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Diurnal changes in the perception of emotions in music: Does the time of day matter?

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Abstract

According to the Hindustani music tradition, the ability of a song to induce certain emotions depends on the time of day: playing a song at the right time is said to maximise its emotional effect. The present exploratory study investigated this claim by combining findings in chronobiology, mood research and music perception. It has already been established that some aspects of our mood fluctuations follow a cyclical pattern. Besides, it is a known fact that our current mood influences our perception and assessment of emotions. However, these elements have never been linked together in a study examining the effect of mood cyclicity on perceived emotions in music. To test the hypothesis of a link between the two, Western film music excerpts were played to 36 participants at two different times (9 am and 4 pm). Their task was to rate the perceived emotional content of each clip. The results showed that sad and tender clips were rated higher on sadness and tenderness in the morning compared to the afternoon. Furthermore, the more tired the participants were in the afternoon, the higher was their perception of fear in angry and fearful music. Although the reported effect sizes were small, these findings could have important implications for ethnomusicologists, emotion researchers and music therapists.

Keywords

Music, emotion, time of day, circadian rhythms, Indian classical music, raga

Introduction

The way our current mood influences how we perceive emotions has been examined in numerous studies. Although these studies use different methodologies and types of stimuli, the general agreement is that our current mood acts as a perceptual filter, creating a bias in our perception and assessment of emotions.

One very common way to investigate the link between mood state and emotional perception is through the assessment of pictures with faces expressing various emotions. Surguladze et al. (2004) for example showed that compared to healthy volunteers, people with major depressive disorder were perceptually less sensitive to happy facial expressions. Along the same line, Gotlib, Krasnoperova, Yue, and Joormann (2004) found that when presented simultaneously with sad and neutral faces, people with major depression exhibited an attentional bias for faces expressing sadness.

Moving now to the field of music psychology, a similar bias has been found for musically-expressed emotions. Vuoskoski and Eerola (2011), for example, studied the role of mood and personality in the perception of emotions in music. They identified several statistically significant correlations: vigour (positive mood) correlated positively with ratings of happiness in the music, and depression (negative mood) correlated positively with ratings of sadness. Punkanen, Eerola, and Erkkilä (2011) made a similar discovery in a study on emotional recognition and depression. They asked a group of participants with depression to emotionally rate the content of musical excerpts. The scores were then compared to the ratings of healthy controls. The results indicated that participants with depression displayed a judgement bias towards negative emotions.

As illustrated by the previous examples, research offers abundant evidence supporting the idea that we perceive emotions differently depending on our current mood. Besides, there seems to be a high degree of congruence between the valence of the mood and the valence of the emotions affected by the resulting perceptual filter. Moreover, although moods are relatively long-lasting emotional states, they are evidently not stable but display a certain level of fluctuation. Is there any indication that our mood fluctuations are not completely erratic but predictable to a certain extent?

We know from chronobiology that every living organism contains biological clocks that regulate and synchronise its activity to the time of day and the seasons (Reinberg & Smolensky, 1983). What comes to humans, chronobiologists have established that countless physiological processes follow a predictable rhythm of ups and downs, for instance, brain wave activity, hormone production, body temperature, blood pressure and alertness (Palmer, 2002). Because of the entrainment effect of the day and night cycle, many of these rhythms display a 24h pattern and are therefore called circadian rhythms (from the Latin *circa*, around and *dies*, day). Although longer and shorter cycles have also been identified, for example, circannual (one year) or ultradian rhythms (less than 24 hours), circadian rhythms are by far the most studied and best known biological rhythms.

Since most, it not all, of our physiological processes display some form of circadian rhythmicity, it is legitimate to assume that at least some aspects of our daily mood states are governed by similar rhythms. Furthermore, these rhythms might to a large extent be endogenous, meaning that they originate within the organism and are unaffected by outside events. According to findings in mood research, such seems indeed to be the case.

When studying a person's mood, researchers commonly distinguish between Positive Affect (PA) and Negative Affect (NA) to describe positive and negative moods. Interestingly enough, PA and NA have been found to be largely autonomous dimensions that fluctuate independently from each other (see e.g. Stone et al., 2006; Vittengl & Holt, 1998; Watson, Clark, & Tellegen, 1988). In other words, low PA does not necessarily imply high NA, because they are not two ends of the same spectrum.

Looking now more closely at mood cyclicity, a majority of studies using the PA-NA paradigm found that PA, but not NA, was following a daily rhythm (e.g., Clark, Watson, & Leeka, 1989; Hasler, Mehl, Bootzin, & Vazire, 2008; Murray, Allen, & Trinder, 2002; Wood & Magnello, 1992). Typically, PA will be at its lowest early in the morning and late in the evening, and reach a peak at some point during the day. Several studies concluded that the PA pattern over 24h can be adequately approximated with a fitted sinusoidal curve (Hasler et al., 2008; Murray et al., 2002). However, researchers disagree as to the time of that peak, and whether we experience one or several peaks. Nevertheless, this overall low-high-low pattern in PA has proven to be a solid finding of mood research. Furthermore, there is strong evidence to suggest that the PA cycle is driven by endogenous clocks. Indeed, the diurnal PA pattern is not fundamentally affected by lifestyle factors, such as a person's daily schedule or activities like socialising, eating and exercising (Hasler et al., 2008; Watson, 2000).

In contrast, NA usually does not display any predictable pattern and tends to remain low in the absence of external stressors (real or imagined). The explanation that has been advanced is that PA and NA belong to different motivational systems. According to Watson (2000), PA is the expression of a reward-seeking mechanism whose goal is to allow humans to successfully coordinate their efforts, while NA belongs to a pain-avoiding mechanism that is only triggered in the presence of an immediate threat.

In addition to the current state of our circadian clock, the proximity of sleep has also proven to be another important determinant of our subjective mood. If a person has just risen or is about to retire, his or her PA score will be very low, independently from the time of day (Clark et al., 1989). Several studies have placed the peak in PA roughly 8 to 10 hours after waking up (Hasler et al., 2008; Watson, 2000). Taking 7 am as a common wake-up time, this means that a fair amount of people will reach their peak in positive mood around 4 pm.

Another factor that is likely to influence our mood is our current level of tiredness. Commonly, people who are not tired are in a better mood, and therefore see negative things in a more positive light. Conversely, tiredness is typically accompanied by a lower mood and a negative perceptual bias. Thayer (1987), for example, has established that people perceived their personal problems as being much worse when their level of energetic arousal was low, in other words, when they were tired. Similarly, Kanning (2010) has demonstrated that when people's level of energetic arousal increased, so did their positive mood.

To summarise the findings presented so far, we know that our current mood influences the way we perceive emotions in general, including musically-expressed emotions. We also know that some aspects of our mood states are endogenous and follow a daily rhythm. The logical conclusion from these two premises is that musically-expressed emotions should be perceived differently depending on the time of day. Is there any aspect in our practice and experience of music that might support this hypothesis?

Unfortunately, there is no tradition in Western music linking the emotional content of a piece with a specific performance time. One might object that Western classical music does associate certain pieces with specific times of the day, such as Grieg's 'Morning Mood' ('Morgenstemning'), Falla's 'Nights in the Gardens of Spain' ('Noches en los Jardines de España') or Purcell's 'Welcome, Welcome, Glorious Morn'. However, this association is only a theme present in the composition of the piece, not a recommendation as to when the piece should be played. Nevertheless, one music tradition that does associate specific songs with specific performance times is Indian classical music. It therefore represents a suitable starting point for investigating the relevance of such an association.

Indian classical music

Navarasa

The Indian aesthetic tradition is based on a set of nine emotions. An initial list of eight items was established in the *Natya Shastra*, a treatise on performing arts dating back to the 3rd century AD. A ninth emotion was added in the 10th century AD, and the list became subsequently known as the *navarasa* (from the Sanskrit *nava*, nine and *rasa*, sentiment). All the classical Indian art forms are aiming at expressing these *rasas* and evoking them in the audience. The *Natya Shastra* specifies that although several *rasas* can be present in a given work of art, only one should be dominant (Bharata, 1996).

The following are the *navarasa*, as described by Raja (2005): *shringaara* (love, attractiveness), *karuna* (pathos, compassion, sadness), *haasya* (mirth, joy, laughter), *raudra* (anger), *veera* (valour, heroism, majesty), *bhaya* (fear), *bibhatsa* (disgust), *adbhut* (surprise, marvel, amazement) and *shaanta* (peace).

Scholars and musicians frequently mention a tenth *rasa* called *bhakti*, which is a feeling of devotion and spirituality. However, as Shankar (2008) points out, *bhakti* could also be seen as a combination of *shaanta* (peace), *karuna* (sentimentality, sadness) and *adbhut* (marvel).

Since the *navarasa* were established for performing arts in general, not all of them can be easily expressed in every art form. The sentiments of *bhaya* (fear) and *bibhatsa* (disgust) for example are the least suitable for Indian classical music and are therefore hardly ever expressed musically (Shankar, 2008).

Navarasa and the Geneva Emotional Music Scale

One unresolved issue in the field of music psychology has to do with the cross-cultural ability to accurately assess the intended emotions expressed in music. Is this ability culture-specific, or does it transcend cultural boundaries? In other words, are the *navarasa* universal or specific to Indian culture?

These questions cannot be answered with certainty yet, as studies focussing on emotional recognition across cultures are few and far between. However, the existing studies indicate that there is indeed a certain degree of universality, at least for some basic emotions. In a study by Balkwill and Thompson (1999), 30 Western listeners were tested on their ability to recognise joy, sadness, anger, and peace in specific pieces of Indian classical music. The authors concluded that at least joy, sadness, and anger could be recognised by the participants, although all of them were naïve listeners of this type of music. The two authors repeated the experiment with 147 Japanese listeners, and had similar results (Balkwill, Thompson, & Matsunaga, 2004).

A more systematic approach to determine which musical emotions might be the most frequent and most recognisable would be to perform a survey across several genres and cultures. This was precisely the task undertaken by Zentner, Grandjean, and Scherer (2008), although they limited themselves to Western musical genres.

Zentner et al. (2008) first compiled a list of 146 emotion terms and tested their frequency across several groups of listeners with different music tastes. After having reduced the data through exploratory factor analyses, they carried out a field study during a music festival in order to test the validity of the extracted factors. The result is a nine-factorial model of music-induced emotions, known as the Geneva Emotional Music Scale (GEMS). The identified factors are wonder, transcendence, tenderness, nostalgia, peacefulness, power, joyful activation, tension, and sadness.

First of all, we would like to draw the reader's attention to the striking similarity between the GEMS and the *navarasa*. Table 1 shows a descriptive list of the GEMS items with the corresponding *rasas* from Indian classical music.

[Insert Table 1 about here]

It is also worth mentioning that the creators of the GEMS had 'disgust', 'fear' and 'anger' in their initial affect list, but they were eventually discarded. Indeed, since their participants very seldom mentioned these emotions in relation to music, the authors concluded that they could not be considered musical emotions (Zentner et al., 2008). This is interesting because as we just saw, a similar discarding happened to the *navarasa*, with *bhaya* (fear) and *bibhatsa* (disgust) being considered not suitable for Indian classical music. Although *raudra* (anger) has remained in the list, it can easily be assimilated to the ‘tension’ factor of the GEMS (see Table 1).

The fact that the GEMS so closely matches an 1800-year-old list from another culture is quite interesting to say the least. It also constitutes a strong argument in favour of the universality of these musical emotions.

Raga

As we just saw, the goal of Indian classical music is to express a certain set of emotions or *rasas*. In order to do so, Indian musicians rely on melodic frameworks known as ragas.

As the term ‘melodic framework’ indicates, a raga is neither a pre-composed melody nor a scale, but something in between. Raja (2005) gives us the following definition: ‘A raga is a psycho-acoustic hypothesis, which states that melody, created and rendered in accordance with a certain set of rules, has a high probability of eliciting a certain quality of emotional response’ (p. 392).

When talking about Indian classical music, one has to distinguish between the Hindustani music from the north and the Carnatic music from the south. From this point on, the focus will be solely on Hindustani music, as the time theory that will soon be addressed does not concern Carnatic music.

Many treatises have been written about Hindustani classical music, but the treatise nowadays regarded as the reference is called *Hindusthani Sangeet Paddhati* (Bhatkhande, 1990). Written by the musicologist Vishnu Narayan Bhatkhande (1860-1936), it is an attempt to reconcile theory with centuries of practice. Bhatkhande’s main contribution to Hindustani music is the creation of a coherent classification system to organise the hundreds of existing ragas. Although it has attracted some criticism (e.g., Roy, 1937), Bhatkhande’s theory is nowadays widely accepted.

Bhatkhande organised the ragas into groups according to their parent scale or *thaat*. There exist ten of these *thaats*, all bearing the name of a prominent raga (*Bilawal*, *Marwa*, *Bhairav*, *Poorvi*, *Bhairavi*, *Todi*, *Asavari*, *Kalyan*, *Khamaj* and *Kafi*). However, unlike a raga, a *thaat* is only a theoretical construct that serves as the basis for their derivative ragas. Therefore, a *thaat* does not have different ascending and descending lines, nor does it have emotional qualities. As Kaufmann (1965) says, a raga is ‘alive’ whereas a *thaat* is ‘impersonal’ (p. 283).

We have now defined the nature of a raga, as well as its purpose, which is to induce specific emotions. Quite logically, the next step is to find ways to enhance and maximise this emotional effect. In the West, we mainly rely on musical features and interpretation skills. While Indian music does not ignore these aspects either, it has added an extra factor to the equation: the time factor.

Raga and performance time

The Hindustani music tradition contains a very elaborate system of specific time associations for each raga. The idea is that people are more or less receptive to certain *rasas* depending on the time of day. Therefore, playing a raga at the right time is said to increase its emotional impact (e.g., Batish & Batish, 1989; Deva, 1980; Shankar, 2008). In other words, successfully conveying an emotion requires not only a skilled musician and an appropriate vehicle (the raga), but also an appropriate time frame.

As we will now see, there are different aspects to the time associations existing in the Hindustani tradition. The most studied of these aspects are the structural features of the music, starting with the parent scales. Similarly to the circle of keys and spiral of fifths found in Western music, the ten parent scales are following each other in two consecutive cycles called the circle of *thaats*. Roy (1937) notes that the principle behind these cycles is simply 'the tendency of ragas to follow the line of least resistance in the easy transition from scale to scale' (p. 82). Each cycle lasts 12 hours, starting at 7 am. Consequently, every *thaat* is appearing twice in the course of 24 hours, once during daytime and once during the night.

Furthermore, Bhatkhande divided the 24 hours of the day into eight *praharas* or 'beats' of three hours each. All ragas fall into one of these *praharas*. In Bhatkhande's system, the first *prahara* starts at 7 am, whereas some other authors make the cycle start at 6 am (e.g., Kaufmann, 1965). This division is therefore not so strict and should rather be regarded as an approximate time frame.

What comes to the general emotional qualities of the ragas, Yardi and Chew (2004) have shown that ragas performed between late night and morning are what they call 'bottom heavy', whereas ragas performed between late morning and early evening are 'top heavy'. Bottom heavy ragas are characterised by solemn and grave emotions, whereas top heavy ragas evoke lighter and happier emotions.

The preceding description focussed mainly on a raga's structural features to explain the time associations. However, this is only one of the possible approaches, since scholars and musicians do not seem to agree about the actual origin of the time theory. Shankar (2008) for instance lists several possible origins, such as tradition, historical anecdotes or the Hindu time division, where the day is divided into lucky and unlucky moments. Some authors also see in the time associations a direct application of principles found in Ayurvedic medicine (Batish & Batish, 1989; Westbrook, 1998). This last point deserves to be developed, as Ayurvedic medicine contains elements perfectly compatible with the notion of circadian rhythms described earlier.

Ayurveda is a medical system that was originally described in the Vedas, the oldest Hindu scriptures. Literally, Ayurveda means 'science of life'. It is based on the concept of *doshas,* which are basic principles or humours deriving from the combination of the five elements (Air, Fire, Water, Earth and Ether). There exist three *doshas*, called *kapha*, *pitta* and *vata*.

Together they form what is called the *tridosha* (*tri* meaning 'three' in Sanskrit). *Kapha* can be broadly associated with the ideas of cohesion and structure, *pitta* with fire and transformation, and *vata* with air and movement. It is described in Ayurveda that all living things are made of these three *doshas* combined in different amounts, with one *dosha* usually dominant (Ninivaggi, 2010).

Another central concept in Ayurvedic medicine is the idea of the *tridosha* cycle. It is said that *kapha*, *pitta* and *vata* alternate over a cycle of 24 hours, starting with *kapha* at 6 am. Every four hours, one of the *doshas* becomes dominant and influences the body/mind/soul in a specific way, making us for example more sensitive to certain emotions (Ninivaggi, 2010). According to Batish and Batish (1989) and Westbrook (1998), Indian music tradition has developed by taking into account and respecting the *tridosha* cycle. The possible existence of a link between Ayurvedic health principles and Indian classical music is further supported by the fact that the eight *praharas* of Bhatkhande's time theory and the *tridosha* cycle of Ayurvedic medicine both start at 6 or 7 am.

Interestingly enough, the idea behind the *tridosha* cycle is the same as the idea behind circadian rhythms. Although their paradigms are different, Ayurvedic medicine and Western chronobiology both came to the conclusion that our physiology follows a predictable and cyclical pattern over the course of 24 hours. For the second time, we are encountering a striking similarity between Indian and Western ideas. This accumulation of similarities (*navarasa* and GEMS, *tridosha* cycle and circadian rhythms) indicates that the Indian time theory could be investigated with empirical methods outside the Indian context. In other words, nothing speaks against transposing the Indian time theory into a Western context and testing its validity with Western music and Western listeners.

Music-listening experiment

The following experiment was designed to investigate the possible influence of the time of day on perceived emotions in music. The overall idea was to ask a group of people to rate the emotional content of selected music clips at two different times of the day, and then to compare the results. The experiment was conducted over a two-week period, from 30 January to 15 February 2012. It took place at [removed to allow blinded review].

Given the findings in chronobiology, mood research and music perception presented above, the hypothesis was that musically-expressed emotions would be affected by a perceptual bias corresponding to the general PA curve described earlier. In other words, we expected to find a higher sensitivity to negative emotions when PA was low (typically in the morning and in the evening). With regard to tiredness, we predicted that tired participants would be more sensitive to negative emotions than non-tired participants.

Participants

A total of 36 people participated in the experiment. All the participants were recruited among students or researchers from the University of [removed to allow blinded review].

Their age ranged from 19 to 39 (M = 25, SD = 4.2). A majority of them were female (75%). As to their nationality, 15 participants were [removed to allow blinded review] and the remaining 21 were international students. Most of the [removed to allow blinded review] were Europeans, with a few exceptions (two Chinese participants and one West-African participant). None of the participants were native English speakers. All of them were familiar with Western film music, and 86% said that they pay quite a lot attention to music when watching a film. The level of self-assessed musicality was rather high, with an average of 4 on a scale of 1–5 (SD = 1). The first 30 participants were compensated with a free cinema ticket.

Session choice

The experiment consisted of two parts: one morning session at 9 am and one afternoon session at 4 pm. The chosen times roughly corresponded to two extremes of a typical PA curve, with one point taken at the lower end (morning) and another point taken near the theoretical acrophase (afternoon).

A total of six morning and five afternoon sessions were organised. Each participant had to choose one morning session and one afternoon session, but not necessarily on the same day or in that order. In other words, the participants' first session might be a morning or an afternoon session, and they might do the sessions on the same day or on different days.

In the end, 16 participants started with a morning session and 20 with an afternoon session. Furthermore, 13 participants did both parts on the same day, and 23 participants did them on different days.

Music stimuli

In many studies on music and emotion, the music clips are arbitrarily chosen, meaning that there is no guarantee they will accurately convey the intended emotion. Another common problem is that the chosen clips are often well-known pieces of Western classical music. Being easily recognisable by the average participant, episodic memory linked to that specific piece could interfere with the emotional perception or effect the researcher is trying to investigate.

To avoid these problems, Eerola and Vuoskoski (2011) created a dataset of music clips specifically designed for the study of music and emotion. The 110 clips constituting this dataset were carefully selected through a pilot study followed by a large validation study. They were all unfamiliar excerpts from recent film soundtracks, lasting around 15 seconds each. The style was Western classical music, which is the dominant style in film scores.

During the validation study, each clip had been rated by 116 non-musicians using both the discrete and dimensional model of emotion (for a critical review of these models, see Eerola & Vuoskoski, 2013). The target emotions were anger, fear, happiness, sadness and tenderness. For the present experiment, three highly representative examples and two moderate examples of each target emotion were chosen, according to the ratings obtained with the discrete model. On a scale of 1–9, the average rating was 6.24 for highly representative examples (*SD* = 0.44) and 4.8 for moderate examples (*SD* = 0.55).

Because of the within-subject design, using the same playlist twice could have led to implicit or explicit memory effects. Therefore, two different but comparable playlists of 25 clips each were created, referred to from now on as playlist A and playlist B (for the detail of the playlists, see Appendix). In order to counterbalance the presentation of the stimuli, half of the participants listened to playlist A in the morning and B in the afternoon, while the other half listened to playlist B in the morning and A in the afternoon. Furthermore, the presentation order of the clips inside the playlists was randomised for each participant.

Apparatus

The experiment was conducted on iMac computers. Each computer was equipped with an MBox 2 audio interface and high-quality headphones (AKG K141). The music clips were MP3 files encoded at 160 Kbps (variable bit rate). The interface for the music listening part was designed with PsychoPy, version 1.72. This open-source, cross-platform application allows for the presentation of stimuli and the collection of rating results (Peirce, 2007).

Initial questionnaire

Each session consisted of a questionnaire followed by the actual music-listening part. The questionnaire was used to collect general information and to assess the current mood of each participant. For the mood evaluation, we chose the Positive Affect Negative Affect Schedule (PANAS). The PANAS is composed of 20 mood adjectives, 10 for Positive Affect (active, alert, attentive, determined, enthusiastic, excited, inspired, interested, proud, strong) and 10 for Negative Affect (afraid, scared, nervous, jittery, irritable, hostile, guilty, ashamed, upset, distressed). Each item was rated on a scale of 1–5. In order to extend the scope of the PANAS, three extra items were added to the evaluation (tired, calm and sad). On average, it took the participants five minutes to complete the initial questionnaire.

As noted by Thompson (2007), the original PANAS poses some problems when used in an international context with non-native English speakers. Many of the mood adjectives have shown to be unclear or ambiguous in the context of ‘international English’. Thompson therefore conducted an extensive cross-cultural validation of the original 20 items and proposed a short form of the PANAS with only 10 items. Since we wanted to keep the original PANAS, the language problem was circumvented by adding some semantic explanations to the most unfamiliar and ambiguous items.

We mentioned earlier that the sleep-wake cycle was known to have an influence on the phase of various circadian rhythms. Therefore, the participants were also asked how many hours they slept last night and at what time they woke up that day.

Music rating

After the initial questionnaire, the participants had to listen to 25 film music excerpts with an average length of 15 seconds each. Their task was to rate the emotional content of each clip using five rating scales, one for each target emotion (anger, fear, happiness, sadness and tenderness). The rating scales ranged from 1 to 9. The participants were explicitly asked to rate the perceived emotions and not the felt emotions. The instructions contained a short explanation of the difference between the two. As far as the interface is concerned, it was designed in such a way that participants could only proceed to the next clip once all the five ratings were done. They were also given the possibility to replay the clip if needed. Most participants completed the music-listening part in 25 minutes or less.

Results

Mood evaluation

The analysis of the initial questionnaire indicated that participants slept on average 6.7 hours before the 9 am session (SD = 1.3) and 6.9 hours before the 4 pm session (SD = 0.97). A paired samples t-test revealed that this difference was not statistically significant (p = .4). Furthermore, 80% of the participants slept at least 6 hours before the morning session, and 95% did so before the afternoon session. The sample was therefore very homogeneous in terms of sleep length, and that length was long enough to assume that none of the participants were experiencing disrupted circadian patterns because of sleep deprivation.

As to the proximity of sleep, participants awoke on average 1.5 hours before the 9 am session (SD = 0.7 hour) and 7.9 hours before the 4 pm session (SD = 1.3 hours). The range was quite small in the morning (3 hours), but it became very large in the afternoon (7 hours) because of two extreme values (one participant woke up at 6:30 am and another at 12:15 pm).

In order to determine the existence of possible outliers, the Mahalanobis Distances were calculated for each participant, using two sets of variables (NA_am - NA_pm and PA_am - PA_pm). No one exceeded the critical value for df = 2 and $p < .001$ (critical value: 13.82). Looking specifically at the mood scores of the two participants with extreme values in wake-up time, both had very similar PANAS scores, and these scores were close to the group's average (within one standard deviation of both PA and NA). It therefore appeared that their difference in wake-up time did not affect their mood scores. Given those two findings, the whole dataset (N = 36) was used to analyse the mood scores.

When averaging the mood scores for all the participants, NA and PA were almost identical between the morning and the afternoon: 14.25 for NA_am (SD = 4.47), 14.81 for NA_pm (SD = 5.67), 31.72 for PA_am (SD = 6.68) and 31.75 for PA_pm (SD = 7.04). None of these differences were statistically significant. At first sight, it would therefore appear that the participants' mood did not follow the expected fluctuations observed in previous studies.

In order to investigate the matter further, correlation measurements were made between the PANAS scores and other participant data collected through the initial questionnaire. Because not all the factors followed a near-normal distribution, a non-parametric measure of correlation (Spearman's ρ) was used to analyse the variables.

Only two significant correlations existed in the morning: a positive correlation between Sad and NA ($r_s = .374$, $p < .05$), and a negative correlation between Calm and NA ($r_s = -.430$, $p < .05$). These correlations were to be expected, since sadness and calmness are a negative and a positive affect respectively. It is also worth mentioning that there was no significant correlation with the tiredness scores, which indicates that participants' morning mood scores were not related to their reported level of tiredness.

Interestingly, the same analysis performed on the afternoon scores yielded many additional correlations. Unlike in the morning, the level of tiredness now correlated positively with the NA score ($r_s = .448$, $p < .01$) and negatively with the PA score ($r_s = -.507$, $p < .01$). Additionally, tiredness also correlated positively with sadness ($r_s = .607$, $p < .001$).

Furthermore, whereas the NA and PA scores appeared completely unrelated in the morning, they correlated negatively in the afternoon ($r_s = -.610$, $p < .001$), meaning that Negative Affect decreased as Positive Affect increased. Such a correlation was rather unexpected, because one of the robust properties the PANAS is to consist of largely uncorrelated scales (Watson et al., 1988). Subsequent studies have shown that the correlation between NA and PA usually ranges from -.05 to -.35 (Watson & Clark, 1999). A correlation of -.610 was therefore largely beyond the expected values and hinted at the presence of a confounding factor. The sudden presence of afternoon correlations between NA, PA and Tiredness indicated that Tiredness might be this confounding factor.

Thus, the mood scores were analysed again, following the creation of two tiredness groups using a median-split. Since the morning PANAS scores were uncorrelated to the morning tiredness scores, the tiredness labels were attributed according to participants' afternoon tiredness scores. Because of the within-subject design, this solved the category attribution problem for participants with diverging morning and afternoon tiredness scores. Participants scoring 1 or 2 ($n = 13$) were placed in the category 'Not Tired', whereas participants scoring 4 or 5 ($n = 15$) were labelled 'Tired'. As to participants scoring 3 ($n = 8$), they were dropped from the dataset.

[Insert Figure 1 about here]

As can be seen in Figure 1, the mood scores of tired versus non tired participants displayed diverging trends. Both groups started out with morning scores that were very similar. However in the afternoon, tired participants experienced an increase in NA and a decrease in PA, whereas not tired participants saw their PA increase and no change in their NA. The decrease in PA displayed by tired participants was statistically significant ($t(14) = -3.08$, $p < .01$), and so was their increase in NA ($t(14) = 2.19$, $p < .05$). As to the non tired participants, their increase in PA was also statistically significant ($t(12) = 4.07$, $p < .01$), but the difference in NA scores was not ($t(12) = .06$, $p = .96$).

These results explain why the mood scores for the entire dataset displayed no variations between the morning and the afternoon: when pooling together all the ratings, the opposite trends between tired and non tired participants cancelled each other out, resulting in almost identical mean scores. Besides, it is interesting to observe that only participants with low afternoon tiredness had mood scores in line with the expected trend (no significant change in NA, and an increase in PA between the morning and the afternoon).

Music ratings

Cronbach's alpha (i.e., the degree of agreement between the participants) was calculated for each scale under both conditions (morning and afternoon). The inter-rater reliability was very high for the anger, fear and happiness scales ($\alpha > .99$, both in the morning and the afternoon), and only slightly lower for the sadness and tenderness scales ($\alpha > .98$ in the morning and $\alpha > .97$ in the afternoon for both scales). We therefore concluded that the ratings were consistent and could safely be pooled together for analysis.

Similarly to the mood scores, the presence of possible outliers was investigated using Mahalanobis Distances. Two sets of variables were used for each participant (anger_am, fear_am, happiness_am, sadness_am and tenderness_am for the first set; anger_pm, fear_pm, happiness_pm, sadness_pm and tenderness_pm for the second set). No participant exceeded the critical value for df = 5 and $p < .001$ (critical value: 20.52). Therefore, the whole dataset ($N = 36$) was used to analyse the music ratings.

Since some mood indicators did not follow a normal distribution, a non-parametric measure of correlation (Spearman's ρ) was used. After calculating the correlation coefficients between the emotion ratings and the various mood indicators, several statistically significant relationships became apparent:

- Happiness_am correlated positively with PA_am ($r_s = .390$, $p < .05$) and Calm_am ($r_s = .318$), but the latter correlation only approached significance ($p = .059$).

- Sadness_pm correlated positively with NA_pm ($r_s = .378$, $p < .05$).

- Fear_pm correlated positively with NA_pm ($r_s = .316$, $p = .06$) and negatively with PA_pm ($r_s = -.289$, $p = .087$), however these correlations only approached significance.

In order to detect possible rating differences between the morning and the afternoon, the clips were grouped according to their target emotion, and the average rating for each group calculated on each scale. This made it possible to discover how clips were rated on the scale measuring that specific emotion (e.g., how the happy clips were rated on the happiness scale), but also how the clips were rated on the other four scales (e.g., how the happy clips were rated on the anger, fear, sadness and tenderness scales). The results are presented in Figure 2.

[Insert Figure 2 about here]

Repeated measure ANOVAs carried out for each of the five rating scales revealed the existence of several statistically significant differences between the morning and the afternoon. First of all, fearful clips were rated significantly higher on anger in the afternoon ($M = 3.72$, $SD = 1.51$) compared to the morning ($M = 3.20$, $SD = 1.27$), with $F(1, 35) = 4.54$, $p < .05$, $\eta^2 = .03$. In other words, fear expressed by music was perceived as more angry in the afternoon. Surprisingly, such a difference was not found for the angry clips rated on the anger scale.

Furthermore, the time factor also had a main effect on the way sad and tender clips were perceived in terms of tenderness, with $F(1, 35) = 4.67$, $p < .05$, $\eta^2 = .02$ for the sad clips and $F(1, 35) = 4.81$, $p < .05$, $\eta^2 = .02$ for the tender clips. Both sad and tender clips were rated significantly higher on tenderness in the morning ($M = 4.97$, $SD = 1.57$ and $M = 7.15$, $SD = 1.44$) compared to the afternoon ($M = 4.57$, $SD = 1.59$ and $M = 6.65$, $SD = 1.95$). While creating the music dataset used in the present study, Eerola and Vuoskoski (2011) noticed that sad and tender clips were easily confused when rated on tenderness, with both types of clips usually receiving high tenderness ratings. Therefore, the current results indicate a general reduction of participants' sensitivity to tenderness in the afternoon.

The same trend could be observed for the sadness rating of the sad clips, with higher rating of sadness in the morning ($M = 7.12$, $SD = 1.04$) compared to the afternoon ($M = 6.77$, $SD = 1.08$). However, the rating difference only approached statistical significance, with $F(1, 35) = 4.09$, $p = .05$, $\eta^2 = .03$. To be very accurate, p was equal to 0.051, so at the very limit of the conventional significance level. A summary of the significant ANOVA results is presented in Table 2.

[Insert Table 2 about here]

In order to assess the magnitude of the effect size, Cohen (1988) gave the following rule of thumb for eta-squared: 0.01 = small, 0.06 = medium, 0.14 = large. Therefore, the effect of the time of day on the perception of anger, tenderness and sadness was relatively small.

Correlation analysis between the tiredness scores and the music ratings revealed the existence of statistically significant correlations on the fear scale between Tired_pm and Angry_pm ($r_s = .33$, $p < .05$), as well as between Tired_pm and Fearful_pm ($r_s = .49$, $p < .05$). These correlations indicate that the more tired the participants were in the afternoon, the more fearful was their perception of angry and fearful music. Similarly to what has been said about sad and tender clips, both fearful and angry clips tend to receive high ratings on the fear scale (Eerola & Vuoskoski, 2011). Therefore, the ratings of fearful and angry clips can be linked to the perception of fear in general

Similarly to the mood scores, tiredness only seemed to play a role in the afternoon. Indeed, no correlations were found with Tired_am, on any of the rating scales. This systematic absence of morning correlations involving tiredness – both in the mood evaluation and the music rating – will be addressed in the discussion.

Discussion

In this study, we investigated the hypothesis that our perception of musically-expressed emotions changes with the time of day. The starting point was the classical music tradition of northern India, where each raga is being assigned a specific performance time in order to maximise its emotional effect. The results of our music-listening experiment revealed that participants were more sensitive to musically-expressed sadness and tenderness at 9 am compared to 4 pm. Furthermore, the level of afternoon tiredness was linked to the perception of fear: tired participants perceived fear in music as more fearful than participants who were not tired. The non-significant effects are also worth mentioning, since only two emotions out of five (sadness and tenderness) displayed statistically significant rating differences. The other three musical emotions (anger, fear and happiness) had almost identical perception levels between the morning and the afternoon.

Interestingly enough, the findings involving the perception of sadness and tenderness are being corroborated by the traditional performance habits of Hindustani ragas. Indeed, the following is a list of prominent morning ragas (in chronological order) and a description of their typical emotional content (Kaufmann, 1965):

- *Bhairava* (early morning): sad and serious, with an awe-inspiring feeling of grandeur
- *Bhairavi* (early morning): peaceful, serious, slightly sad and loving
- *Todi* (morning): gentle peacefulness, idyllic adoration
- *Bilaval* (late morning): affectionate, tender joyfulness

We notice that morning ragas predominantly express the feelings of love, devotion, sadness and tenderness. Sadness is especially dominant in the early morning, and as the hours go by, it is progressively replaced by a more joyful content, in line with the concepts of bottom heavy and top heavy ragas presented earlier.

It therefore appears that the Hindustani tradition exposes listeners to sad and tender music at the appropriate moment, meaning when listeners are especially sensitive to these emotions. On the other hand, we did not obtain a corresponding support for the happier and lighter afternoon ragas, since no significant rating difference was found for the happy clips. Nevertheless, the present study will be of particular interest for ethnomusicologists and Indian musicians, who are now presented for the first time with empirical evidence to partially support and justify a long-standing tradition.

Moreover, by highlighting the importance of considering the time of day when planning an experiment, the current results also have implications for researchers studying music and emotion. Should these results be confirmed by subsequent studies, then controlling for the time factor might prove to be important in order to maintain consistency and avoid distortions in the results.

Finally, the present findings open a promising avenue for music therapists, who might be able to optimise the efficacy of musical interventions by taking into account the chronobiological state of the clients. Increased awareness for the interaction between mood cyclicity and music perception could be applied to music therapy in several ways. Schedule permitting, sessions could take place at moments deemed most beneficial for the clients, depending on the issue at hand and the therapeutic goals. If personalised scheduling is not feasible, then therapists could still adjust their interventions and modulate their interpretation of the events that occurred in the session.

Quite understandably, since this study was only exploratory and the emotion ratings not connected to any clinical outcome measures, it is difficult at this stage to make any claims in terms of practical impact. However, the study by Punkanen et al. (2011) mentioned earlier allows us to put the current results into perspective. Indeed, in their study on emotional recognition and depression, the authors also used music clips from the dataset created by Eerola and Vuoskoski (2011), and they tested the participants on the same five target emotions as we did. Most of their reported effect sizes ranged from .01 to .03, with the notable exception of the tender clips rated on the tenderness scale ($\eta^2 = .07$). It therefore would appear that in terms of emotional perception of music, the effect of the time of day is as strong as the effect of being depressed. In other words, the results obtained in the present study might actually be relevant in practice, even if the effect sizes are small. This will have to be confirmed by future studies that are more clinically-oriented.

Regarding the absence of correlations involving tiredness ratings in the morning, one possible explanation could be that participants were not rating tiredness in the sense of mental exhaustion and physical fatigue, but sleepiness. Sleepiness can be defined as the desire to sleep or the efforts to resist sleep. Since tiredness and sleepiness frequently co-occur, the terms are often used interchangeably. However, they refer to two separate phenomena that can also happen independently from one another. A confusion could have easily occurred in the present experiment, for two reasons. First of all, the questionnaire did not specify the exact meaning of ‘tired’, leaving the door open to multiple interpretations. Secondly, we know from chronobiological studies that everybody experiences a slight morning depression after waking up, which dissipates after ca. two hours (Smolensky & Lamberg, 2001). The morning sessions were characterised by a sleep proximity of less than two hours for most participants (*M* = 1.5, *SD* = 0.7). In other words, most of them were still in that two-hour time frame where they had presumably not yet reached their normal daytime mood. Under these circumstances, it is plausible that only their afternoon ratings were assessing true physical and mental tiredness, whereas their morning ratings were about the feeling of not being fully awake.

Interestingly enough, the statistically significant correlations between Happiness_am and PA_am, as well as between Sadness_pm and NA_pm are corroborated by Vuoskoski and Eerola (2011). In their study, they used clips from the same dataset and tested the same five target emotions, although time of day was not controlled for. Instead of the PANAS, they used the POMS (Profile of Mood States) to assess participants' initial mood. Their results showed a positive correlation between Vigour and the ratings on the Happiness scale ($r = .32$, $p < .01$), as well as a positive correlation between Anger and the ratings on the Sadness scale ($r = .33$, $p < .01$). Given the adjectives that make up the two dimensions of the PANAS, POMS Vigour can be assimilated to PA and POMS Anger to NA (Watson & Clark, 1999). Although these correlations are not very strong, they support the idea that people's current mood influences their perception of emotions expressed by music.

Quite obviously, the results presented in this article are only the first step in a promising and new direction. This study's main limitation comes from the fact that measurements were taken at only two moments in time. It would be important and valuable to expand the present experiment by adding more time points, so as to cover participants' entire waking hours. Increasing temporal granularity would allow to better capture the diurnal cyclicity of mood fluctuation and emotional perception.

Another potentially fruitful idea would be to look not only at circadian but also circannual rhythms. Indeed, research has confirmed the existence of seasonal variations in depression, as well as in other mood states such as anger, irritability and anxiety. This is true for both healthy and depressed individuals, the mood variations of the latter simply being much more pronounced (Harmatz et al., 2000). Indian classical music could again serve as a starting point, since the Hindustani time theory also associates certain ragas with each season of the year.

Besides, a seasonal approach could have useful applications in music therapy. We might for example discover that certain therapy processes are easier or have different outcomes depending on when they are started. This type of reasoning is especially important for issues like Seasonal Affective Disorder (SAD), where depressive symptoms tend to appear during one specific season (usually in the winter). In this case, it would probably be wise to start the therapy process before and not during the season in question.

On a more general note, we hope the present article will serve as a reminder that time possesses a double aspect: it is not only quantitative and linear, but also qualitative and circular. Far from being mutually exclusive, these two aspects can actually co-exist and support each other, as exemplified by the findings in chronobiology and their valuable application in chronotherapy (Smolensky & Lamberg, 2001).

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Tables and Figures

Table 1. Comparison between the Geneva Emotional Music Scale (GEMS) and the *navarasa*.

GEMS factor	Associated emotions [a]	Corresponding *rasa* [b]
Wonder	Happy, filled with wonder, allured, dazzled, moved	*Adbhut* (marvel)
Transcendence	Inspired, feeling of transcendence, feeling of spirituality, thrills	*Bhakti* (spirituality)
Tenderness	In love, sensual, affectionate, tender, mellowed	*Shringaara* (love)
Nostalgia	Sentimental, dreamy nostalgic, melancholic	*Karuna* [c] (pathos)
Peacefulness	Calm, relaxed, serene, soothed, meditative	*Shaanta* (peace)
Power	Energetic, triumphant, fiery, strong, heroic	*Veera* (valour)
Joyful activation	Stimulated, joyful, animated, feel like dancing, amused	*Haasya* (mirth)
Tension	Agitated, nervous, tense, impatient, irritated	*Raudra* (anger)
Sadness	Sad, sorrowful	*Karuna* [c] (pathos)

[a]Emotion terms from the 40-items version of the GEMS.
[b]These are the *navarasa* adapted to music, meaning the nine original emotions plus *bhakti* (spiritual feeling), minus *bhaya* (fear) and *bibhatsa* (disgust).
[c]*Karuna* appears twice because the Indian tradition regroups nostalgia and sadness under the same concept.

Table 2. Repeated measure ANOVA comparing morning and afternoon ratings.

	F	Effect size (η^2)	1 - β[a]	Correlation[b]
Anger: fearful clips	4.54*	.03	.56	.46
Sadness: sad clips	4.09†	.03	.51	.52
Tenderness: tender clips	4.81*	.02	.62	.71
Tenderness: sad clips	4.67*	.02	.56	.75

Only statistically significant results are reported.
[a]Observed power (post hoc).
[b]Correlation between the repeated measures (Pearson's r). All correlations are significant at the .01 level.
†p = .05, *p < .05

Figure 1

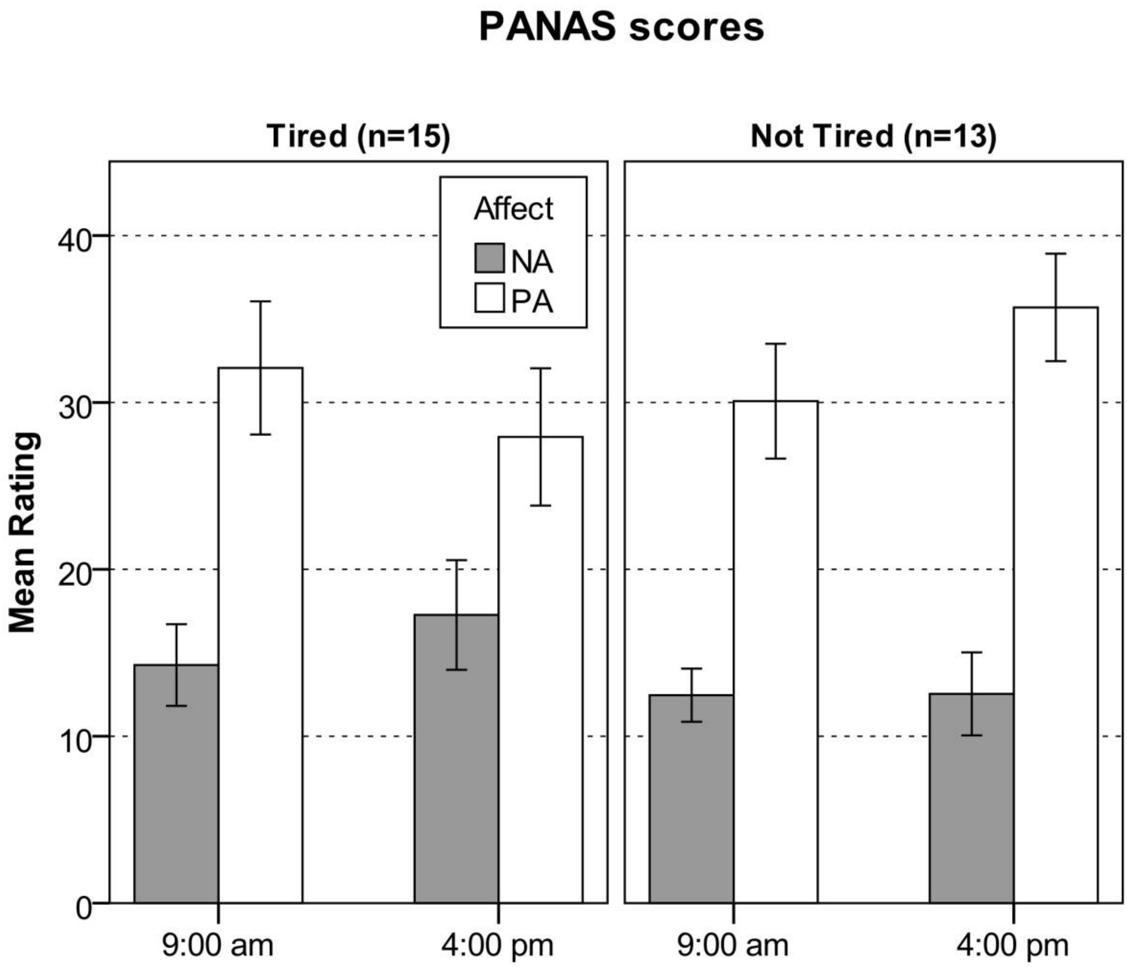

Figure 1. Mean PANAS scores of Tired vs. Not Tired participants (error bars: 95% CI)

Figure 2

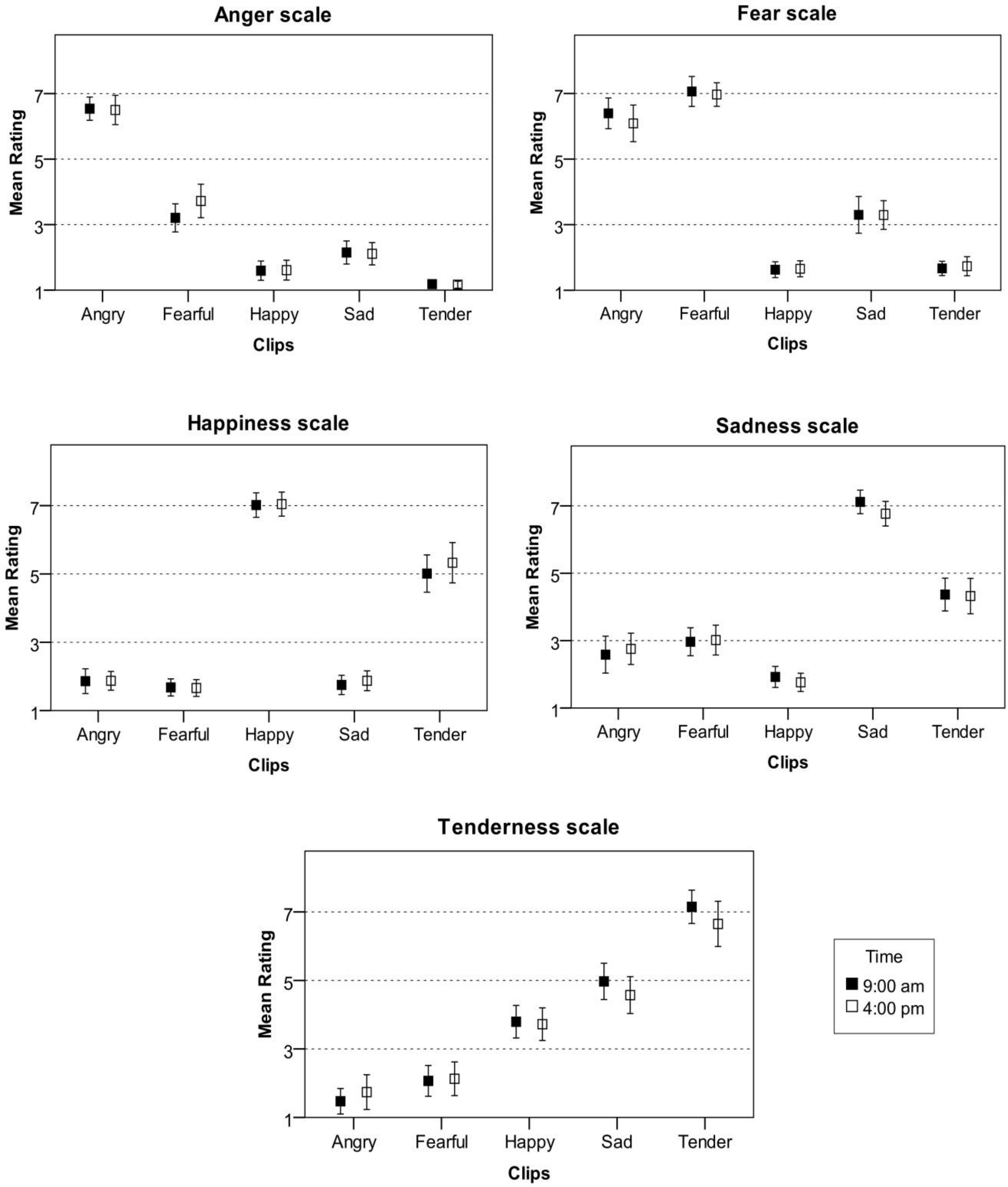

Figure 2. Mean ratings on the five rating scales of the clips regrouped by target emotion. Participants: N = 36. Error bars: 95% CI.

Appendix

Playlist A

No.	Target emotion	Rating	Album name	Track	Min:Sec
1	ANGER_HIGH	6.13	The Fifth Element	19	00:00-00:20
2	ANGER_HIGH	6.38	Hellraiser	5	00:00-00:15
3	ANGER_HIGH	6.47	The Fifth Element	13	00:17-00:31
4	ANGER_MODERATE	4.64	Batman Returns	2	00:18-00:33
5	ANGER_MODERATE	4.18	Man of Galilee CD1	2	03:45-04:02
6	FEAR_HIGH	6.34	JFK	8	00:08-00:25
7	FEAR_HIGH	6.79	The Alien Trilogy	5	00:26-00:41
8	FEAR_HIGH	6.17	Grizzly Man	16	01:05-01:32
9	FEAR_MODERATE	4.58	Running Scared	6	02:53-03:07
10	FEAR_MODERATE	5.28	Cape Fear	2	01:25-01:40
11	HAPPY_HIGH	6.63	The Rainmaker	3	02:55-03:13
12	HAPPY_HIGH	6.89	The Untouchables	6	01:50-02:05
13	HAPPY_HIGH	6.36	Shine	5	02:00-02:16
14	HAPPY_MODERATE	5.60	Dances with Wolves	10	00:28-00:46
15	HAPPY_MODERATE	4.87	Shine	15	01:00-01:19
16	SAD_HIGH	6.78	The English Patient	18	00:07-00:32
17	SAD_HIGH	5.73	Man of Galilee CD1	8	01:20-01:37
18	SAD_HIGH	6.17	Blanc	18	00:00-00:16
19	SAD_MODERATE	5.28	Oliver Twist	2	00:00-00:29
20	SAD_MODERATE	4.89	Dracula	5	00:11-00:27
21	TENDER_HIGH	6.66	Shine	10	01:28-01:48
22	TENDER_HIGH	6.06	Pride & Prejudice	1	00:10-00:26
23	TENDER_HIGH	5.39	Oliver Twist	8	01:15-01:32
24	TENDER_MODERATE	4.62	Blanc	12	00:51-01:06
25	TENDER_MODERATE	4.85	Big Fish	8	00:12-00:34

Playlist B

No.	Target emotion	Rating	Album name	Track	Min:Sec
1	ANGER_HIGH	6.39	Lethal weapon 3	8	04:15-04:29
2	ANGER_HIGH	6.31	The Alien Trilogy	9	00:03-00:18
3	ANGER_HIGH	5.42	Cape Fear	1	02:15-02:30
4	ANGER_MODERATE	4.13	The Untouchables	8	01:38-01:53
5	ANGER_MODERATE	3.27	Crouching Tiger, Hidden Dragon	8	01:12-01:25
6	FEAR_HIGH	6.52	Hannibal	1	00:40-00:54
7	FEAR_HIGH	6.19	The Fifth Element	9	00:00-00:18
8	FEAR_HIGH	6.12	JFK	8	01:26-01:40
9	FEAR_MODERATE	5.74	Shallow Grave	4	01:04-01:19
10	FEAR_MODERATE	4.98	Shakespeare In Love	11	00:21-00:36
11	HAPPY_HIGH	6.81	Batman	18	00:55-01:15
12	HAPPY_HIGH	6.60	Batman	4	02:31-02:51
13	HAPPY_HIGH	6.28	Oliver Twist	1	00:17-00:34
14	HAPPY_MODERATE	5.11	Man of Galilee CD1	2	00:19-00:42
15	HAPPY_MODERATE	4.79	Gladiator	17	00:14-00:27
16	SAD_HIGH	6.38	Juha	16	00:00-00:15
17	SAD_HIGH	6.12	Big Fish	15	00:55-01:11
18	SAD_HIGH	5.66	Blanc	10	00:13-00:31
19	SAD_MODERATE	5.15	Running Scared	15	02:06-02:27
20	SAD_MODERATE	4.85	Crouching Tiger, Hidden Dragon	13	01:52-02:10
21	TENDER_HIGH	6.57	Lethal weapon 3	10	01:59-02:17
22	TENDER_HIGH	5.48	Pride & Prejudice	12	00:01-00:15
23	TENDER_HIGH	5.34	Grizzly Man	1	00:00-00:27
24	TENDER_MODERATE	4.70	Nostradamus	2	01:09-01:28
25	TENDER_MODERATE	4.43	Dracula	4	00:55-01:09

The values in the column 'Rating' are the average ratings of the target emotion (scale: 1 – 9) obtained by Eerola and Vuoskoski (2011) in the second part of their pilot study. These values were used as reference for selecting the clips. The complete datasets (360 and 110 clips respectively), along with the aforementioned paper, can be freely accessed here:

www.jyu.fi/hum/laitokset/musiikki/en/research/coe/materials/emotion/soundtracks