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PERCEPTION OF EMOTION IN MUSIC: A CROSS-CULTURAL INVESTIGATION

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A thesis submitted to the Faculty of Graduate Studies
in partial fulfillment of the requirements
for the degree of

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Perception of Emotion in Music:
A Cross-Cultural Investigation

by Laura-Lee Balkwill

a thesis submitted to the Faculty of Graduate Studies of York University in partial fulfillment of the requirements for the degree of

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Abstract

It is generally accepted that humans associate music with emotion. Studies supporting the existence of the link between music and emotion have been primarily focussed on studies of listeners' sensitivity to emotion in music of their own culture. This sensitivity may reflect listeners' enculturation to the conventions of their culture's tonal system. However, it may also reflect responses to basic psychophysical cues that are independent of musical experience. The current study addressed the latter hypothesis using a cross-cultural approach. The following questions were investigated: Can people identify the intended emotion in music from an unfamiliar tonal system? If they can, is their sensitivity to intended emotions associated with perceived changes in psychophysical characteristics of music? A group of Western listeners (n = 30) rated the emotional content of 12 Hindustani raga excerpts (field recordings obtained in India) according to four target emotions: joy, sadness, anger, and peace. They also rated each piece according to their perceptions of tempo, rhythmic complexity, melodic complexity, and pitch range. An unrated coded variable, timbre, was included in the correlation and regression analyses. Results indicate that Western listeners were sensitive to the intended emotion in ragas when that emotion was joy, sadness, or anger. Regression analyses indicated that judgements of emotion were related to judgements of psychophysical elements. These findings support the hypotheses that listeners are sensitive to musically-expressed emotion embedded in an unfamiliar tonal system, and, that this sensitivity is facilitated by the perception of psychophysical elements of music.

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"The whole problem can be stated quite simply by asking, 'Is there a meaning to music?' My answer would be, 'Yes.' And 'Can you state in so many words what the meaning is?" My answer to that would be, 'No.'"

– Aaron Copland (1900-1990)

"Music is the universal language of mankind"
– Henry Wadsworth Longfellow (1807-1882)

A sequence of sounds impinges upon our senses: a car in the distance, the wind in the trees, the first few notes of a melody. Asking people to describe the emotional content of the first two examples might seem peculiar, but when it comes to music, it seems quite natural to discuss it in terms of emotional expressiveness. What is it about music that differentiates it from other forms of auditory stimuli in this respect?

Music has an undeniable effect upon human emotions. This is evident in that music is widely used by individuals and organizations to enhance or alter mood. Individuals tend to use music intuitively, rarely stopping to think about why one particular piece of music makes them feel uplifted and energized, while another conveys a calm, reflective mood. On another level, music can be acknowledged as representative of a specific emotion or mood, regardless of whether the same emotion is actually induced in the listener. Thus, we may play music we perceive as representing a romantic mood for the purpose of inducing a romantic mood. However, given a multitude of other factors that may influence mood, we may or may not actually succeed in our endeavor. Despite these risks, the unflagging public interest in 'love' songs indicates an enduring faith in music's power to influence, enhance or alter mood.

In psychology, music is often used to induce changes in mood, to facilitate communication with autistic individuals, and to trigger emotional associations in therapy. Underlying these therapeutic applications are nearly a century of efforts to define and quantify how the relationship between music and emotion is formed and how it may be affected by developmental change, musical training, gender, social situation, and other variables. The outcomes of these studies have yielded several consistent findings indicating that, on average, people arrive at similar conclusions regarding which emotion is expressed by a given piece of music (Gabrielsson & Juslin, 1996; Hoshino, 1996; Gerardi & Gerken, 1995; Robazza, Macluso, D'Urso, 1994; Behrens & Green, 1993; Kratus, 1993; Thompson & Robitaille, 1992; Terwogt & Van Grinsven, 1991; Dolgin & Adelson, 1990; Deva & Virmani, 1975). Further, it appears that the ability to identify musically-expressed emotions, such as joy or sadness, is present in children as young as three years old, but rapidly improves as a function of age and/or cognitive maturation (Kastner & Crowder, 1990).

In view of such findings, it is tempting to conclude that the link between music and emotion is universal. However, such an interpretation is complicated by the uni-cultural focus of previous research. With few exceptions (Gregory & Varney, 1996; Hoshino, 1996; Deva & Virmani, 1975), the existing research has focussed primarily on music from the Western tonal system[1], and on the judgements of Western listeners[2]. This research cannot, therefore, disentangle universal and cultural influences on the perception of emotion in music. As a response to this difficulty, my thesis employed a cross cultural approach to assess the possible existence of universal influences on sensitivity to emotion in music. If sensitivity to emotion in music depends only on long-term knowledge of the music

1. Referring to the composition conventions of the diatonic scale which dominates the music of Europe, the United Kingdom and North America.
2. Referring to people who have been enculturated to the Western tonal system.

of one's culture, then listeners should not be able to identify an intended emotion in music from an unfamiliar tonal system. However, if listeners are able to transcend cultural boundaries and recognize intended emotions in music from an unfamiliar tonal system, then they may be attending to perceptual cues that are universally associated with specific emotions.

1.1 Perception

The perceptual cues relevant to this thesis take the form of *psychophysical elements*. in music. The use of the term psychophysical specific to music may be distinguished from its use in the broader field of psychophysics. Traditionally, the term psychophysical refers to the relationship between a physical variable like 'decibels' and a perceptual variable like 'perceived loudness' (see Boring, 1942, for a historical perspective). The relationship may be a logarithmic function as described in Fechner's Law, or an exponential relationship as described in Stevens' Power Law (Stevens, 1975).

The term psychophysical has been used in the literature of music psychology to refer to physical properties of music (e.g. tempo, pitch, rhythmic complexity) that may be defined and assessed independently of the musical conventions of any particular culture. For example, tempo can be measured in beats per minute (bpm), a quantifiable measure of occurrence over time which could apply to any type of stimulus. In contrast, the function of a deceptive cadence can only be understood and interpreted with reference to Western tonal music.

In other words, the characteristics of music that have been termed psychophysical in this study represent those qualities which are not restricted to a particular musical style or culture. Rather, they are those characteristics of music to which basic auditory processes naturally respond (e.g. tempo/ pulse speed).

Thus, listeners do not require detailed musical knowledge in order to interpret them, or to respond to them on an emotional level.

1.2 Emotion

In general, psychological models of emotion emphasize the role of perception, physiological sensation, and cognition. In one model of how emotion is experienced, we perceive a stimulus (e.g. soft, melodious tones) through our senses, and attach a cognitive label (e.g. soothing) to it which governs the emotion (e.g. peacefulness) we subjectively experience in response to the physiological arousal (Schachter & Singer, 1962). In another model, we perceive a stimulus (e.g. a loud, crashing noise) and the physiological effects are immediately experienced as emotion (e.g. fear) before cognition enters into the fray (Zajonc, 1980).

In either case, specific physical aspects of the stimulus (e.g. loudness, timbre) play a role in the type of emotion that is ultimately experienced or perceived. It follows then, that when we hear a piece of music, our perception of the musically-expressed emotion may be affected by our perception of the psychophysical elements of music, as well as whatever learned associations we may have as a result of passive exposure to a tonal system.

Throughout this paper I will refer to the *emotional content of music*, and to *musically-expressed emotion*. These terms will be used to refer to listeners' subjective perceptions of mood/affect/emotion conveyed by any given piece of music. That is, their assessment or opinion of what emotion the music conveys to them. This is distinct from, but not mutually exclusive of felt emotion. For example, one can identify a piece of music as representative of sadness without actually feeling sad. However, even though one is capable of making the objective

assessment that a piece of music is intended to express sadness, this does not preclude the experience of a subjective feeling of sadness in response to the music.

1.3 Purpose of The Present Study

In order to further our knowledge of how the relationship between music and emotion is formed and how it functions, we must first find a way of determining if there are any elements of this relationship that are universal to humans. The present study was designed to test two hypotheses:

1) People enculturated to one tonal system can accurately perceive the intended emotion of music from an unfamiliar tonal system.

2) There are psychophysical elements of music that listeners use as perceptual cues to identify musically-expressed emotions, which transcend cultural differences.

In order to test these hypotheses, I sought to design an experimental paradigm that could be used to assess listeners' perceptions of the emotional content of music from an unfamiliar tonal system as well as their perceptions of some of the psychophysical characteristics of music. In choosing the listeners, tonal system, music materials, and psychophysical elements for this study, I drew from the procedures and findings of a long history of empirical approaches to the study of music and emotion. These empirical approaches were, in turn, founded upon centuries of debate and discussion regarding the relationship of music and emotion. While a complete discussion on the history of theory and experimenta-

tion in this area is beyond the scope of this paper (see Langer, 1957; Meyer, 1956; Hodges, 1980, and Fiske, 1996 for reviews), I will touch upon the most relevant theories and research pertaining to the present study.

2. Emotional Meaning in Music

There are several fundamental issues which have pervaded theories of music and emotion. The first is whether music is actually representative of emotion or whether it should be regarded as a non-referential stimulus which has had emotional meaning ascribed to it. If we accept that music can represent emotion, we must consider what kind of representation we mean: does music actually induce felt emotion in individuals or does it trigger an association with felt emotion causing it to be cognitively labeled as representative of that emotion? Another issue is whether associations made between music and emotion are idiosyncratic (subject to individual differences in age, mood, personality, gender, education, and culture), or whether individual listeners tend to arrive at similar conclusions as to which emotion is conveyed by a piece of music.

Aristotle is often credited with the first major theory of aesthetics in the history of Western thought. In determining whether music was a suitable topic of study in his ideal educational system, he noted its influence upon the emotions, and postulated that music, if selected judiciously, could enhance the formation of good character in his students. He theorized that elements of music such as rhythm and melody were imitative of emotions and qualities of character and that listening to music caused corresponding changes in the listeners' affect and character:

> ...when men hear imitations, even apart from the rhythms and tunes themselves, their feelings move in sympathy...even in mere melodies there is an imitation of character, for the musical modes differ essentially from one another, and those who hear them are differently affected by each.
> (Aristotle, Politics, Book Eight - V, 356 B.C./1984)

This idea that music somehow sounds like emotions feel has been reiterated in this century by Suzanne Langer (1957). She asserts, "Because the forms of human feeling are much more congruent with musical forms than with the forms of language, music can reveal the nature of feelings with a detail and truth that language cannot approach" (p. 235). In essence, she suggests that music symbolizes emotions in the context of a logical framework of analogy to felt emotion.

The most famous opponent of the idea that music is referential to emotions is Eduard Hanslick (1885/1974). Reacting against the emphasis on emotion in music, which was popular in the Baroque and Romantic periods of the 19th century (e.g. Wagnerian opera, Italian tone painting), he characterized music as a purely cognitive experience of technical relationships between the elements of musical structure: "In the art of music there is no content opposed to form, because music has no form over and above its content" (Hanslick, 1885/1974, p.133).

In his review of theories of music and emotion, Meyer (1956) categorized those who contend that musical meaning is embedded within the structure and relationship of the musical elements of each piece as *absolutists*, and those who take the view that music goes beyond such abstract meanings to convey references to extramusical behaviors, actions and emotions as *referentialists*. He made a further distinction between those who argue that the meaning in music is primarily cognitive or intellectual – *formalists*, and those who say it is emotional –

expressionists. These two levels of distinction are not mutually exclusive: An absolute expressionist would contend that the perception of musical relationships within a piece of music is the means by which people perceive the emotional content. This was the stance adopted by Meyer (1956).

Meyer proposed a theory of melodic expectation in which the experience of listening to music is characterized as a series of expectations which are gratified or delayed thereby creating arousal or affect in the listener. These expectations are based on the listeners' passive exposure to the music of their culture and its conventions. For example, Western listeners expect a piece of music to end on the tonic[3], and this expectation may create a slight arousal response at the penultimate musical event. If this expectation is gratified, the arousal from the suspense is relieved, producing a pleasant or soothing affect. But if this expectation is thwarted, as in a deceptive cadence[4], the listener experiences an increase in arousal which may evoke excitement of a positive or negative nature. Meyer's theory has been praised for providing a more useful context for evaluating studies of emotion in music, but it has also been criticized for lacking adequate operational definitions of stimuli and responses (Hodges, 1980).

Since Meyer (1956) and Langer (1957), theorists have continued to grapple with the nature of emotional meaning in music. While Meyer made it clear that he was concerned primarily with felt emotion induced by music, other theorists question whether music does induce emotion on its own, or whether it serves as a trigger to the recall of extramusical events that have aroused 'real' emotion in an individual's past.

3. The first note of a scale on which a melody is based in the Western tonal system. The tonic is often, but not always, the first and the last note of the melody.
4. A chord, or sequence of chords, which seems to be leading to a resolving chord (signifying closure in the Western tonal system) but instead, leads to a chord of continuance or ambiguity.

Kivy's theory of musical expressiveness (1989) argues that there is an important qualitative difference between 'meaning' and 'expressiveness' in music. He uses an analogy: a Saint Bernard may look sad, from a human's perspective, without actually feeling sad, and similarly, a piece of music - a series of tones - may sound sad to an individual but does not actually contain sadness. While admitting that music seems to evoke the 'garden-variety' emotions (e.g. joy, sorrow, fear and anger) he contends that music is not a primary cause of real emotional arousal. If this were so, he argues, why do people not avoid music that is expressive of negative emotions like sadness, fear, and anger? Kivy makes a clear distinction between 'real' emotion which he says require beliefs about intentions (people are happy or sad or angry *about* something or someone), and the emotion aroused by abstract musical sounds. He acknowledges that recognizing musically-expressed emotion is an act of cognition which may yet still arouse a vestige of emotion corresponding to the identification. However, he maintains that this secondary process is a far cry from the experience of real, visceral emotion.

Kivy's theory is not that dissimilar to Langer's in that he characterizes musically-expressed emotion as merely resembling felt emotions. His theory seems to be a reaction to those who would insist too zealously on music's power to evoke strong emotion. On the one hand he contends that the experience of specific emotion in response to music is the result of personal associations made by the listener between the music and some event known only to themselves. On the other hand, he observes that there are many cases of a specific piece of music being experienced as expressive of the same emotion for a variety of listeners. Kivy attributes this agreement among listeners to their shared experience of the conventions of the tonal system within their culture.

Dowling (1986) has distinguished three ways that music can represent emotions, by making use of Peirce's classification of signs: Index, icon, and symbol (Peirce, 1931-1935, as cited in Dowling & Harwood, 1986). In his examples of how music fulfills the criteria of each form of meaning, Dowling notes that these forms are not mutually exclusive and that a single piece of music may contain all three forms overlapping with one another.

As an index, a piece of music may represent an emotion by its association with an emotionally connotative event in the past. Dowling characterizes this as a form of classical conditioning, in which hearing a song triggers the emotion one experienced in response to an extramusical event that occurred the last time that song was heard. This description of the link between music and emotion was the one most acceptable to formalists like Hanslick (Langer, 1957).

Iconic representation of emotion in music is similar to Langer's idea that music sounds the way emotions feel. According to Dowling (1986, p.205) "the ebb and flow of tensions and relaxations in the music mirror the form of emotional tensions and relaxations." From this explanation, it could be argued that iconic meaning in music may be affected by the manipulation of psychophysical elements related to tension and relaxation.

Dowling describes the symbolic meaning of music as something which is embedded within the shared musical experience of listeners, as well as an evolutionarily shared mechanism of emotions. He refers to Mandler's (1984, as cited in Dowling, 1986) theory of emotion in which an emotional response is comprised of the physiological reaction to interrupted expectation and the cognitive search for the meaning of interruption. Through long-term exposure, listeners internalize persistent regularities in the music of their culture, resulting in a continuous series of expectations as to the next musical event within a piece of

music. When these expectations are delayed or denied, physiological arousal ensues and cognitive interpretation is activated, creating a positive or negative emotional experience. Much, if not all of these processes are unconscious, says Dowling, which might explain why people find music meaningful in ways they find difficult to verbalize.

In summary, current theories of music and emotion agree on the following points:

1. Music can be perceived as being representative of specific emotions regardless of whether it induces felt emotion.

2. People can experience felt emotion in response to music.

3. The emotional meaning in music may be due to indexical association with an extra-musical event, and/or due to the iconic use of musical elements, and/or due to the symbolic meaning embedded in cultural conventions.

4. The similarity of conclusions reached by individuals, separately tested, regarding emotional meaning in music is based upon the shared musical experience of listeners within the same culture.

2.1 Empirical Approaches to the Perception of Emotion in Music

There have been many empirical attempts to explore the validity of these theories. One of the enduring problems in the literature is the myriad differences between definitions of emotional response, methods of measurements, and choices of musical stimuli. However, despite these differences, a number of consistent findings have emerged.

Studies investigating perception of emotion in music have addressed a number of issues. In addition to examining the sensitivity of listeners to intended emotion in music, researchers have examined mediating factors such as gender,

level of musical training, social situation, personality, and age from the perspectives of developmental, social, physiological, neurological, clinical, and cognitive psychology.

With the exception of age, the results of these studies have been contradictory or inconclusive (for reviews see Hodges, 1980, Dowling & Harwood, 1986). However, it has been demonstrated repeatedly that people do associate music with emotion, that groups of people can agree independently upon which emotion is conveyed by a given piece of music, and that several psychophysical elements are consistently associated with musically-expressed emotion.

2.1.1 Psychophysical Factors

Possibly the most influential research in this area was conducted by Kate Hevner in the 1930's. She systematically altered one psychophysical element (tempo, rhythm, harmonic complexity, modality, and melodic direction) at a time in a set of Western melodies and asked adult Western listeners to make emotion judgments about each variation they heard using an adjective checklist. The results of this and subsequent experiments (Hevner 1935, 1936) revealed that listeners associated melodies presented in major and minor modes with positive and negative emotional adjectives, respectively. Tempo also had a highly significant influence on the assessment of emotional content in music (fast tempi were highly correlated with positive emotional adjectives). In addition, pitch level, complexity and rhythm were found to influence the perception of musical expressiveness in these studies.

Hevner's work spawned an enormous amount of research, which can be grouped into two categories: (1) studies that focus on the influence of psychophysical elements of Western music on the perception of emotion in music;

(2) studies that focus on the influence of factors related to individual differences in Western listeners (e.g. gender, age, musical training) on the perception of emotion in music.

There have been a succession of studies investigating the influence of psychophysical elements on the perception of emotion in music which have replicated Hevner's findings (for reviews see Hodges, 1980; Nielzén & Cesarec, 1993). The following psychophysical elements of music have been found to have a significant impact on assessments made by Western listeners regarding the emotional content of Western music: tempo, modality, melodic contour, harmonic complexity, melodic complexity, rhythmic complexity, articulation, dynamics, consonance/dissonance, pitch register, and timbre (Hevner, 1935; 1936; Rigg, 1940; Vitz, 1966; Wedin, 1972; Crozier, 1974; Scherer & Oshinsky, 1977; Nielzén & Cesarec, 1982; Holbrook & Anand, 1990; Kastner & Crowder, 1990; Kratus, 1993; Gerardi & Gerken, 1995; Gabrielsson & Juslin, 1996).

In a recent study, Gabrielsson and Juslin (1996) asked musicians to perform short melodies with the intention of expressing specific emotions (happiness, sadness, anger, fear, tenderness, solemnity, and no expression). Recordings of these performances were analyzed for objective measures of tempo, note duration, articulation, sound level, vibrato and intonation. Listeners were asked to judge all performances on emotion scales (0 to 10) and were able to make significantly distinct assessments of all melodies on the basis of expressed emotion (except for the comparison of sad vs tender melodies).

The melodies were grouped according to perceived emotion and a profile of psychophysical elements common to each category was created. For example, happy melodies were characterized by fast tempo, moderate variations in timing, moderate to loud sound level, sharp contrasts between long and short

notes, airy articulation, rapid tone onsets, bright timbre, and fast and light vibrato. Sad melodies were characterized by slow tempo, large deviations in timing, low or moderate sound level, softer contrast between long and short notes, legato articulation, slow tone onsets, slow and deep vibrato, and flat intonation in tone bending.

This study essentially supports and updates Hevner's pioneering work on the relationship between psychophysical elements of music and perceived emotion. Despite the methodological differences in selection of music stimuli and measures of emotional response that exist among the studies conducted over the past 60 years, the results have been strikingly similar, indicating that, within Western cultures at least, there are consistent relationships between specific psychophysical elements, (e.g. tempo) and perceived emotion in music. In addition, these studies have also reported a significant level of independent agreement between participants regarding the emotional content of musical stimuli, providing further support for Meyer's (1956) expressionist view. Thus, not only do the psychophysical elements of music seem to play a role in how people perceive emotion in music, but people seem to interpret these cues similarly, arriving at the same conclusions as to which emotion is being conveyed.

This similar assessment of musically-expressed emotion has been attributed by some theorists to the influence of shared expectations based on listeners' enculturation to the musical conventions of their culture's tonal system. However, many researchers have been interested in exploring the development of these shared associations and whether there are individual differences which also play a role in the perception of emotion in music.

2.1.2 Individual Differences

As previously mentioned, factors such as gender, personality variables, and level of musical training have not yielded consistent results in the literature (for a review see Abeles, 1980). Some of this inconsistency has been due to methodological differences regarding the types of emotion assessed and the ways of measuring perceived emotion. Nonetheless, developmental findings have been largely consistent.

Developmental studies have typically involved a comparison of judgements of emotion in music made by children in different age groups, and adults. Such studies help to evaluate the contribution of experience and learning to the formation of emotional associations with music. The procedures used to assess judgements of emotion in music are asking listeners to circle line drawings of facial expressions (most common for children), or to check off appropriate descriptive terms on an adjective check list, or to assign ratings on Likert-type scales. The emotional content of music used in these studies is usually previously assessed by the experimenter, or by music theorists, and/or by independent raters. Several experiments have shown that children and adults are equally sensitive to joy and sadness (Gerardi & Gerken, 1995; Robazza, Macluso, D'Urso, 1994; Terwogt & Van Grinsven, 1991, 1988; Dolgin & Adelson, 1990; Cunningham & Sterling, 1988). Varying degrees of agreement for other emotions, such as anger, fear, excitement and peace, have also been reported (Gabrielsson & Juslin, 1996; Kratus, 1993; Thompson & Robitaille, 1992; Kastner & Crowder, 1990).

However, studies which tested both adults and children also report that adults do better at this task than children (Cunningham & Sterling, 1988; Terwogt & Van Grinsven, 1988; Dolgin & Adelson, 1990 ; Terwogt and Van

Grinsven, 1991; Robazza, Macluso, D'Urso, 1994). For example, Terwogt & Van Grinsven (1991) asked 30 adults (age 21 - 64) to rate 100 mood state words from 0 to 4 according to how well they could be expressed by music. Only the words rated 3 or 4 were included in the subsequent factor analysis. Selected moods fell into three categories: happiness, anger and sadness. These categories, in addition to a fourth category for fear, were used as emotion labels for the next experiment. Two groups of children, ages five and 10, and one group of adults were asked to match one of these emotion labels to eight orchestral excerpts. The music was selected by independent raters as representing one of the target emotions, and line drawings of faces were used to represent happiness, sadness, anger and fear. The results indicated that children and adults are able to make systematic distinctions between the music on the basis of perceived emotion, particularly happiness and sadness. Adults were better at the task than children overall. There was a tendency to confuse angry and fearful melodies, particularly within the five-year-old group.

The authors suggest that the superior performance of adults over ten-year-olds and the ten-year-olds' superior performance over five-year-olds points to the existence of a developmental trend of improvement in the recognition of musically-expressed emotion. Although, they discuss the possibility of this improvement being due to the neurological changes in memory capacity that occur with maturation, they conclude that the improvement is more likely due to older listeners' increased experience with the music of their culture.

However, there is evidence which indicates that infants as young as three days-old are able to discriminate between sounds on the basis of pitch, rhythm, and other psychophysical elements in much the same way as adults, and many more studies which demonstrate the ability of infants within their first six

months of life to recognize changes in musical stimuli (Cohen, Thorpe & Trehub, 1987; Morrongiello & Roes, 1990; Trehub & Trainor, 1993). Further, there are studies in which infant looking or sucking behavior in response to auditory cues is thought to indicate positive or negative affect (Walker-Andrews, 1997; Walker-Andrews & Grolnick, 1983). However, the issue of whether early sensitivity to emotion in music is innate or acquired is complicated by the unknown effects of in utero auditory experience.

Developmental research has greatly advanced our knowledge of this area in some respects, but since the vast majority of authors have focused on Western music and Western listeners, it is not clear whether their findings are generalizable across cultures. Some researchers (Gerardi & Gerken, 1995, Kratus, 1993) have recognized the limitations of developmental studies of music and emotion, and advocate a cross-cultural approach. For example, Western and non-Western children may acquire their sensitivity to musically-expressed emotion according to the same developmental trend. This would indicate that the basic abilities necessary to associate music and emotion are universal properties of cognition and perception. However, if they are not able to identify the musically-expressed emotion in music of another tonal system to the same degree, this would indicate that the association of specific musical features with specific emotions is dependent upon to exposure to the music of one's culture.

This paradigm has yet to be taken up in the form of systematic study. In general, there are very few studies which have explored the associations made between emotion and music by individuals within other cultures, and fewer still which have taken a cross-cultural perspective. There is a certain amount of disagreement over the validity and usefulness of cross-cultural comparison. Before reviewing those studies which involve other cultures, it will be helpful to con-

trast two theoretical approaches to understanding the connection between music and emotion in relation to culture.

3. Cultural Relativism & Universalism

There are two main schools of thought regarding associations between music and emotion in relation to culture: cultural relativism and universalism. The cultural-relativist position is that emotional meaning in music is something we learn as we mature, along with social mores, and is inextricably entwined with culture. Researchers and theorists who subscribe to this viewpoint tend to focus on the differences that can be observed between tonal systems, timbres, and accepted uses of music between cultures. In his writings regarding the power of music upon the emotions and the body, Jean Jacques Rousseau provides an extreme example of this point of view:

> The Italian must have Italian tunes, the Turk would need Turkish tunes. Each is only affected by accents familiar to him...Bernier's Cantatas are said to have healed a French musician's fever; they would have caused it in a musician of any other nation." (Rousseau, 1755, p. 165).

A more recent example of this view is provided by John Blacking (1992), a prominent voice in ethnomusicological literature:

> In spite of claims to the contrary, the meanings of similar musical sounds and "languages" vary greatly from one culture and one individual to another...There is no convincing evidence that the same musical patterns will have the same meanings for people brought up in the same society, let alone of those reared in different cultural traditions. Nor is there evidence that particular melodies, rhythms, or timbres will in themselves precipitate altered states of consciousness or general feelings of joy, sorrow, or nostalgia. (Blacking, 1992, p. 302).

Although Blacking argued against universals in musical meaning in some of his writings, he did not discount the possibility of the existence of psychophysical commonalities between disparate tonal systems. Even though he firmly believed that the conventions of a musical system and people's emotional response to those conventions are cultural constructs, he admitted that some relatively unchanging biological processes must be taken into account:

> ...it is clear that the creation and performance of most music is generated first and foremost by the human capacity to discover patterns of sound and to identify them on subsequent occasions. Without biological processes of aural perception, and without cultural agreement among at least some human beings on what is perceived, there can be neither music, nor musical communication.
> (Blacking, 1973, p. 9)

Blacking suggested that physiological sensations in response to music are a key part of the subjective response to music. However, unless two people shared the exact same 'bodily experience' in response to a piece of music, he did not see how their emotional experience to music could be exactly the same (Blacking, 1973). This idea, that no two person's subjective experience of the same piece of music is exactly the same, seems to be one of the major objections to theories of universal meaning in music. From a cultural-relativist perspective, it is granted that people within the same culture may come to share one level of perceived meaning associated with music of that culture, but it is recognized that many other factors may affect each individual's perceptions (e.g. musical preference, training, former associations with a specific piece, social situation, etc.). However, even if it is accepted that people of the same culture tend to agree upon the emotional content of music within their culture, there is a much

stauncher objection to the idea that people of different cultures can do so. In a discussion of musical communication, Feld (1994) provides an example of this perspective, "All musical sound structures are socially structured in two senses: they exist through social construction, and they acquire meaning through social interpretation." (p. 85).

In other words, there is no objective meaning to be found in music (including emotional meaning). All meaning is said to be socially negotiated into shared constructs which change as a function of culture, social situation, political climate, and the fashion of the time. In a commentary regarding the question of understanding music of other cultures, Walker (1996) espouses this viewpoint and argues against the validity of a search for universals in music. While he does discuss research indicating the universality of auditory functioning and tone discrimination, he dismisses these findings as irrelevant to the translatability of musical meaning: "Understanding the music of another culture requires assimilation of the influences affecting musical behavior as much as of the resultant musical products." (Walker, 1996, p. 113). He contends that musical behavior develops in response to the specific needs of a culture and varies as a function of available material for instruments, and societal structure. Since these conditions are not necessarily generalizable across cultures, he argues, then neither are the meanings associated with their musical products. However, I will argue that universals in music do exist beneath the surface of cultural variation, and I will describe evidence in support of this argument.

3.1 The Case for Universal Aspects of Music

Theories in favour of the universality of musical behavior are informed in part by findings in the anthropological literature. For example, in 1995, the dis-

covery of the remains of a bone flute, thought to be between 45,000 and 80,000 years old at a Neanderthal archeological site in Slovenia, may have a major impact on theories of the evolution of music behavior (Fink, 1997). This artifact is now the oldest musical instrument unearthed to date. The discovery of the Neanderthal flute has profound implications for theories relevant to the origins of musical behavior, particularly in relation to the development of language. The idea that musical behavior and speech evolved one after the other in human history stems from theories that speech evolved from musical sounds (Blacking, 1973) or that music evolved from singing behavior (Sachs, 1943). It has long been thought that Neanderthals were incapable of speech due to the shape of their vocal apparatus (Kennedy, 1975) and that singing behavior, music and speech were hallmarks of the development of early Homo Sapiens. The question of whether or not Homo Neanderthalis had spoken language awaits further evidence, but the discovery of the Neanderthal flute is a compelling argument in favour of a much earlier development of music in human evolution.

The farther back the appearance of musical behavior can be traced in the phylogenetic record, the more likely it is that music in societies around the world shares characteristics derived from a common ancestry. Every culture known today has music in some form, and there do appear to be some basic similarities in these forms. Dowling lists several elements of music found in the tonal systems of diverse cultures, such as the octave ratio. In a meta-analysis of studies which compared the tunings of instruments from Burman, Indonesian and Western cultures, the octave ratio was substantially similar. Other universals in pitch-based music include: the existence of scales, a finite number of discrete pitches within scales, and an ordered hierarchy of tones within scales, as well as the use of a beat structure and rhythmic contours. At a more basic level,

regardless of whether a culture has a system of notation or a comprehensive theory of music composition, all people within all cultures display singing behavior (Dowling, 1986).

It is one thing to assert that the existence of music is universal in all human cultures, and to postulate some common structural characteristics in the music of all cultures. It is a much more complicated matter to gather evidence in support of the existence of universal correlates of emotion in music[5].

The case for universal correlates of emotion in music depends upon several underlying arguments which tend to overlap at various points in their development. I will outline these arguments in three parts and how they are linked to the central issue:

I. The expression and understanding of emotion is universal to humans.

Evidence from a number of cross-cultural studies support this argument. Following from Darwin's (1872) theory that there are a basic set of emotions which evolved as survival-oriented responses, Ekman (1972, 1992) conducted several studies in which people of several different cultures were exposed to pictures of prototypical facial expressions representing a set of 'basic' emotions. The results of these and other studies (Frijda, 1986; see also Russell, 1994 for a review) revealed that, despite cultural differences regarding emotion names, intensity and frequency of emotional expression, and individual differences, people's interpretations of these basic expressions of joy, fear, anger, disgust, were similar. It follows then, that if visual stimuli are universally associated with similar emotion categories, then there may be auditory stimuli which are also associated with similar emotion categories. However, evidence is needed to

5. Referring to psychophysical elements of music which are common to all sounds, which, alone or in combination with one another, are used by composers and performers and understood by listeners to represent emotion in music. For example, slow tempo may be a universal correlate of

support the assertion that humans do differentially associate emotions with auditory stimuli.

II. Humans associate emotions with auditory stimuli.

From a natural selection perspective, the association of emotion to auditory stimuli may have been a survival advantage. Conceivably, humans who experienced fear in response to threatening noises would be more likely to flee and survive than humans who did not react until the source of the threat was visible. The ability to distinguish between different types of auditory stimuli and react differentially to them is not unique to humans. Studies conducted with various species of birds (Gillis, 1990; Hulse & Braaten, 1995), primates (D'Amato & Colombo, 1988; Rauschecker, Biao, & Hauser, 1995), and crickets (Wyttenbach, May, & Hoy, 1996) indicate that this ability is present very early in our phylogenetic history.

It could be argued that a cricket's ability to discriminate between different sounds and move to or away from the source is a far cry from the complex process involved in the human ability to experience and/or attribute different emotions to different sounds. However, the perceptual abilities involved in the discrimination of auditory stimuli, and the corresponding responses to them, may be hard-wired. Leaving aside evolutionary theory, the evidence from infant studies indicates that the ability to respond differentially to auditory stimuli appears very early in development.

There are proportionately far more studies examining emotion responses/associations to visual cues than auditory cues. However, there is evidence which suggests that humans do associate specific sounds with emotion beginning in

sadness in music. Universal correlates of emotion may also combine with culture-specific correlates of emotion in music (such as time of day in the case of Hindustani raga).

infancy and possibly even earlier. For example, Aldridge (1994, as cited in Walker-Andrews, 1997) measured the sucking behavior of neonates in response to happy, sad and angry voices. He reported that the infants sucked harder to activate the sound of happy voices and avoided sucking which would activate sad or angry voices. Several studies investigating infants' differentiation of emotions based on visual, auditory and multi-modal cues have reported that children aged two to seven months respond better to auditory cues alone, or in combination with visual cues, than to visual cues alone (Walker-Andrews & Grolnick, 1983; Walker-Andrews & Lennon, 1991, as cited in Walker-Andrews, 1997).

This sensory dominance is thought to be related to the infants' lack of visual acuity in the first few months of life. While the auditory system is fully developed and functioning as early as 16 weeks in utero (Cooper & Aslin, 1990), the visual system is not fully functional until four or five months post-natally (Banks, 1980). Thus, in the first few months of life, emotional associations may be most strongly associated with auditory stimuli. The widened pitches and crooning aspects of infant-directed speech (motherese) are typically associated with pleasant affect in infants; crying of other infants, harsh, or loud sounds are typically associated with unpleasant affect in infants (Fernald, 1992; Cooper & Aslin, 1990)[6].

To summarize the case for universal correlates of emotion in music so far, evidence has been presented in support of the universality of emotions and the universality in the perceptual abilities required to perceive auditory signals which may trigger emotional response. There is also evidence that infants younger than one month old may be predisposed to respond with different affect to specific auditory cues. If responses to music are similar to responses to

6. In these studies, pleasant affect was attributed to infants who displayed longer looking behavior at objects associated with auditory stimuli, increased sucking behavior to elicit a preferred auditory stimulus, and/or overt displays of positive or negative affect (e.g. cooing vs crying).

motherese and other auditory stimuli traditionally associated with emotion, then we would expect infants and adults to associate emotion with music.

III. Music is a type of auditory stimulus that shares characteristics of other auditory stimuli traditionally associated with emotion. As a result, humans associate emotion with music.

In all cultures, music involves sound varying in frequency, duration, density, timbre, and other psychophysical characteristics. In the first months of life humans are exposed to a multitude of sounds, predominantly human voices, which differ along the same dimensions. Infants are particularly exposed to motherese, a form of speech with exaggerated inflection and pitch range that people tend to use when speaking to infants and small children (Fernald, 1992). For all intents and purposes, the sound of motherese is very similar to music, especially from the vantage point of the pre-lingual infant. A similar experience can be demonstrated when adults are exposed to an unknown language. Lacking any knowledge of the symbolic meaning of the words being spoken, the sound of this speech is experienced as a sequence of tones/syllables varying in duration, intensity and inflection. Naive listeners may guess at the intent of the speech by attending to the emotional cues embedded in the inflection and emphasis of certain sounds. In this way, the infants pre-verbal environment simulates that of the uni-lingual exchange student in a foreign culture.

Cooper and Aslin (1990) compared infant preference for adult-directed or infant-directed speech. Results indicated that four-month-old infants looked longer at a visual stimulus, when looking activated a recording of infant-directed speech than when it activated a recording of adult-directed speech. The

melodic contour of infant-directed speech, as mapped and graphed by Cooper and Aslin (1990), exhibits a number of characteristics which this type of auditory stimulus shares with simple folk songs and lullabies. These characteristics include: a greater proportion of descending contours than ascending contours, simpler contours overall, and exaggerated pitch range (Trehub, Unyk & Trainor, 1993). A number of studies have reported that the use of motherese to communicate with infants appears to be universal (Fernald et al., 1989; Grieser & Kuhl, 1988; Papousek, Papousek & Symmes, 1991). Trehub and her associates noted that in addition to motherese, infants are often exposed to lullabies which may serve many of the same functions as motherese. "Singing to infants could be expected to reflect and convey the emotional state just as speech does." (Trehub, Unyk & Trainor, 1993, p. 286).

Thus, there is evidence which indicates that the psychophysical elements of music are similar to motherese and are actively present in lullabies, two types of auditory stimuli humans experience from birth. Further, there is evidence that infants distinguish between happy, sad, and angry infant-directed speech and may associate emotional states with sounds bearing similar characteristics. Beyond infancy, the studies reviewed in section 2.1 indicate that young children associate music with emotion with reasonable consistency. Although the majority of these studies have been conducted within the confines of Western culture, there is a growing body of research investigating the perception of emotion in music within other cultures.

3.2 Research Within and Across Cultures

In the psychological literature there are a few studies which have investigated the perception of emotion in music within non-Western cultures. For example, Deva and Virmani (1975) compared the intended mood of Hindustani ragas with the perceived mood ratings made by Indian listeners. In one experiment, four excerpts from ragas (approximately 2 minutes each) were played to 37 listeners, who were asked to choose from a list of mood-adjectives the emotion which they believed was expressed. The authors report substantial similarity between the intended mood of the ragas and the perceptions of the listeners. In a second experiment, 228 listeners were asked to rate an excerpt from one raga according to their perceptions of expressed mood, associated colour, season, and time of day. The raga (Bhairav) was rated by listeners as being dominant in empathy and compassion, and also conveyed vitality, positive affect, and courage. It was also assigned high ratings of tranquility. The majority of listeners associated this raga with the colour white or yellow, the season of autumn and the time of early morning or early evening. According to Deva and Virmani, these ratings matched closely with the intended mood of the raga. They also note that their results indicate the aesthetic meaning of Hindustani ragas has remained relatively stable over three centuries, as the perceptions of their listeners (none of whom had any special musical training) agree with ancient texts describing the moods commonly associated with the ragas.

Hoshino (1996) compared the emotional reactions of music and non-music students to the different musical modes of Japanese music with the aim of discovering whether there is a difference in perception of emotion as a function of mode, musical training and/or age. The tonal material was based on the major and minor modes of the Western tonal system, which have been an influence in

Japanese music for the past 120 years, and the corresponding YOH-sempô and IN-sempô modes of traditional Japanese music. Three groups of women participated in this study: 21 college students with no musical training, 24 music majors, and 21 middle-aged women with no musical training. After hearing each of 20 short melodies, listeners were asked to select a colour from a chart to match the emotional expression of each piece and to provide verbal descriptions of the emotions they associated with each colour.

Results indicated no significant differences between the two groups of college students and the two musically untrained groups in their associations of colours and emotions with the Western major mode (warm colours = bright, warm, joyous) and minor mode (neutral colours = melancholy, dark, sad). The two student groups also agreed on their associations with the Japanese major/YOH-sempô mode (cooler colours = bright, refreshing, calm) and minor/IN-sempô mode (muddy colours = dark, old-fashioned, calm). In general, listeners were able to distinguish between modes, and although the Western modes yielded more vivid contrasts than the Japanese modes, both comparisons demonstrated the tendency of listeners to arrive at similar conclusions regarding the emotional content of the music.

Gregory and Varney (1996) asked Western and Indian listeners to assess the emotional content of commercially recorded excerpts of Hindustani ragas, Western classical music, and Western new age music. All listeners were between the ages of 18 and 25 and were residents of Britain, although the Indian listeners were reported to come from families who maintained cultural traditions. The intended emotional expression of the Western classical and new age excerpts was derived from the title, or from written opinions of music theorists and musicians. In the case of the raga excerpts, descriptions of associated moods

were taken from Daniélou (1980). Listeners indicated their assessment of the emotional content in the pieces by selecting adjectives from a list of mood terms taken from Hevner (1936).

Results showed that both groups of listeners agreed on their perception of emotions in Western classical and new age music, but not in Hindustani ragas. Furthermore, the most frequently reported adjectives did not agree with Gregory and Varney's predictions. This research is of particular relevance to the present study as it also involves the perception of emotion in Hindustani ragas by Western listeners. Several methodological problems may have contributed to the apparent lack of sensitivity to intended emotion in the ragas. First, the use of commercially recorded ragas brings the intended emotion into question. The experimenters had no way of knowing which emotion the recorded performers were intending to convey in each raga -- and as performers have a great deal of leeway in their expression emotion in ragas (see Appendix A), a textbook interpretation is perhaps not the best validity check. Second, ragas in commercial recordings may have contained a number of irrelevant qualities, which, for Western listeners, may have masked the emotional content of the music. Third, the Indian terminology for musically-expressed moods is limited to nine moods (rasas), so it is possible that the mood term list did not offer recognizably equivalent terms that both Western and Indian listeners could assign to the raga excerpts.

It is clear that much more research needs to be done from a cross-cultural perspective to explore systematically whatever similarities and differences exist in the association of emotional meaning with music. These studies do, however, provide evidence that the human tendency to associate music with emotion is universal.

To summarize, the evidence presented constitutes a solid foundation for the argument in favour of the existence of universal correlates of emotion in music: The interpretation of a basic set of emotions appears to be universal, music appears to be universal, and the perceptual abilities necessary to attend to and respond to auditory cues with different emotions seems to be universal. People of cultures studied in this context do associate music with emotion, and furthermore, they tend to agree independently upon the emotion represented by a given piece of music from their own culture. The research reviewed in section 2.1.1 also indicates that there are a number of psychophysical elements of music that appear to be associated with perceptions of emotion, at least within uni-cultural studies. To strengthen the case for universal correlates of emotion in music, evidence is needed which indicates that humans are able to perceive the intended emotion in music from an unfamiliar tonal system .

At this point, it is important to note that I do not deny the influence of culture, past experience, and individual differences on the process of associating music with emotion. However, underlying all of these influences, there may be a set of universal (i.e. psychophysical) cues embedded in music which directly correspond to a universally understood set of emotions.The first step in evaluating the origin and function of the link between music and emotion, and the relative roles of culture and biology, is to determine whether there are universal correlates between the psychophysical characteristics of music (e.g. tempo, rhythmic complexity) and the expression of specific emotions.

4. Considerations in the Creation of the Experimental Paradigm

Our current state of knowledge in the perception of emotion in music is that people in general do agree on the emotional content of a given piece of music presented in their own culture's tonal system. We also know that certain psychophysical elements of music, at least those identified in Western music, have a substantial impact upon the perception of musically-expressed emotion. What is not known is whether people can identify the intended emotion in music that has been composed and performed in the tonal system of another culture, and if they are able to do so, what psychophysical elements are influencing their judgements.

In order to address these questions, a group of adult Western listeners were asked to assess the emotional content of Hindustani raga excerpts. They were also asked to make judgements regarding several psychophysical elements of the music they heard. The major difference between this paradigm and the Western studies reviewed is that, in this study, the listeners are being asked to identify the emotional meaning of music from an unfamiliar culture and tonal system -- a task at which they should not succeed according to the cultural-relativist point of view.

The selection of the listeners, tonal system, target emotions, psychophysical elements, and music materials was done according to the following considerations and criteria:

4.1 The Listeners

There were two groups of listeners: A group of people raised in Western cultures, who were unfamiliar with Hindustani music, and a group of Hindustani

music experts. The criteria for inclusion in the Western group was adequate hearing and little or no exposure to Hindustani music. The expert group was comprised of people who had been deeply immersed in the study and practice of Hindustani music. The experts were asked to verify the validity of the music materials used in the study.

4.2 The Tonal System

It was necessary for the chosen tonal system to be substantially different from the Western tonal system in its scale patterns, harmonic and melodic structures, and instrumental timbres, and one to which most Westerners would not have been exposed. Although several tonal systems meet these criteria, Hindustani music was particularly suitable due to the *raga - rasa* system. Hindustani classical theory specifically outlines traditional relationships between the ragas and their corresponding moods, or rasas (For a more detailed description of the North Indian raga-rasa theory and how it compares to the conventions of the Western tonal system, see Appendix A). Another beneficial aspect of classical Hindustani music is the performer's influence over the expressed rasa of each piece. This aspect was used to advantage in the field recording of the music materials.

4.3 The Music Materials

Recording of the music materials used in this study took place during a field research trip to Pune, India (December 1996 to January 1997). In order to get a clear idea of the relationship between perceived emotional content and perceived psychophysical elements, it was necessary to use the most parsimonious rendition of Hindustani raga possible -- one melody instrument without any

accompaniment. This allowed a more focused examination of the factors under consideration. For example, If the rhythmic complexity of the melody instrument was found to influence perception of emotion, for example, this finding would not be confounded by the rhythmic contribution of accompanying instruments and their interaction with the melody line. This design criterion rendered commercial recordings of Hindustani music unsuitable because such recordings are accompanied by the *tampura* (drone) and the *tabla* (drums).

Another advantage of using field recordings instead of commercial recordings is the opportunity to gain more knowledge about the performer's intent to convey emotion in the ragas. In Hindustani music, individual performers have a great deal of latitude in their interpretations of classical ragas. Thus, although a raga may be associated with the rasas of peacefulness/*karuna* and sadness/*shan - ta*, for example, performers may choose to emphasize one or the other emotion, depending on the occasion, their own state of mind, and other factors. As a result, it was important to obtain samples for which the individual performer's intention to evoke a specific rasa could be reasonably verified.

Short excerpts of ragas performed by Hindustani musicians were recorded for use in this study. The musicians were asked to play ragas they would normally choose to represent the target emotions.

4.4 The Target Emotions

As reviewed in the literature, large adjective lists of emotions tend to fall into a few basic emotion categories, such as joy, sadness, and anger, and listeners tend to respond most frequently within these categories. These basic categories are similar to the set of 'basic emotions' postulated by Darwin (1872) and Ekman (1992) to be universally expressed and understood by humans.

The target emotions of interest in this study are joy, sadness, anger and peace. Joy and sadness have been the most reliably identified and distinguishable musically-expressed emotions in Western music by Western listeners. If any emotional meaning in music is likely to transcend cultural boundaries, these are the most likely candidates. Anger has been identified in Western music, albeit with less consistency (Behrens & Green, 1993) but is not as often conveyed in Hindustani music ((personal communication with Dr. A. Ranade, Dr. S. Rao & Pandit Shreeram Devasthali, December 1996 to January 1997). The corresponding rasa, *Raudra,* is very rarely used. Thus we would expect this emotion to be more difficult for Western listeners to identify. Peace, on the other hand, is considered the basic rasa of all ragas, and should be more easily identified. Peace was also included as a more suitable opposite to anger than fear and because several studies have indicated that peacefulness (a.k.a. restfulness, no expression) is reliably perceived in music (Terwogt & Van Grinsven, 1991; Thompson & Robitaille, 1992; Gabrielsson & Juslin, 1996).

4.5 The Psychophysical Elements

The selection of psychophysical elements for this study was influenced by several considerations, including the findings of previous studies, the characteristics of the Hindustani tonal system, and the desire to focus on listeners' perceptions rather than on external measures. This last criterion arose out of the observation that while external measures of psychophysical measures are reliably correlated with listeners' assessment of emotion in music, listeners are more likely to base their judgements of emotional content in music on their own perception of psychophysical elements, which may not be adequately reflected in external measures.

Nonetheless, studies reporting a correlation between external measures of psychophysical elements with emotion have provided a likely list of candidates for inclusion in cross-cultural research. Regardless of the methodological differences between these studies in terms of assessment measures for perceived emotion (i.e. a variety of adjective checklists, forced choice of a few specific emotion terms, finger tapping, and interview techniques), and criteria for the selection of music stimuli, there have been a number of consistent findings, which appear to be robust regardless of the type of music chosen or the means of measuring emotional response to music. It is reasonable to suspect then, that if there are universal correlates of musically-expressed emotion, these psychophysical elements; tempo, rhythmic complexity, melodic complexity, melodic contour, modality, and pitch, would be the most logical choices for cross-cultural testing.

The psychophysical elements selected for inclusion in this study were tempo, rhythmic complexity, melodic complexity, and pitch range. Tempo has been most consistently associated with emotional content in the music psychology literature. Defined as the overall speed of pulse, the perception of tempo reflects the listener's sense of time as influenced by the temporal flow of the music. Even though, the music materials used in this study are not accompanied by the overt pulse of a percussion instrument, it has been demonstrated that listeners tend to extrapolate pulse from unpulsed music (Gabrielsson, 1993). Although this study need not commit to any view of the origin of a relationship between tempo and emotion, tempo has frequently been linked to biological rhythms such as heart rate. As the most omnipresent sound in the womb is the mother's heartbeat, it may be that human infants are predisposed to associate periods of rest and relaxation with slower heart rate and periods of excitement with increased heart rate. If this is the case, then we would have an additional ratio-

nale for predicting that tempo is a universal psychophysical correlate of emotion in music.

The pulse of maternal heart rate and respiration is generally slow and regular during periods of rest. This would suggest that slow tempi should be associated with peacefulness. However, sadness has also been associated with slow tempi (Hevner, 1935, 1936; Gabrielsson & Juslin, 1996). Analogously, excitement due to joy, fear, anger, and surprise is generally accompanied by faster heart rate and respiration so there may be psychophysical cues other than tempo which help to differentiate between these emotions. It may be that variation in rhythmic complexity is one of the cues which serve this purpose. For example, peacefulness may be associated with slow tempi and very simple rhythms, while sadness may be associated with slow tempi and more complex rhythms.

Rhythmic complexity is defined for the purposes of this study as the perceived durational organization of the pulse of each piece (without the augmentation of accompanying percussion). It was expected that pieces characterized by regular, or repetitive rhythms would be more strongly associated with peace or joy, and pieces characterized by more varied, irregular or novel rhythms would be more strongly associated with anger or sadness.

Melodic complexity may also be useful in the differentiation of emotions in musical stimuli. In the literature reviewed (see section 2.1), simpler melodies, that is, those containing fewer variations of melodic themes or motifs and more repetition, have been more strongly associated with positive and peaceful emotions. More complex melodies, that is, those featuring more variation and less repetition, have been more strongly associated with anger and sadness.

Presumably, simpler melodies are easier to process because they are low in information and high in redundancy and predictability. However, such a pro-

cessing advantage would be countered by the novelty of ragas, which were unfamiliar to listeners. A possible conseqeunce of these conflicting influences could be a medium level of perceived complexity, which, according to Berlyne's (1971) optimal complexity model, should be most pleasing to listeners. Ragas that are most pleasing, in turn, should be assigned relatively high ratings for positive emotions (joy and peace), and relatively low ratings for negative emotions (anger and sadness). This reasoning would also apply to ratings of rhythmic complexity.

The inclusion of pitch range was based on the hypothesis that Westerners' perceptions of the different registers of Hindustani ragas and the performing instruments might influence their emotion ratings. Specifically, since the degrees of change in pitch in the Hindustani tonal system are generally smaller than in the Western tonal system and since chromatic movement can be associated with sadness in Western music (Cooke, 1959) Westerners might be influenced by this variable to assign more emotionally negative ratings for ragas they perceived as being narrower in pitch range.

Pitch range also may be linked to emotions through expectancy mechanisms. If, as Narmour's (1991) implication-realization model suggests, pitch proximity makes a melody more predictable, then ragas rated as being narrower in pitch range might also be perceived as being melodically simple. Ragas which are perceived as being wider in pitch range may be less predictable, yielding higher arousal, and may be perceived as being more melodically complex. In the context of Bregman's (1990) auditory scene analysis, it may be that ragas perceived as having a narrower pitch range are more easily processed as one auditory stream, and hence may be easier to process, while ragas perceived as having a wider pitch range may pose more of a challenge to auditory streaming mecha-

nisms, and hence may be more difficult to process. Ragas that are easier to process, in turn, should be assigned relatively high ratings for positive emotions (joy and peace), and relatively low ratings for negative emotions (anger and fear).

In addition to the above four psychophysical factors, I also assessed the influence of timbre on judgements of emotion in ragas. Two instrumental timbres were used in the ragas: flute and strings. Flute timbre was coded as '0' and string timbre was coded as '1' for correlational and multiple regression analyses.

While it was expected that each of the psychophysical elements included in this experiment would have a significant relationship with listeners' judgments of emotion, the directionality was clearest for tempo and timbre. Specifically, it was expected that an analysis of ratings of tempo would reveal a significant positive relationship with ratings of joy and anger, and a significant negative relationship with ratings of sadness and peace in the ragas. This prediction was based on the findings previously discussed in the literature review which indicate that faster tempi are consistently associated with joyful, excited or angry emotion in music, while slower tempi are consistently associated with sad, relaxing, or peaceful emotion in music (see section 2.1).

For timbre, I predicted that listeners would associate the flute with peace, and strings with anger. Interviews conducted during a field research trip to India with experts on Hindustani music indicated that the rasa of *raudra*/ anger is rarely evoked in ragas. However, when *raudra* is expressed, it is most effectively expressed on traditional stringed instruments, particularly *sitar*, and it is almost never expressed on the *bansuri* flute (personal communication with Dr. A. Ranade, Dr. S. Rao & Pandit Shreeram Devasthali, December 1996 to January 1997).

5. Method

5.1 Listeners

Thirty people volunteered to participate as listeners in this study. The group was comprised of students and staff from York University, Toronto. There were 15 men and 15 women, ranging in age from 23 to 46 years. All 30 were raised in a Western culture and exposed to music of the Western tonal system. Two of them reported a minor amount of exposure to Hindustani music as interested listeners but had no knowledge of the conventions of the Hindustani tonal system. The remaining 28 listeners indicated no familiarity with Hindustani music.

Four experts on Hindustani music also volunteered to go through the same experimental procedure. These listeners had either taught or studied Hindustani music for an average of 33 years each. The experts were asked to identify each raga in addition to specifying the dominant rasa. All of them asserted that the performances they heard were competent renditions of the ragas and that these ragas could be associated with the intended rasas.

5.2 Materials

A brief demographic questionnaire was filled out by each listener. Some of the items included were age, gender, cultural background, and exposure to Western and North Indian music (see Appendix B).

Cassette recordings of the alap portions of 12 raga performances were used in this experiment. The alaps in this study were field recordings of performances by two professional Hindustani musicians: a bansuri flute player, and a sitar player who was also an accomplished dilruba and surbahar player. Both of these performers had been studying classical Hindustani music since they were children and had extensive experience playing before audiences and making

professional recordings. They agreed to play short renditions of the alap, or improvisational, portion of ragas they would normally choose to evoke each of the four target emotions.

The performances were recorded on a portable AIWA cassette recorder and later dubbed onto separate cassettes for randomization of presentation to listeners. The recording sessions were conducted separately, so it is interesting to note in the table below that the two performers independently chose two of the same or similar ragas to convey the same emotions: *Bhupali* for joy and *Yaman/Yaman Kalyan* for peace.

Table 1

Musical Stimuli

RAGA	RASA	INSTRUMENT
1. Bhupali	Hasya (Joy)	Bansuri Flute
2. Khamaj		Sitar (stringed)
3. Bhupali (stringed)		Surbahar
4. Jogya	Karuna (Sadness)	Dilruba (stringed)
5. Bhairavi		Bansuri Flute
6. Bhopali-Todi		Bansuri Flute
7. Hindol	Raudra (Anger)	Bansuri Flute
8. Adana		Sitar (stringed)
9. Sohini		Bansuri Flute
10. Yaman Kalyan	Shanta (Peace)	Bansuri Flute
11. Yaman (stringed)		Surbahar
12. Bhilaskhani		Dilruba (stringed)

5.3 Procedure

Western listeners provided ratings of four target emotions and four psychophysical elements according to their perceptions of 12 Hindustani ragas. Of the 12 ragas, three were intended to convey joy, three were intended to convey sadness, three were intended to convey anger, and three were intended to convey peacefulness.

Each listener was tested individually. After filling out a demographic questionnaire, they were told they would be hearing 12 ragas ranging in length from one to four minutes, through a set of headphones. It was explained that after hearing each raga they would be asked to decide which of the four target emotions was most dominant in their opinion. Listeners were encouraged to elaborate on their responses, particularly if they believed a raga conveyed an emotion other than one of the four target emotions. However, they were told they would then be asked which of the four target emotions they believed was closest to the alternative emotion they suggested in order to proceed with the ratings.

After identifying the dominant emotion in each piece, listeners were asked to rate the degree to which they believed that emotion was conveyed on a bipolar scale (one = emotion not conveyed, nine = emotion very strongly conveyed). Next, they were asked to rate each piece on similar scales for the other three target emotions, as well as for the four psychophysical elements (tempo, rhythmic complexity, melodic complexity and pitch range). Before beginning the actual testing session, listeners were shown the bipolar scales and given definitions of the psychophysical elements (For complete text of instructions and definitions, see Appendix B). Each listener was encouraged to ask questions and seek clarification of any terms they were unsure of throughout the testing session.

Finally, after completing the ratings task for all 12 ragas, listeners were given a brief exit interview, during which they could voice their comments about the study and ask questions regarding research design, purpose and theory.

6. Results & Discussion

Table 2 displays mean ratings of each emotion scale for ragas intended to convey joy, sadness, anger, and peace. The highest ratings for joy and sadness were, as predicted, assigned to joyful and sad ragas, respectively. However, the results were less clear for ratings of anger and peace. There was a high degree of variability among ratings for different ragas and different emotion scales, which was likely due to listeners' lack of familiarity with the Hindustani tonal system. Nevertheless, subsequent analyses indicated that these results were statistically significant and supportive of previous predictions.

Table 2

Mean Ratings of Emotions Perceived in Hindustani Ragas

Emotion Rating	Type of Melody in Terms of Intended Emotion			
	Joy	Sadness	Anger	Peace
Joy	**5.61**	3.122	2.30	4.40
SE	(.41)	(.34)	(.38)	(.35)
Sadness	2.99	**5.27**	2.75	5.06
SE	(.38)	(.39)	(.36)	(.40)
Anger	5.12	3.54	**3.37**	3.69
SE	(.47)	(.41)	(.46)	(.39)
Peace	2.59	5.58	3.50	**4.61**
SE	(.35)	(.39)	(.39)	(.48)

Note: Values in brackets are mean standard errors.

6.1 ANOVAs & Mean Contrasts

Repeated measures oneway analyses of variance were conducted for each emotion scale, to evaluate whether the mean ratings for each emotion varied significantly among the 12 ragas. As shown in Table 3, there was a significant main effect of raga ($p < .0001$) for all four emotion scales, indicating that listeners perceived differences between the ragas on the basis of emotional content, and that there was a significant level of agreement among listeners as to those differences.

Table 3

Results of Repeated Measures Oneway Analysis of Variance: Listeners' Mean ratings of Emotion in Hindustani ragas

Emotion		*SS*	*df*	*MS*	*F*	*P*
JOY	Listeners	244.6556	29	8.4364		
	Ragas	965.8889	11	87.8081	18.8083	.0001
SADNESS	Listeners	302.7889	29	10.4410		
	Ragas	600.2222	11	54.5657	13.4974	.0001
ANGER	Listeners	35.4472	29	15.0154		
	Ragas	326.1639	11	29.6513	7.3026	.0001
PEACE	Listeners	213.1782	29	7.6135		
	Ragas	250.2385	11	22.7490	4.7810	.0001

Contrast analyses were then conducted to assess the prediction that mean ratings of a given emotion should be significantly higher for the ragas that were intended to convey that emotion than for ragas not intended to convey that

emotion. The mean ratings for the three ragas corresponding to the rated emotion were compared with the nine ragas that were intended to convey a different emotion (see Table 4).

This analysis indicated that listeners were sensitive to the intended emotions in ragas when that emotion was joy, sadness or anger but not when that emotion was peace. Specifically, the mean ratings of joy were significantly higher for joyful melodies than for non-joyful melodies ($F(1, 11) = 60.43$, $p < .0001$), mean ratings of sadness were significantly higher for sad melodies than for non-sad melodies ($F(1, 11) = 13.50$, $p < .0001$), and mean ratings of anger were significantly higher for angry melodies than for non-angry melodies ($F(1, 11) = 4.41$, $p < .0366$). However, mean ratings of peaceful melodies were not significantly higher than mean ratings of non-peaceful melodies ($F(1, 11) = .70$, $p = .4032$.).

Table 4

Mean Ratings of Emotion for Ragas Intended to Convey Specific Emotions vs Ragas Intended to Convey Other Emotions.

Emotion Rated	Mean Rating of Ragas		Mean Contrast Results	
	Intended (n = 3)	Other (n = 9)	F	P
Joy	5.61 (.41)	3.57 (.40)	60.4323	.0001
Sadness	5.27 (.39)	4.80 (.40)	23.4535	.0001
Anger	3.37 (.46)	2.85 (.38)	4.4060	.0366
Peace	4.61 (.48)	4.45 (.42)	.7008	.4032

Note: Values in brackets are mean standard errors

These results provide strong support for the hypothesis that people enculturated to one tonal system can accurately perceive the intended emotion in music of an unfamiliar tonal system.

6.2 Correlations & Multiple Regression

Correlation and regression analyses were next conducted to examine the relationship between each emotion and the four psychophysical elements. In addition to the psychophysical elements rated by the listeners, a fifth element, timbre, was added to these analyses. As half the ragas were performed on flute and half on stringed instruments, this variable was coded '0' for flute and '1' for strings. This coded variable was included in the analyses to assess whether timbre had any effect upon perception of emotional content in the ragas. Table 5 lists correlations between mean ratings of the four emotions and mean ratings of the four psychophysical elements, as well as timbre.

Table 5

Correlations – Mean Ratings of Emotions & Five Psychophysical Factors

	Tempo (1-tailed)	Rhythmic Complexity	Melodic Complexity	Pitch Range	Timbre (1-tailed)
Joy	.9315**	.7824**	.6790**	.5235	.0137
Sadness	-.9174**	-.7490**	-.6442*	-.5264	-.0045
Anger	.0063	.2650	.3205	.1193	.5576*
Peace	-.6364*	-.7744**	-.7053**	-.4108	-.5406*

** p<.01 * p<.05

Note. One-tailed significance levels were used for Tempo and Timbre due to the directional predictions made for these two variables. Tempo was expected to correlate positively with mean ratings of joy and anger, and negatively with mean ratings of sadness and peace. Timbre was expected to correlate positively with anger and negatively with peace. Two-tailed significance levels were used for the remaining variables for which there were no directional predictions.

Mean ratings of joy for the 12 ragas were significantly and positively correlated with mean ratings of tempo ($r = 0.85$, $p<.0001$), rhythmic complexity

($r = 0.76$, $p<.002$) and melodic complexity ($r = 0.66$, $p<.01$), indicating that perceptions of joyfulness in the ragas were associated with perceptions of faster tempi, as well as more complex rhythms and more complex melodies. The correlations with mean ratings of pitch range ($r = 0.44$, $p = .15$), and timbre ($r = .13$, $p = .69$) were not significant.

Mean ratings of sadness were correlated negatively and significantly with tempo ($r = -.92$, $p< .001$), rhythmic complexity ($r = -.75$, $p < .005$) and melodic complexity ($r = -.64$, $p< .024$), indicating that listeners' perceptions of sadness were strongly related to perceptions of slower tempi, simpler rhythms and simpler melodies. Pitch range and timbre were not correlated significantly with mean ratings of sadness.

Interestingly, none of the listener-rated psychophysical elements were correlated significantly with perceptions of anger. Since the oneway ANOVA indicated that listeners did perceive angry ragas as distinct from the other types of ragas, these results suggest that listeners may have based their judgements of anger on psychophysical elements other than those included in this study. Timbre may have been one of these elements as it was correlated significantly and positively with mean anger ratings ($r = .56$, $p < .05$). It appears from these results that ragas performed on stringed instruments were associated with listeners' perceptions of anger.

Mean ratings of peace in the ragas were correlated negatively and significantly with mean ratings of tempo ($r = -.62$, $p< .030$), rhythmic complexity ($r = -.77$, $p< .003$), melodic complexity ($r = -.69$, $p< .013$), and timbre ($r = -.55$, $p < .031$), indicating that listeners associated slower tempi, simpler rhythms, simpler melodies, and flute timbre with peacefulness. Mean ratings of pitch range were not correlated significantly with perceptions of peace.

The predictions of directionality for tempo were supported partially by this analysis. Mean ratings of tempo were correlated significantly and positively with mean ratings of joy but not with mean ratings of anger, and correlated significantly and negatively with mean ratings of sadness and mean ratings of peace. The predictions for timbre were also supported by a significant positive correlation with mean ratings of anger and a significant negative correlation with mean ratings of peace.

Two additional correlational analyses were conducted to evaluate how ratings of target emotions related to each other, and how psychophysical measures related to each other. The negative correlations in Table 6 between mean ratings of sadness and joy ($r = -.84$, $p < .001$), and between mean ratings of anger and peace ($r = -.65$, $p < .024$), suggest that these emotions were perceived as opposites of each other. No other correlations between the target emotions were significant.

Table 6

Correlations – Mean Ratings of Emotion

	Joy	Sadness	Anger	Peace
Joy	1.0000	-.9521**	-.3152	-.4011
Sadness	-.9521**	1.0000	.2698	.3845
Anger	-.3152	.2698	1.0000	-.6382*
Peace	-.4011	.3845	-.6382*	1.0000

** p<.01 * p<.05

The listener-rated psychophysical elements were correlated very strongly with one another (see Table 7). Mean tempo ratings, for example, were correlated significantly and positively with mean ratings of the other three listener-

rated psychophysical elements, indicating that perceptions of faster tempi were associated with perceptions of more complex rhythms, more complex melodies and wider pitch ranges. It is possible that faster paced ragas were also more complex rhythmically and melodically and contained wider pitch ranges. However, it is also possible that perceptions of faster tempo influenced perceptions of the other psychophysical variables. The coded variable, timbre, was not significantly correlated with any of the listener-rated variables.

Table 7

Correlations – Psychophysical Elements

	Tempo	Rhythmic Complexity	Melody Complexity	Pitch Range	Timbre
Tempo	1.0000	.9161**	.8497**	.6655**	.1177
Rhythmic Com.	.9161**	1.0000	.9460**	.7545**	.2365
Melodic Com.	.8497**	.9460**	1.0000	.8694**	.1032
Pitch Range	.6655**	.7545**	.8694**	1.0000	-.1983
Timbre	.1173	.2365	.1032	-.1983	1.0000

** $p<.01$ * $p<.05$

Given these high intercorrelations, a series of stepwise regressions were conducted to assess whether mean emotion ratings could be modeled as a weighted sum of mean ratings of the four psychophysical elements. In other words, these analyses addressed the question of which psychophysical elements most influenced listeners' perceptions of emotion in the ragas.

Table 8

Stepwise Multiple Regression – Mean Joy Ratings

R Square =	.91328				
Adj R Square =	.89401				
Standard Error =	.55713				
F =	47.3894	Signif F =	.0001		
Variables in the Equation					
Variable	B	SE B	Beta	T	Sig T
TEMPO	1.195656	.174519	1.27532	6.851	.0001
MELODIC COM.	-.646131	.297252	-.404623	-2.174	.0578

As illustrated in Table 8, mean joy ratings can be predicted by a weighted sum of mean tempo ratings (b =1.19, p = .0001) and mean melodic complexity ratings (b = -.65, p = .0579). Together, these two variables accounted for 91% of the variance in mean joy ratings. It is important to note that, in contrast to the bivariate correlations in Table 5, the coefficient for mean ratings of melodic complexity is negative in this analysis. This result suggests that the positive correlation between melodic complexity and joy was the result of a strong positive relationship between tempo and both of these variables. That is, listeners associated increased tempo with both increased joy and increased melodic complexity, resulting in a spurious positive correlation between joy and melodic complexity. Once the effect of tempo was controlled statistically (i.e. in the regression analysis), it was revealed that higher ratings of joy were actually more associated with simpler melodies.

Table 9

Stepwise Multiple Regression – Mean Sadness Ratings

R Square =	.90757				
Adj. R Square =	.88703				
Standard Error =	.45329				
F =	44.18732	Signif F =	.0001		
Variables in the Equation					
Variable	B	SE B	Beta	T	Sig T
TEMPO	-.983456	.141993	-1.330989	-6.926	.0001
MELODIC COM.	.612562	.241851	.486729	2.533	.0321

For mean ratings of sadness, both mean tempo ratings (b = -.98, p = .0001) and mean melodic complexity ratings (b = .61, p = .0321) contributed unique predictive power in the equation. As shown in Table 9, these two predictors were highly significant and accounted for 91% of the variance in mean ratings of sadness in the ragas. However, as in the regression analysis for mean ratings of joy, the direction of the relationship between mean ratings of melodic complexity and mean ratings of sadness was the reverse of the bivariate correlations. The correlations in Table 5 suggests that listeners rated ragas they perceived as having simpler melodies higher on the sadness scale. When the variance explained by mean ratings of tempo was removed, however, it appears that listeners associated sadness in the ragas with more complex melodies.

Table 10

Stepwise Multiple Regression – Mean Anger Ratings

R Square =	.31094				
Adj. R Square =	.24204				
Standard Error =	.86564				
F =	4.5126	Signif F =	.0596		
Variables in the Equation					
Variable	B	SE B	Beta	T	Sig T
TIMBRE	1.061667	.499775	.557623	2.124	.0596

Consistent with the lack of significant correlations between mean ratings of psychophysical elements and mean ratings of anger, a stepwise multiple regression failed to enter any of the listener-rated variables. However, as Table 10 reveals, timbre was a significant predictor of mean anger ratings (b = 1.06, p = .0596), accounting for 31% of the variance. Thus it appears listeners associated the string timbre with anger in the ragas.

Table 11

Stepwise Multiple Regression – Mean Peace Ratings

R Square =	.73498				
Adj. R Square =	.67608				
Standard Error =	.49394				
F =	12. 47971	Signif F =	.0025		
Variables in the Equation					
Variable	B	SE B	Beta	T	Sig T
RHYTHM	-.520677	.134275	-.684846	-3.878	.0037
TIMBRE	-.629143	.293506	-.378576	-2.247	.0607

Table 11 reveals that, for mean ratings of peace, mean ratings of rhythmic complexity (b = -.52, p = .0037), and timbre (b = -.63, p = .06) contributed significant predictive power in the equation. These two variables accounted for 74% of the variance in mean ratings of peacefulness. In contrast to the regression analyses for mean ratings of joy and sadness, no reversal of direction in the correlational relationship between either of the predictors and the dependent variable occurred.

Although initial results indicated that Western listeners were not reliably sensitive to the intended emotion of peacefulness (see Table 4), it appears that simpler rhythms and flute timbre were used by listeners as psychophysical cues in assigning ratings of peacefulness in all the ragas. It is possible that these elements are associated with peaceful emotion in Western music, but provide insufficient cues for peacefulness in Hindustani ragas. The Hindustani music experts who participated in this study commented that all ragas were inherently peaceful and that this emotion was the most difficult to rate separately as stronger or weaker because it pervades all of the music. They also affirmed the opinions of the experts interviewed in India, (personal communication, Dr. Rao, Dr. Ranade, Pandit Devasthali from December 1996 to January 1997), when they observed that the flute timbre is very often used in peaceful ragas but very rarely in angry ragas.

6.3 Post-hoc Analyses

Although the number of participants in the expert group was too small for their data to be used for meaningful statistical analyses, an overview of the mean ratings of the expert group provides an interesting comparison to the mean ratings of the naive Western listener group. In Table 12, expert and naive

listener data are displayed in the form of mean ratings for the three ragas intended to represent each emotion along with the mean ratings for the nine ragas not intended to represent the same emotion.

Table 12

Mean Ratings of Emotion in Ragas by Naive and Expert Listeners

Emotion Rated	Naive Group		Expert Group	
	Intended (3)	Other (9)	Intended (3)	Other (9)
Joy	5.61 (.41)	3.57 (.40)	6.25 (.76)	3.25 (.37)
Sad	5.27 (.40)	4.80 (.40)	6.17 (.68)	4.28 (.71)
Anger	3.37 (.46)	2.85 (.38)	2.5 (.25)	1.00 (.00)
Peace	4.61 (.48)	4.45 (.42)	6.25 (.38)	5.06 (.37)

Note: ratings were made on bipolar scales from one to nine
Note: values in brackets are mean standard errors

For the expert group, mean ratings of joy and sadness were relatively high for the ragas intended to represent those emotions compared to the mean ratings of the ragas intended to represent other emotions. This is the same pattern seen in the mean ratings for these ragas made by naive listeners. However, the difference between the mean ratings for the ragas intended to represent those emotions and for the ragas intended to represent other emotions is greater for the expert group than for the naive group. This is also true for expert and naive mean ratings of angry and peaceful ragas. Particularly in the case of angry ragas, the difference in the expert mean ratings of ragas intended to represent anger and the ragas intended to represent other emotions is 1.5. The difference between the naive mean ratings of ragas intended to represent anger and the ragas intended to represent other emotions is .51. This suggests that the experts

made clearer distinctions between the ragas they perceived as representing an emotion and the ragas they perceived as representing other emotions.

It is also interesting to observe that, similar to the pattern observed in the naive listener data, the difference in mean ratings for peaceful and not peaceful ragas is the smallest difference of the four comparisons. This reflects the experts' comments regarding the difficulty of assessing peacefulness as a separate emotion in ragas. However, the experts appeared to have far less difficulty than the naive listeners as the difference between expert mean ratings of peaceful and not peaceful ragas (1.19) is much greater than the difference in naive mean ratings of peaceful and not peaceful ragas (.16).

In Table 13, below, a correlational analysis of expert and naive mean ratings provides some clues regarding the similarities and differences in the way these two groups perceive emotion in Hindustani ragas. For example, naive and expert mean ratings of joy and sadness were correlated significantly and positively, indicating that the two groups tended to arrive at similar assessments of which ragas were joyful and sad. It is also interesting to note that the naive listeners' mean ratings of sadness in ragas is correlated significantly and positively with experts' mean ratings of peacefulness. This suggests that naive listeners tended to perceive a quality of sadness in ragas which expert listeners interpreted as peaceful. Although the results of this analysis are purely speculative, given the small size of the expert group, they may inform subsequent comparisons of ratings between expert and naive groups of comparable size.

Table 13

Correlations – Expert & Naive Ratings of Emotion in Ragas

	Expert Joy	Expert Sad	Expert Anger	Expert Peace
Naive Joy	.6085*	-.6479*	.4048	-.4417
Naive Sad	-.8207**	.8245**	-.3793	.5904*
Naive Anger	-.0732	.5295	.3580	-.1148
Naive Peace	-.4627	.0703	-.5622*	.4736

** $p<.01$ * $p<.05$

6.4 Summary of Findings

1. Mean contrast analyses revealed that Western listeners were sensitive to the expression of joy, sadness and anger in Hindustani ragas, but not the expression of peace. Thus results for three of the four emotion scales support the hypothesis that people can perceive the intended emotion in music of an unfamiliar tonal system.

2. Correlation analyses indicated that perceptions of joy were associated strongly with perceptions of tempo, rhythmic complexity, and melodic complexity. As predicted, the correlation between joy and tempo was positive. Multiple regression analyses indicated that ratings of tempo and melodic complexity were significant predictors of mean joy ratings, accounting for 91% of the variance.

3. Correlation analyses indicated that perceptions of sadness were associated strongly with perceptions of tempo, rhythmic complexity, and melodic complexity. As predicted, the correlation between sadness and tempo was

negative. Multiple regression analyses indicated that ratings of tempo and melodic complexity were significant predictors of mean sadness ratings, accounting for 91% of the variance.

4. As predicted, perceptions of anger were associated strongly with ragas played in the string timbre. No other variables were significant predictors of mean anger ratings. Timbre accounted for 31% of the variance in the multiple regression analysis.

5. As predicted, ratings of peace were associated strongly with flute timbre, as well as listeners' perceptions of rhythmic complexity. Multiple regression indicated that both of these variables were significant predictors of mean peace ratings, accounting for 74% of the variance.

6. The pattern of mean ratings was similar for naive and expert listeners. Not surprisingly, experts appeared to be more proficient than naive listeners at distinguishing between ragas intended to convey an emotion from ragas not intended to convey that emotion.

7. General Discussion & Conclusions

During my field research trip in India I was fortunate to be able to spend some time with Pandit Shreeram Devasthali, a respected teacher and performer of Hindustani raga. In the course of one of our conversations about music, he remarked,

> I think it is the pleasantness of the sound that is universal. I have a collection of flutes from different parts of the world. But more or less tonally they are all the same. There is little difference. Then you notice that there is similarity between the families of instruments - basically they are similar. So whenever you listen to a similar instrument, then obviously it invokes a pleasurable feeling.
>
> (S. Devasthali, personal communication, December 1996, Pune, India)

In his opinion, the elements of tempo, timbre, and intonation were of great importance in the expression of rasa in all music. However, he believed that it would be difficult for naive listeners to appreciate fully the intended rasa in Hindustani ragas. Difficult, he said, but not impossible.

The 30 naive listeners who participated in this study were, on average, sensitive to emotions of joy, sadness and anger in Hindustani ragas, suggesting that musically-expressed emotion may not be as difficult to perceive across cultures as previously thought. A repeated measures oneway analysis of variance for each emotion revealed a main effect of raga on ratings, indicating that listeners were able to discriminate between ragas on the basis of the emotion they were perceived to represent. Further, mean contrast analyses revealed that mean ratings of the ragas intended to represent a specific emotion, differed significantly from mean ratings of the ragas not intended to represent that emotion, except in the case of peace. This was contrary to expectations that listeners would have difficulty recognizing anger in ragas and little difficulty recognizing peace. Thus, in three out of four categories of emotion, the primary hypothesis of this study, that people of one culture can perceive the intended emotion in music based on an unfamiliar tonal and cultural system, was supported.

The secondary hypothesis of the study, that listeners' perceptions of emotion in music may be influenced by psychophysical elements, was also supported.

Correlation and regression analyses indicated strong associations between judgements of emotion and judgements of tempo, rhythmic complexity, and melodic complexity, as well as the coded variable for timbre. The prediction that pitch range would also have a significant influence on emotion ratings was not supported.

One of the most interesting aspects of these results is how closely they correspond to the results of uni-cultural studies. For example, it was predicted on the basis of findings in uni-cultural studies (Hevner, 1935, 1936; Gabrielsson & Juslin, 1996) that listeners' perceptions of tempo would influence their ratings of emotion. Specifically, it was predicted that perceptions of fast tempi would be associated with perceptions of joyfulness and anger, and that perceptions of slow tempi would be associated with perceptions of sadness and peacefulness in the ragas. For ragas intended to evoke joy and sadness, this prediction was supported.

The influence of perceived tempo is particularly remarkable in view of the unpulsed nature of the alap sections of Hindustani ragas. How were Western listeners able to assess the tempo of these pieces in the absence of overt percussive cues? During the testing sessions, listeners were observed to attempt physical tracking of tempi in the form of finger-tapping, head-nodding, foot-tapping, and/or general body motion. As Gabrielsson (1993) has noted, even an unaccompanied melody may imply an underlying pulse. In any case, what is important here is not whether tempo can be objectively determined, but that listeners perceived the ragas as conveying tempo, and that this perception was related to their judgements of emotion.

Similarly, listeners perceived rhythmic and melodic complexity in the ragas and these elements were related to their ratings of joy, sadness and peaceful-

ness. As with tempo, these findings parallel the results of uni-cultural studies (Hevner, 1935, 1936, see also Nielzén & Cesarec, 1982). Perceptions of joy were associated with perceptions of simpler melodies, and perceptions of sadness were associated with perceptions of more complex melodies.

Contrary to predictions, mean ratings of melodic complexity and tempo were not significant predictors of mean ratings of peacefulness. However, as expected, mean ratings of rhythmic complexity were significant ratings of mean ratings of peacefulness. It is possible that, as both peaceful and sad ragas employed slow tempi, listeners attempted to use other cues in order to distinguish between them. The multiple regression results suggest that the presence of simple rhythms may have influenced listeners' judgements of peacefulness. However, as previously mentioned, listeners' were unsuccessful in their attempts to identify peaceful ragas. Together these results suggests that the psychophysical cue of rhythmic complexity was somehow insufficient in helping listeners distinguish peaceful ragas from sad ragas.

Timbre was also a significant predictor of mean ratings of peacefulness and anger. The direction of this influence was as predicted: flute timbre was strongly associated with peacefulness, and string timbre was strongly associated with anger. The overall influence of timbre, however, seems weak. For example it did not appear to help listeners distinguish peaceful ragas. Moreover, although it was significantly associated with mean ratings of anger, it only accounted for 31% of the variance.

Pitch range failed to influence significantly listeners' perceptions of any of the four target emotions. Previous evidence has indicated that pitch range plays a role in expectancy (Narmour, 1991), and expectancy, in turn, has been linked to emotion (Meyer, 1956). Quite possibly, however, the 'emotions' associated

with expectancy mechanisms may be generalized arousal, rather than specifiable emotions such as joy or anger. This interpretation would explain why pitch range did not appear to influence the identification of specific musically-expressed emotion in Hindustani ragas.

The current study was not intended as an exhaustive investigation of all possible psychophysical elements associated with emotion in music. Thus, these results are best viewed as a springboard for further research. Although some of the psychophysical variables tested were not strongly associated with some of the emotions assessed, it may be that other psychophysical variables not included in this study are more strongly associated with these emotions, or that the existing psychophysical variables are more strongly associated with other emotions. However, the patterns of association between assessments of psychophysical elements and emotions that were observed in this investigation, while by no means conclusive, provide a basis for further exploration of universal correlates of emotion in music.

7.1 Conclusions

In summary, Western listeners were sensitive to emotions in Hindustani ragas. In the absence of relevant culture-specific knowledge regarding the conventional associations of emotion and music in the Hindustani tonal system, listeners relied upon the only resource at their disposal: psychophysical cues. This strategy succeeded for the perception of joy, sadness and anger but not for the perception of peacefulness. Evidently, psychophysical correlates of emotions in Western music and Hindustani music were similar enough for Western listeners to identify successfully ragas intended to convey joy, sadness and anger in the ragas. The most influential cues in this study were tempo, rhythmic complexity,

melodic complexity, and timbre. These psychophysical cues appear to have helped Western listeners transcend some of the cultural boundaries of the Hindustani tonal system, and thus can be considered possible universal correlates of emotion in music.

It is important to acknowledge that, although this study is concerned with the link between music and emotion, I recognize that not all musical experiences involve emotion, that not all music is written with the conscious purpose of expressing emotion, and that not all performances of music are intended to evoke emotion. The connection we make between music and emotion is not an inevitable consequence of every musical event. However, evidence suggests that we often do make this connection, that some music is written specifically to express emotion, and that musicians do sometimes consciously attempt to evoke emotion through their performances. My concern is with these instances of purposeful intent to represent emotion in music .

The influence of psychophysical elements on perceived emotion in music in no way conflicts with the role of cultural influences on the representation of emotion in music. I believe that consciously and/or intuitively, composers and musicians draw upon both psychophysical and culturally-determined resources to achieve the goal of expressing emotion. In effect, composers and performers have access to a toolkit of culture-specific and universal correlates of emotion in music, and listeners' understanding of the ensuing musically-expressed emotion is affected by their familiarity with the tools employed.

In the context of this 'toolkit' model, the expression of an emotion through music in a given culture's tonal system should be most salient to listeners of the same culture, due to the shared understanding of the conventional representation of emotion within that tonal system. However, the presence of psychophys-

ical elements which may be universally associated with that emotion allow listeners who are unfamiliar with that culture's tonal system to gain a general understanding of the intended emotion.

There may be instances in which listeners of one culture have difficulty appreciating fully the intended emotion of music from another culture due to the dominance of culture-specific correlates of emotion which interfere with, or mask universal correlates of emotion. For example, in this study, Western listeners had difficulty recognizing the expression of peacefulness in Hindustani ragas intended to convey that emotion. Instead, they appeared to interpret those ragas as representative of sadness. It has been suggested that the scales commonly associated with peacefulness in the Hindustani tonal system are similar in modality to the scale commonly associated with sadness in the Western tonal system (G. Collier, personal communication, August 2nd, 1997). If this is the case, the culture-specific correlates of emotion in these pieces may have served to distract Western listeners from the possible universal correlates of emotion that were also present in these pieces (slow tempo, and simpler rhythms). In addition, the two peaceful ragas which listeners perceived as sad were performed in string timbre instead of flute timbre. Since peacefulness was strongly correlated with flute timbre, this element may have contributed to listeners' apparent confusion of sad and peaceful ragas.

For ragas intended to convey joy and sadness in this study, the toolkit model would assert that the use of universal correlates of emotion strongly outweighed the use of culture-specific correlates of emotion. Thus, the manipulation of tempo and melodic complexity to represent joy and sadness in Hindustani ragas was understood by Western listeners in spite of the presence of unfamiliar timbres and scale patterns. An alternative explanation is that the

tonal systems of Western and Hindustani cultures are more similar than previously thought. However, this possibility seems unlikely given the documentation of existing differences (see Appendix A) and the opinions of music theorists and experts to the contrary (see section 3).

7.2 Future Directions

An important goal of this study was to introduce a paradigm for further research. Aside from the need to test this paradigm with people and music of a wider variety of cultural and tonal systems, there are a few other aspects of the paradigm which could be refined.

In addition to the subjective measures of psychophysical elements, objective measures could be incorporated, such as beats per minute for tempo, and note density and repetition for melodic complexity. For music in which no score is available, expert listeners could be recruited to assist in the evaluation of these measures. These efforts would provide an additional basis for assessing the role of psychophysical elements.

A number of other psychophysical variables could also be evaluated, such as loudness/amplitude, and melodic contour. While modality is not as easily dealt with in a cross-cultural context, a closer analysis of the structures of different modalities may also be useful. Further research should also evaluate cross-cultural sensitivity to a wider range of emotions that may be represented in music.

A number of questions remain: how do psychophysical cues interact with culture-specific cues, cognitive functioning and physiological response to produce the perception of emotion in music? At what intensity do psychophysical cues actually stimulate felt emotion in response to music? Is the experience of felt emotion in response to music influenced by cultural norms governing the

social expression of emotion? Are psychophysical cues linked to the development of music as an extension of survival-oriented auditory cues?

Before these questions can be addressed, further cross-cultural research is necessary to determine the robustness of the psychophysical cues identified in this study (tempo, rhythmic complexity, melodic complexity, and timbre) and to explore the influence of cues not yet tested, such as melodic contour, modality and loudness. If it can be demonstrated that any of these cues are strongly associated with perceptions of emotion in the various tonal systems of the world, then the existence of universal correlates of emotion in music will have a profound influence on theories of music, theories of emotion, and subsequent exploration of the intrinsic appeal of music to the human species.

8. References

Abeles, H. F. (1980). In D. Hodges (Ed.) *Handbook of Music Psychology* (pp. 105-140). Lawrence, Ks: National Association for Music Therapy.

Aristotle (1984). *The Politics.* (Carnes Lord, Trans.). Chicago: University of Chicago Press.

Banks, M.S. (1980). The development of visual accommodation during early infancy. Child Development, 51, 646-666.

Behrens, G.A. & Green, S. (1993). The ability to identify emotional content of solo improvisations performed vocally and on three different instruments. Psychology of Music, 21, 20-33.

Berlyne, D.E. (1971). *Aesthetics and Psychobiology* New York: Appleton-Century-Crofts.

Blacking, J. (1973). *How Musical is Man?* University of Washington Press.

Blacking, J. (1992). The biology of music-making. In Helen Myers (Ed.), *Ethnomusicology: An Introduction.* (pp. 301-314). New York: W.W. Norton & company.

Boring, E.G. (1942).*Sensation and Perception in the History of Experimental Psychology*. New York: Appleton-Century-Crofts.

Bregman, A.S. (1990). *Auditory Scene Analysis.* Cambridge, Massachusetts: The MIT Press.

Cohen, A.J., Thorpe, L.A., & Trehub, S.E. (1987). Infants perception of musical relations in short transposed tone sequences. Canadian Journal of Psychology, 41, 33-47.

Cooke, D. (1959). *The Language of Music.* London: Oxford University Press.

Cooper, R.P. & Aslin, R.N. (1990). Preference for infant-directed speech in the first month after birth. Child Development, 61, 1584-1595.

Cunningham, J.G. & Sterling, R.S. (1988). Developmental change in the understanding of affective meaning in music. Motivation and Emotion, 12, 399-413.

D'Amato, M.R., & Colombo, M. (1988). On tonal pattern perception in monkeys. Animal Learning & Behavior, 16(4), 417-424.

Darwin, C. (1872). *The Expression of Emotion in Man and Animals.* New York: Philosophical Library.

Deva, B.C. & Virmani, K.G. (1975). A study in the psychological response to ragas. Research Report II of Sangeet Natak Akademi. New Delhi: Indian Musicological Society.

Dolgin, K. G. & Adelson, E. H. (1990). Age changes in the ability to interpret affect in sung and instrumentally-presented melodies. Psychology-of-Music, 18(1), 87-98.

Dowling, J. W. & Harwood, D. L. (Eds.) (1986). *Music Cognition.* New York: Academic Press, Inc. Harcourt Brace Jovanovich, Publishers.

Ekman, P. (1992). An argument for basic emotions. Cognition and Emotion, 6, 169-200.

Ekman, P. (1972). Universals and cultural differences in facial expressions of emotion. In J. Cole (Ed.), *Nebraska Symposium on Motivation* (pp. 207-283). Lincoln: University of Nebraska Press.

Fernald, A., Taeschener, T., Dunn, J., Papousek, M., de Boysson-Bardies, B., & Fukui, I. (1989). A cross-language study of prosodic modifications in mothers' and fathers' speech to preverbal infants. Journal of Child Language, 16, 477-501.

Fernald, A. (1992). Human maternal vocalizations to infants as biologically relevant signals: An evolutionary perspective. In ,Jerome H. Barkow, Leda Cosmides, & John Tooby (Eds.)*The Adapted Mind* (pp. 391-428). New York, Oxford: Oxford University Press.

Fink, B. (1997). A Detailed Analysis of the Neanderthal Bone Flute : An Exciting New Discovery [on-line]. Available: http://www.webster.sk.ca/greenwich/fl-compl.htm

Fiske, H. E. (1996). *Selected Theories of Music Perception* . Lewiston, NY: E. Mellen Press.

Frijda, N. (1986). *The Emotions*.. Cambridge, England: Cambridge University Press.

Gabrielsson, A. (1993). Complexities in Rhythm. In Thomas J. Tighe, W. Jay Dowling (Eds.)*Psychology and music: The understanding of melody and rhythm.* (pp. 93-120). Hillsdale, NJ, US: Lawrence Erlbaum Associates, Inc.

Gabrielsson, A., & Juslin, P. N. (1996). Emotional expression in music performance: Between the performer's intention and the listener's experience. Psychology of Music, 24, 68-91.

Gerardi, G. M. & Gerken, L. (1995). The development of affective responses to modality and melodic contour. Music Perception, 12(3), 279-290.

Gillis, A. M. (1990). What are birds hearing? BioScience, 40 (11), 810-816.

Gregory, Andrew H. & Varney, Nicholas. (1996). Cross-cultural comparisons in the affective response to music. Psychology of Music, 24, 47-52.

Grieser, D.L., & Kuhl, P.K. (1988). Maternal speech to infants in a tonal language: Support for universal features in motherese. Developmental Psychology, 24, 14-20.

Hanslick, E. (1974). *The Beautiful in Music* (7th ed.). (Gustav Cohen, Trans.). Da Capo Press, New York. (Original work published 1885).

Hevner, K. (1935). Expression in music: A discussion of experimental studies and theories. Psychological Review, 42, 186-204.

Hevner, K. (1935). Experimental studies of the elements of expression in music. American Journal of Psychology, 48, 248-268.

Hodges, D. (Ed.) (1980). *Handbook of Music Psychology.* Lawrence, Ks: National Association for Music Therapy.

Holbrook, M. B. & Anand, P. (1990). Effects of tempo and situational arousal on the listener's perceptual and affective responses to music. Psychology of Music, 18(2), 150-162.

Hoshino, E. (1996). The feeling of musical mode and its emotional character in a melody. Psychology of Music, 24, 29-46.

Hulse, S, B. D, & Braaten, R. (1995). Auditory discrimination of chord-based spectral structures by European starlings. Journal of Experimental Psychology General, 124(4), 409-423

Jay, M. F., & Sparks, D. L. (1984). Auditory receptive fields in primate superior colliculous shift with changes in eye position. Nature, 309, 345-346.

Kastner, M.P. & Crowder, R.G. (1990). Perception of the major/minor distinction: IV. Emotional connotations in young children. Music Perception, 8, 189-202.

Kaufmann, W. (1968). *The Ragas of North India*. Indiana University Press.

Keil, C. & Feld, S. (1994). *Music Grooves: Essays and Dialogues*. The University of Chicago Press: Chicago and London.

Kennedy, K. A. R. (1975). *Neanderthal man*. Minneapolis: Burgess Pub. Co.

Kivy, P. (1989) *Sound Sentiment: An Essay on the Musical Emotions*. Philadelphia: Temple University Press.

Kratus, J. (1993). A developmental study of children's interpretation of emotion in music. Psychology of Music, 21, 3-19.

Langer, S.K. (1957). *Philosophy in a New Key* (3rd ed.). New York: New American Library.

Meyer, L. B. (1956). *Emotion and Meaning in Music*. University of Chicago Press.

Morrongiello, B.A. & Roes, C.L. (1990). Developmental changes in children's perception of musical sequences: Effects of musical training. Developmental Psychology, 26(5) 814-820.

Narmour, E. (1991). The top-down and bottom-up systems of musical implication: Building on Meyer's theory of emotional syntax. Music Perception, 9(1), 1-26.

Nielzén, S., & Cesarec, Z.. (1982). Emotional experience of music as a function of musical structure. Psychology of Music, 10(2), 7-17.

Papousek, M., Papousek, H., & Symmes, D. (1991). didactic adjustments in fathers' and mothers' speech to their three-year-old infants. Journal of Psycholinguistic Research, 16, 306-319.

Rauschecker, J. P., Biao, Tian, & Hauser, M. (1995). Processing of complex sounds in the macaque nonprimary auditory cortex. Science, 268, 111-114.

Rigg, M.G. (1940). Speed as a determiner of musical mood. Journal of Experimental Psychology, 27, 566-571.

Robazza, C., Macluso, C., D'Urso, V. (1994). Emotional reactions to music by gender, age, and expertise. Perceptual and Motor Skills, 79(2), 939-944.

Rousseau, J.J. (1972). *The miscellaneous works of Mr. J. J. Rousseau* (1712-1778). New York: B. Franklin.

Russell, J. A. (1994). Is there universal recognition of emotion from facial expression: A review of cross-cultural studies. Psychological Bulletin, 115(1), 102-141.

Schachter, S. & Singer, J. Cognitive, social and physiological determinants of emotional state. Psychological Review, 65, 379-399.

Scherer, K.R., & Oshinsky, J.S. (1977). Cue utilization in emotion attribution from auditory stimuli. Motivation and Emotion, 1, 331-346.

Stevens, S.S. (1975). *Psychophysics: Introduction to its perceptual, neural and social prospects*. New York: John Wiley.

Terwogt, M. & Van Grinsven, F. (1991). Musical expression of moodstates. Psychology of Music, 19, 99-109.

Terwogt, M. & Van-Grinsven, F. (1988). Recognition of emotions in music by children and adults. Perceptual-and-Motor-Skills, 67(3), 697-698.

Thompson, W. F. & Robitaille, B. (1992). Can composers express emotions through music? Empirical Studies of the Arts, 10(1), 79-89.

Trehub, S. E., Unyk, A., & Trainor, L. J. (1993). Maternal singing in cross-cultural perspective. Infant Behavior and Development, 16, 285-295.

Vitz, P.C. (1966). Affect as a function of stimulus variation. Journal of Experimental Psychology, 71, 74-79.

Walker, R. (1996). Open Peer Commentary: Can we understand the music of another culture? Psychology of Music, 24, 103-130

Walker-Andrews, A. S. (1997) Infants' perception of expressive behaviors: Differentiation of multimodal information. Psychological Bulletin, 121 (3), 437-456.

Wedin, L. (1972). A multidimensional study of perceptual-emotional qualities in music. Scandinavian Journal of Psychology, 13, 241-257.

Wyttenbach, R. A., May, M., L. & Hoy, R. R. (1996). Categorical perception of sound frequency by crickets. Science, 273, 1542-1543

Zajonc, R.B. (1980). Feeling and thinking: Preferences need no inferences. American Psychologist, 35(2), 151-175

Appendix A

Hindustani Raga Theory & Practice: An Overview

This brief overview of the Hindustani tonal system is not meant to be exhaustive, but to provide a basic comparison of the differences in tonal organization between it and the Western diatonic tonal system. For a more complete description of Hindustani music theory and practice, suggested readings are provided at the end of this section.

The *raga* (pronounced rahgah) is the foundation of classical music in India. There are two major systems, the South Indian, or Karnatic tradition, and the North Indian, or Hindustani tradition. Although these two systems may share some ragas, the approaches to performance and meaning are very different — and treated as entirely separate systems within Indian culture.

Each raga has its own particular scale pattern of five to seven *swaras* or tones. These tones are derived from a *saptak,* consisting of 22 distinct pitches as compared to the Western diatonic octave of 12 distinct pitches. A saptak differs from the Western concept of the octave in that the end of one saptak is the beginning of another saptak based on a different starting note, implying a more openended structure. The Western octave begins and ends on the same note in a higher register, not the note of another scale, giving a sense of closure.

The 22 tones of a saptak are based on seven *shuddha* (natural) tones and five *vikrit* (flattened or sharpened) tones. The alteration of the five vikrit swaras is usually less than the Western semi-tone, creating quarter-tone or micro-tone ornamentation to the basic tones of the scale. These five intermediate tones, or

vikrit swaras, are not fixed pitches in the way that, say the Western A# (sharp) or Eb (flat) are. Instead they are altered differently for each raga — and are referred to as *shrutis*, or microtones.

The basic scale pattern of each raga is a pattern of swaras and intermediate swaras and shrutis, just as the basic scale pattern of each 'key' of a composition in the Western tonal system is a pattern of tones and semi-tones. The scale pattern of a raga consists of an ascending scale or *arohu* and a descending scale or *avaroha*. The ascending and descending scale may differ from each other in their inclusion of swaras and shrutis. A change in the scale pattern fundamentally changes the raga and is not permitted in the traditional performance of ragas.

Another difference between these two traditions is the inclusion of improvisation. In Western classical music, each piece is a complete composition to which musicians are expected to rigidly adhere. In Hindustani rag there are two types of performance: There is *abubaddha* music which is not set and bound within the framework of a specific rhythmic cycle (*tala*) or composition, and there is *nibaddha* music which is bound by a tala and a set composition. Within a raga these two types of performance are called the *alap* and the *gat*. During the alap, the performer must still adhere to the requirement of the specific scale pattern of the raga, but may freely vary the sequence, rhythm and the duration of the tones in improvisation. During the gat, the performer stops improvising and plays a set traditional composition. It is during the alap, however, that the performer strives to set the mood/*rasa* of the gat, and thus the alap is considered most evocative of the rasa.

Each raga is associated with a specific season, a month within that season, a day within that month, an hour within that day, and a range of moods or rasas.

In fact, each tone of the saptak is considered to have its own rasa which combines with other tones to produce other rasas. The juxtaposition of one tone with another can have a profound effect on the rasa of the entire raga. Thus the rasa of a raga can be multi-layered and complex, and many are considered to evoke or represent several different moods. However, there are also ragas which are said to have a dominant rasa, those which represent overwhelming joy or profound grief, for example. It is the performer, however, who has the greatest leeway in determining how expressive a raga may be of a specific rasa, particularly during the alap.

Taking these elements of Hindustani musical tradition into consideration, the performers who participated in this study were asked to play only the alap section of a raga they would choose to evoke a specific emotion. The expert listeners agreed that the ragas chosen by these two performers are traditionally associated with the stated emotions — although other performers may have chosen to interpret them differently.

Suggested Readings:

Rao, Vidya. (1991). Music Appreciation: A three part understanding of Hindustani music. Living Media India Limited, New Delhi.

Kaufmann, Walter (1968). The ragas of North India. Indiana University Press.

APPENDIX B:

Demographic Questionnaire

Subject no. _____ age: _____ gender: _____

Cultural background: (country of birth, any other culture you have spent a great deal of time in) _____

_____

_____

First Language: _____
Other languages: _____

Educational background (highest level achieved to date): _____

_____

_____

Current occupation: _____

State of hearing (normal or otherwise): _____

_____

Musical background: (include any public school or casual band or choir involvement)

_____

_____

Instruments played (if any): _____

_____

Familiarity with Western Music: (frequency of exposure, what genres)

_____

_____

Familiarity with North Indian raga system: _____

_____

Experiment Instructions:

You will be listening to 12 excerpts of Hindustani raga music, between one and four minutes in duration, through a set of headphones. After each piece, I will ask you to tell me what you think is the dominant emotion expressed by that piece.

There are four target emotions: joy, sadness, anger and peace. If you feel strongly that the piece you have just heard does not fall into any of those emotion categories then you will be asked to say which emotion you believe it does convey. Then you will be asked to choose which of the target emotions your alternate emotion most closely resembles so that we can continue with the rating procedure.

After you have identified the dominant emotion for a piece, you will be asked to rate how strongly that emotion was conveyed on a scale like this one (indicate an emotion scale). A rating of one indicates that the emotion was not conveyed by that piece at all, and a rating of nine indicates that the emotion was very strongly conveyed. You will be asked to rate each piece on all four emotion scales. You may rate each raga at any of the nine points on the scale, you may rate every raga on the same point on the scale, and please do not hesitate to use the top and bottom ends of the scale if that is how you perceive the expression of that raga.

You will also be asked to rate each piece on these four element scales (indicate a psychophysical element scale). Here are the definitions we are using for these elements:

Tempo:

This refers to the overall pace of the piece. Is it a fast song or a slow song?

Rhythmic Complexity:

This is different from tempo. There is no percussion accompaniment on these pieces but if there were a drummer, imagine if the beat would be a simple, repetitive pattern, or a more complex, changing pattern. Is there a lot going on rhythmically or not?

Melodic Complexity:

This refers to the melodic line of a piece. For example, "Mary Had a Little Lamb", is a very simple melody — it repeats the same pattern and you learn it very quickly. Then there is something like post-modern jazz which tends to have a lot of different things happening melodically and is harder to predict.

Pitch Range:

This refers to the range of pitches within each piece. Again, "Mary Had a Little Lamb" stays within the same narrow pitch range whereas something like an Italian aria ranges across several octaves. You will be asked to judge whether the pitch range in each piece is relatively narrow or wide.

(Participants were asked if they had any questions about these definitions. Clarification and further examples were provided when necessary. After participants indicated they understood the task, the listening/rating procedure was begun.)

APPENDIX C

Raw Data

List of Variables:

AGE GENDER MUSTR GROUP SEQAANG SEQBANG SEQ-
CANG SEQDANG SEQEANG SEQFANG SEQGANG SEQHANG
SEQIANG SEQJANG SEQKANG SEQLANG SEQAJOY SEQBJOY
SEQCJOY SEQDJOY SEQEJOY SEQFJOY SEQGJOY SEQHJOY
SEQIJOY SEQJJOY SEQKJOY SEQLJOY SEQAPEA SEQBPEA
SEQCPEA SEQDPEA SEQEPEA SEQFPEA SEQGPEA SEQHPEA
SEQIPEA SEQJPEA SEQKPEA SEQLPEA SEQASAD SEQBSAD
SEQCSAD SEQDSAD SEQESAD SEQFSAD SEQGSAD SEQHSAD
SEQISAD SEQJSAD SEQKSAD SEQLSAD SEQATEMP SEQBTEMP
SEQCTEMP SEQDTEMP SEQETEMP SEQFTEMP SEQGTEMP SEQHTEMP
SEQITEMP SEQJTEMP SEQKTEMP SEQLTEMP SEQAMELO SEQBMELO
SEQCMELO SEQDMELO SEQEMELO SEQFMELO SEQGMELO SEQHMELO
SEQIMELO SEQJMELO SEQKMELO SEQLMELO SEQAPITC SEQBPITC
SEQCPITC SEQDPITC SEQEPITC SEQFPITC SEQGPITC SEQHPITC
SEQIPITC SEQJPITC SEQKPITC SEQLPITC SEQARHYT SEQBRHYT
SEQCRHYT SEQDRHYT SEQERHYT SEQFRHYT SEQGRHYT SEQHRHYT
SEQIRHYT SEQJRHYT SEQKRHYT SEQLRHYT

Participant 1:

34	2	1	1	2	1	2	8	2	5	3	7	6
4	6	2	6	1	3	1	8	3	9	3	3	6
3	7	8	5	7	3	6	6	6	2	5	3	4
7	6	5	6	7	1	8	1	8	6	4	4	1
3	4	6	4	8	5	9	9	3	8	7	4	4
7	8	6	8	7	8	9	3	7	8	3	2	5
7	4	8	6	3	9	2	7	7	2	4	7	9
6	9	8	7	9	3	7	9	3				

Participant 2:

33	2	1	1	2	8	3	2	6	3	1	4	5
1	1	3	3	1	2	2	2	2	8	7	1	7
5	1	4	1	4	7	3	5	5	3	2	6	7
2	6	6	7	5	5	6	1	2	7	2	2	7
4	3	2	5	7	3	8	6	3	3	3	5	4
5	3	6	6	7	7	7	6	6	7	4	5	5
3	6	6	4	8	6	6	5	7	7	5	6	7
6	8	6	9	6	6	5	7	7				

Participant 3:

29	1	1	1	6	2	5	5	5	6	2	5	4
3	2	4	5	8	8	8	7	6	9	7	5	5
6	4	4	4	3	4	4	8	5	6	6	7	8
8	8	2	7	7	5	5	2	3	3	6	4	6
1	5	1	2	8	7	9	8	6	3	1	2	2
3	2	2	8	7	8	8	6	4	1	3	2	5
2	5	2	8	3	7	8	4	3	5	3	5	1
2	7	6	8	7	5	4	1	2				

Participant 4:

28	2	1	1	1	2	5	8	1	2	1	7	1
1	9	2	6	4	3	2	8	5	1	4	3	4
1	5	5	5	6	3	2	3	3	6	5	6	1
7	2	3	7	5	1	6	1	3	2	6	8	2
2	4	2	3	6	5	8	8	6	6	2	2	3
2	2	6	3	8	9	8	5	2	4	1	2	7
4	5	4	5	6	4	4	3	3	2	2	7	2
6	4	6	9	5	4	2	4	1				

Participant 5:

31	2	1	1	1	1	1	2	1	1	1	5	1
1	5	1	5	5	1	1	7	6	9	8	6	5
1	2	9	6	9	4	2	9	1	1	2	4	8
6	4	3	3	8	5	3	1	5	5	2	7	6
3	5	2	5	6	3	8	7	4	8	4	2	6
4	5	4	6	7	5	7	8	7	3	5	4	6
3	4	3	7	5	3	6	5	8	2	4	5	3
6	4	4	7	2	5	5	6	3				

Participant 6:

32	2	1	1	2	1	1	2	1	2	1	3	2
1	5	1	2	4	1	1	5	5	8	4	2	3
1	2	4	6	7	3	5	5	2	2	4	6	2
5	5	2	2	8	2	3	1	5	5	2	4	4
4	2	1	1	4	3	7	8	3	4	1	1	5
3	4	2	3	7	7	4	7	2	2	2	6	5
2	2	4	8	8	2	6	4	2	4	6	2	5
2	5	6	7	2	6	3	2	2				

Participant 7:

33	2	1	1	2	4	4	1	4	1	2	7	1
1	4	1	1	1	1	2	1	7	8	1	1	5
1	3	3	5	6	8	1	5	4	1	5	4	5
8	8	7	6	3	6	1	1	5	6	2	4	2
1	2	1	1	5	6	4	2	3	1	1	4	2
4	4	1	8	8	6	8	5	5	1	6	8	5
1	1	7	7	3	6	5	7	2	4	1	2	2
1	8	4	7	3	3	2	1	2				

Participant 8:

27	2	2	1	1	6	6	1	1	7	1	9	3
7	8	2	6	2	8	7	8	2	9	1	6	2
1	2	6	3	8	7	8	4	9	2	6	3	2
8	3	6	9	2	2	8	1	8	7	7	6	7
4	8	1	2	9	3	9	8	4	9	5	4	3
5	1	2	9	6	3	9	2	3	7	7	5	7
1	2	5	8	2	7	2	3	3	9	5	2	1
3	9	7	7	9	3	5	5	6				

Participant 9:

30	2	2	1	3	7	6	7	1	2	3	8	4
6	6	2	2	2	1	4	7	6	8	2	5	1
2	3	2	3	2	1	8	6	6	2	6	2	3
6	8	6	2	5	3	3	3	2	4	6	6	3
5	6	2	1	8	2	8	7	6	4	4	5	7
7	3	7	6	8	7	8	8	6	8	6	4	7
5	8	7	4	9	8	7	5	6	8	7	6	4
1	8	7	8	8	9	6	7	3				

Participant 10:

25	1	2	1	1	1	3	2	3	1	1	8	5
1	4	7	5	5	2	1	6	8	7	2	2	7
1	2	9	5	4	3	5	7	1	1	2	7	8
4	8	6	7	8	3	4	2	7	5	2	9	5
3	3	2	4	7	4	8	8	4	3	2	3	8
9	6	6	9	9	6	9	9	8	5	5	9	7
5	5	6	7	6	8	7	5	6	6	6	7	5
5	5	7	5	6	7	7	7	6				

Participant 11:

23	1	2	1	1	1	2	1	8	1	9	3	1
1	6	1	1	5	1	1	1	9	1	2	8	8
1	1	9	9	4	8	1	5	1	5	4	7	4
8	5	1	8	9	2	1	3	6	1	2	2	2
2	2	2	2	7	2	8	8	7	2	3	2	5
4	3	2	6	4	7	8	5	3	8	2	4	3
5	4	4	5	7	8	4	4	6	3	3	4	2
2	3	4	9	9	3	3	7	2				

Participant 12:

24	1	2	1	5	1	1	4	1	3	2	9	2
1	7	2	2	7	1	1	9	1	8	2	2	8
1	4	2	3	5	3	1	2	1	1	7	5	1
8	8	2	9	6	1	7	1	1	6	1	8	2
5	3	3	4	9	4	8	6	4	4	4	3	5
6	8	7	8	7	9	5	5	6	9	7	4	6
3	8	4	6	7	4	4	4	7	2	3	3	6
6	8	5	8	8	3	6	5	7				

Participant 13:

26	1	2	1	2	2	7	8	1	1	2	1	7
1	3	1	2	3	3	1	8	8	9	8	2	5
5	3	8	7	1	1	8	9	2	6	2	7	7
8	6	4	8	7	2	2	1	2	8	5	3	7
3	8	1	2	2	3	7	8	2	5	2	2	3
8	2	7	3	8	7	9	2	6	6	2	7	9
2	7	8	3	2	8	3	7	8	3	5	8	6
7	8	7	6	8	5	7	3	4				

Participant 14:

40	2	2	1	5	4	3	3	6	2	1	1	7
2	3	2	3	4	7	1	3	5	9	9	1	5
2	5	2	4	7	3	1	6	6	7	1	8	5
8	8	6	6	4	8	5	3	4	8	5	4	7
3	5	8	4	7	5	9	9	8	7	6	2	3
7	4	5	4	8	9	9	6	5	5	2	3	5
5	5	6	9	7	7	6	6	4	2	3	5	4
6	4	7	9	8	5	6	5	2				

Participant 15:

25	1	2	1	7	1	3	4	2	6	4	1	2
1	5	1	1	8	2	1	8	1	7	9	1	7
3	4	1	4	8	3	6	2	3	6	2	5	1
7	4	1	3	3	1	6	1	1	6	1	1	2
1	4	1	1	7	2	8	8	5	4	1	1	1
6	2	5	8	4	9	9	7	3	1	2	5	5
4	8	9	8	8	9	8	5	2	5	1	4	1
3	5	4	8	8	5	3	1	2				

Participant 16:

34	1	2	1	6	1	6	6	1	1	1	1	1
1	1	1	3	5	1	1	8	5	8	7	5	7
1	1	2	8	1	2	4	8	6	5	4	6	5
3	5	3	5	5	1	3	2	1	4	3	7	5
5	4	2	1	7	6	8	7	6	6	2	5	6
5	2	6	8	6	4	3	7	4	3	5	4	6
2	7	6	6	4	4	5	4	3	5	5	6	3
3	8	5	6	7	5	5	2	5				

Participant 17:

32	1	2	1	1	1	4	3	1	1	1	7	2
1	5	2	2	2	1	1	7	5	9	8	3	6
1	1	6	5	1	1	8	6	4	3	5	5	2
2	3	3	6	6	1	2	2	1	3	1	8	4
3	7	5	4	8	2	9	9	1	5	1	2	4
5	8	9	7	3	9	8	2	3	9	5	5	5
6	7	9	3	8	6	4	2	7	3	2	5	8
9	8	2	9	9	2	5	7	3				

Participant 18:

46	2	2	1	1	1	4	2	1	1	1	1	2
1	7	2	1	7	1	4	9	2	8	7	3	2
1	3	4	5	2	4	3	5	1	2	5	4	1
4	8	1	6	6	1	5	1	1	2	7	5	4
4	4	1	3	6	5	7	6	5	4	3	2	3
4	2	7	6	5	4	7	4	2	3	4	6	3
4	7	6	3	5	7	4	3	5	4	3	3	1
7	7	2	3	7	5	2	7	2				

Participant 19:

36	2	2	1	1	1	4	4	1	2	4	7	1
5	6	1	2	8	1	2	8	2	7	1	5	2
1	6	6	6	2	2	5	7	1	1	4	1	1
9	4	3	7	6	2	2	2	3	1	6	2	1
4	5	3	3	7	5	7	7	4	5	2	3	8
4	4	5	8	5	7	7	6	6	2	5	4	4
3	5	6	5	3	6	3	4	3	5	4	4	4
4	8	5	6	7	4	5	3	5				

Participant 20:

31	2	2	1	1	1	1	1	1	1	1	1	1
1	1	1	2	7	3	1	9	2	9	9	8	8
3	8	3	4	5	3	1	3	1	2	3	3	2
2	6	8	5	7	1	8	1	1	5	1	5	7
3	5	3	4	7	5	7	7	4	6	1	4	7
6	6	5	7	8	3	7	6	5	2	4	6	3
4	7	6	8	4	5	5	5	2	5	7	6	6
5	8	8	2	2	7	5	4	4				

Participant 21:

35	1	2	1	1	1	5	1	4	1	4	2	1
1	6	1	1	2	1	5	1	1	7	6	1	7
3	3	8	2	4	9	3	8	7	6	6	3	8
8	4	1	7	6	7	6	6	4	1	5	5	7
2	4	3	3	7	4	9	6	2	7	3	3	4
4	4	5	7	5	9	7	3	8	4	3	4	4
4	6	7	5	7	8	4	8	4	3	2	4	3
6	7	3	8	8	2	7	3	3				

Participant 22:

32	1	2	1	1	1	7	7	1	1	1	1	5
1	8	1	1	2	1	1	6	1	7	8	1	3
1	1	1	6	1	2	7	2	2	8	2	7	1
3	8	6	7	6	2	7	1	2	7	3	6	8
1	3	1	2	7	2	9	8	3	3	1	4	5
7	6	5	7	6	2	4	8	7	6	5	7	7
4	5	7	6	5	4	8	7	5	7	2	2	6
5	3	2	7	5	1	2	1	5				

Participant 23:

34	1	2	1	1	1	1	3	1	1	1	2	1
1	2	2	2	5	1	1	7	2	8	7	5	3
1	1	6	8	2	1	3	5	3	1	3	6	3
3	4	1	7	6	2	5	1	4	1	2	4	5
2	5	4	4	7	2	8	6	5	5	3	2	2
6	4	4	7	4	8	8	6	4	7	1	2	7
4	4	6	2	7	7	2	2	5	2	2	7	4
4	6	2	7	7	2	2	5	1				

Participant 24:

24	2	2	1	2	6	7	3	6	2	7	9	6
4	7	1	6	3	5	3	7	4	4	2	7	2
3	7	6	5	5	6	2	4	3	1	3	6	8
7	5	8	7	6	3	7	3	2	4	8	4	3
2	3	1	2	7	2	4	7	2	1	1	1	2
2	1	1	2	3	2	9	3	2	2	2	5	7
2	1	7	7	2	8	8	5	7	7	1	2	2
2	8	2	2	8	3	2	3	2				

Participant 25:

24	2	2	1	3	3	4	3	2	5	1	2	4
3	1	1	5	5	1	1	7	1	9	7	7	2
5	2	2		2	5	5	1	3	1	1	2	6
7	1	3	8	6	3	7	1	1	1	5	1	2
5	7	4	5	7	6	8	8	7	4	6	5	5
8	4	8	9	8	9	9	8	6	7	7	4	6
4	8	8	8	8	8	6	5	7	8	4	7	4
7	8	8	9	9	7	5	6	4				

Participant 26:

23	2	3	1	2	7	3	8	2	7	5	6	6
3	8	2	6	3	2	4	8	3	9	6	5	7
2	4	8	4	8	6	5	4	3	2	3	6	7
7	5	5	8	6	2	8	2	7	7	4	8	6
3	6	3	1	5	2	5	7	3	3	3	2	5
5	8	9	7	9	8	8	5	8	9	8	6	5
4	9	6	8	8	8	6	8	6	7	7	3	7
8	3	7	6	6	6	7	8	8				

Participant 27:

30	1	3	1	2	7	7	7	2	8	8	9	1
1	9	2	7	1	1	1	7	3	9	8	2	8
1	2	8	6	3	2	2	3	2	1	9	8	1
7	6	8	9	8	7	8	2	2	2	4	8	7
1	3	2	4	6	3	8	8	5	2	2	3	4
3	2	7	5	5	8	8	4	2	3	3	6	4
3	8	4	8	7	6	6	2	4	5	5	3	2
8	4	6	8	8	6	2	3	3				

Participant 28:

44	1	3	1	1	1	1	1	1	1	1	1	1
1	1	1	1	7	4	1	8	1	9	9	8	8
3	2	7	4	6	6	3	5	4	5	5	2	2
8	4	1	5	8	1	9	1	1	3	3	5	3
3	7	2	3	7	4	8	9	7	6	4	4	4
5	5	4	7	5	4	8	6	5	6	4	6	7
5	4	5	8	5	7	4	5	4	5	4	6	4
4	8	5	7	8	6	4	5	4				

Participant 29:

30	1	3	1	1	1	2	3	1	5	1	7	1
1	2	1	1	6	2	2	7	4	7	2	3	6
1	4	4	5	5	3	6	7	3	1	3	5	4
8	5	1	6	6	1	2	1	1	6	1	7	2
5	7	7	5	6	5	8	9	6	5	8	4	5
6	7	3	7	6	8	7	6	4	9	4	6	6
4	5	4	7	7	6	5	3	5	4	5	5	3
5	3	6	8	8	5	3	7	4				

Participant 30:

36	2	3	1	1	2	1	1	8	5	1	8	1
1	2	1	7	2	5	1	2	2	8	3	2	3
1	1	9	5	8	4	3	4	3	1	5	6	6
6	1	7	5	8	6	8	1	5	8	6	9	9
5	6	3	3	8	7	8	8	6	7	3	4	6
4	4	6	6	7	6	5	4	5	5	5	7	4
3	4	6	7	6	5	5	5	4	7	4	4	3
5	7	5	8	7	6	3	4	5				

Expert Participant 1:

64	2	2	2	1	1	1	1	6	1	1	3	6
1	1	1	1	6	1	1	7	1	8	8	1	5
1	1	8	7	3	6	1	7	5	1	1	7	3
4	4	1	7	8	1	2	1	1	1	1	9	8
3	7	2	4	7	3	8	8	6	2	3	3	7
4	3	6	7	5	8	8	5	3	4	4	5	9
4	8	8	5	8	7	7	6	7	8	4	5	4
3	6	3	6	8	4	2	4	3				

Expert Participant 2:

50	2	1	2	1	1	1	1	1	1	1	3	1
1	1	1	7	8	6	6	6	7	8	5	7	8
8	1	5	3	6	6	4	7	7	5	6	5	8
2	3	1	7	8	1	8	3	1	5	1	9	3
7	6	3	4	7	6	8	8	5	5	2	5	7
3	8	7	6	8	6	8	7	4	8	5	6	3
2	2	3	7	5	3	3	3	6	7	7	5	6
4	6	4	7	7	6	6	7	3				

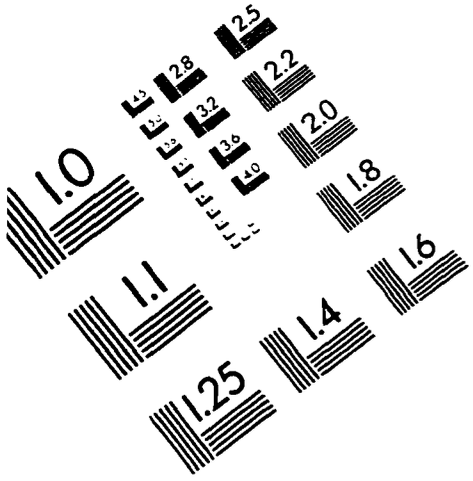
Expert Participant 3:

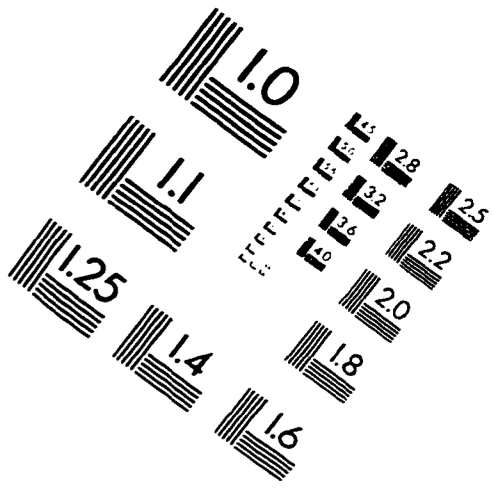
50	2	1	2	1	1	1	1	1	1	1	2	1
1	1	1	1	5	4	2	1	1	7	4	1	4
2	1	7	4	6	4	5	6	2	1	4	5	7
7	6	3	2	6	7	5	1	7	7	3	8	5
3	4	2	2	5	3	7	6	5	4	2	3	5
4	6	5	5	7	5	6	6	3	3	5	5	5
4	5	7	6	8	4	4	4	4	5	2	3	2
2	3	2	4	6	3	2	2	3				

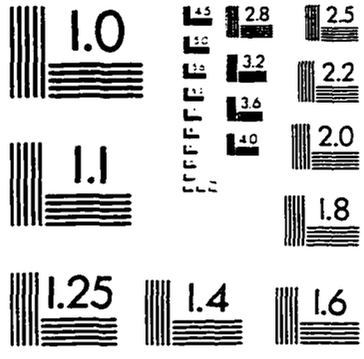
Expert Participant 4:

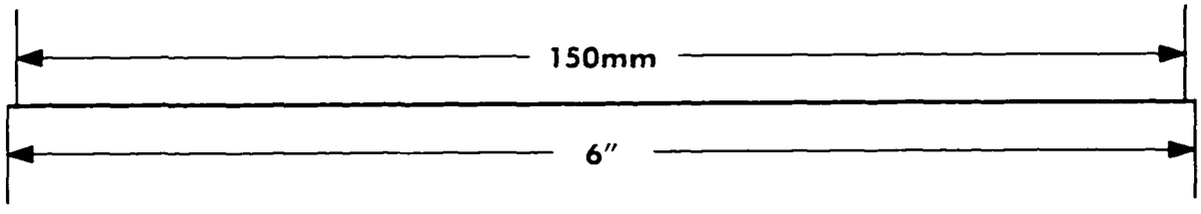
50	1	1	2	1	1	1	1	1	1	1	4	1
1	1	1	1	4	1	1	7	1	8	1	1	4
6	6	7	5	7	8	5	8	7	6	8	5	8
8	8	4	8	8	5	8	1	7	8	5	7	5
3	6	2	3	7	2	8	7	5	5	3	3	5
5	4	7	8	7	7	6	6	4	7	6	6	6
3	7	7	8	7	6	8	5	3	7	4	5	3
3	7	3	4	7	5	4	4	4				

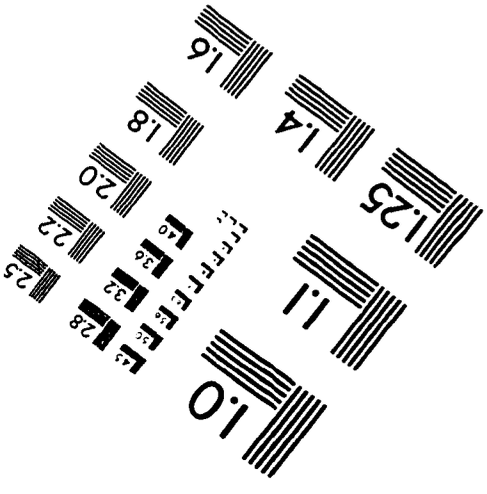
IMAGE EVALUATION
TEST TARGET (QA-3)

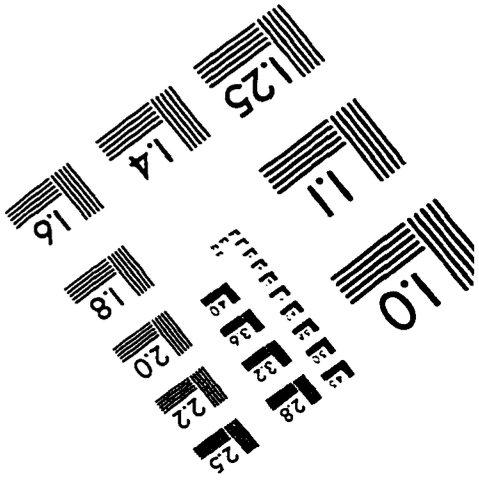












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