Emotions and Their Intensity in Hindustani Classical Music Using Two Rating Interfaces

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Abstract

One of the very popular techniques of assessing music is using the dimensional model. Although it is used in numerous studies, the discrete model is of great importance in the Indian tradition. This study assesses two discrete interfaces for continuous rating of Hindustani classical music. The first interface, the Discrete emotion wheel (DEW) captures the range of eight aesthetic emotions relevant to Hindustani classical music and cited in *Natyashastra*, and the second interface, Intensity-rating emotion wheel (IEW) assesses the emotional arousal and identifies whether the additional cognitive load interferes with accurate rating. Forty-eight participants rated emotions expressed by five Western and six Hindustani classical clips. Results suggest that both the interfaces work effectively for both the music genres, and the intensity-rating emotion wheel was able to capture arousal in the clips where they show higher intensities in the dominant emotions. Implications of the tool for assessing the relation between musical structures, emotions and time are also discussed.

Keywords Arousal, continuous response, discrete emotions, Hindustani classical music, interface

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Continuous assessment of music stimuli emerged as a tool in 1980s, a field dominated by self-report or post-performance ratings till then (Kallinen, Saari, Ravaja, & Laarni, 2005;

Schubert, 2001). In self-report or post-performance, the participant listened to the stimulus and reported thereafter the perceived or experienced emotions verbally or by writing. However, it troubled researchers as it did not provide a clear picture of the emotion being evoked or perceived by the listener, especially during the process of listening. Ratings were simple to collect, but when they were averaged, they were difficult to interpret; whether it was the final moments of the musical piece on which the emotion was being rated, or the sum of the previous moments was not clear (Juslin & Laukka, 2004). These limitations in self-reports demanded a more effective method that could measure emotions with change in time.

Advances in computer-controlled sampling devices made continuous rating (CR) of time-dependent responses to stimuli possible (Girard, 2014). This allowed the collection of moment-to-moment changes in perception and experience at regular and relatively short intervals as the music unfolded (Egermann, Nagel, Altenmüller, & Kopiez, 2009; Schubert, 2004; Zentner & Eerola, 2010). Participant watched or listened to the stimulus and reported its nature by clicking a mouse or pressing a joystick (McKeown & Sneddon, 2013; Schubert, Ferguson, Farrar, Taylor, & McPherson, 2012). First, it allowed the researcher to identify the remembered affect of a stimulus; the listener's affective responses to a stimulus were dependent more on the peak moments rather than the previous moments. These moments occurred in various time zones of the stimulus, and were purported to be the strongest predictors of musical experience (Rozin, & Goldberg, 2004). Second, in contrast to the self-report method, listener exerted less effort to remember the emotion, and it did not put extra cognitive load on her memory (Egermann et al., 2009). Other benefits of this method included tapping of conflicting emotions (Egermann et al., 2009), elimination of memory biases, registration of the users' response to the stimuli by

providing direct feedback and scope for augmenting evaluation of the changing characteristics of the interface (Kahnemann, 1999; Nagel, Kopiez, Grewe, & Altenmüller, 2007).

Interfaces for continuous measurement per se have focused heavily on augmenting aspects such as technical standards, user-integration, and use of different modalities. For example, considerable efforts have been exerted in the improvement of human-system interaction to eliminate designer bias (EMOTRACE; Lottridge, 2008), develop robust interfaces for media annotation (CARMA; Girard, 2014), incorporate qualitative and quantitative methods for observations (DARMA; Girard & Wright, 2018), and measure experienced emotions (EmuJoy; Nagel et al., 2007). Open access software such as EmuJOY focused on experimental and technical standards for continuous measurement for a better comparison of results. A recording system was also developed for playing multimodal stimuli in the background while listeners participated in the experiment (Nagel et al., 2007). FEELTRACE tracked the emotional content of speech as participants perceived it over time. The shift in the cursor from one to the other was depictive of change in the mood (Cowie et al., 2000). Egermann et al. (2009) tested the validity of auditory web experiments using a two-dimensional space on continuous measurement of emotions to musical stimuli. A comparison of responses with a lab study done earlier affirmed that web-based methods were convenient and valid tools for researching music.

One of the major approaches utilized by these interfaces was the dimensional approach to gauge emotions with a wide variety of music clips and audio-visual stimuli. Dimensional or arousal-valence approach proposes that the affective space is bipolar (Russell, 1980). It is represented with two orthogonal axes, popularly known as arousal (excited or sleepy) and valence (positive and negative emotion) (Barrett, 2010). The distinction between the two approaches becomes blurred when the intensity of a particular emotion is rated in a discrete scale

(Schubert et al., 2012). The other major approach, discrete or categorical approach, measures discrete emotions, are a small set of independent emotions on orthogonal monopolar axes, separate from each other and governed by a marked biological and physiological phenomenon (Kragel & LaBar, 2013).

Recently, Schubert et al. (2012) discovered that less number of discrete emotions could also be used for the continuous measurement. They created an interface based on facial expressions (emoticons) 'aligned in clock-like distribution', through which survey participants quickly and easily rated emotions in music continuously. The facial expressions interface belonged to a range of emotions that were expressed by music. The emoticons used depicted six facial emotions: Excited, Happy, Calm, Sad, Scared, and Angry. The interface was further tested, and its reliability and validity were established by comparing the results against a discrete self-report survey. The emotions recognized in the interface were similar to that of the emotions in the self-report. Also, more than one emotion-face was expressed by music at the same time, and the shift in emotions was attributed to the musical structure.

Recent studies have shown that discrete emotions are easily recognized in music (Chong, Jeong, & Kim, 2013). However, there are objections whether musical expression can be understood with lesser number of categories (Bigand, Vieillard, Madurell, Marozeau, & Dacquet, 2005). It has been noticed that judgement of emotions and deciphering musical cues of music pieces were better within-cultural groups as opposed to cross-cultural groups (Laukka, Eerola, Thingujam, Yamasaki, & Beller, 2013; Argstatter, 2016). Cross-cultural participants also found difficulty in deciphering emotions of music pieces like the emotion of disgust which is a complex and a culturally conditioned response (Argstatter, 2016).

As per the ancient Indian treatise on dramaturgy, *Natyashastra* (400 BC–200 AD), components of dramatic composition communicate emotions. This tradition has strongly influenced the Indian Classical Music (ICM) which proposes nine basic aesthetic emotions (*rasas*) that can be used to assess any aesthetic work: *sringara* (romantic), *hasya* (happy), *karuna* (sad), *raudra* (anger), *veera* (exciting), *bhayanaka* (fear), *bibhatsa* (odious), *adbhuta* (wonder) and *santa* (calm). Studies also suggest that at a given time, a *raga* can express one or more than one emotion simultaneously (Deva, 1973; Wieczorkowska, Datta, Sengupta, Dey, & Mukherjee, 2010). Even today musicologists, music critics and listeners use the ancient nine-emotion framework to understand and appreciate ICM (Mathur, Vijayakumar, Chakrabarti, & Singh, 2015). Therefore, we contend that to understand emotions represented in Hindustani Classical Music (HCM), one of the major streams of ICM, CR interfaces employing discrete emotions are appropriate.

While the dimensional model has been well explored, the discrete model is rarely studied (Schubert et al., 2012) and it is appropriate in the context of HCM. The previous work on discrete emotions (Schubert et al., 2012) addresses only a limited number of emotions. It does not cover emotions cited in the Indian context and for music of different genres, and address the issue of arousal level. Introducing measurement of arousal would permit the capture of arousal component of dimensional model within a discrete framework, thus overcoming a major limitation of discrete emotion rating and would be able to integrate the best of both models. Mapping arousal manifests the richness of the temporal nature of music in the peaks and troughs in emotional intensity that ultimately leads to the musical experience (Schäfer, Zimmermann, & Sedlmeier, 2014). To that end, we have developed two discrete intuitive CR interfaces for continuous measurement of emotions in HCM. We will address two relevant aspects: (a)

measurement of valence (positive or negative emotion), and (b) of arousal intensity on a five-point rating scale.

The Development of Discrete Interfaces

Two interfaces are developed for the study, the Discrete emotion wheel (DEW) (Fig. 1.1) to identify the effectiveness of the Indian musical emotions and the Intensity-rating emotion wheel (IEW) to assess the intensities of experienced emotions (Fig.1.2). The interfaces employ eight of the nine discrete emotions based on the *navarasa* of *Natya Shastra*. They are: sad, calm, happy, anger, romantic, wonder, fear, and exciting along with two others options, ‘don’t know,’ and ‘other emotions’. ‘Other emotions’ represents the absence of a particular emotion word from the interface and ‘don’t know’ suggests the indecisiveness of the user in choosing an emotion. The emotion disgust or ‘*bibhatsa*’ is omitted as it is not considered an appropriate musical emotion in both Indian and Western contexts (Zentner & Scherer, 2008). To make the two wheels relevant, we have also taken into consideration the short nine-emotions of Geneva Emotional Musical Scale (GEMS) (Brabant & Toiviainen, 2014; Mathur, Vijayakumar, Chakrabarti, & Singh, 2015) in finalizing the emotion words.

The interfaces have circular wheel-like layouts with emotion-words distinctly demarcated with different color-zones. The distinctive colors in the emotion spaces are based on a survey where participants were asked to give color preferences for the eight emotions. The emotion-word space in IEW has concentric circles divided into five sub-regions indicating the intensity levels of the emotions. The saturation of the colors is lighter in the inner ring, indicating lower intensity, compared to heavier colors toward extreme end of the ring, indicating higher intensity.

The interfaces have three distinct segments: (a) central segment contains the play and pause buttons for commencing and stopping the music; (b) neutral segment is the decision-

making region where the cursor rests when a person decides on the appropriate response; (c) the emotion-word space consists of the ten emotion-words. The participants were permitted to operate the interfaces with a mouse click on the play button and pause for any kind of interruption. They could move their mouse to the emotion space and click on it as soon as they perceive any emotion while the music was listened. The response time is registered after each click of the participant, displayed in a small window below the interfaces.

We argue that if the intensity rating of the emotions of the music clip does not vary across the stipulated time, the interface can be considered as incorrectly designed. The higher occurrences of ratings of 'other emotions' would indicate the deficiency of adequate emotion-words and fewer occurrences indicate sufficiency of emotion-words. The 'do not know' response would represent confusion in identifying emotions expressed by the music clip. If the emotion-words used in the emotion representation model are self-explanatory and clear enough, the extent of 'do not know' response would be negligible. Thus, like Schubert et al. (2012), we wish to examine whether the discrete emotion words used are sufficient for CMR, both for rating HCM and Western music.

The demarcated regions for emotion-words make the interfaces easier for capturing the individual emotions, which is not possible in the dimensional model. Unlike Schubert et al. (2012), the emotion-words in the interfaces do not share proximal semantic space, for example, excited and happy. That can lead to biases or choice for related emotions. Hence, emotion-words with high and low valence and arousal are plotted in the interfaces at different locations to prevent biases in decision-making. In case of recognition of mixed emotions, e.g., happy and sad expressed by the clip successively, one can report multiple emotions by separately choosing them.

Fig 1.1 Discrete emotion interface

Fig 1.2 Intensity rating emotion interface

Data recording in the interfaces

The web page is created and designed using PHP (version 5.6.8), Dreamweaver, Javascript and CSS. The data related to the questionnaire is stored in a MySQL database (version 5.6.24). Rand function, which is a probability method in MySQL, is selected automatically and at random from the predetermined list of pieces. The responses in the study are collected through the web hosting platform Godaddy.com. The participants' self-reported emotions while listening to music clips were transmitted and recorded in separate data files in real-time. For each distinct mouse-movement and mouse-click, the absolute position of the user's mouse in the emotion space (browsing history) and the corresponding time point response is registered. A higher sample rate allows the effective assessment of peaks and extremities in participants' self-report. It makes convenient for the experimenter to collect data on stimuli in shorter duration. The sampling rate in the interfaces is set to 30 Hz.

Method

Participants

The participants were undergraduate students at Indian Institute of Technology Kharagpur. Forty-eight participants aged 20-25 ($M=22.5$, $SD=1.16$) participated. They received two course credits for completing the web-experiment. Website links were sent to all the participants through the internet to their personal mail account. A window of 48 hours was given to complete the experiment. At a time, many participants could log-in in the interface and assess emotions in music clips at their convenience.

Stimuli used

The stimuli used were taken from Schubert et al. (2012) study and a discrete-rating survey conducted using HCM clips. Five clips taken from Schubert's study were labeled as angry, calm, excited, fear, and sad. The other set of six clips were HCM clips comprised of happy and sad emotions by a discrete survey earlier.

Table 1. Excerpts used in the study

Sl. No	Stimulus code	Film music excerpt	Duration of clip (secs)
Clip 1	Anger	Up: 52 Chachki Pickup	17
Clip 2	Calm	Finding Nemo: Wow	16
Clip 3	Exciting	Toy Story: Infinity and Beyond	16
Clip 4	Fear	Cars: McQueen's Lost	11
Clip 5	Sad	Toy Story 3: You Got Lucky	21
Clip 6	Happy	<i>Adana</i>	15
Clip 7	Happy	<i>Adana</i>	51
Clip 8	Happy	<i>Hameer</i>	21
Clip 9	Happy	<i>Jaunpuri</i>	34
Clip 10	Sad	<i>Komal Rishav Asavari</i>	42

Clip 11	Sad	<i>Komal Rishav Asavari</i>	25
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Procedure

The participants had to log into the interface where a welcome message, the objective of the survey, and expected time to complete the survey were mentioned. Participants were urged to use headphones rather than inbuilt desktop or laptop speakers for better listening. Following that they had to fill up their demographic information. After completion, they were redirected to the instructions page. Since the experiment was divided into two tasks, two instruction pages were created. Participants were required to complete the first task in order to proceed to the next. The first task was to rate the clips in the DEW followed by rating in the IEW. The sequence of clips for all the participants was randomized. The instruction pages had the structure of the interfaces with areas highlighted showing the pause and play buttons to start and stop the music, and the neutral region to place the cursor before deciding their response to the music clip. Participants were instructed to rate the music clips by clicking on the emotion-words on the interface based on the emotion they perceived. After they had comprehended the instructions successfully, they could confirm by clicking the start button to start the experiment. A user form was given after every interface asking questions about the difficulty level of the interface.

Data Analysis

The tools for analysis included descriptive statistics for both the interfaces and the self-report music rating study. The emotions of a clip were estimated by dividing the frequency of hits of emotions that occurred in a particular clip by the total number of samples. The intensity rating was calculated using the following method. The total number of clicks by user u for clip c is given by:

$$N^{c,u} = \sum_x n_x^{c,u}$$

where $n_x^{c,u}$ is the number of clicks on the emotion x for clip c by user u . Let $I_x^{c,u}(1), I_x^{c,u}(2), \dots, I_x^{c,u}(n_x^{c,u})$ be the intensities of each of $n_x^{c,u}$ responses.

Average intensity for each emotion is given as:

$$\bar{I}_x^{c,u} = \frac{\sum_{k=1}^{n_x^{c,u}} I_x^{c,u}(k)}{n_x^{c,u}}$$

We obtain the average intensity of a particular emotion x for a clip c for a given set of U users by:

$$\bar{I}_x^c = \frac{\sum_{u=1}^U \bar{I}_x^{c,u}}{U}$$

We define intensity of an emotion x for a clip c for a given set of U users by:

$$W_x^c = \frac{\bar{I}_x^c}{\sum_x \bar{I}_x^c}$$

The higher intensity of an emotion indicates the more intensified feeling of that particular emotion in clip c , for given sample of users.

Results and Discussion

The two interfaces, discrete emotion wheel (DEW) and intensity-rating emotion wheel (IEW), were compared against clips from Schubert et al. (2012) study and a self-report study to test their reliability and validity as reported in figure 2. In the self-report music rating study,

participants rated the emotions perceived in the music after they listened to the whole piece. This method of comparing against a baseline is supported by Fuentes (2015), who found that 80% of the analyzed interfaces implemented a second method (objective and subjective) to validate the emotions users reported. It was suggested that its importance lay in contesting drawbacks that all instruments inherently have. Furthermore, intensity attributed to the music clips was also measured to look at participants' agreement to rating of intensity across the emotions which is reported in table 2.

Summary responses of Schubert's clips in DEW and IEW

The graphs (see Figure 2) depict the percentages of emotions identified in each clip in the interfaces. These graphs are compared with the findings of Schubert et al. (2012) to see whether the interfaces were able to yield consistent results. In clip 1, where the dominant emotion was anger, 'fear' also got high ratings in Schubert's study. The clip, therefore, was expressing two emotions, anger and fear, consistently in both interfaces. In clip 3, 'wonder' was perceived as dominant along with 'exciting' in both interfaces. But our results are not in line with Schubert's findings in accordance to the secondary emotion perceived. However, the dominant emotion 'exciting' was perceived significantly. Furthermore, results in Schubert's study in the 'sad' clip showed a close association with calm. Here in clip 5, only sadness was perceived distinctively. Other clips containing emotions such as 'calm' in clip 2 and 'fear' in clip 4 were recognized as dominant in both the interfaces. A quick review of the two interfaces suggests that the dominant emotions perceived were similar to Schubert's clips. Moreover, participants showed agreement with the dominant emotions the clips intended to express.

Fig 2. Emotions recognized in discrete and intensity- rating emotion wheel on Schubert's clips

Summary responses of HCM clips in DEW and IEW

The two wheels were also tested using HCM. Fig 3 depicts the participants' emotions in the self-report study and interfaces. It can be observed that in the clips 6 and 7 of *Adana*, the emotion 'happy' was perceived as very high in the self-report study. Similarly, ratings in both the interfaces evidenced 'happy' as the most rated emotion. The self-report study revealed 'happy' as a dominant emotion in *Hameer* (clip 8) and *Jaunpuri* (clip 9). Significant ratings were also observed in 'happy' in the first and second interface for the clips. The *Komal rishabh asavari* clips (10 and 11) were distinctly identified as 'sad' in the self-report survey as well as in the interfaces.

Thus, there was a consistent pattern of emotions recognized both in the interfaces and the self-report indicating the reliability of the interfaces. The profile contours of emotions in the wheels matched the emotions as indicated in the self-report study. Similarly, the validity of the interfaces has been established as they fulfill the intention of measuring emotions in music. The western music clips were also assessed in the interfaces and they yielded consistent results of perceived emotions. It can be claimed that both the interfaces have a universal appeal signifying cross-cultural consistency in dominant emotions. Still new emotions have appeared that may due to cultural uniqueness.

The dominant emotions identified for different music clips reveal that participants spent considerable time in that emotion space and hence received confident ratings (Schubert et al., 2012). In clips where 'happy' was the leading emotion, other positive emotions followed, such as calm, exciting, romantic and wonder. In clips that were perceived as distinctly sad, calm, and wonder achieved secondary ratings. Furthermore, the validity of the interfaces is assured as the occurrence of 'Other emotions' were almost negligible. In other words, the emotion-words in the interface corresponded to what participants preferred to choose in the interfaces.

Schubert et al. (2012) in their study asserted that the selection of the faces in the Six-emotion clock interface was consistent as participants selected many faces at a go. The reason inferred was that of the semantically related regions in which the emotion faces were located; the faces were placed alike the regions of the two-dimensional space. However, it is clear from the findings that the semantic relatedness is not a putative factor in the selection of emotions. The emotion-words in the wheels were not superimposed in a two-dimensional space. It implicates that the emotion-words, though positioned at different locations in the wheel, were significantly

Fig 3. Emotions recognized in discrete and intensity-rating emotion wheel on HCM clips

rated. Emotions are inherent in the music, and so a response triggers irrespective of their location. In spite of more emotion-words embedded in interfaces, they gave reliable results. Hence, this suggests that the emotion-words used in the interfaces are sufficient to evoke responses.

While the two interfaces are designed, keeping HCM specifically in mind, it is found that it is effective for Western and Indian music. Both the interfaces, depending on a researcher's needs, can be used for a wide variety of musical genres.

Intensity perceived in IEW

The results in the IEW show a pattern of perceived intensity in the music clips. For example, in Clip 3 'exciting' (1.68) and 'wonder' (1.04), Clip 7 'happy' (1.95) and 'exciting' (1.86), Clip 8 'happy' (1.92), and in Clip 9 'happy' (2.03) were rated highly. In Clip 1, although 'fear' was the second most perceived emotion after anger, 'excited' was rated as high in intensity. The participants perceived the highest intensity in the emotion 'calm' (2.80) of clip 2, and the lowest was perceived in Clip 7 (1.20). It can be observed that except clip 1, all the clips that had dominant emotions were attributed to high intensities. Hence, this interface operated on a dual axis that could differentiate between emotion and peaks of observed emotional intensity. Here, the findings suggest that the dominant emotion of a clip showed sync between frequency of hits and high intensity.

Table 2. Intensity rated in the interfaces

	Ex	Wo	Ca	Ha	Ro	Sa	Fe	An	Oe
Clip 1	0.59	0.08	0.00	0.06	0.00	0.08	0.63	1.91	0.11
Clip 2	0.11	0.35	2.80	0.24	0.15	0.00	0.00	0.00	0.08

Clip 3	1.68	1.04	0.01	0.21	0.04	0.07	0.21	0.00	0.15
Clip 4	0.77	0.41	0.17	0.07	0.28	0.36	1.28	0.09	0.02
Clip 5	0.08	0.26	0.58	0.03	0.49	2.10	0.02	0.00	0.02
Clip 6	0.30	0.30	0.42	1.63	0.21	0.43	0.04	0.03	0.00
Clip 7	0.70	0.22	0.42	1.20	0.37	0.13	0.03	0.10	0.13
Clip 8	0.37	0.18	0.62	1.23	0.83	0.00	0.00	0.00	0.04
Clip 9	1.03	0.31	0.14	1.35	0.33	0.05	0.10	0.08	0.00
Clip 10	0.01	0.07	0.53	0.06	0.19	2.38	0.17	0.03	0.21
Clip 11	0.00	0.18	0.53	0.00	0.15	1.90	0.07	0.03	0.91

Notes. Ex= Exciting, W= Wonder, C= Calm, Ha=Happy, Ro= Romantic, Sa =Sad, Fe=Fear, An= Anger, Oe= Other emotion

The motive for designing these interfaces was to address issues about the measurement of discrete emotions in HCM, incorporating an arousal rating scale along with discrete emotions. The IEW is one which is able to map the different intensities of emotion ratings from time to time. Thus, one of the key components of the dimensional rating, ‘arousal,’ is being mapped here. It is observed that emotional intensity is not necessarily constant over the pieces of music and participants perceive variations that clips convey. Higher intensities are rated for dominant emotions in the music clips. These findings are in line with the study by Schäfer, Zimmermann, and Sedlmeier (2014) where they found that participants attribute higher intensities to single events in a musical clip. At the same time, it is the cumulative rating of specific moments in the music clip which influences the final impression of the emotion perceived. Therefore, the IEW can be considered as a sensitive interface compared to first DEW.

Conclusion and Future Directions

We present in this paper two interfaces for measuring discrete emotions in HCM, thereby highlighting the importance of CR method. The use of discrete emotions in HCM is pervasive, and interfaces with eight emotion words seem sufficient and give reliable results across genres of music. Moreover, IEW is able to capture arousal levels as well, thus making the discrete method more sensitive, a point made by Schubert (2012).

The wheels are both powerful and flexible, since depending on the complexity of tasks and needs, they can be used for a variety of contexts. In the future, the interfaces can have the option of introducing both substitute emotion words as well as new emotion words in other languages, thus extending their use. The correlation between time and music feature are not analyzed. Future studies can look into this aspect to help identify features in music that correlate with specific emotions, and to map relations of emotion intensity with features. A fundamental question in music perception is which elements make us remember a musical piece as sad or happy, persistence over time or intensity levels. It is expected that IEW would be able to address this in the future.

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