The effect of short-term musical training on speech perception in noise

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Abstract

The aim of the study was to assess the effect of short-term musical training on speech perception in noise. In the present study speech perception in noise was measured pre- and post- short-term musical training. The musical training involved auditory perceptual training for raga identification of two Carnatic ragas. The training was given for eight sessions. A total of 18 normal hearing adults in the age range of 18-25 years participated in the study wherein group 1 consisted of ten individuals who underwent musical training and group 2 consisted of eight individuals who did not undergo any training. Results revealed that post training, speech perception in noise improved significantly in group 1, whereas group 2 did not show any changes in speech perception scores. Thus, short-term musical training shows an enhancement of speech perception in the presence of noise. However, generalization and long-term maintenance of these benefits needs to be evaluated.

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Introduction

Pitch, timing, and timbre are the basic elements of both speech and music. Therefore, expertise in music may help in processing of pitch, timing, and timbre and may enhance speech perception.[1] This could be due to shared neural pathways for both speech and music. Long-term musical practice has been found to result in enhancement of various auditory and cognitive skills such as auditory attention[2] auditory stream segregation,[3] processing of emotion in speech,[4] working memory,[5] temporal resolution[6] and processing of prosody and linguistic features in speech.[7] Studies have demonstrated that musicians have better processing of speech in noise compared to non-musicians.[8,9]

Parbery-Clark *et al.*[8] studied speech in noise perception in musicians and non musicians using hearing in noise test (HINT) and Quick-SIN in younger adults. They reported that musicians had higher speech in noise scores compared to non-musicians. Similar results have also been reported for brain stem responses.[10] They studied the effect of musical experience on the neural representation of speech in noise in a group of trained musicians and compared it with non musicians. Results showed that speech evoked auditory brainstem responses were robust and had early response time in the presence of noise for musicians.

These long-term effects have been attributed to music induced plastic changes in the cortical and sub-cortical neurons. It has been shown that musical training induces plastic changes in the sub cortical and cortical auditory system and strengthens cortical and sub cortical mechanisms of auditory processing.[11,12] It induces both structural and functional changes in the auditory system. Gaser and Schlaug[12] found that gray matter (cortex) volume was highest in professional musicians (practices for at least 1 h per day), intermediate in amateur musicians, and lowest in non-musicians in several brain areas involved in playing music: motor regions, anterior superior parietal areas and inferior temporal areas. Also, at the sub cortical level, musicians have higher brain stem amplitudes for both music and speech when compared to non-musicians.[13]

Thus, the effects of musical training on brainstem processing demonstrates top down modulation and shows enhancement not only in musical sound processing, but also in speech encoding and other non-musical neural functions. Even though there are specific areas in the brain for processing music and speech,[14,15] shared mechanisms are also used to process sound in both domains.[16,17] These shared mechanisms can account for the structural[12,13] and functional[18,19] enhancements for auditory processing of speech because of long-term musical training.[15,20,21]

Thus, it is evident that there is a functional and an anatomical difference in the auditory system between musicians and non-musicians and musicians have enhanced auditory perception and speech perception in noise. However, these positive effects have been demonstrated only on those musicians who have undergone long-term formal training in music. Thus, it would be interesting to see whether these advantages would extend for short-term perceptual musical exposure also. Therefore, the present study was taken up to evaluate the perceptual changes in the auditory system, if any, due to short-term perceptual music training. This study measured the effect of short term auditorily perceptual training of two Carnatic ragas on auditory system. Furthermore, this study also measured the effect of short-term perceptual training of music on speech perception in noise.

Materials and Methods

Participants

To fulfill the objectives of the study, two groups of participants were included within the age range of 18-25 years. Participants selected randomly from University College did not undergo any formal musical training. Participants in group 1 consisted of ten adults (7 males, 3 females) and were same as those participated in our earlier study (Jain, Mohamed & Kumar, 2014; in press). Participants in group 2 consisted of eight adults (5 females, 3 males). Participants in group 1 underwent musical training and no musical training was given for participants in group 2. All participants had normal hearing sensitivity, as indicated by their four-frequency (500 Hz, 1000 Hz, 2000 Hz and 4000 Hz) pure-tone average threshold of ≤15 dB HL and *A* type tympanogram with acoustic reflex thresholds in normal limits (90 dB at 1000 Hz). Participants selected for the study did not have any complaints of difficulty in understanding speech either in quiet or in the presence of background noise. They were amateur or a rare listener of Indian classical music, which was ascertained from a structured interview. All the listeners' participation was voluntary and they were not paid for their participation in the study. Ethical clearance was obtained from the relevant ethics committee at the institute prior to commencement of experimentation.

General procedure

Written consent was taken from all the participants for willingly participating in the study. The study was carried out in three stages. In first stage, speech perception in the presence of noise was assessed for both groups. In the second stage, auditory perceptual training was given for raga identification only for group 1 participants. In the third stage, speech perception in noise was assessed again for both groups. Figure 1 shows the block diagram of the experiment. Raga identification by listening to small excerpts of music was also done for group 1 in both pre training and post training phase.

Phase I. Pre training assessment

Phase I involved assessment of speech in noise testing for participants in both group 1 and group 2.

Speech perception in noise

Speech perception in noise was evaluated by measuring signal to noise ratio (SNR) required to understand 50% of the presented speech (SNR-50)[22] in Kannada. SNR 50 was measured in the presence of four talker babble under the earphones (Sennheiser HD 449). Test consisted of 7 equivalent lists and two different lists were used in pre-training and post-training assessments to measure SNR 50. This design ensured that observed results are not due to familiarity or practice effect. Each list contained seven sentences with five key words each. All the sentences in the test were homogenous and the key words were assessed for familiarity. The signal to noise ratio decreased from +8 dB SNR to -10 dB SNR in 3 dB steps from sentence 1 to 7 in each list. The participants were instructed that they will be presented with sentences in Kannada in the presence of multi-talker babble in the background at different SNRs and they were asked to write the target sentences. The number of correct key words identified was counted at each SNR. The SNR-50 was calculated using the Spearman-Karber equation[23] as:

$$\text{SNR-50} = I + \tfrac{1}{2}(d) - (d)(\#\ \text{correct})/(w) \quad (1)$$

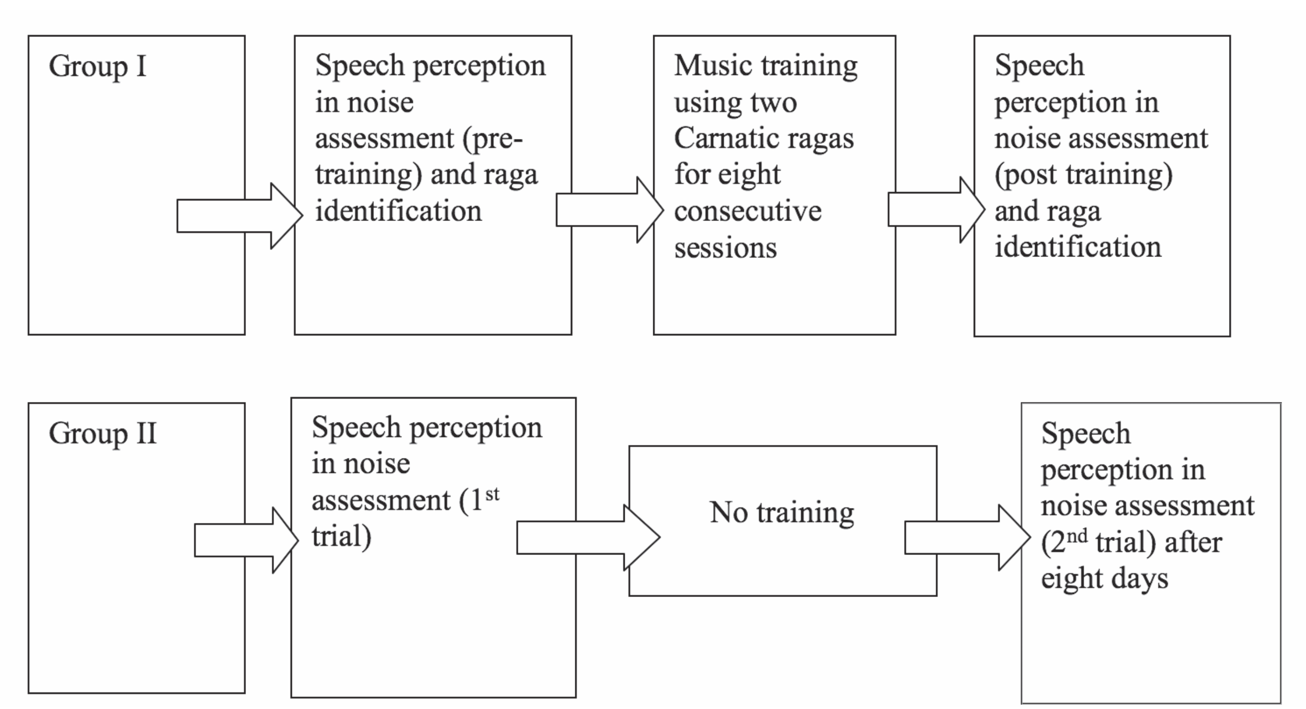

Figure 1. Block diagram of the experiment.

where:
I = the initial presentation level (dB S/B);
d = the attenuation step size (decrement);
w = the number of key words per decrement;
# correct = total number of correct key words.

Phase II. Training

After pre training assessment musical training in auditory mode was given to the participants in group 1. During the training, participants listened to 15 min composition of two Carnatic ragas (*Kalyani* and *Mayamalavagola*) with the help of a personal computer through high fidelity headphones (Sennheiser HD 449) everyday. Stimuli consisted of violin compositions from both the ragas. These two are the basic ragas of South Indian classical music wherein *Mayamalavagola* is a *shudh madhyam raga* and *Kalyani* is a *prati madhyam raga*. Also the frequency of 2nd note (ri), 4th note (ma) and 6th note (da) differs in both the ragas.[24] A Carnatic violinist with more than 15 years of experience and who had passed *senior level* music examination and practices for at least 2 to 3 hours daily was selected to play the two ragas. He was asked to play several sample songs in both *Kalayani* raga and *Mayamalavagola* raga each lasting for about 15 min. After each training session participants were made to listen to small music excerpts from both the ragas and were instructed that whenever they hear the excerpts from *Kalyani* raga they had to identify the raga as *Kalyani*. Similar task was performed for *Mayamalavagola* raga, too. In training sessions, participants were given immediate feedback about their responses. Training was given for eight consecutive days.

Phase III. Post training evaluation

At the end of the 8th day of the training session post training assessment was done using the same test mentioned in phase I of the study for group 1 and it was also done after 8 days for group 2 participants who did not undergo any musical training.

Results

Effect of musical training on speech perception in noise was assessed

Mean and one-standard-deviation error bars of SNR-50 in pre-training and post-training conditions for group 1 participants are shown in Figure 2. In order to find the significance of the difference in means between pre and post-training conditions, a Wilcoxon signed rank test was performed between the pre-training and post-training SNR-50. Results showed that there was a significant improvement in SNR-50 after musical training (Z=3.059, P<0.05). Mean and one-standard-deviation error bars of SNR-50 were also assessed for group 2 participants in trial 1 and trial 2 are shown in Figure 3. In order to find the significance of the difference in means of SNR-50 between the two conditions a Wilcoxon signed rank test was performed. Results showed that there was no significant change in SNR-50 in the two trials (Z=-0.828, P>0.05).

Correlation between raga identification and SPIN scores

Spearman correlation was done to assess the correlation between the ability of the subject to recognize the type of raga and speech in noise score. The difference in pre training scores and post training scores of raga identification and speech in noise was calculated for each individual and it showed positive correlation of 0.63. This shows that as the scores in raga identification improved, there was also an improvement seen in speech in noise scores. Figure 4 shows the scatter plot of both the variables.

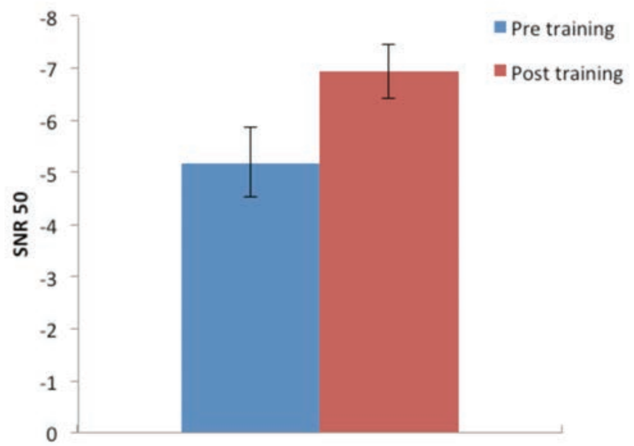

Figure 2. Mean scores and one-standard-deviation error bars for SNR-50 in pre-training and post-training conditions.

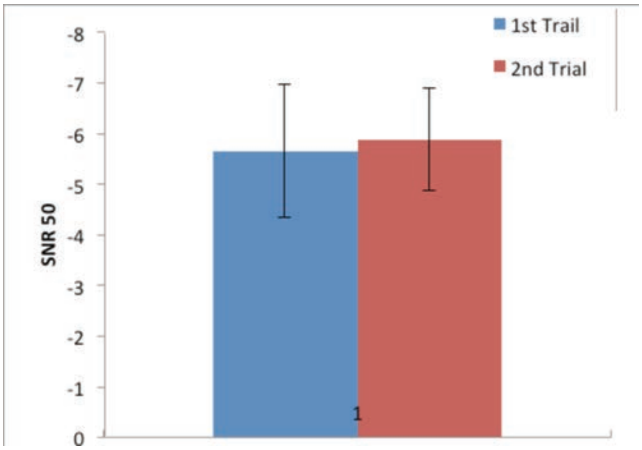

Figure 3. Mean scores and one-standard-deviation error bars for SNR-50 in trial 1 and trail 2 conditions.

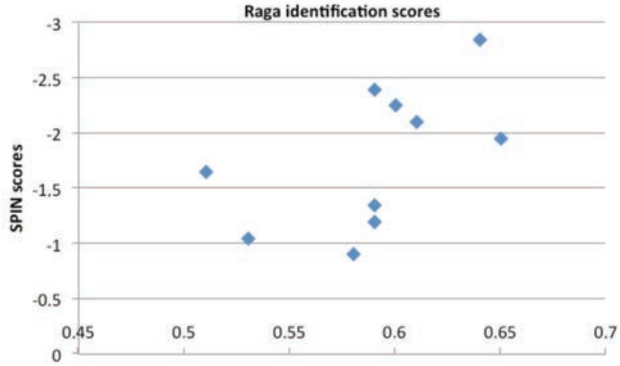

Figure 4. Scatter plot of raga identification scores and SPIN scores.

Discussion

The aim of the present study was to document the effect of short term musical training on speech perception in noise. Ragas in Carnatic music have specific note sequences which can be identified by trained musicians. The results of the present study showed that with short-term perceptual training, even non-musicians can learn to identify these ragas and good correlation was seen between the ability to identify ragas and speech perception in noise scores. Furthermore, the results also indicated that short term perceptual training of music resulted in improved speech perception in noise.

Similar results have been reported in the past and have shown that long-term musical training results in enhanced performance in perceptual identification of music and listening in background noise.[8-10] Parbery-Clark *et al*.[10] investigated speech perception in noise, working memory and frequency discrimination on musicians and non-musicians. The results revealed that musicians outperformed non-musicians on all the tasks. The authors concluded that long-term musical experience could enhance speech in noise performance, working memory and frequency discrimination. There was also a positive correlation between the speech perceptions in noise and working memory performance, which suggests that there lies a shared mechanism for the processing of the two.

Strait and Kraus[9] studied speech perception in noise and auditory attention in musicians and non-musicians. The result revealed that the speech perception in noise and auditory attention was superior in musicians when compared to non-musicians and there was a positive correlation between the perception of speech in noise and auditory attention. Strait *et al*.[2] studied the effect of long-term musical training on auditory attention tasks and the results indicated an enhanced auditory attention performance in musicians when compared to non-musicians.

However, all the above-mentioned studies have taken trained musicians to compare speech perception in noise. To the best of our knowledge, the effect of short-term music training on speech perception in noise has not been studied and the present study shows that even short term training can improve speech perception in noise. Furthermore, in the present study the speech perception in noise scores after a gap to assess long-term effects of perceptual training could not be done as the part of the study due to time constraints.

Conclusions

Short-term perceptual musical training shows an improvement in the identification of ragas and enhancement of speech perception in the presence of noise. However, generalization and long-term maintenance of these benefits needs to be evaluated.

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