Comparison of Rhythm Perception in Dancers and Musicians

[1]Arya Chand & [2]K. Rajalakshmi

Abstract

The present study compared the rhythm perception abilities in Carnatic musicians (vocalists) and Bharatanatyam dancers. Twenty Carnatic musicians and 20 Bharatanatyam dancers (aged 19-39 years), with experience of 5 years or more in the respective fields were recruited for the study. The testing was conducted in 2 parts - (i) Synchronization with the rhythm of a musical excerpt (ii) Perceptual judgment of whether an imposed click train follows the beat of a musical excerpt. For the first part of the testing the participants were asked to tap the perceived rhythm of a given musical excerpt of average 30s duration. For the second part of the testing, participants were made to perceptuallyÂ judge whether a click track superimposed on a musical excerpt follows the rhythm of the excerpt (on beat condition), or if the click tempo is faster or slower than the musical excerpt or the clicks are not on beat of the excerpt (off beat condition). One way MANOVA was carried out for the statistical analysis. Results of the statistical analysis showed that there is no significant difference between dancers and musicians in the rhythm perception skills. Results also showed that experience correlated positively with rhythm skills.

Keywords: *Rhythm perception, dancers, musicians, beat perception.*

Introduction

Rhythm is defined as an ordered recurrent alternation of strong and weak elements in the flow of sound and silence. The experience of rhythm involves movement, regularity, grouping, accentuation and differentiation (Handel, 1989). Rhythm perception and production is a basic skill which helps us to synchronize with music like tapping, clapping, dancing, playing musical instruments and synchronizing oneself with other performers. The perception of rhythm is a dynamic process and it involves the synchronization of external musical stimuli with internal rhythmic processes (Jones & Boltz, 1989). Anatomically, the correlates of rhythm perception are attributed to basal ganglia (Grahn, 2009) and also to Supplementary Motor Area (bilaterally) and also extending into regions of cingulate gyrus, basal ganglia (Geisler, Zaehle, Jancke & Meyer, 2008).

Two important factors in rhythm perception are meter and pulse or beat. Beat is a perceived pulse that marks equally spaced points in time. Cooper and Meyer (1960) define pulse as a series of regularly recurring, precisely equivalent psychological events that arise in response to a musical rhythm. It is because of beat perception that we are able to relate the onset of temporal intervals as multiple or subdivisions of the beat, thus perceiving related intervals and not as unrelated intervals which in turn help in rhythm perception and production (Drake & Gerard, 1989; Ross & Houtsma, 1994; Patel, Iversen, Repp & Chen, 2005). Perception of beats occurs when we synchronize the external stimuli with an internally generated temporal pattern. The temporal properties which the listeners use to generate the internal rhythm are not clearly known. One property that may be important for beat perception in rhythm is the presence of simple integer ratio relationships between intervals in a sequence (Essens, 1986; Sakai et al., 1999). Another factor that aids beat perception is the perception of accents. Accents cause a particular note to feel more prominent than its surrounding notes. Previous research has shown that a listener's attention is attracted to accented events (Jones & Boltz, 1989). In musical contexts, the accents are created by non-temporal cues such as pitch, volume, and timbre, yet even rhythms without these cues can induce listeners to feel a beat internally (Brochard, Abecasis, Drake, Potter & Ragot, 2003).

The terms meter and metrical structure refer to patterns of regularly recurring stronger and weaker pulses (Lerdahl & Jackendoff, 1983). Lerdahl and Jackendoff's (1983) system, the fundamental pulse periodicity (the rate at which one might spontaneously tap with a musical rhythm) would be notated as a single row of beats, and the pattern of strong and weak pulses as additional rows of beats at related frequencies. Metrical structure or meter is temporal pattern created by the simultaneous perception of beats by different temporal scales.

Most studies in rhythm perception have compared musicians and non-musicians. Though dancers are a population who also depend on rhythm perception for their performance only few studies have pondered into the rhythm perception abilities of dancers. Hence a comparative study of rhythm skills in musicians and dancers would throw light onto which group have superior skills. The Bharatanatyam dance form and Carnatic music share similar musical compositions and are exposed to the same rhythms and they are trained similarly. But while performing and practicing, rhythm is maintained in different manner by the two groups. The Carnatic musicians maintain rhythm by tapping with the

[1]Email: aryachand46@gmail.com,
[2]Professor of Audiology, Email: veenasrijaya@gmail.com

palm and Bharatanatyam dancers maintain practice by stamping it on their feet. Understanding the perception of rhythm in dancers and musicians will throw light on which mode of rhythm maintenance could be utilized for training rhythm to the speech and hearing impaired individuals.

Beat perception is one factor expected to have an effect on rhythm perception. But the role of beat perception in rhythm is not studied much. Thus investigating the role of beat perception in rhythm can help us understand as to how to impart rhythm training for individuals with poor rhythm skills.

Method

Participants

Twenty individuals trained in Carnatic music and 20 others trained in Bharatanatyam dance were recruited for the present study. Age range of the participants varied between 19 years and 29 years. The participants were otologically and audiologically normal with hearing thresholds not exceeding 20dB at any frequencies between 250 to 8000Hz. The participants were also ruled out of any middle ear infections and any history of neurological disorders. All the recruited participants had received 5 years or above 5 years training in music or dance.

Instrumentation

A calibrated audiometer with TDH 39 headphones was used for Air Conduction testing and radio ear B-71 was used for bone conduction testing. GSI Tympstar was used for ruling out middle ear infections. Audacity software was used for generating the test stimuli and for recording the responses.

Procedure

The testing consisted of 2 parts; Synchronizing with the rhythm of a musical piece and Perceptual judgment of imposed rhythms on a musical piece.

Test 1: Synchronizing with the rhythm of a musical piece

Each participant was given 5 stimuli, (Carnatic instrumental pieces) one at a time. The musical excerpt had duration in the range of 25 to 30sec. The participants were made to listen to the stimuli twice and were asked to tap and report about the perceived rhythm of the piece. The participant's taps were recorded during the recording trail (3^{rd} trail) and were mixed with the original composition using the Audacity software. Information on the participants' tapping and about the meter of the composition as perceived was noted. The taps were compared with the original rhythm of musical excerpt and were also checked for the presence of any tapping errors in terms of phase or tempo. The participants were also asked about the familiarity of the musical composition.

The different rhythms selected were such that they formed the frequently taught and most common rhythms in both Carnatic music as well as Bharatanatyam dance.

Test 2: Perceptual judgment of imposed rhythms on a musical piece

For this part of the experiment, the participants were presented with a musical composition upon which a click train had been imposed. The click trains are superimposed in 3 conditions; hence there are three variations of the same composition. The three conditions are on beat and off beat (tempo error) and off beat (phase error).

On beat condition: For generation of this condition, the click train was generated with the same tempo as that of the compositions. The original tempo of the song was calculated by computing the beats per second (BPS). BPS was calculated by tapping to the song and calculating the number of taps per second. A click train generated with the same BPS was aligned to the composition in such a way that, the first click coincided with the original beats of the composition. Thus, the clicks fell exactly on the points where we expect the composition's beats to fall. A musically trained listener was made to judge whether the tempo was matching the composition's tempo.

Off beat condition (tempo error): For this condition the click train was generated in such a way that tempo of the click train was either greater or lesser than the actual tempo of the composition. For this condition, the original tempo of the song (BPS) was found out and was aligned with the composition for checking matching of the tempo. Once both the tempo matched, then the particular click train was removed and another click train was generated with a tempo which is 20% lesser than (slower tempo) or 20% faster than (faster tempo) that of the original tempo of the composition. This click train was aligned to the composition in such a way that, the first click of the composition falls on beat with the beat of the composition, but the tempo being different from the composition's original tempo.

Off beat condition (phase error): For generation of this condition, the click train with the same BPS as that of the song was generated, but the click train was aligned in such a way that, the first click fell either before or after the point where the actual beat of the song falls such that every time the clicks fell either before or after the intended beat.

The above mentioned three conditions were randomly mixed and the participants were required to report whether the click train imposed on a musical piece (Carnatic composition) follows the rhythm of that particular composition. The participants were exposed to 3 iterations of a stimuli such that in one falls in on-beat, in one, there is a off-beat in terms of phase error (early or late) and in the third one, there is a off-beat in terms of tempo error (slow or fast). Each subject was exposed to 5 stimuli, twice during testing. The participants were asked to report whether the clicks were falling on-beat with the composition or off beat with the composition. If the clicks are falling off -beat, the participants were asked to report whether there was an error in terms phase or tempo. If the error was reported to be phase, then participants had to report whether the clicks were early or late with reference to the beat of the composition and if the error was reported to be in tempo, then the participants had to report whether the beats were faster or slower when compared with the original composition. The participants were also asked regarding the years of experience with music or dance and familiarity with the musical compositions included in the study.

Scoring

Test one: Test one consisted of 5 compositions. For each composition, a maximum score of 3 was given, which was consisted of the scores for the three domains tested. The three domains tested are: Identification of the rhythm of a composition, synchrony of the participant's tapping phase with the phase of the composition and synchrony of the participant's tapping tempo with the tempo of the composition. A correct response in each domain was awarded 1 point. Thus, each composition gets a maximum of 3 points. Hence, the maximum total score in the Test one is 15.

Test Two: The stimuli in Test two was composed of 5 compositions each iterated 3 times (3 different conditions), thus making a total of 15 presentations of the stimuli. Identification of offbeat condition was awarded with 0.5 point. A score of 1 was awarded when the participant identified the exact offbeat condition in terms of whether it is a tempo error or phase error. The maximum score of 2 was awarded when (i) participant correctly identified whether in tempo error i.e. The click tempo as fast or slow than the composition's beats or (ii) participant correctly identified whether in phase error, the clicks were early or delayed with reference to the original composition. Hence the maximum score for each stimulus is 2. Thus, a total score of 30 is the maximum score in Test 2.

Results and Discussion

The data from 40 participants (20 dancers and 20 musicians) was subjected to statistical analysis. The data was tabulated and analyzed using SPSS (17.0). In order to compare the rhythm skills in dancers and musicians, a one way MANOVA was carried out between both the groups for the test scores obtained in the two tests, another one way MANOVA to compare the skills across the domains tested in each test, and correlation of various parameters of the two tests and correlation of the rhythm skills and experience of the participants.

Comparison of Scores Obtained in each domain tested in Test 1 between Musicians and Dancers (Musicians: Group A, Dancers: Group B)

The main aim of the study was to compare the rhythm skills of dancers and musicians. Thus the scores obtained for each domain in Test one was compared across the two groups using a one way MANOVA. The domains tested were (i) identification of the rhythm (ii) tempo synchrony (iii) phase synchrony. The mean, standard deviation, F value, significance level are shown in Table 1.

The p values for identification domain is p= 0.596, for tempo synchrony domain is p= 0.771 and phase synchrony domain is 0.912. Hence the statistical analysis showed that there is no significant difference between the two groups across any of the domains tested in Test one.

The results of the statistical analysis imply that the rhythm perception abilities in dancers and musicians are comparable. Participants in both the groups could identify the rhythm; synchronize with the musical composition according to its phase and tempo to the same extent. The reason for getting no significant difference between the two groups in the test can be attributed to factors like similarity in training imparted to both the groups, the rhythms selected for testing. The two groups considered under the study i.e. dancers and musicians would have both been exposed to the same kind of music during learning i.e., Carnatic Music since the rhythms and compositions used in the Carnatic music are commonly used in Bharatanatyam dance training. Also the rhythms used in the tests were common to both Carnatic music and Bharatanatyam dancers.

Table 1: Mean, Standard Deviation, F value, Significance for the two groups for the Test 1

Domains tested	Group	Mean	SD	F value	p
Identification	A	3.70	1.52	0.28	0.59
	B	3.45	1.43		
Tempo synchrony	A	4.25	1.06	0.08	0.77
	B	4.15	1.08		
Phase synchrony	A	3.90	1.48	0.01	0.91
	B	3.85	1.34		

Comparison of the Scores Obtained for the Identification of the Three Conditions in Test Two between Musicians and Dancers

Further to compare the rhythm skills under Test two, a one way MANOVA was carried out. The two groups were compared for their ability to identify 3 conditions of imposed beats on a musical composition namely- on-beat condition, off beat-tempo error condition and off beat-phase error condition. The mean, standard deviation, F value, are given in Table 2. Hence, the statistical analysis has shown that there is no significant difference between the 2 groups for identification of different conditions in the Test Two.

The results of the statistical analysis showed that both dancers and musicians have similar abilities in perception of beats. The perception was similar for perception of on-beat condition, off beat phase error condition and off beat tempo error condition. Previous study on general population (untrained in rhythm) by Iversen and Patel (2008) had indicated that on-beat conditions were identified more correctly than the tempo error or phase error condition. Such a pattern is not observed in musicians and dancers i.e. they identified off beat condition and on beat conditions easily. This could be attributed to the training effect and similarity in training rhythm in both the groups. The study of Iversen and Patel (2008) was carried out on general population who received no training in rhythm, hence the authors could not find out the similarity in perception of rhythm in their participants.

Comparison of the Total Scores for Both the test between the 2 Groups

For comparing the rhythm skill for the two tests (total score) for the two groups, the total scores obtained for each test were calculated and were compared using one way MANOVA.

Results from the statistical tests revealed no significant difference between the 2 groups for the two tests. The reasons for the non-significant difference between the two groups are because of similar training and rhythms chosen for testing. The rhythms chosen were present

Table 2: Mean, Standard deviation, F-value, Significance for the two groups for Test Two

Conditions	Group	Mean	SD	F value	p
On beat	A	8.80	1.88	0.03	0.85
	B	8. 90	1.51		
Off beat tempo error	A	7. 25	1.91	2.50	0.12
	B	6.30	1.88		
Off beat Phase error	A	5.82	2.3	0.60	0.43
	B	5.25	2.2		

Table 3: Mean, Standard deviation, F value for total scores of the two tests for the two groups

Test	Group	Mean	SD	F value	p
Test 1	A	11.65	3.963	0.02	0.88
	B	11.45	3.720		
Test 2	A	21.97	5.861	0.75	0.38
	B	20.45	4.695		

in both Carnatic music and Bharatanatyam dance. The compositions were also selected in such a way that it is not very common, so as to remove prior knowledge of the rhythm. It was noted during the testing that for those participants who had been exposed to the compositions before i.e. those who were trained in that particular composition had better scores than for those participants for whom the compositions were novel.

Computation of the Correlation between the Two Tests)

The second aim of the study was to find whether, perception of beat influences the synchronizing to a rhythm. To study this, correlation between the two tests used in the study was carried out. Correlation was found by considering the total 40 participants as a single group. The results of the analysis showed significant correlation for the two tests [Pearson's correlation coefficient: 0 .690 at 0.05 level of significance]. Correlation results are shown in Table 4.

Previous work on general population by Iverson and Patel (2008) on the correlation of beat perception and synchrony with a composition's rhythm showed weak correlation (correlation coefficient = 0.38; $p<0.03$). But in the current study, there is a positive correlation between the two indicating the enhanced abilities in dancers and musicians, owing to training effects and better exposure and familiarity with the compositions.

For each domain, the influence of Test one over Test two was found out by finding out the correlation between domains tested in Test one with the corresponding condition in Test two. Thus off-beat phase error condition in Test two was checked for correlation with phase synchrony in Test one. Similarly off beat tempo error condition in Test two was checked for correlation with tempo synchrony domain in Test one. The analysis resulted in significant correlation between detection of tempo error and the tempo synchronization ability (Pearson's Correlation Coefficient: 0.383 at 0.05 level of significance) and significant correlation between detection of phase error and phase synchronization ability (Pearson's correlation coefficient: 0.571 at 0.01 level of significance). Correlation results are shown in Table 4.

Thus, the positive correlation results between domains of Test one and Test two indicated that correct detection

Table 4: Results of correlation

Variable one	Variable two	Correlation Coefficient
Test one	Test two	0.690 **
Tempo error	Tempo synchrony	0.383*
Phase error	Phase synchrony	0.571**
Experience	Test one	0.679**
Experience	Identification of rhythm	0.710**

** Correlation is significant at the 0.05 level (2-tailed).*

of an off-beat tempo error aids in better synchrony with the tempo and a correct detection of an off-best phase error aids in better synchrony with the phase.

The third aim of the study was to find whether experience plays a role in rhythm perception. Thus correlation of the participants' test scores and the subject's experience was calculated using Pearson's Correlation coefficient. Results of the analysis have showed that experience was positively correlated significantly with test one scores [Pearson's correlation coefficient: 0.679 at 0.05 level of significance]. Correlation was calculated between identification scores in test one and experience of the participants. Results of the analysis, showed significant correlation between the two [Pearson's correlation coefficient: 0.710 at 0.01 level of significance]. Correlation results are shown in Table 4.

Thus, results of statistical analysis have showed that experience plays an important role in rhythm perception. In both the groups, participants with greater years of experience got better scores in rhythm. Thus experience is a factor which affects rhythm perception.

Previous study by Batalha and Macara (2008) had also got similar results. Their study has shown that when compared to dance students, professional dancers have better rhythm perception abilities. This is owing to better experience and exposure to the rhythm. In the present study, both dancers and musicians showed a positive correlation with experience. Thus confirming the fact experience plays an important role in rhythm perception.

Conclusions

Thus, the results of the present study indicated that dancers and musicians perform similarly on the identification of rhythm, tempo, synchrony and phase synchrony. Also, the performance of dancers and musicians was similar in on beat, off beat tempo error condition and off beat phase error condition. Further, beat perception has positive correlation with identification and synchronization with the rhythm.

References

Brochard, R., Abecasis, D., Potter, D., Ragot, R., Drake, C. (2003).The "ticktock" of our internal clock: Direct brain evidence of subjective accents in isochronous sequences. *Psychological Science , 14*(4), 362-6.

Cooper. G., & Meyer, L.B. (1960). *The rhythmic structure of music.* Chicago: The University of Chicago.

Drake. C., & Gerard, C. (1989). A psychological pulse train: how young children use their cognitive framework to structure simple rhythms. *Psychological Research, 51,* 16 -22.

Essens, P. J. (1986). Hierarchical organization of temporal patterns. *Perception & Psychophysics, 40,* 69-73.

Geisler, E., Zaehle, T., Jancke, L., & Meyer, M.(2008). The neural correlate of speech rhythm as evidenced by metrical speech processing. *Journal of Cognitive neuroscience, 20*(3), 541-52.

Grahn,J.A. (2009). The Role of the Basal Ganglia in Beat Perception. *Annals of the New York Academy of Sciences, 1169,* 35-45.

Handel, S. (1989) *Listening.* Cambridge, MA: MIT press.

Iversen, J. R., & Patel, A. D., (2008). The Beat Alignment Test (BAT): Surveying beat processing abilities in the general population. *Proceedings of the 10th International Conference on Music Perception and Cognition (ICMPC 10).* Sapporo, Japan.

Jones, M. R., & Boltz, M. (1989). Dynamic attending and responses to time. *Psychological Review, 96,* 459-491.

Macara, A., & Batalha, A. P. (2008). Self-Perception of the Body of Dancers in Performance. *Proceedings Business Bodies.* International Conference - Universities of Finland (pp.175-181). Theatre Academy. IADE, Helsinki.

Patel, A., Iversen ,J. R., Repp, B. H., & Chen, Y. (2005). The influence of modality and metricality on synchronization with beat. *Experimental brain research, 163,* 226-238.

Ross. J., & Houtsma. A.J. (1994). Discrimination of auditory temporal patterns. *Perception and Psychophysics, 56,* 19-26.

Sakai, K., Hikosaka, O., Miyauchi, S., Takino, R., Tamada, T., Iwata, N. K., et al. (1999). Neural representation of a rhythm depends on its interval ratio. *Journal of Neuroscience, 19,* 10074-10081.