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3pMU3. Perception and orchestration of melody, harmony and rhythm on instruments with 'chikari' strings

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The use of 'chikari' strings on instruments such as the sitar and sarod manifests principles of Auditory Scene Analysis in creating a harmonic reference, melodic contrast and rhythmic accompaniment. Unlike the principal 'baj' strings on which the main melody is played, or resonant 'tarb' strings that reinforce volume, the 'chikari' strings are sounded at strategic points in performance to provide a drone, add texture, outline chords, mark rhythmic positions and keep tempo. Listening and transcription experiments conducted with recordings of interleaved notes played on 'chikari' and 'baj' strings validate how differences in their timbre and tuning help to keep them perceptually apart while forming more coherent patterns based on timbre similarity and pitch proximity. Such grouping and segregation can affect the perception of temporal order, maintain the illusion of melodic continuity and in some cases of virtual polyphony. These observations add to the growing body of evidence supporting the role of timbre as a structural dimension of music and illustrate how a single instrument can bring about orchestral effects via the strategic use of devices such as 'chikari' strings.

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INTRODUCTION

An orchestra typically implies an ensemble of instruments playing together to generate music in a collaborative manner. With multiple instruments, an extended palette of pitches and timbres becomes available that allows melody, rhythm and harmony to be supported or contrasted and facilitates the creation of rich textures, novel sound colors and auditory chimera. Solo instruments are usually constrained by their physical properties to produce sounds within a limited range of pitches, timbres and durations. Electronic instruments have come a long way in breaking free from such constraints, but even before their advent, many innovations in acoustic instrument design as well as performance techniques, enabled some solo instruments to be played in a more complete, ‘orchestral’ fashion. The piano and guitar are examples of instruments that can produce multiple sounds simultaneously, generating their own accompaniment and melodic, rhythmic and harmonic interplay. In Indian music, some instruments such as the sitar and sarod have also evolved in a manner that allows orchestral effects to be achieved to some extent.

The sitar and sarod are string instruments used prolifically in India, primarily in classical, but also in popular performance practice. The sitar is a long-necked, lute-like fretted instrument with a wooden body and one or two resonating chambers made of dried and varnished gourds. The sarod has a wooden body with an unfretted, metal-covered fingerboard and its main resonating chamber is covered with parched hide. Both instruments have some primary playing strings (baj and jod), a couple of drone strings (chikari) and several resonating strings (tarb).

In sitar and sarod performance, the chikari strings are used strategically to provide melodic fillers, a harmonic backdrop and rhythm markers. This paper focuses on the use of chikari on the sitar. Observation of live performance, interviews with performers, listening and transcription exercises provide complementary information that elucidates how and why chikari strings are able to serve the multiple functions they do. The psychoacoustic basis for this multifunctionality derives from principles of Auditory Scene Analysis that come into play when sounds of different pitch and timbre are juxtaposed in temporal sequences (Bregman, 1990).

What keeps the chikari notes perceptually apart from the notes of the melody? How are chikari strings used to create harmonic and rhythmic accompaniment? What role do timbre and tuning play in facilitating such perception? The present study was undertaken in the pursuit of answers to such questions. While research on the subject is ongoing, current findings and observations are shared here.

THE SITAR: NOTATION, STRINGS AND TUNINGS

The sitar has been evolving over time with changes made to dimensions, materials used and tunings. Two of the prevalent sitar types in current use are the Ravi Shankar style ‘kharaj pancham’ sitar and the Vilayat Khan style ‘gandhar pancham’ sitar, named after eminent performers who influenced their design and the tuning of some of the strings (‘kharaj’ referring to the low tonic Sa, ‘pancham’ or Pa is the fifth degree of the scale and ‘gandhar’ or Ga, the third degree).

Pitch naming in Indian music is similar to the western solfege, with Sa Re Ga Ma Pa Dha Ni Sa equivalent to Do Re Mi Fa So La Ti Do. The Sa or tonic note is like a variable Do, assignable to any reference pitch that suits the performer. Written music is not the norm, however, with no universally standardized notation system. People and ‘schools of music’ often invent their own manner of transcription, the most common being to denote the pitch names using the alphabet, e.g. SRGMPDNS’ for the notes of the major scale. Flat and sharp pitches, microtonal variants, note duration and timing information require tweaking of the notation, which tends to be somewhat arbitrary. In this paper, the basic alphabetic solfege notation is used to describe pitch patterns and string tunings.

Both sitars have the same basic structure, but differ in the number, type and tuning of the strings. The main ‘baj’ string located on the lower side of the neck, is tuned to the fourth degree above the tonic of the scale (the Ma above the Sa) in both cases. The two dedicated chikari strings fastened to pegs on the topside of the neck are tuned to lower and upper tonic notes (Sa and Sa’) on both instruments. The middle strings, however, are arranged and tuned differently. The kharaj-pancham (Ravi Shankar style) sitar has an additional second string tuned to the tonic that is absent in the gandhar-pancham (Vilayat Khan style) sitar. The two strings above that are tuned to the lower fifth (Pa
or pancham) and the lower tonic (kharaj Sa) and another string tuned to the higher Pa on the kharaj-pancham sitar. It may also have a small gourd resonator at the head of the body in addition to the larger one at the base. These features give the sitar a deep, lower range. The gandhar-pancham sitar has a lighter, brighter sound with one less string and instead of a second Pa, one of the top strings is tuned to the third degree (Ga), spelling out the root chord Sa-Ga-Pa-Sa’ when strummed along with the tonic chikaris. Both sitars have a double bridge with a layer of a dozen or so sympathetic resonant strings called ‘tarb’ below the main strings. The two sitar models are shown in Figure 1.

Most melodic exposition on the sitar happens on the ‘baj’ string, but the middle strings may be used occasionally for melodic embellishment. Movable frets and the flexibility to create gliding tones (‘meend’) by pulling on a string along a fret allow microtonal notes to be produced as well. Though the upper pair of strings tuned to the low and high tonic are specifically called ‘chikari’ strings, the term is used more broadly to refer to the consolidated chordal sound produced when they are strummed along with the other strings using the edge of the ‘mizrab’ wire pick worn on the index finger.

![Figure 1](image)

**FIGURE 1.** Typical kharaj-pancham and gandhar-pancham sitars are shown with their string tunings. The extra tonic (Sa) and fifth (Pa) on the kharaj-pancham sitar extend the pitch range into the lower bass octaves. The ‘Ga’ on the gandhar-pancham sitar along with the Sa and Pa and chikari strings, outlines the root chord of the scale when strummed together to produce a consolidated ‘chikari’ sound.

**USE OF CHIKARI**

**Melodic Filler, Phrasal Punctuator, Harmonic Reference**

A typical sitar recital commences with a very slow unaccompanied ‘alap’ section, in which the pitches belonging to the featured raga (modal scale) are gradually revealed, elaborated on and woven into melodic patterns. The chikari strings are strummed in this section as phrasal or temporal markers to punctuate the melodic lines being developed on the main string. In addition to adding timbral color, they also provide a harmonic reference for the scale as they outline the root chord of the raga (comprising the low and high tonic Sa, the fifth - Pa and/or the third - Ga).
In the performance of Indian classical music, a harmonic drone is extremely important as it enables both the performer and listeners to understand and appreciate the reference scale relative to which all improvisation will take place. A 4-stringed instrument called the ‘tanpura’ is typically used to provide the drone, with the tonic and fifth (or fourth, depending on the raga) played repeatedly to create a wall of sound that serves as the harmonic reference. In sitar performance, the instrument can act as its own tanpura, providing the drone with the chikari and supplementary strings strummed together.

**Timbre Streamer**

In subsequent sections during a performance, as the composition speeds up after the alap, the chikari strings are strummed more frequently and provide a timbral counterpoint that leads to the illusion of polyphony. As in the phenomenon of auditory streaming, the similar timbre of the chikari sounds causes them to link up with each other perceptually while separating from the melody sounds that have a different timbre (Singh, 1987; Singh and Bregman, 1997). A rich texture is created as a backdrop, against which the melody notes are played in the foreground. The melodic notes played on the baj string have long sustained portions that are further prolonged by the resonance of the sympathetic strings that lie below the main bridge. The physical continuity of sound is another factor that helps glue the melody notes to each other, while segregating them perceptually from the brighter, texturally dense chikari sound.

**Rhythm Marker**

As a sitar performance builds up to a finale, the chikari strings are employed even more frequently and vigorously in the climactic ‘jhala’ section. The chikari starts to emphasize the rhythm, being played on strategic beats of the ‘tal’ in which the composition is set metrically. In the 16-beat Teen Tal, for example, the chikari strokes can be used as a contrast, coming in on beats 2-3-4, 6-7-8, 10-11-12 and 14-15-16 while the main melody string plays on the 1, 5, 9 and 13, outlining the four ‘vibhags’ or metrical sub-sections of the (4x4)-beat tal. In ‘ulta jhala’ style, there is a role reversal and the chikari may take on the job of marking the beats that outline the vibhag sections, while the melody string plays on the secondary beats. The performer may get even more playful, interleaving chikari and melody notes within the vibhags and indulge in syncopation and rhythmic creativity.

**LISTENING EXPERIMENTS**

The field of Auditory Scene Analysis has come a long way in elucidating how we form perceptual and cognitive representations of complex acoustic environments (Bregman, 1990). Music performance and appreciation depend on our ability to organize sound in a meaningful and expressive manner. Some of the principles of Gestalt psychology (Todorovic, 2008) that form the bases for Auditory Scene Analysis come into play in the performance of music on the sitar as well. The principles of ‘good continuity’, ‘proximity’ and ‘similarity’ have particular relevance in affecting how sounds are grouped perceptually, based on pitch and timbre similarities and differences.

Auditory sequences that juxtapose sounds divergent in pitch and timbre will likely break apart at rapid rates of presentation to form perceptual streams in which the differences are reduced (McAdams and Bregman, 1979; Singh and Bregman, 1997). The perceptual reorganization of the sequence may lead to disruption in the perception of temporal order as the timing of events that occur in different streams becomes difficult to identify precisely (Bregman and Campbell, 1971). If alternate events are grouped perceptually, a correlated tempo change may be perceived as well. With this foreknowledge, a listening task was designed using sitar sounds to explore the role of the chikari in initiating perceptual grouping.

**Experimental Design and Task**

In sitar performance, chikari sounds are typically interleaved with melody notes over time, yet they remain perceptually distinct while the melody notes cohere into melodic patterns. To simulate such a scenario, a set of 4-note sequences was created using actual chikari and baj notes extracted from recordings of a sitar performance. In
some cases, the first two notes and the last two notes were made to be of the same timbre and pitch. When such pairs are juxtaposed in a sequence, the perception of temporal order should not be disrupted as no stream segregation should occur and the notes should be perceived in the order they occur, at the tempo they occur. If the second and fourth notes are then replaced by chikari sounds, a change in perception would be expected because of the timbre difference between adjacent sounds. Alternate sounds of similar timbre would be expected to cohere together instead and break perceptually from their neighboring sounds. In this case, the perception of order is affected and the tempo, too, is perceived to be slower. To identify the perceptual correlates for these sequences, a labeling task similar to that used by Singh (1987) was assigned to 6 listeners, 3 male and 3 female. Their ages ranged from 12 to 52 years and they had normal hearing. The task was illustrated visually using graphics as shown in Figure 2 as well as via audio examples of different sequences prior to the actual running of the experiment.

FIGURE 2. Response labels available to listeners for describing sequences with different pitch and timbre relations. Option 1 would be expected to be used if the pitch pairs maintained their coherence and were perceived at the quicker tempo. Option 2 would be expected to be used if adjacent sounds split from each other and grouped with the alternates instead, leading to a perceived reduction in tempo. Option 3 was available for binning any confusing sequences that did not appear to fall into either of the other categories.

Stimulus Construction and Procedure

Samples of notes from Raga Yaman (Sa, Re, Ga, Ma#, Pa, Dha, Ni, Sa’) were derived from digital recordings of a professional performer playing on a gandhar-pancham sitar. The recordings were made using a cardioid microphone placed three-quarters of a meter away from the performer and were digitized with 16-bit resolution at a 44.1 kHz sampling rate. The sounds were edited initially on a PC and eventually a Macintosh computer, using Audition, Audacity, sequencing and presentation applications. The sounds were not normalized for loudness, as the relative levels needed to be preserved to reflect actual performance differences. However, to have more temporal control, the sounds were equalized in duration and some envelope editing was required to avoid onset and offset clicks. As the strummed strokes have quick attacks and long decays, the rise time of the envelope was minimally tampered with, but a fade out imposed over the latter part of the sound. A duration of 500 ms with a 10 msec rise time and 50 ms decay time was decided on to keep the sounds long enough to get spectro-temporal information related to their pitch and timbre features. In the 4-note sequences used in the listening experiment, the sounds were sequenced with a stimulus onset asynchrony (SOA) of 250 ms. There was thus a partial overlap in the sounds, as is the case in actual performance given the sustained nature of the notes produced. The overall rate was thus equivalent to 4 beats/sec (240 bpm).

The 4-note sequences were repeated 10 times per trial with a gap of 500 ms. The same test sequence was presented twice within a block and two blocks presented with randomized order of sequences across trials.
Results and Discussion

Figures 3 and 4 show the proportion of trials on which particular labels were used for different sequences, averaged over the 6 listeners.

**FIGURE 3.** Proportion of trials on which particular response labels were used by listeners when listening to isotimbral sequences featuring adjacent pitch pairs played on the baj string with no intruding chikari. The overwhelming use of label 1 indicates that the pitch-based grouping was maintained in the absence of any other differences.

**FIGURE 4.** Proportion of trials on which particular response labels were used by listeners when listening to sequences with chikari sounds inserted between melodic intervals played on the baj string. The high proportion of use of label 2 indicates that timbre was the organizing cue for these sequences with even large pitch intervals greater than a fifth (S-D, S-N, S-S') being held together because of the timbre similarity of the alternate sounds.

For sequences that had no change in timbre, it is evident from Figure 3, that the actual pitch relations were maintained perceptually. The temporal order of the sounds appears to be perceived correctly, with the low-pitched pair followed by a high-pitched pair (or at the same pitch for the unison interval). Not surprising, as adjacent pitches were the same and with no timbre differences as a contrast, one would expect to hold on to the actual presented pattern.

Figure 4 shows the labeling data for sequences in which the chikari sounds were introduced, interleaved between the melodic pitch interval played on the main string. Most listeners selected the second labeling option for these, grouping alternate sounds perceptually, despite their being different in pitch. The similarity of the timbre of alternate
sounds was a powerful cue for grouping them together. The data indicate that listeners grouped alternate pitches to make the interval, while the chikari sounds broke away perceptually into another timbre stream. The effect of the chikari appears to be so strong, there was hardly any confusion in sorting out the sequence set into the appropriate categories. Although this was the effect expected, there was some expectation that listeners might get confused by the individual notes within a compound chikari stroke and group melody notes with those component notes. In slow, transcription activities with musicians, that was observed occasionally, but in the current experiment, there was apparently no such confusion.

**TRANSCRIPTION TASKS**

The listening exercise described above validated the role the chikari sounds can play as cues in initiating stream segregation. To get some more insights into interval and melody recognition when chikari sounds are inserted, some transcription activities were conducted with 2 professional musicians. In the first task, they were asked to identify the interval formed by the alternate pitches placed at position 1 and 3 in in 4-note sequences with chikari sounds playing at position 2 and 4. The sequences were played at a rate of 120 bpm in a random order with repetitions allowed up to 10 times. To get the correct answer, the subjects would have to ignore the chikari and pay attention to the melodic notes only. The task turned out to be very simple with no adverse effect of the intruding chikari sounds on identification. Both the subjects (GH and GA) got between 80-100 % correct as shown in Figure 5.

![Melodic interval identification with intruding chikari sounds](image)

**FIGURE 5.** Percent correct responses for identification of melodic pitch intervals in 4-note sequences with interleaved chikari sounds. Both the subjects (professional musicians GH and GA) scored between 80-100 %, indicating no adverse effect of the intruding chikari on the task.

After the very successful melodic interval identification activity, the musicians were assigned a more challenging task to transcribe embedded melodies heard in different contexts, alternating with chikari sounds or interleaved with other notes played on the same melody ‘baj’ string. Four melodic patterns of 5 notes were constructed with 5 possible intruding sounds to generate 20 melodies. These were presented in a random order with repetitions allowed until the musicians felt comfortable transcribing them. The task was conducted at 2 rates of presentation, 120 bpm and 240 bpm.
The results are given in Figure 6 in terms of % correct identification of the notes.

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<th>Melody</th>
<th>Intruder</th>
<th>GH (slow)</th>
<th>GH (fast)</th>
<th>GA (slow)</th>
<th>GA (fast)</th>
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<tr>
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<td>100</td>
<td>70</td>
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<td>20</td>
<td>50</td>
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<tr>
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<td>30</td>
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<td>100</td>
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<tr>
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<td>100</td>
<td>40</td>
<td>100</td>
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<tr>
<td>SGPNS'</td>
<td>Ga</td>
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</table>

**Average across sequence:** 94 94 55.5 89

FIGURE 6. Percent correct responses for identification of four 5-note melodic fragments embedded in five different contexts, with different intruding sounds. While subject GH performed consistently well at both speeds, subject GA was struggling at low speeds but improved tremendously when the patterns were sped up.

In the melodic fragment transcription task, subject GH did consistently well with all the intruders at both rates of presentation. Subject GA, however, had a difficult time identifying the patterns at the slow rate, though intrusion by the chikari was the least disturbing. The other melody notes intervening caused more confusion. For the higher rate of presentation, his average score for all patterns jumped up from 55.5% to 89%. Playing patterns at high speeds throws certain features into relief, and streaming type segregation of the intruding sounds with each other could also have helped in accomplishing the task.
CONCLUSIONS

The current study confirms the observation that chikari strings play a strategic role in sitar performance in being able to serve multiple functions. The results support the principles of Auditory Scene Analysis, with timbre similarity of intervening chikari sounds and the common tuning of the strings helping the chikari segregate from other sounds in melodic patterns and also helping to create a background harmonic drone. In rhythmic patterns, accents marked by the chikari can help in clarifying and supporting the rhythm. For all of these roles, the chikari sound needs to remain perceptually distinct from the other melodic sounds. To bring this about, thinner gauge strings are used to attain a brighter, shriller sound. The strumming of the two tonic chikaris with the other open strings (S, G, P) also creates a compound harmonic chordal sound that is timbrally richer and easily separable from the more mellow tones of the thicker ‘baj’ melody string.

The observations and empirical data presented in this report supplement the growing body of evidence supporting the role of timbre as a structural dimension of music and illustrate how a single instrument can bring about orchestral effects via the strategic use of devices such as ‘chikari’ strings.

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