stimulus. Thought various stimuli can be used the perceptual and processing of these are quite different. The P300 ERP studies have been reported on speech sounds and non-speech sounds however there is also need to study the evoked responses using music stimulus for musician and non-musicians. Most of the studies have been done using instrumental stimuli alone or vocalic stimuli alone. So the present study is taken up to fill this gap in literature by comparing both the stimuli.

Most of the studies that are reported are evoked by western musical stimuli, However there are limited studies on P300 using Indian musical stimuli. In carnatic music ra:ga scale can be defined as a specific set of notes creating a musical theme. Note transitions play important roles in the domain of classical music. A note to note transition includes the ending part of the decay (or release) of one note, the beginning and possibly all of the attack of the next note, and whatever connects the two notes. Transitions include a change in pitch, amplitude, and spectrum. Therefore, this transition provides unique opportunity to study the processing of complex spectro-temporal changes. Hence, in our study a transition portion between two notes of the ra:ga played in violin was taken as musical stimuli for eliciting the AEPs (Devi & Kumar, 2016).

Carnatic musical stimuli differ in western musical stimuli. There are some basic difference between Indian and Western classical music in terms of pitch structure and temporal patterning. Some basic elements of Indian music i.e. ta:ḷa (rhythmic pattern), shruti (relative musical pitch), ra:ga (melody) and swara (the musical sound of a single note) are rarely found in western classical music. These features are difficult to perceive for western listeners without special training. In the case of vocal singers, control of pitch is important and is done by biomechanical and aerodynamic systems. Investigators agree that the ability to produce a precise pitch is very important for the professional vocal musicians (Sanju & Kumar, 2016).Literature shows that accurate pitch control mainly depends on auditory perceptual monitoring, proprioceptive feedback of the laryngeal system and phonatory reflex systems (Jones & Munhalli, 2000; Murbe, Pabst, Hofmann &Sundberg, 2004). The Recent literature reported enhanced auditory skills through different behavioral tests in Indian classical musicians (Sangamanatha, Fernandes, Bhat, Srivastava, & Prakrithi, 2012; Mishra, Panda & Herbert, 2014; Mishra et al., 2015; Kumar et al., 2015; Sanju & Kumar, 2015a; Sanju & Kumar, 2015b).It is interesting to know the effect of music training and practice on attentive auditory discrimination skills in musicians through an electrophysiological test like P300. There is a lack of literature regarding attentive auditory discrimination skills in using music stimuli. Hence, there is a need to compare attentive auditory discrimination skills in musicians with non-music.

1.2 Aim

To study the effect of musical ability on music (vocal and violin) evoked P300 responses.

1.3 Objectives

I. To compare the latency and amplitude of P300 Vocal music stimuli between Musician and Non-musician

II. To compare the latency and amplitude of P300 Violin musical stimuli between Musician and non-musician

III. To compare the latency and amplitude of P300 responses between vocal and instrument evoked P300 within each group of participant.

1.4 Hypothesis

The null hypotheses were framed for each main objective of the study

1. There is no significant difference in the amplitude of P300 responses between musicians and non-musicians.
2. There is no significant difference in the latency of P300 responses between musicians and non-musicians.
3. There is no significant difference in the latency and amplitude and latency of P300 responses within musicians and non-musicians for vocal stimuli and violin.

CHAPTER 2

Review of literature

The research done on musicians has revealed advantages in different aspects of perception and processing when compared to non-musicians. Studies have reported that music training can not only enhance the skills related to music perception, but also other aspects like linguistic skills, working memory, temporal abilities, perception of emotions and the ability to perceive speech in the presence of noise. These enhancements are directly related to the presence of various structural and functional differences between musician and their untrained peers.

2.1 Anatomical variations in musician and non-musician

Highly trained musicians exhibit unique anatomical, functional and event-related specialization as opposed to non-musician. For instance, musician have more neural cell body (grey matter volume) in the auditory, motor and visuo-spatial areas of the brain(Gaser & Schlang, 2003) and also have more axonal projections that connect the right and left hemispheres (Schlaug et al.,1995) perhaps as components of these enhancements, professional instrumentalist, compared to amateurs or untrained controls. Display greater activation in auditory areas such as Heschl's gyrus (Schneider, Schergdosch, Specht, Gutschalk, &Rupp 2005)and the planumtemporals (Ohishi, Matsuda, Asada, Aruga, Hirakata, & Nishikawa, 2001).

Studies using magnetic resonance imaging (MRI) have shown structural differences in brain organization between musicians and non-musicians, musician will have larger corpus callosum (Schlaug, Jancke, Huang, & Steinmetz, 1995) and planumtemporale in musicians (Schlauget al., 1995), and auditory cortex (Pantev et al., 1998). The event-related brain potentials (ERPs) the amplitude of late positive components, elicited by pitch contour violations in music, is found to be larger, and their onset latency shorter for musicians than for non-musicians (Besson, Faita, &Requin, 1994).Studies have indicated that daily musical training, as used by professional musicians will increase and maintain their skill, can induce functional reorganization of the cerebral cortex (Elbert et al., 1995; Schlaug et al., 1995; Pantev et al., 1998).

Pantev et al (1998) through magnetic resonance morphometry revealed that the anterior half of the corpus collosum was significantly larger in musicians. This difference was due to the larger anterior corpus collosum in musicians.Ridding, Brouwer, and Nordstrom (2000) assessed interhemispheric communication through transcranial magnetic stimulation (TMS) in musicians and non-musicians. Musicians had reduced interhemispheric inhibition, depending on the level of expertise. Schmithorst and Wilke (2002) performed diffusion tensor imaging on subjects with and without any musical training. The fractional anisotropy (FA) had greater corpus callosum in individuals who had undergone musical training, which could be a result of the cognitive processes involved in music. Ohnishi et al (2001) studied cerebral activity in pattern with musical perception in musician and non-musician using functional magnetic resonance imaging. The passive musical listening task was given. Results revealed that the musicians showed activation of planumtemporale and left posterior dorsolateral prefrontal cortex. The degree of activation well correlated with the musical training of the individual started the musical training. Schneider et al (2002) conducted a Magnetoencephalography (MEG) study which showed neurophysiological and anatomical differences between musician and non-musician. The results indicate that activity evoked in musicians specifically in the primary auditory cortex and the gray matter volume of the anteromedial portion of Heschl's gyrus was larger than non-musician. In addition, the study also concluded that both the morphology and neurophysiology of Heschl's gyrus have an essential impact on musical ability.

Instrumental musicians are also found to have relatively improved auditory processing skills. Gaser & Schlaug(2003) studied the trained musicians who plays keyboard and found that they learn complex motor and auditory skills at early age. The anatomical changes in gray matter volume difference in motor as well as auditory and visuospatial brain regions compared to non-musicians. In trained piano players, Bangert & Schlaug (2006) found an increased activation of ipsilateral premotor and primary motor contributions; with an increased involvement of primary and secondary motor cortices in motor learning which is in turn dependent on experience. And also interhemispheric transfer effects were present in musicians.

Hutchinson et al (2003) reported MRI study on professional keyboard players, who had undergone training early and throughout life. They compared the professional keyboard players with non-musicians who had not undergone any training. The results showed that musicians had larger cerebellar volumes than non-musician group. Another MRI study was done by Bermudezet.al (2009) to see the neuroanatomical correlation of cortical thickness in 71 musicians and 64 non musicians. The results showed that cortical thickness was more in musicians with peaks in superior temporal and dorsolateral frontal regions. Cortical thickness within the right frontal cortex and greater gray matter concentration was seen in musicians in the poster lateral aspects of Heschl’s gyrus. Shahin, Bosnyak, Trainor, & Roberts (2003) studied trained violinists and pianists and non-musician. Task was to listen piano tones, violin tones, and pure tones matched in fundamental frequency to the musical tones. Passive attention was needed. Results showed that both groups had larger N1c latency and P2 latency responses to the three types of tonal stimuli. These results suggest that the tuning properties of neurons are modified in distributed regions of the auditory cortex in accordance with the acoustic training of the subject.

Shahin, Roberts, & Trainor (2004) studied on development of mature synaptic connections in the upper neocortical lamina known to occur between 4 and 15 years of age. Auditory Evoked Potentials were studied on piano, violin, and pure tones were measured twice in a group of 4-15 year old children in trained musician and non-musicians. Results showed that P1 was larger in musicians for all tones and P2 was enhanced specifically for the instrument of practice (piano or violin). And concluded that neocortical synaptic matrix is shaped by an accumulation of specific auditory experience. Thus, these entire anatomical enhancements are seen to translate into improved auditory and cognitive skills as is evidence by various studies that have examined the behavioral adaptations of musicians as an effect of training. Among these enhanced skills, of particular note are the enhanced perception of pitch and the improvement seen in working memory.

The cognitive advantage of musicians was examined by Schulze (2011) using fMRI. The working memory (WM) of musician and non-musician was examined though verbal and tonal WM in both non-musicians (who are trained in speech, but not in music) and highly trained musicians (who are trained in both domains). Results showed that WM are involved in both tonal and verbal WM (Broca’s area, premotor cortex, pre-

SMA/SMA, left insular cortex, inferior parietal lobe), although with significantly different structural weightings, in both non-musicians and musicians. Musicians activated specific subcomponents only during verbal (right insular cortex) or only during tonal WM (right globus pallidus, right caudate nucleus, and left cerebellum). These results reveal showed that there are two working memory for musicians a phonological loop for phonological information and tonal loop for tonal information the difference between tonal and verbal within musician it mainly related to structures involved in controlling, programming and planning of actions. Treille et al (2017) compared thetrained pianists (musician) and non-pianists (non-musician) using magneto encephalography (MEG) experiment. They compared the motor activation in pianists and non-pianists while listening to piano tones. Results showed that in pianist's statistically significant increase of activity above the region of the contra lateral motor cortex. They concluded that trained pianists exhibit involuntary motor activity involving the contra lateral primary motor cortex than non-pianists.

2.2 Auditory evoked potentials in musician and non-musicians

Functionally, the brain responses of adult musician and non-musician also differ as measured by EEG and MEG some event related potentials from auditory cortical areas such as the N1, N1c and P2 were found to be more robust in musician as compared to non-musician (Pantev et al., 1998; Shahin, Bosnyak, Trainor, Roberts, & Larrey, 2003). Enhanced P2 in musicians (Shahin et al., 2003) demonstrated training specific sensitivity of this auditory evoked component. Endogenous evoked responses related to the automatic auditory processing have been shown to be enhanced in musicians when the stimuli involve processing of melodic, harmonic or temporal structure (Tervaniemi et al., 2001; Koelsch et al., 2001; Fujioka et al., 2004, 2005; van Zuijen et al., 2004, 2005).

Levett & Martin (1992) presented complex musical stimuli to two groups, musicians and non-musicians. Familiar music context was given which influenced familiar context-updating process and elicitation of P300. They recorded P300 for ongoing musical context and found larger amplitude in musicians than non-musicians. These findings were attributed to the use of additional processing to a greater extent by musicians than the non-musicians because of experience. Besson, Faita and Requin (1994) recorded P300 in musicians and non-musicians who were presented with short musical phrases that were either selected from the classical musical repertoire or composed for the experiment. The phrases terminated either in a congruous or a ‘harmonically’, ‘melodically’, or ‘rhythmically’ incongruous note. Results showed that musicians are faster than non-musicians in detecting incongruities. This study provides further neurophysiological evidence concerning the mechanisms underlying music perception and the differences between musical and linguistic processing.

Crummer, Walton, Wayman, Hantz, & Frisina (1994) investigated P3 component of an endogenous-related potential between adult musicians versus non-musicians. The stimulus used were three timbers with same pitch which contains timber series, i.e. (1) cello and viola string instruments in the identical family (2) flutes made of wood and silver, and (3) instruments of slightly different size (F tubas vs B-flat). The amplitude and latency of the P3 component varied systematically as a function of musical experience and type of timbre discrimination. The difficult timbre task resulted in mean P3 amplitudes which were larger for musicians relative to non-musicians; however P3 amplitudes were similar for the two additional timbre series. The mean P3 latencies for musicians were shorter when compared to non-musicians across all three series. In comparison, the AP subjects displayed the shortest mean P3 latencies, but had smaller P3 amplitudes relative to both musicians and non-musicians. The implications of these findings suggest that perceptual tasks involving one of the fundamental building blocks of music, namely timbre, do elicit differential brain activity from memory or information processing systems from subjects with varying degrees of musical training.

Caldwell and Riby (2007) recorded P300 from 16 classical and rock musicians during a standard 2 stimulus visual oddball task, while listening to classical and rock music. During the oddball task participants were required to discriminate between infrequent target stimuli. The P3 and N2 ERPs were elicited in response to the infrequent target stimuli. Resulted showed that reduction in amplitude of the P3 for classical musicians exposed to classical music and rock musicians exposed to rock music. at the pre-attentive stage of processing (N2) beneficial effects of exposure to classical music were observed for both groups of musicians. These data are discussed in terms of short and long-term music benefits on both conscious and unconscious cognitive processes. Wayman, Frisina, Walton, Hantz and Crummer (1992) measured the neural activity of 11 listeners without musical training, 14 highly trained musicians, and 10 musicians possessing ‘‘absolute pitch’’ (AP) ability. The P3 was elicited using the classical ‘‘oddball’’ paradigm with a sine-tone series. Subjects’ musical backgrounds were evaluated with a survey questionnaire. AP ability was verified with an objective pitch identification test. The P3 amplitude, latency and wave shape were evaluated along with each subject’s performance score and musical background. The AP subjects showed significantly smaller P3 amplitude than either the musicians or non-musicians, which were nearly identical. The P3 latency was shortest for the AP subjects, and was longest for the non-musicians. Performance scores were uniformly high in all three groups. It is concluded that AP subjects do exhibit P3 ERPs, smaller amplitudes and shorter latencies. The differences in neural activity between the musicians and AP subjects were not due to musical training, as the AP subjects had similar musical backgrounds to the musician group. It is also concluded that persons with the AP ability may have superior auditory sensitivity at cortical levels and use unique neuropsychological strategies when processing tones. Hantz, Crummer, Wayman, Walto, and Frisina (1992) measured P300 for 3 subject groups: musician, without absolute pitch, musician with absolute pitch, and non-musician. The tasks were two interval discrimination task and simple two-note contour task and difficult interval-size discrimination task. Absolute pitch ability reduces the amplitude and shorten the latency, or eliminate P3 altogether. Says that use of long-term memory strategy involved in the correct discrimination task rather than performing the task by updating working memory each time a target occurs. This data were contrasted to those timber and sine tone discrimination task. Hirose, Kubota, Kimura, Ohsawa, Yumoto and Sakakihara(2002)recorded a P300 component of event-related potentials associated with auditory oddball tasks in nine absolute pitch (AP) possessors and seven non-AP possessors. The previous studies demonstrated that AP possessors did not appear to employ working memory during auditory oddball tasks because they have a fixed tonal template in their memories. However, the present findings showed that the AP possessors exhibited similar P300 as the non-AP possessors and did update the tonal context in the auditory oddball tasks. This result suggests that the AP possessors do not always refer to the fixed tonal template in their memories when executing the oddball tasks and they employ working memory properly according to the difficulty of the auditory tasks.

Trainor, Desjardins and Rockel (1999) studied the ability to perceive sounds and correctly categorize them within musical scale in musician and non-musician. In music the physical features of stimulus rate always change because the melodic consists of a series of notes with different pitch characteristics. 10 musicians and 10 non musicians were presented with an auditory stimulus (tone, chord, chord sequence, Mozart and Bach melodies). 2 tasks were given contour (up/down) and intervals (pitch distance between the notes) electrical and magnetic recording was done. MMN and P300 was recorded results showed that there was significantly correlates musical score and as the paradigm difficult increases. In musicians largest frontal P3a (attention) and P3b was observed. In contour task did not differ in both groups where as in interval task smaller and delayed in non-musician. They concluded that topologies were similar for P3a and P3b in both groups P3b in musician negatively correlated with the age of the onset of music lessons. And also suggest that contour processing more; interval processing more affected than contour by experience, and similar brain network are involved in generating the P3a and P3b in musicians and non-musicians.

Levy, Granot and Bentin (2001) investigated processing specificity of human voice stimuli using oddball paradigm in 2 experiment conditions. Human voice and fundamental frequency matched instrumental tones served as distracters and piano tone as target. P300 was recorded in 2 experimental conditions. In experiment 1, 68 acoustically different sounds i.e.13 musical instruments and 4 singers at 4 fundamental frequencies were used. Where vocal stimuli and brass instrumental stimuli served as infrequent frequency with a relative frequency of 45% and piano tones were targets with relative frequency 10%. They recorded P300 in 3 scalp distributions Fz, Cz, and Pz. The results showed that significant distinction between greater positive component elicited by human voice compare to instrumental at about 320ms and they attributed the findings could be because of stimulus equiprobability of infrequent. So experiment 2 was carried out. In Experiment 2, same vocal and instrumental stimuli as in experiment 1 was used. Subjective as well as objective probability of the infrequent categories was equal. They used same vocal and instrumental stimuli for the testing. In both the experiment, they found earlier and larger p300 peak and they attributed it may be associated with a human voice-specific to neural process. And they also concluded that Pz location position obtained good morphology waveform and higher amplitude than Cz and Fz position.

Shahin, Bosnyak, Trainor, & Roberts (2003) studied auditory evoked potential (AEP) on pitch discrimination in musician and non-musician subjects. To check the neuroplasticity components of the AEP are enhanced in musicians in accordance with their musical practice. Highly skilled violinists and pianists and non-musician controls listened under conditions of passive attention to violin tones, piano tones, and pure tones matched in fundamental frequency to the musical tones. Compared with non-musician controls, both musician groups evidenced larger N1c (latency, 138 ms) and P2 (latency, 185 ms) responses to the three types of tonal stimuli, enhanced P2 and N1c responses in musicians. Shahin et al (2003) studied auditory evoked potentials in response to pure tones, violin tones, and piano tones in adult and children musicians versus non-musicians. It was found that the P2 evoked response is larger in both the groups' of children and adults who learnt the music then non-musician. Also auditory training enhances this component in musician children and adults with a greater cortical representation if training starts in childhood.Scho, Magne, and Besson (2004) studied pitch processing in music and language (F0) in13 musician children at the age of 8 years with 5 years of musical training and 13 non musician. They used short musical and linguistic phrases with melodically/prosodically congruous or incongruous final word/note. Results showed that adult musicians not only detected variations of pitch in melodic phrases better than non-musicians, but that they also detected variations of fundamental frequency in sentences (linguistic prosody) better than non-musicians.

Van Zuijen et al (2004) did MMN on musician and non-musician who were presented with isochronous tone sequences. Four consecutive tones in a sequence could be grouped according to either pitch similarity or good continuation of pitch. The tone-group length was violated by a deviant tone. Results showed that MMN was only elicited in musicians when the sounds could be grouped according to good continuation of pitch. These results suggest that some forms of auditory grouping depend on musical skill and that not all aspects of auditory grouping are universal. Shahin, Roberts, Pantev, Trainor and Ross (2005) studied auditory evoked potentials N1 and P2 which were modulated by the spectral complexity of musical sounds in pianists and non-musicians. Stimuli three variant of a C4 piano tone equated for temporal envelope but differing in the number of harmonics contained in the stimulus. A fourth tone was a pure tone matched to fundamental frequency of the piano tones. And also electroencephalographic (EEG) and magnetoncephalographic (MEG) recording was done. Results found that P2 amplitude was larger in musician and increased with spectral complexity, but did not differ in N1. They concluded that P2 increases in amplitude due to musical training/practice.

Tervaniemi, Just, Koelsch, Widmann, & Schroger (2005) investigated P3 responses in 13 professional violin players' musicians and age-matched non-musicians. The study was carried out in attentive and reading conditions. The results showed that P3 responses found at the time of attentive listening were of larger amplitude in musicians then non-musicians. In contrast, P3 responses recorded in the reading condition could not be differentiated between musicians and non-musicians. Nikjeh (2006) measured Mismatch negativity (MMN) on instrumentalist and vocalist musicians and psychoacoustic Difference limens for frequency (DLFs) were used to assess pitch perception and production along with pre-attentive and active pitch discrimination between non-musicians and both classes of musicians. Stimulus used was piano tones. Results reported that Pitch perception and production there was no much difference between vocalists and instrumentalists. Pitch production was most reliable within the vocalist group. Pitch perception and production well correlated with instrumental musicians. Vocalists showed minimal inconsistency for both perception and Production. MMN responses signify that vocal musicians and instrumental musicians have higher sensory memory representations.

Musacchia, Strait& Kraus (2008) studied the relationship between evoked potentials and musical experience. They simultaneously recorded brainstem and cortical evoked potentials (EP) in musicians and non-musicians. Because previous studies showed that musician related effects extended to speech and multi-sensory stimuli, the speech syllable /da/ was presented in three conditions; when subjects listened to an auditory stimuli in isolation, when the subjects watched a video of a male speaker saying /da/ in conjunction with the auditory stimulus and when they viewed the video in isolation. The analysis was focused on the comparison of measures of the speech evoked brainstem response that were previously reported being enhanced in musician with well-established measurements of cortical activity (e.g. P1-N1-P2) it was found that recent musical training improves auditory memory and shapes P1-N1 response and encoding of F0. The correlation between electrophysiological and behavioral measures suggests that performance on complex auditory task is related to the strength of the P1-N1 response. The musician performed better on the behavioral tests and showed steeper P1-N1 slopes than non-musician. With regard to evoked potentials thought to arise primarily from cortical structure, musician show enhancements of the P1-N1-P2 complex to in response to pitch, timing, and timber features of music, relative to non-musician (Pantev et.al 2001).

Strait et al (2009) recorded ABR for complex vocal sounds in musician and non - musicians. The acoustic features that contribute to the perception of emotion at the sub-cortical level were analyzed. The results revealed that the encoding of the emotions was superiorly represented in the ABR for the musicians. The study concluded that the experience in music had persistent effects on neural fine tuning of the auditory system. This study also supports that corticofugal system helps to shape the primary auditory cortex, thalamus, and auditory brainstem. This enhancement of processing of vocal emotions would also promote the interface between cognitive and sensory processes. The higher ability for music can extend beyond the domains of language and emotion.

Bidelman, Gandour and Krishnan (2011) recorded the FFR in musician and non-musician which showed a faster and enhanced neural synchronization and enhanced brain stem encoding for defining characteristics of musical sequence regardless of whether they were in or out of tune. Whereas non-musicians had relatively stronger representation for minor/major chords but showed poor responses for detuned ones. A study done by Bidelmanet al (2011) compared auditory evoked responses from brain stem among 11 English and Mandarin Chinese speaking musicians in the age range of 21 to 25 years. 11 non musicians were also considered for the study. The musicians with musical experience of more than 10 years tuned and detuned musical cords. The results showed that musician and native speaker of Mandarin Chinese had enhanced representation of definite pitches of musical sequences at brain stem level in comparison to non-musicians. The authors concluded that long-term experience enhanced the sensitivity to linguistically relevant variations in pitch. Thus, specific language experience changes the FFR in a manner similar to that of music experience.

The benefits of musical training have been studied in pediatric population by many researchers. Chobert (2011) studied MMN in 9-year-old children on passive (as reflected by MMN) and active (as reflected by discrimination accuracy) processing of speech sounds. The author compared the musician and non-musician children wherein they were presented with a sequence of syllables that included standards and deviants in vowel frequency, vowel duration, and VOT. Results showed that both the passive and the active processing of duration and VOT deviants were enhanced in musician compared with non- musician children. No effect was found on the passive processing of frequency, active frequency discrimination was enhanced in musician children. They concluded that training effect from music leads to more abstract phonological representations of speech syllables in children with musical training.

George and Coch (2011) studied the association of music training with improvements in various cognitive (working memory) and linguistic skills using event-related potentials (ERPs) and a standardized test of working memory. ERPs were recorded in standard auditory and visual oddball paradigms, results reveal that behaviorally, musicians out performed than non-musicians on standardized subtests of visual, phonological, and executive memory. Electrophysiologically, musicians demonstrated faster updating of working memory (shorter latency P300s) in both the auditory and visual domains and musicians allocated more neural resources to auditory stimuli (larger amplitude P300), Electrophysiologically, musicians demonstrated faster updating of working memory (shorter latency P300s) in both the auditory and visual domains and musicians allocated more neural resources to auditory stimuli (larger amplitude P300).

Okhrei, Kutsenko, and Makarchouk (2012) investigated P3 in 7 musicians and 10 non-musicians using tonal stimuli which showed that the peak latency of P3 component in the left hemisphere was significantly shorter in musicians then non-musicians. Superior attentive auditory discrimination skills were seen in musicians than in non-musicians. They also observed there was a significant difference in latency between the left and the right hemispheres. Ungan, Berki, Erbil, Yagcioglu, Yüksel, & Utkucal (2013) found dissimilarity among musicians and non-musicians in their skills to identify changes in rhythm. The stimuli used were three equally spaced and consecutive drum beats. The results showed that P3 evoked via rhythm change was significantly enhanced in amplitude and smaller in latency in musicians then in non-musicians. Rabelo, Neves-Lobo, Rocha-Muniz, Ubiali, and Schochat, (2015) investigated P300 amplitude and latency behavioral using contralateral stimulation (noise) in musicians and non-musicians between the age of 20 and 53 years. The results reveal that musicians had shorter latency and higher amplitude than non-musicians. The auditory system of musicians shows a special characteristic in electrophysiological responses due to plasticity from musical practice and training.

The above literature shows musicians have enhanced attentive auditory discrimination skills compared to non-musicians with respect to P300 latencies are shorter (better) and amplitudes larger (better). However, the review of literature on P300 in musician highlights that sensory and/or cognitive advantage of musician seen over and non-musician. And it also showed that musician will have better auditory discrimination skills than non-musician.

2.3 Musical activities enhance the auditory skills

Functional and structural changes due to musical experience take place at various stages of the auditory pathway, from the brainstem(e.g., Wong et al., 2007), to primary and surrounding auditory cortices (e.g., Bermudez et al., 2009; Schneider et al., 2002), to areas involved in higher-order auditory cognition (e.g., Lappe et al., 2008). Music has been used both as an active training protocol and as a stimulus in the context of purely auditory training.

Tremblay and Kraus (2002) recorded P300 in 7 normal-hearing young adults with speech-sound training. Participants were given two synthetic speech variants of the syllable /ba/. When subjects learned to correctly identify the two stimuli, the recording was done Results showed that changes in P1, N1, and P2 amplitudes were observed. Of particular interest is that P1, N1, and P2 components of the N1-P2 complex responded differently to listening training. Significant changes in P1 and N1 amplitude were recorded over the right but not the left hemisphere. In contrast, increases in P2 were observed bilaterally. These results indicate that training-related changes in neural activitydistinct patterns of neural change, reflecting hemispheric specialization.

Schon, Magne, and Besson (2004) studied the effect of extensive musical training on pitch contour processing not only in music but also in language. They manipulated the final notes or words fundamental frequency (F0) tested behavioral and electrophysiological. Musicians and non-musicians were compared. Results revealed that musicians detected weak F0 manipulations better than non-musicians. F0 manipulations within both music and language elicited similar variations in brain electrical potentials, with overall shorter onset latency for musicians than for non-musicians. Scalp distribution of an early negativity in the linguistic task varied with musical expertise, being largest over temporal sites bilaterally for musicians and largest centrally and over left temporal sites for non-musicians. These results are taken as evidence that extensive musical training influences the perception of pitch contour in spoken language.

Fujioka et.al (2006) studied auditory evoked responses in trained musician and untrained children at age 4-6 years using a violin tone and a noise-burst stimulus was recorded. 4 repeated AEPS measurements over a 1-year and also magneto encephalography (MEG) were used over a period of time. Results showed that auditory evoked magnetic fields showed prominent bilateral P100m, N250m, P320m and N450m peaks. Larger P100m and N450m amplitude as well as more rapid change of N250m amplitude and latency was associated with the violin rather than the noise stimuli. Larger P100m and P320m peak amplitudes in the left hemisphere than in the right are consistent with left-lateralized cortical development in musical group. A clear musical training effect was expressed in a larger and earlier N250m peak in the left hemisphere in response to the violin sound in musically trained children compared with untrained children. Whereas in untrained children a similar change was present regardless of stimulus type. This transition could be related to establishing a neural network associated with sound categorization and/or involuntary attention, which can be altered by music learning experience.

Watanabe, Savion-Lemieux and Penhune (2007) studied on musician who began training early trained and later trained before and after the age of 7. The groups were matched for years of musical experience, years of formal training and hours of current practice learning of a timed motor sequence task was given. Results showed that early training musician performed better than late training musicians, early training has its greatest effect on neural systems involved in sensorimotor integration and timing. These findings support that sensitive period in childhood where enriched motor training through musical practice results in long-lasting benefits for performance later in life. These results are also showing structural changes in motor-related regions of the brain in musician that are specifically related to training early in life.

Moreno et al (2009) conducted a longitudinal study on 32 non musician children wherein musical training was given about 9 months to 1year to see if there exists any functional difference between musical training improves non-musical brain function of reading and linguistic pitch processing. Results showed that ERPs shows improvement in pitch not only music also in speech and reading and pitch discrimination abilities in speech. Non musician children were tested again after the 6months of the training using the same tests. This study concluded that short period of 6 months of musical training significantly improves behavior and neural process in brain wave activity.

Kannyo and DeLong (2011) reported that musical training will improve in perceiving changes in pitch, timber, and rhythm across different auditory sequence. The authors studied on quality of musical training and musical experiences in voice, percussion instrument and non-percussion instrument affects musical characteristics of perception. They studied on three groups 0-4 year of experience musicians (13 non musicians); 5-7 years of experience (13 intermediate musicians), and more than 8yrs of experience (13 advanced musicians). The stimuli consisted of pairs of 2.5s sequences of computer generated piano, guitar, flute and saxophone tones that are same stimuli (no change in trails), changed by one musical feature (timber change, rhythm change, or pitch change), and changed by two musical features (timber and pitch change, rhythm and pitch change, or rhythm and timber change) presented through headphones. Results shown that advanced and intermediated musician performed better than non-musician there was no significant difference in musical expertise.

The above literature shows musicians have enhanced attentive auditory discrimination skills compared to non-musicians with respect to P300 latencies are shorter (better) and amplitudes larger (better). However, the review of literature on P300 in musician highlights that sensory and/or cognitive advantage of musician seen over and non-musician. And it also showed that musician will have better auditory discrimination skills than non-musician.

CHAPTER 3

Method

3.1. Research design

To study the objectives of the present study, a mixed design which includes both between-subjects design and within-subjects design (Schiavetti & Metz, 2006) was used. Between-subjects design was used to compare between musician and non-musician on cortical evoked potential P300.Within-subjects design was used to compare the amplitude, and latencies of event related potential components for vocal and violin musical stimuli within each group.

3.2. Participants

A total of 40 participants in the age range of 18 to 40 years were selected for the study. Participants were divided into two groups:

Group I: Trained individual for music, who had under gone musical training for minimum 5years in music (Musician)

Group II: Untrained individual for music (non-musician) who had not under gone any formal musical training (Non-musician).

3.2.1 Participant selection criteria

1. No complaint or history of otological problems, occupational noise exposure or ototoxicity. This was ascertained through a structured interview with the participant. During the structured interview using an informal questionnaire participants‟ music habits were also noted down.

2. Air conduction pure tone hearing thresholds less than or equal to 15 dB HL in both ears at octave frequencies from 250 Hz to 8000 Hz as measured from 35 pure tone audiometry using modified Hughson-Westlake procedure (Carhart & Jerger, 1959).

3. Speech identification scores greater than 90% at 40 dB SL (Ref: average of pure tone hearing thresholds at 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz) as assessed using phonetically balanced word test in Kannada (Yathiraj & Vijayalaksmi, 2005).

4. Normal middle ear functioning as indicated by „A" type tympanogram (Margolis & Heller, 1987).

5. Ipsilateral and contralateral acoustic reflex thresholds within 100 dB HL at 0.5 kHz, 1 kHz and 2 kHz.

The two groups were age and gender matched. Purposive convenient sampling was be used to select the participants.

3.3. Equipments

- A calibrated dual channel clinical audiometer was used for pure tone and speech audiometry.
- A calibrated Immitance meter was used for evaluating middle ear status.
- Intelligent hearing systems (IHS version 4.3.02) AEP system with smart EP software was used for recording and analyzing P300.
- A computer with CSL software to record the music stimuli that was used for P300 potential.

3.4. Testing environment &Procedure

Recording of the stimulus and all the audiological testing was conducted in sound treated rooms where the noise levels are within permissible limits (ANSI. S3.1, 1999). The rooms were also electrically insulated.

Written consent was taken from all participants for their willingness to participate in the study. A routine audiological evaluation was done to check if the participant fulfils the inclusion criteria. Pure-tone thresholds were obtained at octave frequencies between 250 Hz to 8000 Hz for air-conduction and between 250 Hz to 4000 Hz for bone-conduction. Speech recognition thresholds, speech identification scores and uncomfortable level was also be obtained. Immittance evaluation was carried out with a probe tone frequency of 226 Hz for middle ear functioning. Tympanometry was carried out with a probe tone frequency of 226Hz the pressure within the ear canal from +200 to -400 daPa, ipsilateral and contralateral acoustic reflexes thresholds was measured for 500, 1000, 2000 and 4000Hz. Distoration product Otoacoustic emissions was obtained. Stimuli consisted of two pure tone signals of which the frequency ratio 1.20 to 1.22 the L1 and L2 values from 75 to 85dBSPL.

3.5. Administration of the Questionnaire

In order to classify the participants into group I and II the questionnaire "Questionnaire to classify the individuals as with musical and without musical abilities" (Devi et.al 2016) was administered to the participants. Participants with the score range from 16-28 score (mean: 21.45 SD: 3.95) were classified as group I. Participants with the score range from 4-15 (mean: 11.12 SD: 2.6) were classified as group II. Table 3.1 and 3.2 depicts the demographic data of participants with musical abilities including the scores of the ‘Questionnaire to classify the individuals as with musical and without musical abilities that was administered to the participants.

Table 3.1

Demographic data of participants with musical abilities scores for group I participants

Participant	**Age**	**Gender**	**Scores of Questionnaire**
1	23	F	22
2	18	F	26
3	25	F	24
4	20	F	25
5	25	M	30
6	24	F	26
7	19	F	29
8	23	M	28
9	20	M	28
10	24	F	29
11	25	F	24
12	25	F	25
13	19	M	24
14	24	F	27
15	25	F	24
16	19	M	27
17	24	M	26
18	20	F	25
19	23	F	24
20	20	F	26

Table 3.2

Demographic data of participants with musical abilities scores for group II participants

Participant	Age	Gender	Scores of Questionnaire
1	23	F	12
2	18	F	11
3	18	F	10
4	20	M	12
5	20	M	12
6	19	F	14
7	22	M	13
8	25	M	10
9	24	M	11
10	23	F	12
11	18	F	14
12	19	F	15
13	18	F	10
14	23	F	11
15	19	M	12
16	24	M	13
17	23	F	12
18	20	M	15
19	19	F	14
20	19	F	15

3.6 Preparation of stimuli for P300

In order to elicit music evoked cortical response, a basic ra:ga - ma:ya: ma:ḷavagavḷa ra:ga from Carnatic music was taken as the stimulus. It is a shudhmadhyam raga and derived from 15th melakarta ra:ga (Sambamurthy, 1992). A trained violinist who has passed a senior grade in Carnatic music was seated comfortably in a sound treated room played the ma :ya:ma:ḷavagavḷara:ga in a composition where /sa/ and /ga/ notes occurred adjacent to each other. The violinist was instructed to play the ra:gainslow tempo and in rising/sa-ga/ at octave scale. The note transition "/sa/-/ga/" is chosen because the transitions between these two notes are steeper than other notes. Three samples of the ra:gawas recorded using an unidirectional microphone into CSL 4500 model (Kay PENTAX) at a sampling frequency of 48,000 kHz and was saved into a computer. Three experienced violinist was asked to rate the iterations of the stimuli on a 3 point rating scale (good, fair & bad) for quality and its naturalness. A stimulus that receives the highest rating was selected to record ERPs. To record P300, the selected stimuli were edited to contain only /sa/ to /ga/ transition notes. Similarly a trained vocalist who had passed a senior grade in Carnatic music was seated comfortably in a sound treated room and sung a ma :ya:ma:ḷavagavḷara:ga in a composition where /sa/ and /ga/ notes occurred adjacent to each other. The singer was instructed to sing the ra:ga in slow tempo with rising/sa-ga/ pattern& falling /ga-sa/pattern. The note transition "/sa/-/ga/" is chosen because the transitions between these two notes are steeper than other notes. Three samples of the ra:ga was recorded using an unidirectional microphone into CSL 4500 model (Kay PENTAX) at a sampling frequency of 48,000 kHz and was saved into a computer. Three experienced singers were asked to rate the iterations of the stimuli on a 3 point rating scale (good, fair & bad) for quality and its naturalness. A stimulus that received the highest rating was selected to record ERPs. To record P300, the selected stimuli were edited to contain only /sa/ to /ga/ transition notes. Figure 3.1a and 3.1b depicts the waveform of /sa-ga/ vocal and violin music stimuli in rising pattern (slow tempo) used for recording P300respectively 1a and 1b depicts the waveform of /sa-ga/ vocal and violin music stimuli in falling pattern (slow tempo) used for recording P300 respectively.

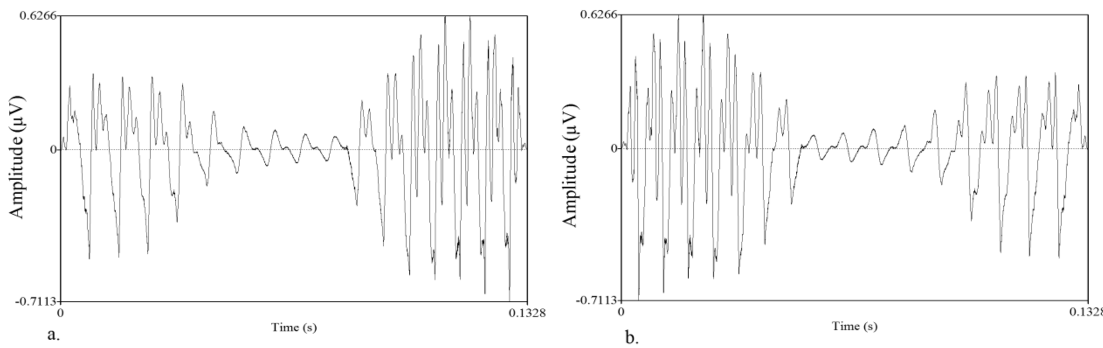


Figure 3.1. Waveform of vocal music stimuli

Figure 3.1.a. depicts the waveform of /sa-ga/ vocal music stimuli in rising pattern (slow tempo) used for recording P300 and 1 b. depicts the waveform of /sa-ga/ vocal music stimuli in falling pattern (slow tempo) used for recording P300.

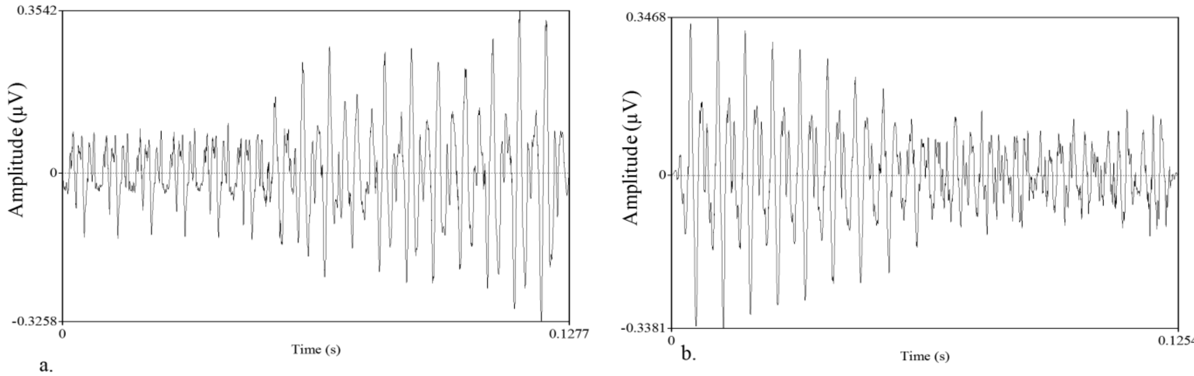


Figure 3.2. Waveform of violin music stimuli

Figure 3.2 a. depicts the waveform of /sa-ga/ violin music stimuli in rising pattern (slow tempo) used for recording P300 and 2 b. depicts the waveform of /sa-ga/ violin music stimuli in falling pattern (slow tempo) used for recording P300.

3.7. Recording of P300 response

The P300 wave is a positive deflection in the human event-related potential. It is most commonly elicited in an "oddball" paradigm when a subject detects an occasional "target" stimulus in a regular train of standard stimuli. The p300 wave only occurs if the subject is actively engaged in the task of detecting the targets. Its amplitude varies with the improbability of the targets. Its latency varies with the difficulty to discriminating the target stimulus from the standard stimuli. Typical peak latency when young adults subjects make a simple discrimination is 300ms.To record P300, the participants were made to sit in a comfortable reclining chair and were asked to relax. The Pz electrode site was cleaned with skin preparation gel and the disc electrodes was placed using a conduction paste. Prior to recording P300, an absolute impedance of less than 5 k Ohms and relative impedance of less than 2 k Ohms were ensured.

The participants were asked to open their eyes and minimize eye blinks of the target EEG to reduce contamination from alpha activity. The stimulus was presented binaurally. The participants were instructed to pay attention to the blocks of stimuli which were presented and to mentally count the infrequent stimulus (/vocalic stimuli/ sa-ga falling and /instrumental stimuli/sa-ga falling) during the auditory presentation mode.

Table 3.3

Summary of the protocol for recording P300

	Stimulus Parameters	
	Frequent	Infrequent
Stimuli	1. /sa-ga/ vocal rising pattern	/sa-ga/ vocal falling pattern
	2. /sa-ga/ violin rising pattern	/sa-ga/ violin falling pattern
	Standard to deviant ratio	4 to 1 (80:20)
	Transducer	Insert
	Ear	Binaural
	Intensity	60 dB HL
	Repetition rate	1.1/s
	Acquisition Parameters	
	Electrode locations	Pz – Non inverting Nose tip - Inverting (Reference) Fpz- Ground
	Others	Occular (vertical montage)
	Total number of trials	500
	Analysis time	-100 ms to 700 ms
	Filter setting	1-30 Hz
	Amplification	25,000
	Number of sweeps	100
	Stimulus duration	130ms for both vocal and violin stimuli

3.8. Response analysis

The P300 responses were identified in each participant, for each stimulus paradigms and the response were analyzed for peak amplitude and latency. Average waves recorded for the frequent and infrequent stimuli were compared. The response were analyzed visually and by two experienced in the field of electrophysiology for 3years and were asked to mark P300 responses.

CHAPTER 4

Results

The primary aim of the present study taken up was to investigate the neural encoding of P300 for vocal and violin (instrumental) musical stimuli in musician and non-musician. Amplitude and latency of P300 were dependent variables, and vocal stimuli and violin stimuli served as independent variable. Forty individuals were assigned to two groups, one with musical ability as group I (musicians) and another without musical ability as group II (non-musicians) based on "Questionnaire to classify the individuals as with musical and without musical abilities". To study the auditory processing abilities of both the groups of participants, the cortical evoked potential P300 was recorded.

Waveform Analysis

The cortical response P300 was considered as that with the large positive peak trough in the latency range of the 250-400ms and amplitude greater than -0.3μV. To analyse the data on P300 collected from both the group of participants, the response waveform that was obtained for frequent stimuli was visually compared with the response waveform of the infrequent stimuli. On comparison, the waveform response for the infrequent stimuli that had a positive peak around 250-400ms was considered as P300. Further two experienced Audiology in the field of Electro physiology was asked to mare the amplitude and latency of P300 responses from the obtained waveforms.

Statistical Analysis

Intelligent hearing system (IHS) software and Statistical package for social sciences (SPPS) software version 17 was further used for the analysis of the obtained response data. Shapiro-Wilks test of normality was administered. As indicated by the normality test, the obtained data for P300 with regard to amplitude and latency were normally distributed ($p>0.05$). Hence, further analyses were carried out using parametric test. Among 40 participants, the data of two participants were outliers hence the data of those two participants were excluded for further analysis.

The outcomes of the analysed data are explained under the following:

1. Comparison of amplitude of P300 responses between Group I and Group II of participants for vocal music stimuli.
2. Comparison of latency of P300 responses between Group I and Group II of participants for instrumental music stimuli.
3. Comparison of the latency and amplitude between vocal and instrument evoked P300 within group

Descriptive statistics (mean and standard deviation) are reported for all the measurements.

4.1. Comparison of amplitude of P300 responses between Group I and Group II of participants for vocal music stimuli and violin music stimuli.

The amplitude and latencies of P300 that were obtained were analysed separately between groups and within groups for vocal and music stimuli.

4.1.1 Comparison of amplitude of P300 for vocal stimuli between two groups of participants

Descriptive statistics was done and the mean and standards deviation (SD) for amplitude of P300 are given in table 4.1 for the both the groups of participants for vocal stimuli.

Table 4.1

Mean and SD for amplitude of P300 for vocal stimuli between group 1 and group2

Groups	Mean	Standard deviation
Group I	3.02	1.21
Group II	1.97	0.99

From table 4.1 it can be inferred that group I participants had higher amplitude of P300 than group II participants for vocal stimuli.

4.2 Comparison of amplitude of P300 for violin stimuli between two groups of participants

Descriptive statistics was done and the mean and standards deviation (SD) for amplitude of P300 are given in table 4.2 for the both the groups of participants for vocal stimuli.

Table 4.2

Mean and SD of amplitude of P300 for violin stimulus between group 1 and group2

Groups	Mean	Standard deviation
Group I	2.73	0.68
Group II	2.15	1.21

From table 4.2 it can be inferred that group I participants had higher amplitude of P300 than group II participants for vocal stimuli.

Further mixed ANOVA (Analysis of Variance) was done to compare between groups and within group if difference any. The results revealed there was main effect of the group, [F (1, 36)=12.21; p <0.05; 2=0.2532], no significant main effect of the stimuli [F (1, 36)=0.055; p <0.05; 2=0.002] and no significant interaction between group and type of stimuli F (1, 36)=0.912; p <0.05; 2=0.25]. The below figure 4.1 depicts the mean amplitude of P300 for both the groups of participants for vocal and violin music stimuli.

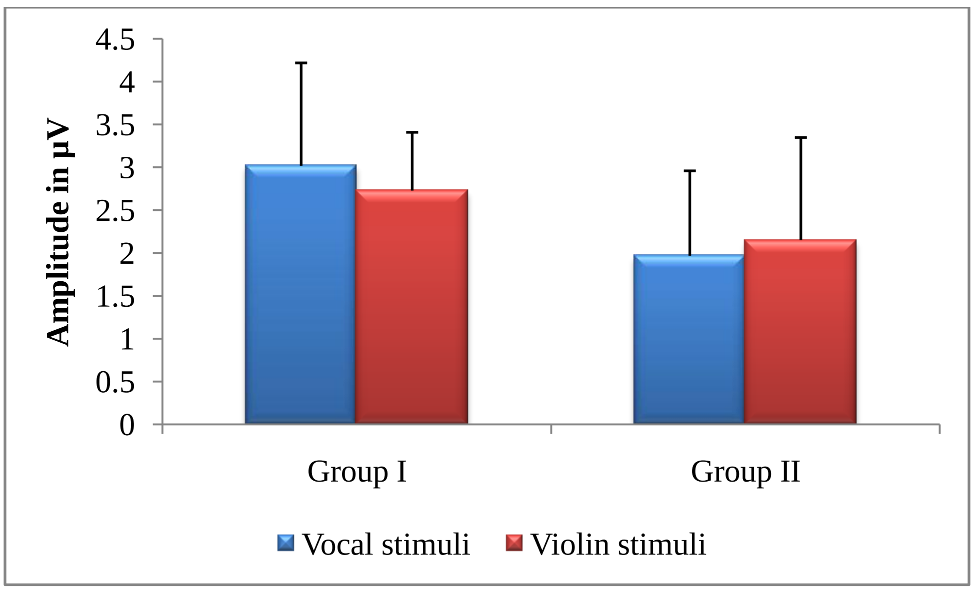


Figure 4.1. Mean amplitude of P300 for both the groups of participants for vocal and violin music stimuli.

4.3 Comparison of latency of P300 responses between Group I and Group II of participants for vocal music stimuli and violin music stimuli

The latencies of P300 that were obtained were analysed separately between groups and within groups for vocal and music stimuli.

4.3.1 Comparison of latency of P300 for vocal stimuli between two groups of participants

Descriptive statistics was done and the mean and standards deviation (SD) for latency of P300 are given in table 4.3 for the both the groups of participants for vocal stimuli.

Table 4.3

Mean and SD for latency of P300 for vocal stimuli between group 1 and group2

Groups	Mean	Standard deviation
Group 1	340.7	37.7
Group 2	349.2	41.0

From table 4.3 it can be inferred that Group I participants had marginally earlier latency of P300 compared to Group II for vocal stimuli.

4.3.2. Comparison of latency of P300 for violin stimuli between two groups of participants

Descriptive statistics was done and the mean and standards deviation (SD) for latency of P300 are given in table 4.4 for the both the groups of participants for vocal stimuli.

Table 4.4

Mean and SD for latency of P300 for violin stimuli between group 1 and group2

Groups	Mean	Standard deviation
Group 1	333.63	37.1
Group 2	341.31	38.3

From table 4.4, it can be inferred that Group I participants had marginally earlier latency of P300 compared to Group II for violin stimuli.

Further mixed ANOVA (Analysis of Variance) was done to compare the latencies of P300 between groups and within group if difference any. The results revealed there was main effect of the group, [F (1, 36)=0.634; p >0.05; 2=0.017], no significant main effect of the stimuli [F (1, 36)=1.054; p >0.05; 2=0.002] and no significant interaction between group and type of stimuli F (1, 36)=0.003; p >0.05;2=0.00. The below figure 4.2 depicts the mean latency of P300 for both the groups of participants for vocal and violin music stimuli.

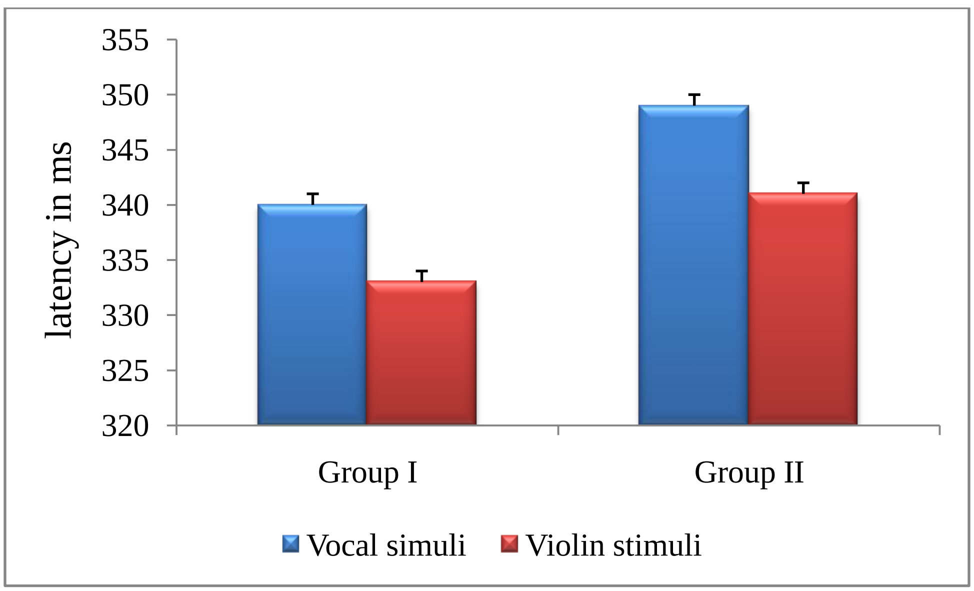


Figure 4.2. Mean latency of P300 for both the groups of participants for vocal and violin music stimuli

The below figure 4.3 (a, b) represents a P300 response waveforms elicited for of one participant from group I and II respectively for vocal stimuli.

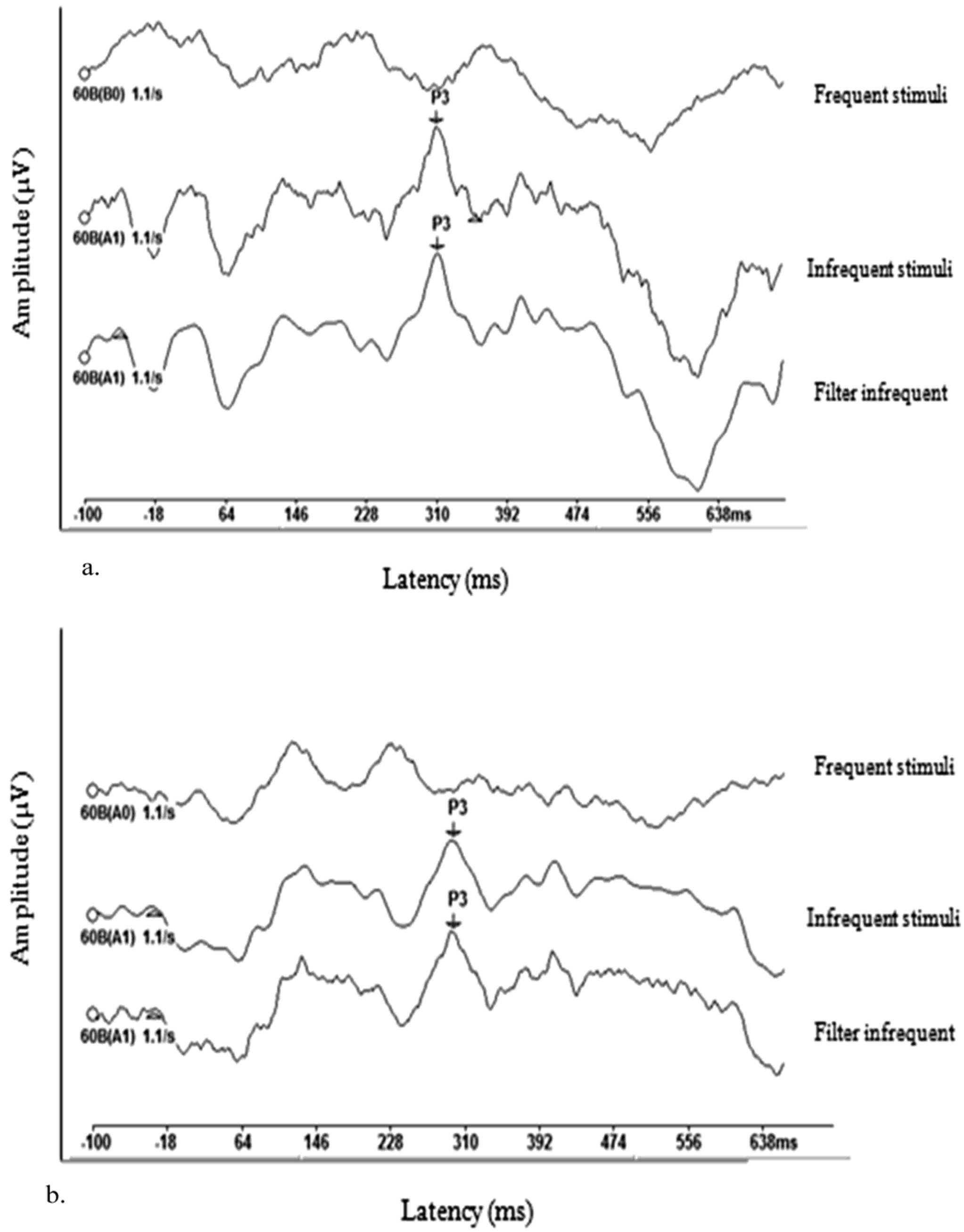
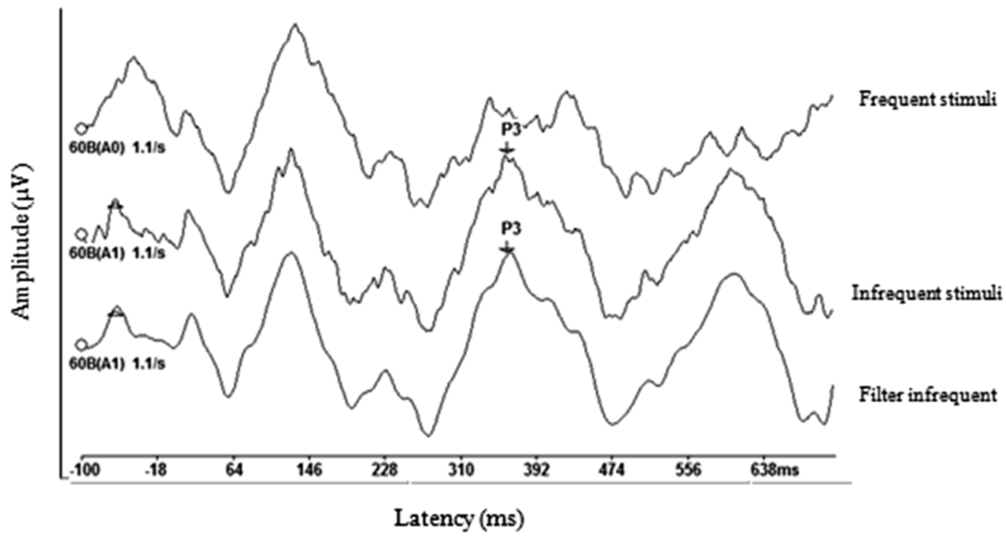
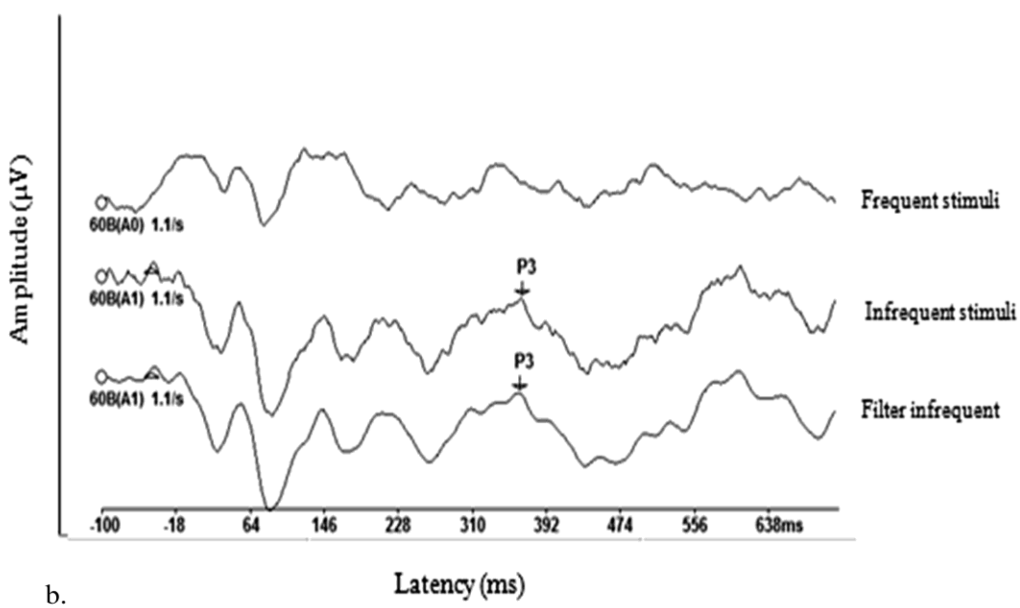


*Figure 4.3*P300 response waveforms elicited for of one participant of each group respectively for vocal stimuli.

The figure 4.4 (a, b) represent P300 data of a single participant for group I and group II respectively for vocal stimuli. In figure the A0 waveform represents response obtained for vocal stimuli in frequent paradigm, A1 waveform represents response obtained for vocal stimuli in infrequent paradigm and A1 waveform represents filter infrequent. Similarly the below figure 4.4 (a, b) represents a P300 response waveforms elicited for of one participant of each group respectively for violin stimuli.



a.



b.

*Figure 4.4.*P300 response waveforms elicited for of one participant of each group respectively for violin stimuli.

The figure 4.4 (a, b) represent P300 data of a single participant for group I and group II respectively for violin stimuli. In figure the A0 waveform represents response obtained for violin stimuli in frequent paradigm, A1 waveform represents response obtained for violin stimuli in infrequent paradigm and A1 waveform represents filter infrequent.

CHAPTER 5

Discussion

The present study aimed at comparing the amplitude and latency of P300 between musician and non-musician for vocal and violin stimuli the results were discussed under three objective of the study.

5.1 To compare the latency and amplitude of P300 responses between (musician and non-musician) for vocal and violin stimuli

5.1.1 Amplitude results for vocal stimuli and violin stimuli

The neural processing was assessed for attentive and auditory discrimination for musical stimuli /sa-ga/ rising and falling pattern. Rising as frequent and falling as an infrequent. For target infrequent stimuli the waveform responses had larger positive peak in 300ms region called P300**.**

The present study results revealed there was significant difference between group I and group II. Group I had higher amplitude than group II. Hence, the hypothesis that was put forth that there is no significant difference in the amplitude of P300 responses between musicians and non-musicians is rejected. This finding suggests that neural processing for the music stimuli are well discriminated by group I than group II. There could be musician auditory system well tune to categorize and discriminate the finer tempo, pitch and intensity with training. Levett and Martin (1992) had also reported that musician found that Musician got larger amplitude than non-musician for on-going musical context as musical stimuli. Musician use additional processing to a greater extent than non-musician because of experience. Another study also supports that using sine tones as stimuli. Wayman, Frisina, Walton, Hantz and Crummer (1992) used sine tone to evoke P300 and found that musician with good pitch subjects showed significantly larger P3 amplitude than the musicians or non-musicians. They concluded that AP subjects do exhibit P3 ERPs, however the differences in neural activity between the musicians and AP subjects were not due to musical training. The persons with the AP might have superior auditory sensitivity at cortical levels or use unique neuropsychological strategies when processing tones. Hantz, Crummer, Wayman, Walton and Frisina (1992) reported a contrast study to that of previous study where Absolute pitch ability had reduces the amplitude and or eliminate P3 altogether in the entire task. The study concluded long-term memory strategy involved in the correct discrimination task rather than performing the task by updating working memory each time a target occurs. Hirose, Kubota, Kimura, Ohsawa, Yumoto and Sakakihara (2002) reported that participants with Absolute pitch with musician exhibited similar P300 as the non-AP possessors and did update the tonal context in the auditory oddball tasks. The result suggests that the AP possessors do not always refer to the fixed tonal template in their memories when executing the oddball tasks and they employ working memory properly according to the difficulty of the auditory tasks.

Besson, Faita and Requin (1994) reported that musicians are faster than non-musicians in detecting the short musical stimuli phrases as infrequent stimuli. And better amplitude for musician, due to the different neurophysiological mechanism for perception of music and linguistic processing. These findings were also similar to those reported in Crummer, Walton, Wayman, Hantz, & Frisina (1994) where its reported that

P3 amplitudes which were larger for different instrumental stimulus were used in musician and non-musician. These findings suggest that perceptual tasks elicit differential brain activity for memory or information processing systems for subjects with varying degrees of musical training.

Trainor, Desjardins and Rockel (1999) revealed that in musicians largest frontal P3a (attention) and P3b was observed. In contrast the contour task did not differ in both groups (musician and non-musician) where as in interval task smaller and responses were seen in non- musician. The study concluded that topologies were similar for P3a and P3b in both groups P3b in musician negatively correlated with the age of the onset of music lessons. And also suggest that contour processing are better and interval processing are more affected than contour due to experience, and similar brain network are involved in generating the P3a and P3b in musicians and non-musicians. Levy, Granot and Bentin (2001) found that significant difference using human voice and different instrumental stimuli as a frequent, and piano tones were infrequent, earlier and larger P300 peak were obtained and it may be associated with a human voice-specific to neural process. Steinbeis, Koelsch and Sloboda (2006) study reveals that higher P3 component in response to the much unexpected harmonies, which was considerably larger for musicians and may reflect the processing of stylistic violations of Western classical music training effect. Fujioka et al (2006) trained musician children showed larger P320m peak amplitudes for violin tone than a noise-burst stimulus. A clear musical training effect was expressed in larger amplitude. Okhrei, Kutsenko, and Makarchouk (2012) P3 component in the left hemisphere was significantly higher amplitude in musicians for tonal stimuli and reported that it’s because of superior attentive auditory discrimination skills and neurophysiological mechanism in musicians. Ungan, Berki, Erbil, Yagcioglu, Yüksel, & Utkucal (2013) reported that rhythm change was significantly enhanced in amplitude in musicians Stimuli used were three equally spaced and consecutive drum beats. Data strongly supported that sensory and cognitive advantage of musicians in detecting rhythm changes does reflect in their P3.

Tervaniemi, Just, Koelsch, Widmann, & Schroger (2005) found that time of attentive listening were of larger amplitude in violinist musicians than non-musicians. In contrast, P3 responses recorded in the reading condition similar for both group this results and not necessarily already at their pre-attentive levels. All the above reports are concurrent with that of are present study. However the present study in the first one to be to be reported with Indian music stimuli. However further more investigation are required for other musical research.

5.1.2 Latency results for vocal stimuli and violin stimuli

The present study results shows there is marginal mean difference in latency between Group I and Group II. Group I had earlier latency than group II for the both musical stimulus. But there was no statistical significant difference between the both groups**.**Hence, the hypothesis that there is no significant difference in the latency of P300 responses between musicians and non-musicians is accepted.

The finding of the current study contrasted finding by Wayman, Frisina, Walton, Hantz and Crummer (1992).The P3 latency was shortest for the AP subjects, and was longest for the musician and non-musicians. Performance scores were uniformly high in all three groups. It is concluded that AP subjects do exhibit P3 ERPs, shorter latencies.

The differences in neural activity between the musicians and AP subjects were not due to musical training. Crummer, Walton, Wayman, Hantz, & Frisina (1994) investigated P3 component in musicians and non-musicians. The instrumental stimulus used were three timbers with same pitch (cello, viola string, flutes, instrument slightly different in size) and results showed that P3 that mean P3 latencies for the musicians were shorter in all series than mean P3 latencies for non-musicians which was attributed to training effect. Besson, Faita and Requin (1994) reported that musicians are faster than non-musicians in detecting incongruities. This study provides further neurophysiological evidence mechanisms underlying music perception and the differences between musical and linguistic processing. Fujioka et al (2006) reported in children which showed earlier P300 latencies for violin tone than a noise-burst stimulus. A clear musical training effect was evidenced to. Whereas in untrained children a similar change was present regardless of stimulus type. Okhrei, Kutsenko, and Makarchouk (2012) also observed there was a significant difference in latency between the left and the right hemispheres. Left hemisphere of musician were significantly shorter than those in non-musician and also says there is no interhemispheric difference of latencies asymmetry was obvious in non-musician. Ungan, Berki, Erbil, Yagcioglu, Yüksel, & Utkucal (2013) smaller in latency in musicians then in non-musicians. Stimuli used were three equally spaced and consecutive drum beats P3 data supports that sensory and cognitive advantage of musician to detecting rhythm changes. Rabelo, Neves-Lobo, Rocha-Muniz, Ubiali, Schochat, (2015) showed that musicians had shorter latency than non-musicians for contralateral stimulation (noise) stimuli. The auditory system of musicians shows a special characteristic in electrophysiological responses due to plasticity from musical practice and training.

Bishop (2007) reported that latency measures are not reliable in cortical potential reported that amplitude measures are more reliable than latency and most studies (Nager et al.,2003;Tervaniemi et al., 2006; Marie et al.,2012) have reported only amplitude measures. In the present study also there was no significant difference in latency of P300, the reason of not getting significant difference in latency between musician and non-musician in the present study may be due to poor reliability and high variability in latency measure of P300. However, larger number of participants might be required to validate the present findings.

5.2 To compare the latency and amplitude of P300 responses between vocal and instrument evoked P300 within musician group

Within groups, there was no significant difference between peak amplitude and latency for vocal and violin stimuli. The hypothesis that there is no significant difference in the latency and amplitude and latency of P300 responses within musicians and non-musicians for vocal stimuli and violin is accepted. However, just by the mean the vocal amplitude is slightly higher than violin amplitude and latency. However, there are contradicting studies. Levy Granot, and Bentin (2001) which had reported that significant difference using human voice and different instrumental stimuli. The P300 component elicited for human voice was larger in amplitude compared to instrumental at 260- 320ms which could be associated with a human voice-specific to neural process. However, Nikjeh (2006) reported of MMN findings that Pitch perception and production there was no much difference between vocalists and instrumentalists. Pitch production was most reliable within the vocalist group. Pitch perception and production well correlated with instrumental musicians. Vocalists shown minimal inconsistency for both perception and production.

The lack in the number of studies and Literature supports on using musical stimuli. The some of the studies were done in western stimuli and western population on cortical potential studies.

CHAPTER 5

Summary and conclusion

The present study was carried out to find whether neural coding difference exists between musician and non-musician using music stimuli. The objective the study was to investigate the difference in amplitude and latency of P300 in musician and non-musician. The P300 was recorded in two groups of participants (group I and group II) in the age range of 18-40 were involved in the study. Group I are those who had gone musical training and had minimum of 5 years of experience and those with no formal training served as group II. 40 individuals were grouped into musician and non-musician based on the questionnaire “Questionnaire to classify the individuals as with musical and without musical abilities”.Participants with the score range from 16-28 score (mean: 21.45 SD: 3.95) were classified as Group I. Participants with the score range from 4-15 (mean: 11.12 SD: 2.6) were classified as Group II (Devi et al, 2017).

The P300 was recorded using musical stimuli consist of vocal and instrumental (violin) stimuli. A basic ma:ya:ma:ḷavagavḷa ra :ga was played and sung by trained violinist and vocalist /sa-ga/ raising /ga-sa/ falling following P300 were recorded with pair of musical stimuli. The pair was having /sa-ga/ rising frequent /ga-sa/ falling have infrequent stimuli in vertical montage with Pz positive electrode reference to the tip of nose. Stimuli were presented in oddball paradigm with probability of 80% frequent and 20% infrequent at 70dbNHL respectively. The identification of P300 on visual detection criteria has been used. The different measure of P300 latency and amplitude were measured in both the groups. To analyse the waveform, two individual experienced in the field of electrophysiology for three years were asked to mark P300 responses.

The results revealed there was significant difference in amplitude between group I and group II. The group I had higher amplitude for vocal and violin stimuli than non-musician. The group I were found to have better categorization perception and better neural synchrony than group II, There was no significant difference between latency in group I and group II for both stimuli. Within group there was no significant difference in amplitude and latency. For vocal and violin stimuli the findings are in agreement with earlier studies that precede the present study, but with different stimuli which was used to evoke P300. It adds to growing literature on the effects of musical training on neural plasticity and neural representation of signal at cortical level.

Clinical implications

- Musical ability of an individual would be an useful tool for prediction of outcome of musical training.
- Auditory training strategies can be modified based on the findings.
- Musical training can be used to enhance attentive and auditory discrimination skills in clinical population i.e central auditory processing disorder, learning disability, slow learners, phonological disorder, schizophrenia, Alzheimer's diseases children with developmental language disorder and children with cochlear implant.
- Enhancement of auditory discrimination due to musical training in this population improves in speech perceptions.

Future directions

- Study could be extended to different group of populations i.e central auditory processing disorders
- Study could be done using other music variants.
- Comparison can be also be done between speech stimuli and musical stimuli

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