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Original Research Article

Pitch Coding in Vocalists and Non Musicians to Carnatic Music Stimuli: A Frequency Following Response (FFR) Study

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ABSTRACT

Objective: The current study investigates pitch coding among Vocalists and Non Musicians for Carnatic Music stimuli.
Method: Two groups of participants were included in the study. First group consisted of 15 trained Carnatic Vocalists in the age range of 18-45 years while the second group consisted of 15 Non musicians. Two types of stimuli were recorded. The first stimulus consisted of three notes of a Carnatic raga (S R2 G3) sung by a trained vocalist. The second stimulus consisted of three notes of a Carnatic raga (S R2 G3) played on violin by a trained violinist. Frequency following responses (FFR) was recorded binaurally at 80dBSPL for both stimuli using neuroscan equipment.
Results: Grand average responses of all participants were generated. To assess participants pitch tracking to the Carnatic music stimuli, stimulus to response correlation, pitch strength and pitch error were calculated. Results revealed that Vocalists had better stimulus to response correlation and pitch strength values with lower pitch error values than non musicians for both vocal and instrumental stimuli. Within the Vocalist group, superior performance was noticed for vocal stimulus compared to instrumental stimuli. No such preference was evident amongst the non musicians.
Conclusions: Classical music training leads to better representation of pitch in the auditory brainstem.

Keywords: Frequency following response, Vocalists, Carnatic music

INTRODUCTION

The frequency following response (FFR) offers a reliable and objective method to study the neural encoding of pitch at the brainstem level. It preserves the spectral and temporal aspects of the original stimulus such as the fundamental frequency. This helps in comparing the frequency components of the stimulus to that of FFR. [1] FFR's have been recorded in literature using pure tones and masked tones, [2] English and Mandarin speech syllables, [3] words, [4] musical notes, [5] and emotionally salient vocal sounds. [6]

Brainstem encoding of complex signals such as music and speech are known to be affected by listener experience, perceptual ability and linguistic experience. For example, in native mandarin speakers there is better representation of F0 on FFR, probably as a result of them requiring to use F0 contour for lexical representation in everyday situations. [7] Likewise, musicians also show better representation of F0 for speech sounds, [8] non native linguistic F0 contours [9] and emotionally salient vocal sounds [6] when compared with non musicians. While extensive research has been carried out on FFR using western musical stimuli, limited studies have focussed on Indian classical music stimuli (Vocal and instrumental). Devi and Ajith [10] recorded FFR to 127 msec Carnatic music transit stimuli. They found higher Pitch Strength (PS), lesser Pitch Error (PE) and better Stimulus to Response Correlation (SRC) in non musicians with musical aptitude than those without musical aptitude. However, studies using musicians as participants, longer duration musical stimuli as well as using both vocal and instrumental Carnatic Music as stimuli needs to be explored. The current study is an attempt to add data in this area.

Indian Classical music has two main branches; the Carnatic and the Hindustani. While the Hindustani music branch is practiced in northern part of India, its counterpart, the Carnatic Music branch is practiced in the southern regions of India. Its elements include Shruthi, Swara, Raga and Tala which forms the basis for composition of musical note sequence for a particular rendition. Musical rendition in Carnatic style involves a small ensemble of musicians, consisting of a vocalist, a melodic accompaniment (probably a violin), a rhythm accompaniment (probably a mridangam), and a tambura, which acts as a drone throughout the performance. Vocalist is the lead performer as well as de facto conductor. Instrumentalists often follow the lead of vocalist.

Aim of the study

The aim of the study was to investigate brainstem encoding of pitch among Vocalists and Non Musicians using Carnatic Vocal and Instrumental Music as the stimuli and compare the results.

The major objectives of the study include

a) To investigate encoding of pitch for three notes of the mo:hana ra:ga (S R2 G3) in Arohana in vocalists for vocal and instrumental stimulus
b) To investigate encoding of pitch for three notes of the mo:hana ra:ga (S R2 G3) in Arohana in non musicians for vocal and instrumental stimulus
c) To compare encoding of pitch for three notes of the mo:hana ra:ga (S R2 G3) in Arohana in vocalists and non musicians for vocal stimulus
d) To compare encoding of pitch for three notes of the mo:hanara:ga (S R2 G3) in Arohana in vocalists and non musicians for instrumental stimulus

METHOD

Participants

A total of 30 participants in the age range of 18-45 years were considered for the purpose of the study. Purposive sampling was used to select the participants. The participants were divided into two groups. First group of participants consisted of 15 trained Carnatic Vocalists (Mean= 23.33 years, SD= 3.53). All Vocalists had cleared junior grade examinations in Carnatic vocal and had 5 years and above experience in Carnatic Vocal music. The vocalists practiced for 2-4 hours per day. The mean duration of formal music training initiation was 9.13 years (SD=4.9 years). The Second group of participants consisted of 15 Non Musicians (Mean= 28.06 years, SD= 4.95). The non musicians had no prior training in Carnatic Vocal music. All participants had bilateral normal hearing sensitivity (Pure tone Air and Bone conduction thresholds within 15dBHL at octave frequencies from 250Hz to 8 kHz and 250 Hz to 4kHz respectively) and no history of otological, neurological problems or noise exposure. All participants had speech identification scores of 90% and above. Absence of any middle ear problems at the time of FFR recording was ascertained with Impedance testing. Bilateral 'Á' type tympanogram with presence of ipsilateral and contralateral reflexes were obtained in all participants. Informed written consent was taken from all participants prior to conducting the study in accordance with the ethical guidelines of the institute where the participants were tested. An informal questionnaire was used to document the education, lifestyle, musical history and medical history of the participants.

PROCEDURE

The study was carried out in two phases. Phase I was related to Carnatic music stimulus preparation while Phase II involve FFR recording to the Carnatic music stimuli.

Phase I – Two types of stimulus were recorded, vocal and instrumental. To record the Carnatic vocal stimulus, a female vocalist trained in Carnatic music sang all the notes of the mo:hanara:ga in Arohana (ascending scale) accompanied by the vowel /a/ (Alapana) in her base pitch. The mo:hana raga is a composition using only five notes (S R2 G3 P D2) of total seven notes. It is a symmetric pentatonic scale. The recording was carried out in a sound treated room using a sensitive microphone and MOTU MICROBOOK II external sound card interface connected to a laptop. Adobe Audition Software was used for the recording purposes. The stimulus was recorded at a sampling rate of 44100Hz. Multiple stimulus tokens were recorded. From the raga, the first three notes (S R2 G3) were extracted for the purpose of the study. The duration of the token was 393msec. A total of 5 tokens were shortlisted based on quality. These 5 tokens were subjected to goodness of fit test by asking 5 experienced vocalists to rate these tokens on a 5 point rating scale based on their naturalness and quality. The highest rated token was selected for the purpose of the study. The pitch contour varied from 241 Hz to 311Hz across the three notes.

For the instrumental stimulus a trained violinist listened to the vocal stimulus recorded earlier. He was then asked to play the violin in such a way that it matched the vocal stimulus as closely as possible with respect to pitch and tempo. The violinist played all the notes of the mo:hanara:ga (S R2 G3 P D2). Using the same procedure as that for vocal, 5 tokens of the first three notes (S R2 G3) were extracted and subjected to goodness test. The highest rated token was selected for the purpose of the study. The pitch contour varied from 241 Hz to 310 Hz across the three notes. The duration of the token was 393msec. Both the vocal and instrumental stimuli were matched with respect to pitch contour and duration.

Phase II - Recording of FFR to music stimuli

All participants were educated about the test procedure. They were instructed to sit on a reclining chair and minimize their body and head movements as much as possible. They watched a muted video with subtitles. The FFR was recorded using Neuroscan equipment (Compumedics, USA). The responses were recorded separately to vocal and instrumental Carnatic stimulus for an 80dBSPL sound presented binaurally using electrically shielded insert earphones to electrodes placed on Nape of neck (C7, inverting), Cz (Vertex, non inverting) and low forehead (ground). The electrode impedances were less than 5k ohms for all participants. The participants heard a total of 2000 sweeps for each of the two stimuli (vocal and instrumental) in alternating polarity to reduce stimulus artifact.

The stimuli were presented through the sound module of Stim 2 (Compumedics, USA). The interstimulus duration (calculated from offset to onset) was 135msec and the stimuli presentation (Vocal and Instrumental) was randomized across participants. Continuous electrophysiological data were collected at a sampling rate of 20,000Hz using a Synamps 2 amplifier. The collected data for Carnatic vocal and instrumental stimuli was subjected to offline data pre-processing which consisted of artifact rejection (±35μV), filtering (80–1800Hz), epoching, and averaging using Curry 7. Grand average responses of all participants in the two groups were generated separately for Carnatic vocal and instrumental stimuli.

Data analysis - The data were analysed using Brainstem toolbox, Version 2013 (Skoe, Nicol& Kraus, 2013) in Matlab™ (Version 7.3). To assess the participants pitch tracking to the Carnatic vocal and instrumental music stimuli, three parameters were considered; Stimulus to Response correlation (SRC), Pitch Strength (PS) and Pitch Error (PE). SRC measures the extent of similarity between stimulus and response F0 contours using Pearson's 'r' value. The analysis uses a short-time running autocorrelation technique wherein the response chopped into 40-ms chunks, is successively time-shifted with a delayed ("lagged") version of itself (in 1 ms steps) and a Pearson's r is calculated at each 1-ms interval. PS refers to the strength of relationship. PE measures the deviation of response in Hz from stimulus pitch on an average.

Statistical analysis: Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 20 (IBM Corp., Armonk, NY, USA). Descriptive statistics including mean and SD were calculated for musicians & non musicians for the two stimuli (Vocal vs instrumental) and three parameters; Pitch error, Pitch strength and stimulus to response correlation. Both within group and between group comparisons were carried out. The results will be discussed in the following categories

Comparison of pitch coding between vocalists and non musicians for vocal and instrumental stimulus

Fig 1 represents the mean values between vocalists and non musicians for the parameters of Pitch Strength (PS), Pitch error (PE) and Stimulus response correlation (SRC) for vocal and instrumental stimulus. Test of normality and Levene's test of homogeneity were carried out prior to ' t' test. Independent t- test was done to compare the mean PE, PS and SRC between the two groups of participants for vocal and instrumental stimuli. For Vocal stimulus, a significant difference for PE [t (28) = -5.93, p<0.001, ηp^2 = -1.58], PS [t (28) = 6.42, p<0.001, ηp^2= 1.71] and SRC [t (28) = 5.49, p<0.001, ηp^2= 1.64] was observed between the two groups of participants. With Instrumental stimulus, the results revealed a significant difference for PE [t (28) = -6.75 (p<0.001, ηp^2= -1.32], PS [t (28) = 4.78, p<0.001, ηp^2= 0.86] and SRC [t (28) = 4.95, p<0.001, ηp^2 =1.09] between the two groups of participants.

Comparison of pitch coding within vocalists for vocal and instrumental stimulus

For vocal stimuli, the mean PE was 7.94 (SD=2.82), PS was 0.44 (SD=0.15) and stimulus-to-response correlation SRC was 0.82 (SD=0.13). For the instrumental stimuli, the mean PE was 15.18 (SD=4.29), PS was 0.13 (SD=0.11) and SRC was 0.62 (SD=0.17). Paired 't' test was carried out to determine if statistically significant difference exists within the group for the two stimuli . The results revealed a significant difference for PE [t (14) = -6.0, p<0.001, ηp^2=-1.60], pPS [t (14) = 6.09, p<0.001, ηp^2=1.62] and SRC [t (14) = 3.67, p<0.005, ηp^2=0.98] for vocal stimulus over instrumental stimulus.

Comparison of pitch coding within non musicians for vocal and instrumental stimulus

For vocal stimuli, the mean PE was 25.87 (SD=11.36), PS was 0.02 (SD=0.20) and SRC was 0.17 (SD=0.44). For the instrumental stimuli, the mean PE was 30.21 (SD=7.47), PS was -0.08 (SD=0.13) and SRC was 0.20 (SD=0.28). Paired 't' test was carried out to determine if statistically significant difference exists within the group for the two stimuli . The results revealed no significant difference for PE [t (14) = -1.56, p>0.005, ηp^2=-.42], PS [t (14) = 2.20, p>0.005, ηp^2=0.58] and SRC [t (14) = -0.16, p>0.005, ηp^2=-0.04] for vocal stimulus over instrumental stimulus.

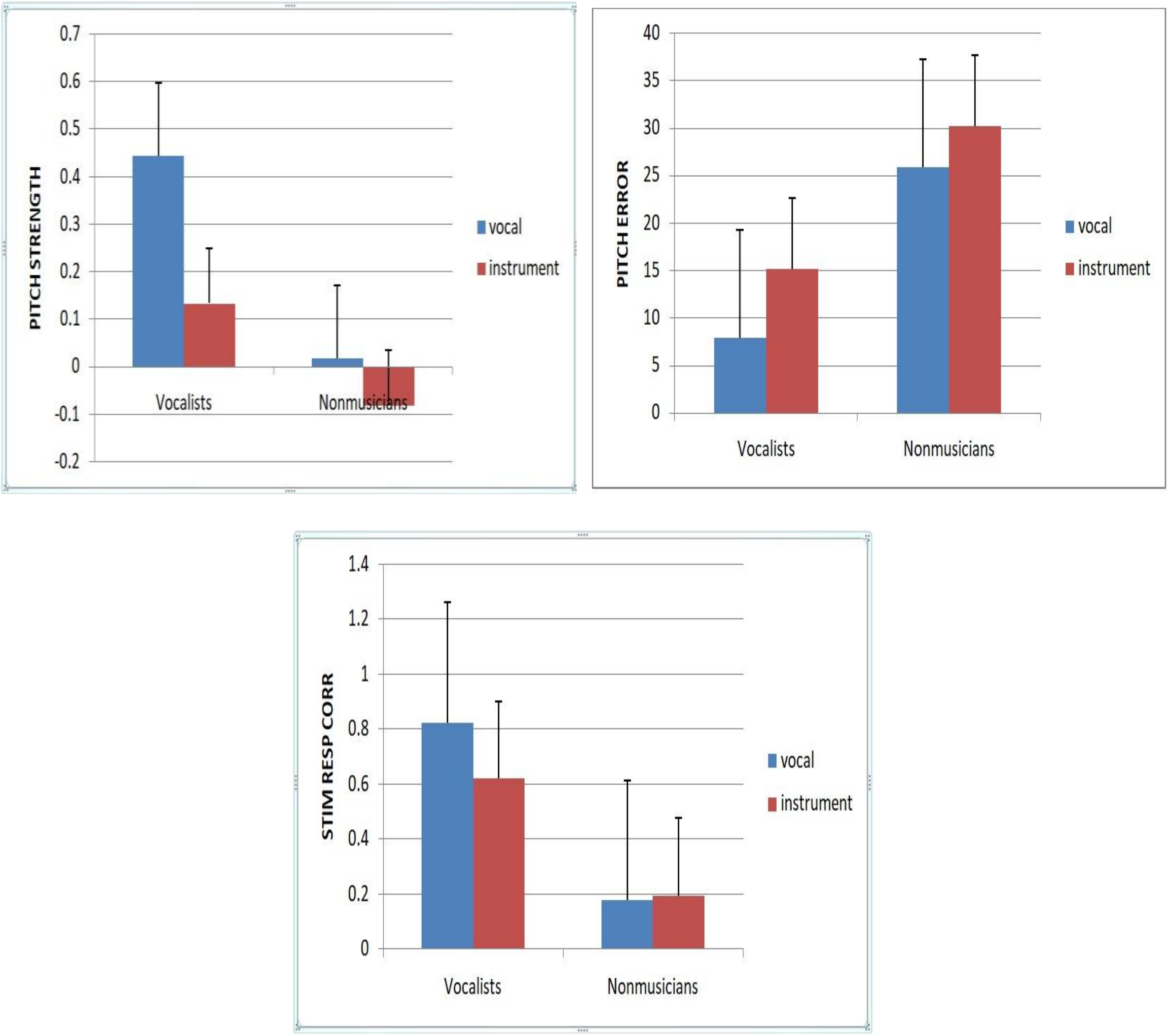

Fig 1: Mean values of Pitch strength, Pitch error and Stimulus response correlation between Vocalists and Non musicians

DISCUSSION

The study was carried out to investigate brainstem encoding of pitch among Vocalists and Non Musicians using Carnatic Vocal and Instrumental Music as the stimuli. The results revealed that for both vocal and instrumental stimuli, mean pitch error was smaller, pitch strength was better and stimulus to response correlation was higher in musicians compared to non musicians. Within the musician group, participants performed better for vocal compared to instrumental stimuli. However no such stimuli specific improvement in FFR was observed amongst the non musicians.

The results of the current study agrees with the literature review [7-10] which demonstrate that experience dependent plasticity enables musicians to have robust temporal and spectral encoding in the brain compared to non musicians. It adds to the available data on neuroplasticity of the brainstem in the encoding of pitch. The genre of music selected for the study is Carnatic and results on this were not previously reported. In Carnatic tradition, vocalists undergo rigorous training under a teacher wherein a daily practice of musical rendition is carried out. It is auditory based learning where the student needs to listen to sequence of notes rendered by the teacher and he/ she imitates till perfection is obtained.

Accurate pitch perception for all the notes in a Raaga is essential and so is the improvision to suit the musical emotion / tone and rhythm/ pace. Therefore, it can be theorized that vocalists demonstrated better pitch coding abilities not only at the cortical level but at the brainstem level too. Further, as their practice is restricted to vocal training, it could explain their superior performance to vocal stimuli compared to instrumental stimuli. The results of the study suggest that indeed this is true. The pitch strength was higher among vocalists and the effect size was also very high suggesting high degree of correlation between Carnatic training and brainstem level encoding of pitch.

CONCLUSION

The study showed that Carnatic Musicians have superior pitch tracking abilities to the musical stimuli with lower pitch error values as compared to non musicians. The results indicate that experience dependent plasticity has its origin at the brainstem level itself. This holds true for any genre of music. Further there might be certain preference by the musicians towards the type of music learnt by them (in this study vocal) as compared to other types of music.

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REFERENCES

1. Skoe, E., & Kraus, N. (2010). Auditory brain stem response to complex sounds: A tutorial. Ear Hear, 31, 302–324.
2. McAnally, K. I., & Stein, J. F. (1997). Scalp potentials evoked by amplitude-modulated tones in dyslexia. *Journal of Speech, Language, and Hearing Research*, *40*(4), 939-945.
3. Aiken, S. J., & Picton, T. W. (2008). Envelope and spectral frequency-following responses to vowel sounds. *Hearing Research*, *245*, 35–47.
4. Wang, J., Nicol, T., Skoe, E., Sams, M., & Kraus, N. (2009). Emotion modulates early auditory response to speech. *Journal of cognitive neuroscience*, *21*(11), 2121-2128.
5. Bidelman, G. M., Gandour, J. T., & Krishnan, A. (2011). Cross-domain effects of music and language experience on the representation of pitch in the human auditory brainstem. *Journal of Cognitive Neuroscience, 23,* 425–434.
6. Strait, D. L., Kraus, N., Skoe, E., & Ashley, R. (2009). Musical experience and neural efficiency–effects of training on subcortical processing of vocal expressions of emotion. *European Journal of Neuroscience*, *29*(3), 661-668.
7. Krishnan, A., Swaminathan, J., & Gandour, J.T. (2009). Experience-dependent enhancement of linguistic pitch representation in the brainstem is not specific to a speech context. *Journal of Cognitive Neuroscience.*2, 1092–1105.
8. Kraus, N., & Chandrasekaran, B. (2010). Music training for the development of auditory skills. *Nature Reviews Neuroscience*, *11*(8), 599–605.
9. Wong, P.C., Skoe, E., Russo, N.M., Dees, T., & Kraus, N. (2007). Musical experience shapes human brainstem encoding of linguistic pitch patterns. *Nature Neuroscience*, *10*, 420–422.
10. Devi, N. & Kumar, A. U. (2015). Brainstem encoding of Indian Carnatic music in individuals with and without musical aptitude: a frequency following response study. *International Journal of Health Sciences and Research*, *5*(8): 487-495.

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