ANALYSIS OF EMOTIONS DUE TO VARIOUS ASPECTS OF CARNATIC AND WORLD MUSIC

BY

B.SAI VENKATESH

ABSTRACT

MUSIC AFFECTS EMOTIONS AND THIS IS A UNIVERSAL TRUTH. CARNATIC MUSIC HAS A WIDE REPERTOIRE OF RAGAS AND HENCE HOUSES A WIDE RANGE OF EMOTIONS. IN THIS DISSERTATION, THE EMOTIONS CAUSED BY THE SWARAS AND OTHER ASPECTS OF CARNATIC MUSIC SUCH AS RAGAS ARE ANALYSED, BOTH QUALITATIVELY AND QUANTITATIVELY, SUCH THAT THE EMOTIONAL EFFECT OF ANY RAGA CAN BE GIVEN AS A “PROFILE” CONSISTING OF PERCENTAGES OF VARIOUS EMOTIONS. THEN A NOTATION SCHEME CONVENIENT FOR EMOTIONAL ANALYSIS IS PROPOSED. THE MUSICAL SYSTEMS FROM DIFFERENT PARTS OF THE WORLD ARE THEN CONSIDERED. TECHNIQUES ARE THEN STATED TO APPLY CHORDS TO CARNATIC MUSIC TO ENHANCE THE EMOTIONAL CONTENT. A FOUR DIMENSIONAL THEORY OF MUSIC AND EMOTIONS IS THEN PROPOSED. FINALLY, A UNIVERSAL QUANTITATIVE AND QUALITATIVE EMOTIONAL ANALYSIS PROCEDURE IS SPECIFIED, WHICH CAN BE APPLIED TO ANY MUSICAL PIECE/SYSTEM FROM ANY PART OF THE WORLD.

KEYWORDS

MUSIC; CARNATIC; EMOTIONS; RAGA; RASA; SWARA; COLORS; NOTATION; CHORD; MELODY; HARMONY; KEY; TEMPO; LYRICS; RHYTHM

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INTRODUCTION

WE START WITH THE FACT THAT THE CARNATIC MUSICAL OCTAVE IS COMPOSED OF SEVEN NOTES, THE SAPTHA SWARAS SA, RI, GA, MA, PA, DHA, AND NI. EACH SWARA HAS A PARTICULAR BAND OF FREQUENCY OF VIBRATION WITH EACH OF ITS SUBTYPES OCCUPYING A FREQUENCY. THROUGH MUSIC WE ARE ABLE TO ARTIFICIALLY "SIMULATE" EMOTIONS AND EXPERIENCE THEM. WE WOULD HAVE OFTEN HEARD OF ANGER INCREASING BLOOD PRESSURE OR THE MIND GETTING DEPRESSED WITH SORROW AND SO ON... THIS TELLS US THE EFFECT OF EMOTIONS ON OUR PHYSICAL BODY.

RAGAS AND EMOTIONS:
WHAT IS A RAGA? A RAGA IS A PATTERNED SEQUENCE OF CERTAIN SWARAS. SO EACH RAGA HAS A SEQUENCE OF SWARAS, WHICH WHEN SUNG INVOKES THE CORRESPONDING EMOTIONS HENCE GIVING RISE TO A MORE COMPLEX EMOTION. THERE ARE INFINITE NUMBER OF EMOTIONS IN TOTAL AND HENCE FOR THOSE FOR WHICH WE DO NOT HAVE ENGLISH NAMES WE COULD EXPRESS IT USING EXAMPLES WHERE WE WOULD EXPERIENCE IT. HOWEVER, THE INDIAN SYSTEM LISTS 9 BASIC EMOTIONS; OTHERS CAN BE DERIVED FROM THESE 9. THEY ARE

1. SHRINGAARA – LOVE,BEAUTY
2. BHIBHATS – HATRED
3. HAASYA – LAUGHTER,JOY
4. KARUNA – SORROW,SYMPATHY
5. RAUDRA – ANGER
6. BHAYAANAKA – FEAR
7. VIRA – COURAGE
8. ADHBBHOOTA – SURPRISE
9. **SHAANTHA – PEACE**

**EXPRESSED EMOTIONS AND FELT EMOTIONS**

Normally, a song or rendering may induce an emotion in us, like joy. But our situation on that day may be such that we are too sorrowful to accept it and we may feel it as sorrow. Or we may remember some previous incident associated with the particular rendering or musician and feel fear or anger. Hence now 2 emotions arise, the expressed and the felt. Anyway the felt emotion depends on the listener and is highly statistical. Hence any emotion referred to in this text represents only the expressed emotion.

**CORRESPONDENCE BETWEEN SOLFEGE SYSTEMS:**

There is a lot of correspondence between Western and Carnatic solfège systems and these are given as follows assuming Indian ragam of Shankarabharanam/Bilawal:

<table>
<thead>
<tr>
<th>Letter Name</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>A</th>
<th>B</th>
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<tbody>
<tr>
<td>Western Name</td>
<td>Do</td>
<td>Re</td>
<td>Mi</td>
<td>Fa</td>
<td>Sol</td>
<td>La</td>
<td>Ti</td>
</tr>
<tr>
<td>Indian Name</td>
<td>Sa</td>
<td>Re</td>
<td>Ga</td>
<td>Ma</td>
<td>Pa</td>
<td>Dha</td>
<td>Ni</td>
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**GRAHA SWARA AND GRAHA BEDHA:**

In Carnatic music, for each raga, there are particular swaras from which any composition should start. These are called graha swaras. This is because these swaras are mostly anuvadhī or samvaadhī to give an initial pleasing effect and cancel all previous emotional states so that the divinity and beauty of music and the God’s grace can be experienced to its fullest through all the 9 emotions.

Similarly, the technique of graha bedha is a pleasing technique but is used very rarely in today’s concerts. It involves singing in a raga, with an aathaara swara of Sa. Then the singer slowly drifts to Ri, Ga or any other swara, takes it as aathaara swara and using the same swaras constructs another raga, elaborates it, and finally returns to the parent raga. This involves an ecstatic and exotic transformation of emotions from one level to another.

**TUNING AND SCALES**

The following table shows the first 16 harmonics, with frequencies and log frequencies, that forms the basis of the frequencies of the swaras.

<table>
<thead>
<tr>
<th>NOTE</th>
<th>RATIO</th>
<th>INTERVAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1:1</td>
<td>UNISON</td>
</tr>
<tr>
<td>1</td>
<td>16:15</td>
<td>MAJOR SEMITONE</td>
</tr>
<tr>
<td>2</td>
<td>9:8</td>
<td>MAJOR SECOND</td>
</tr>
<tr>
<td>3</td>
<td>6:5</td>
<td>MINOR THIRD</td>
</tr>
<tr>
<td>4</td>
<td>5:4</td>
<td>MAJOR THIRD</td>
</tr>
<tr>
<td>5</td>
<td>4:3</td>
<td>PERFECT FOURTH</td>
</tr>
<tr>
<td>6</td>
<td>45:32</td>
<td>DIATONIC TRITONE</td>
</tr>
<tr>
<td>7</td>
<td>3:2</td>
<td>PERFECT FIFTH</td>
</tr>
<tr>
<td>8</td>
<td>8:5</td>
<td>MINOR SIXTH</td>
</tr>
<tr>
<td>9</td>
<td>5:3</td>
<td>MAJOR SIXTH</td>
</tr>
<tr>
<td>10</td>
<td>9:5</td>
<td>MINOR SEVENTH</td>
</tr>
<tr>
<td>11</td>
<td>15:8</td>
<td>MAJOR SEVENTH</td>
</tr>
<tr>
<td>12</td>
<td>2:1</td>
<td>OCTAVE</td>
</tr>
</tbody>
</table>
THEORY OF EMOTIONS

AN EMOTION IS A MENTAL AND PHYSIOLOGICAL STATE ASSOCIATED WITH A WIDE VARIETY OF FEELINGS, THOUGHTS, AND BEHAVIOR. EMOTIONS MAY MANIFEST THEMSELVES AS SUBJECTIVE EXPERIENCES, OFTEN ASSOCIATED WITH MOOD, TEMPERAMENT, PERSONALITY, AND DISPOSITION. THE ENGLISH WORD 'EMOTION' IS DERIVED FROM THE FRENCH WORD ÉMOUVoir. THIS IS BASED ON THE LATIN EMovere, WHERE E- (VARIANT OF EX-) MEANS 'OUT' AND MOVERE MEANS 'MOVE'.[1] THE RELATED TERM "MOTIVATION" IS ALSO DERIVED FROM MOVERE.

NO DEFINITIVE TAXONOMY OF EMOTIONS EXISTS, THOUGH NUMEROUS TAXONOMIES HAVE BEEN PROPOSED. SOME CATEGORIZATIONS INCLUDE:

- 'COGNITIVE' VERSUS 'NON-COGNITIVE' EMOTIONS
- INSTINCTUAL EMOTIONS (FROM THE AMYGDALA), VERSUS COGNITIVE EMOTIONS (FROM THE PREFRONTAL CORTEX).
- BASIC VERSUS COMPLEX: WHERE BASE EMOTIONS LEAD TO MORE COMPLEX ONES.
- CATEGORIZATION BASED ON DURATION: SOME EMOTIONS OCCUR OVER A PERIOD OF SECONDS (E.G. SURPRISE) WHERE OTHERS CAN LAST YEARS (E.G. LOVE).

A RELATED DISTINCTION IS BETWEEN THE EMOTION AND THE RESULTS OF THE EMOTION, PRINCIPALLY BEHAVIORS AND EMOTIONAL EXPRESSIONS. PEOPLE OFTEN BEHAVE IN CERTAIN WAYS AS A DIRECT RESULT OF THEIR EMOTIONAL STATE, SUCH AS CRYING, FIGHTING OR FLEEING. YET AGAIN, IF ONE CAN HAVE THE EMOTION WITHOUT THE CORRESPONDING BEHAVIOR THEN WE MAY CONSIDER THE BEHAVIOR NOT TO BE ESSENTIAL TO THE EMOTION. THE JAMES-LANGE THEORY POSITS THAT EMOTIONAL EXPERIENCE IS LARGELY DUE TO THE EXPERIENCE OF BODILY CHANGES. THE FUNCTIONALIST APPROACH TO EMOTIONS (E.G. NICO FRIJDA) HOLDS THAT EMOTIONS HAVE EVOLVED FOR A PARTICULAR FUNCTION, SUCH AS TO KEEP THE SUBJECT SAFE.

CLASSIFICATION

BASIC AND COMPLEX CATEGORIES, WHERE SOME ARE MODIFIED IN SOME WAY TO FORM COMPLEX EMOTIONS (E.G. PAUL EKMAN). IN ONE MODEL, THE COMPLEX EMOTIONS COULD ARISE FROM CULTURAL CONDITIONING OR ASSOCIATION COMBINED WITH THE BASIC EMOTIONS. ALTERNATIVELY, ANALOGOUS TO THE WAY PRIMARY COLORS COMBINE, PRIMARY EMOTIONS COULD BLEND TO FORM THE FULL SPECTRUM OF HUMAN EMOTIONAL EXPERIENCE. FOR EXAMPLE INTERPERSONAL ANGER AND DISGUST COULD BLEND TO FORM CONTEMPT.

ROBERT PLUTCHIK PROPOSED A THREE-DIMENSIONAL "CIRCUMPLEX MODEL" WHICH DESCRIBES THE RELATIONS AMONG EMOTIONS. THIS MODEL IS SIMILAR TO A COLOR WHEEL. THE VERTICAL DIMENSION REPresents INTENSITY, AND THE CIRCLE REPRESENTS DEGREES OF SIMILARITY AMONG THE EMOTIONS. HE POSITED EIGHT PRIMARY EMOTION DIMENSIONS ARRANGED AS FOUR PAIRS OF OPPOSITES. SOME HAVE ALSO ARGUED FOR THE EXISTENCE OF META-EMOTIONS WHICH ARE EMOTIONS ABOUT EMOTIONS., "META-EMOTIONS".

ANOTHER IMPORTANT MEANS OF DISTINGUISHING EMOTIONS CONCERNS THEIR OCCURRENCE IN TIME. SOME EMOTIONS OCCUR OVER A PERIOD OF SECONDS (E.G. SURPRISE) WHERE OTHERS CAN LAST YEARS (E.G. LOVE). THE LATTER COULD BE REGARDED AS A LONG TERM TENDENCY TO HAVE AN EMOTION REGARDING A CERTAIN OBJECT RATHER THAN AN EMOTION PROPER (THOUGH THIS IS DISPUTED). A DISTINCTION IS THEN MADE BETWEEN EMOTION EPISODES AND EMOTIONAL DISPOSITIONS. DISPOSITIONS ARE ALSO COMPARABLE TO CHARACTER TRAITS, WHERE SOMEONE MAY BE SAID TO BE GENERALLY DISPOSED TO EXPERIENCE CERTAIN EMOTIONS, THOUGH ABOUT DIFFERENT OBJECTS. FOR EXAMPLE AN IRRITABLE PERSON IS GENERALLY DISPOSED TO FEEL IRRITATION MORE EASILY OR QUICKLY THAN OTHERS DO. FINALLY, SOME THEORISTS (E.G. KLAUS SCHERER, 2005) PLACE EMOTIONS WITHIN A MORE GENERAL CATEGORY OF 'AFFECTIVE STATES' WHERE AFFECTIVE STATES CAN ALSO INCLUDE EMOTION-RELATED PHENOMENA SUCH AS PLEASURE AND PAIN, MOTIVATIONAL STATES (E.G. HUNGER OR CURIOSITY), MOODS, DISPOSITIONS AND TRAITS.
PLUTCHIK’S WHEEL OF EMOTIONS IN 2D AND 3D MODELS.
ROBERT PLUTCHIK CREATED A WHEEL OF EMOTIONS IN 1980 WHICH CONSISTED OF 8 BASIC EMOTIONS AND 8
ADVANCED EMOTIONS EACH COMPOSED OF 2 BASIC ONES.

**BASIC EMOTION | BASIC OPPOSITE**
---|---
JOY | SADNESS
TRUST | DISGUST
FEAR | ANGER
SURPRISE | ANTICIPATION
SADNESS | JOY
DISGUST | TRUST
ANGER | FEAR
ANTICIPATION | SURPRISE

**ADVANCED EMOTION | COMPOSED OF... | ADVANCED OPPOSITE**
---|---|---
OPTIMISM | ANTICIPATION + JOY | DISAPPOINTMENT
LOVE | JOY + TRUST | REMORSE
SUBMISSION | TRUST + FEAR | CONTEMPT
AWE | FEAR + SURPRISE | AGGRESSIVENESS
DISAPPOINTMENT | SURPRISE + SADNESS | OPTIMISM
REMORSE | SADNESS + DISGUST | LOVE
CONTEMPT | DISGUST + ANGER | SUBMISSION
AGGRESSIVENESS | ANGER + ANTICIPATION | AWE

**HYPOTHESIS**
THIS SECTION GIVES THE VARIOUS HYPOTHESIS AND EXISTING PRINCIPLES BASED ON WHICH THE FOLLOWING ANALYSES REVOLVE.

1. Any note and its fifth note (like Sa and Pa) or any note and its 4th note (like Sa and Ma) when sounded in concurrence produces harmony. Hence these notes when present in a raga produce joyous emotions.
2. Each and every swara has a particular emotion such as thivra swaras are happier than komal swaras. It is the combination of these swara emotions that forms the main emotion of a Raga and hence of any musical piece.
3. Emotions are based on 4 fundamental emotions based on which others can be derived.
4. Music has essentially 4 dimensions: Melody, Rhythm, Harmony and Lyrics.
5. The emotions of songs can be obtained, based on the rendering of songs by various artists, and either personally hearing or letting others hear the songs and gathering opinions on how they feel. Also, information can be obtained on various blogs as to how the users feel about the musical pieces.

ANALYSIS OF PJ BASED ON VADITHVA
SAMVAADHI, ANUVAADHI AND VIVAADHI SWARA RELATIONSHIPS:

THE EMOTIONAL CONTENT OF A RAGA DEPENDS ALSO ON THE WAY EACH OF ITS SWARAS IS SUNG. IN SOME RAGAS LIKE BOULI, ITS SWARAS MAY BE SUNG IN A PLAIN FASHION WHEREAS IN OTHERS LIKE THODI OR KALYANI, IT MAY BE SUNG WITH A SHAKE OR KAMPITHA. THIS SHAKE SLIGHTLY ALTERS THE FREQUENCY OF THE SWARA THEREBY CHANGING THE EMOTION AS WELL. IN FACT, THOUGH THERE ARE ONLY 7 SWARAS, 22 SIGNIFICANT FREQUENCIES ARE IN VOGUE DUE TO THESE KAMPITHAS.

CERTAIN SWARA PAIRS MAY BE PAIRED UP AS SAMVAADHI SWARAS LIKE SA, PA AND SA, MA. THIS MEANS THAT THEY HAVE A PERFECT HARMONIC RELATION BETWEEN THEM AND GIVE AN EXTREMELY PLEASING EFFECT WHEN PLAYED TOGETHER. THIS MAY BE CONSIDERED ANALOGOUS TO THE FOLLOWING FIGURE:

![Image](72x487)

THIS FIGURE SHOWS THAT THE UPS AND DOWNS OF EACH WAVE IS CANCELLED BY THE OTHER GIVING RISE TO AN OVERALL SMOOTH PATTERN.

CERTAIN SWARA PAIRS MAY ALSO BE PAIRED UP AS ANUVAADHI, LIKE SA, GA. THESE COMBINATIONS ARE A BIT LOPSIDED SO THAT THEY MAY BE SOMEWHAT LESS HARMONIC TO HEAR. CONSIDER THE FOLLOWING CASE:

![Image](72x391)

CERTAIN SWARA PAIRS ARE CLASSIFIED AS VIVAADHI LIKE RI, GA. THIS MEANS THAT THEY HAVE EXTREMELY LOPSIDED CHARACTERISTICS, WHICH GIVE A JARRING EFFECT ON HEARING THEM, GIVING RISE TO THE MOST POWERFUL AND VIOLENT EMOTIONS. CONSIDER THIS

![Image](72x301)

BECAUSE OF SUCH LOPSIDED CHARACTERISTICS, RAGAS WITH VIVAADHI SWARAS MAY KINDLE UNPLEASANT EMOTIONS WHEN SUNG. THIS IS ONE OF THE REASONS WHY PEOPLE ALL THROUGH THE YEARS ALWAYS HAD THE SUPERSTITIOUS BELIEF OF “VIVAADHI DHOSHAM”, THAT IS, CONSIDERING VIVAADHI RAGAS AS TABOO. THE ANUVAADHI AND SAMVAADHI SWARAS HAVE BEEN SCIENTIFICALLY PROVED TO BE IN THE CYCLES OF FIFTHS AND FOURTHS, HENCE ACCOUNTING FOR PLEASING NATURE. THIS IS MENTIONED IN THE BOOK SOUTH INDIAN MUSIC, VOL 5, CHAPTER 11 BY PROF P.SAMBAMOORTHY.

CLASSIFICATION OF SWARAS:

THERE ARE 72 PARENT RAGAS OR MELAKARTHAS IN CARNATIC MUSIC, WHICH HAVE ALL 7 SWARAS IN BOTH THEIR ASCENT AND DESCENT. THE COMBINATIONS OF CERTAIN VARIANTS OF RI, GA, MA, DHA, AND NI FORM THESE. SA AND PA DO NOT HAVE ANY VARIATIONS.

- THERE ARE 3 VARIATIONS OF RI:- SUDDHA(RA), CHATHUSRUTHI(RI), SHATSRUTHI(RU)
- THERE ARE 3 VARIATIONS OF GA:- SUDDHA(GA), SADHARANA(GI), ANTHARA(GU)
- THERE ARE 2 VARIATIONS OF MA:- SUDDHA(MA), PRATHI(MI)
- THERE ARE 3 VARIATIONS OF DHA:- SUDDHA(DHA), CHATHUSRUTHI(DHI), SHATSRUTHI(DHU)
- THERE ARE 3 VARIATIONS OF NI:- SUDDHA(NA), KAISIKI(NI), KAKALI(NU)
A DISSERTATION ON THE EMOTIONAL ANALYSIS OF VARIOUS ASPECTS OF CARNATIC AND WORLD MUSIC

TRADITIONALLY, THESE SWARAS HAVE BEEN SPLIT INTO KOMAL AND THIVRA SWARAS.

HERE, WE WILL BE DEVIATING FROM THE TRADITIONAL METHOD OF CLASSIFYING SWARAS AS KOMAL AND THIVRA; AS SUCH, A DEVIATION IS REQUIRED TO CLASSIFY SWARAS AS BRIGHT AND DULL.

ACCORDING TO OUR CLASSIFICATION, RA (R1), GI (G1), MI (M2), DHA (D1), NI (N1) ARE KOMAL SWARAS.

ACCORDING TO OUR CLASSIFICATION,
RI(R2),GU(G2),MA(M1),DHI(D2),NU(N2),RU(R),GA(G),DHU(D),NA(N) ARE THIVRA SWARAS.

ANALYSIS OF EMOTIONS BASED ON ANUVADHI AND SAMVADHI SWARA PAIRS:
WE CAN ANALYSE THE EMOTIONS OF A RAGA BASED ON THE NUMBER OF ANUVADHI AND SAMVADHI COMBINATIONS PRESENT IN IT, SINCE THEY ADD TO THE PLEASING NATURE OF A RAGA. CONSIDER THE FOLLOWING VEENA SWARASTHANA PATTERN:-

RULES FOR ALLOTING POINTS OF JOY FOR VARIOUS PAIRS:
BASED ON THE CONCEPTS OF KOMAL AND THIVRA SWARAS, AND ANUVAADHI SAMVAADHI PAIRS, POINTS OF JOY (PJ) WERE FOUND USING THE FOLLOWING POINTS:
1. INITIALLY, ALL THE SAMVAADHI AND ANUVAADHI PAIRS OF THE RAGA ARE LISTED.
2. THE PJ OF SAMVADHI SWARAS (SWARA(S) IN A PAIR BEARING A SAMVADHI RELATIONSHIP) WILL HAVE A HIGHER PJ THAN ANUVADHI SWARAS.
3. THIVRA SWARAS, INHERENTLY BEING “HAPPIER SWARAS”, HAVE A HIGHER PJ THAN KOMAL SWARAS.
4. SA AND PA CAN BE CONSIDERED TO BE THIVRA SWARAS.
5. SINCE ONLY RELATIVE VALUES OF PJ ARE REQUIRED, THE ABSOLUTE NUMERICAL PJ VALUES OF A SWARA PAIR IS LEFT TO THE CHOICE OF THE READER.
6. FOR THE PURPOSE OF ILLUSTRATIONS, THE VALUES ARE CHOSEN TO BE ODD NUMBERS, STARTING FROM 1 ONWARDS.
8. TO COMPARE IT WITH OTHER RAGAS, DIVIDE THE PJ BY THE NUMBER OF SWARAS TO GIVE NORMALISED PJ (NPJ). SUCH THAT NPJ=PJ/S WHERE S IS THE NUMBER OF SWARAS IN THAT RAGA.
A RELATIVELY LOWER VALUE OF PJ INDICATES THAT THE RAGA HAS MORE NEGATIVE EMOTIONS LIKE SORROW, FEAR AND SYMPATHY AND SO ON.

WE SHALL SEE HOW TO CALCULATE THIS BY MEANS OF AN ILLUSTRATION.
TAKE MELAKARTHA RAGA 25 MAARARANJANI.
THE FOLLOWING COMBINATIONS ARE SEEN WITH THEIR PJ VALUES:
1. SP
2. R2N
3. M1S
4. PR2
5. NG2
6. SM1
7. R2P
8. G2N
9. PS
10. NR2
11. SG2
12. G2D1
13. M1N
14. D1S
TOTAL = 134 ACCORDING TO THE ODD NUMBER SCHEME SUCH AS THE ONE MENTIONED ABOVE (6TH POINT).

• ALL POINTS THAT ARE ALLOTTED TO A SWARA OR RAGA ARE PURELY ARBITRARY, AS IT IS NOT THE
  POINTS THAT MATTERS, BUT THE RELATIVE COMPARISON OF POINTS OF VARIOUS SWARAS. USUALLY POINT ARE
  TAKEN AS 1, 3, 5, 7, OR 2, 4, 6, 8, SO AS TO HAVE A WIDE INTERVAL. THIS AVOIDS OVERLAPPING OF POINTS OF
  MANY RAGAS.
• IN THIS MANNER THE PJ VALUES CAN BE CALCULATED FOR ALL THE 72 MELAKARTHA (PARENT) RAGAS.

ANALYSIS OF PJ VALUES OF INDIVIDUAL SWARAS:
THE PJ VALUES FOR INDIVIDUAL SWARAS CAN BE FOUND BY TAKING INTO CONSIDERATION THE PJ VALUES
OF MELAKARTHA RAGAS CONTAINING THESE SWARAS AND TAKING THE AVERAGE OF THESE.
BEFORE PROCEEDING TO DO THIS, LET US CALCULATE THE PJ VALUES OF VARIOUS RIGAMA AND DHANI
COMBINATIONS BY THE ABOVE MENTIONED PROCEDURE. THE VALUES WERE CALCULATED FOR THE 12
RIGAMA COMBINATIONS AND THE 6 DHANI COMBINATIONS. THE RESULTS ARE:
1. RAGAMA-109.33
2. RAGIMA-78.67
3. RAGUMA-104.67
4. RIGIMA-108.17
5. RIGUMA-129.5
6. RUGUMA-105.67
7. RAGAMI-89.33
8. RAGIMI-55.5
9. RAGUMI-76.67
10. RIGIMI-84.5
11. RIGUMI-108.5
12. RUGUMI-77.5
1. DHANA-93.67
2. DHANI-74.58
3. DHANU-83.83
4. DHINI-95.83
5. DHINU-112.4167
6. DHUNU-95.58
HAVING KNOWN THIS, WE CAN FIND OUT THE PJ VALUES OF INDIVIDUAL SWARAS, BY TAKING THE HIGHEST OCCURING PJ OF THAT SWARA IN ALL THE RIGAMA OR DHANI COMBINATIONS CONTAINING THESE SWARAS. FOR EXAMPLE, TO GET THE PJ OF RI(CHATHUSRUTHI RISHABHAM), TAKE HIGHEST OF 4, 5 AND 10, 11 IN THE FIRST SET ABOVE. THE VALUES WERE CALCULATED FOR ALL THE SWARAS. THE RESULTS ARE:

1. RA-109.33
2. RI-129.5
3. RU-105.67
4. GA-109.33
5. GI-108.167
6. GU-129.5
7. MA-129.5
8. MI-108.5
9. DHA-93.667
10. DHI-112.4167
11. DHU-95.58
12. NA-93.67
13. NI-95.83
14. NU-112.4167

PJ OF SWARAS - HERE THE HIGHEST OCCURING PJ OF THE SWARA COMBINATIONS IS TAKEN FOR A PARTICULAR SWARA. THE REASON IS AS FOLLOWS. THE METHOD OF FINDING THE PJ OF A SWARA AS THE AVERAGE OF ALL COMBINATIONS CONTAINING THE SWARA IS MEANINGLESS BECAUSE SWARAS LIKE RA HAVE 6 COMBINATIONS(1,2,3,7,8 AND 9) WITH 2 VIVAADHIS(1 AND 7) WHEREAS SWARAS LIKE RI HAVE ONLY 4 COMBINATIONS(4,5,10 AND 11) TO ITS CREDIT WITH NO VIVAADHI SWARA FEATURING. HENCE IT IS ASYMMETRICAL. SO, INITIALLY, ALL SWARAS ARE ARBITRARILY ASSUMED TO HAVE A PREDOMINANTLY HIGH PJ VALUE. LET US TAKE RIGUMA. SINCE RI, GU AND MA HAVE HIGH PJ THE RIGUMA ALSO HAS A HIGH PJ. BUT A SWARA LIKE GI, ALTHOUGH ASSUMED TO HAVE A HIGH PJ VALUE SHOULD HAVE A VALUE LOWER THAN RI, GU OR MA. THAT IS THE REASON WHY RIGIMA HAS LOWER PJ THAN RIGUMA. SO ALTHOUGH RI AND MA HAVE A HIGH PJ, GI PULLS IT DOWN SO THAT THE PJ OF RIGIMA COMES LOWER. HENCE THE PJ OF A COMBINATION CAN BE VIEWED AS EITHER SUM OR AVERAGE OF THE SWARAS IT CONTAINS, WHERE IF THE HIGHEST PJ COMBINATION IS TAKEN FOR A SWARA, IT FOLLOWS THAT WE CAN FIND THE RELATIVE RANKING OF SWARAS IN TERMS OF THEIR PJ. HERE IT IS TO BE NOTED THAT ALTHOUGH PJ WAS CALCULATED WITH SAMVAADHI AND ANUVAADHI PAIRS THAT INVOLVES 2 SWARAS, IT ONLY GIVES A RELATIVE CONTENT OF POSITIVE EMOTIONS. HENCE THE CONCEPT OF PJ VALUE OF AN INDIVIDUAL SWARA IS VALID.

TABLE OF EMOTIONS OF SWARAS AND SWARA COMBINATIONS:

WE KNOW THAT ANY RAGA IS BUILT FROM CERTAIN SWARAS. HENCE UNDERSTANDING OF THE EMOTIONS IF INDIVIDUAL SWARAS IS FUNDAMENTAL TO THE ANALYSIS OF RAGAS. BUT THE INDIVIDUAL EMOTION OF A SINGLE SWARA OR SWARA PHRASE AS SUCH IS TOO SUBTLE TO BE EXPERIENCED DIRECTLY. BUT IT CAN BE FOUND BY COMPARING RAGAS HAVING THAT SWARA ALONE IN COMMON AND TAKING THE EMOTION COMMON TO THOSE RAGAS. FOR THIS PURPOSE, THE 72 MELAKARTHA RAGAS ARE CHOSEN, SINCE THEY COVER THE ENTIRE SPECTRUM OF SWARAS IN ALL POSSIBLE COMBINATIONS. THERE ARE ONLY A FEW COMPOSERS WHO HAVE COMPOSED IN ALL 72 MELAKARThAS, THE TAMIL COMPOSER KOTEESHWARA IYER BEING ONE AMONG THEM. HIS SONGS ARE MOSTLY BASED ON AN EMOTIONAL THEME AND HENCE HIS SONGS WERE CHOSEN. THE RENDERINGS BY THE MUSICIAN/ARTIST S.RAJAM PROVED TO BE OF GREAT HELP. HIS SONGS WERE HEARD WITH THE LYRICS AND NOTATIONS. THE ANALYSIS REQUIRES ONLY AN ESTIMATE OF THE EMOTIONAL CONTENT IN EACH SWARA AS BASED ON THAT EVERYTHING ELSE CAN BE FOUND. THE EMOTION OF EACH OF THE 72 SONGS CAN BE ESTIMATED IN THREE WAYS.
1. **BY LETTING PEOPLE HEAR THE SONGS AND GETTING COMMENTS ON HOW THEY FEEL. HOWEVER, THIS METHOD IS NOT ACCURATE AS THE COMMENTS DEPENDS ON THE PRESENT EMOTIONAL SITUATION OF THE LISTENERS.**

2. **BY PERSONALLY HEARING THESE SONGS KEENLY AND WRITING DOWN THE RESULTS. THIS IS ALSO NOT PERFECT SINCE IT INVOLVES INTUITION ALSO.**


THE REASON FOR ALL 3 METHODS BEING IMPERFECT IS THAT THE EMOTIONS ARE A RATHER ABSTRACT AND RELATIVE CONCEPTS. HOWEVER, THIS IS THE ONLY APPROACH TO START. HENCE ALL 72 SONGS OR 72 RAGAS WERE ANALYSED USING ALL OF THE 3 PROCEDURES AND THE RESULTS ARE SUMMARISED IN THE FORM OF A TABLE.THESE EMOTIONS HAVE BEEN SPLIT UP AS BASIC EMOTIONS TO THE MAXIMUM POSSIBLE EXTENT SO THAT ANALYSIS WILL BE SIMPLE. HERE SUBMISSION REFERS TO BHAKTI RASA, WHERE IT CAN BE CONSIDERED IN TWO FORMS

- CONTAINING MORE OF FEAR, AS IS SEEN WITH RAGAS HAVING KOMAL RI OR DHA.
- CONTAINING MORE OF TRUST OR SYMPATHY, SEEN IN OTHER RAGAS.

THE WORD LITTLE MENTIONED HER AND IN THE TABLES MEANS THAT THAT EMOTION IS LESS INTENSER THAN THE OTHER EMOTIONS MENTIONED.

<table>
<thead>
<tr>
<th>MELA NUMBER</th>
<th>MELA NAME</th>
<th>OBSERVED EMOTION</th>
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<tbody>
<tr>
<td>1</td>
<td>KANAKANGI</td>
<td>SUBMISSION, LITTLE LOVE</td>
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<td>4</td>
<td>VANASPATHI</td>
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<td>THANARUPI</td>
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<td>Emotional Analysis</td>
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<td>71</td>
<td>KOSALAM</td>
<td>JOY, SURPRISE, LITTLE LOVE</td>
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QUALITATIVE EMOTIONAL ANALYSIS

Qualitative analysis of emotions based on Swara combinations:

From the emotions of Melakarthas above we can see the emotions of each combination of Ri, Ga, Ma separately, and each combination of Dha, Ni separately by using the emotion common to all ragas that have that particular Rigama/Dhani combination. For example, emotion of Ragama is the emotion common to Melas 1-6.

Ri, Ga, Ma combinations:
1. Ragama - Fear, (Submission)
2. Ragima - Sympathy, Fear (Submission)
3. Raguma - Fear (Submission), Little Sympathy
4. Rigima - Sympathy, Joy, Love
5. Riguma - Love, Joy, Little Surprise
6. Ruguma - Surprise, Little Joy, Little Love
7. Ragami - Submission, Little Sorrow
8. Ragimi - Submission, Sympathy, Little Sorrow
9. Ragumi - Submission, Little Sympathy
10. Rigimi - Sympathy, Love, Little Submission
12. Rugumi - Surprise, Little Joy

Dha, Ni combinations:
1. Dhana - Fear (Submission)
2. Dhani - Fear (Submission), Little Sympathy, Little Love
3. Dhanu - Fear, Little Sympathy
4. Dhini - Sympathy, Joy, Love, Little Submission
5. Dhunu - Surprise, Little Joy, Little Love
6. Dhunu - Surprise, Little Joy, Little Love

Illustrations for Janaka ragas:
To analyse the Janaka raga emotions, one would use the details about various Rigama and Dhani combinations given above.

- Consider Harikambhoji Mela 28. It uses Rigumadhiini i.e. 5 among Rigama and 4 among Dhani. This means a combination of joy with soothing happiness and sympathy with little happiness, which means joy with little sympathy.
- Bhavapriya-Mela 44-composition Saragimapadhani-sorrow with a tinge of sympathy
- Charukesi-Mela 26-composition Sarigumapadhani-joy with a tinge of deep sorrow
- Naagaanandhini-Mela 30-composition Sarigumapadhunu-ecstatic joy with a tinge of surprise.

Illustrations for Janya ragas:
Case 1: Upanga ragas:
These are ragas in which no swara other than the Mela from which is derived is present and it mostly does not contain all the seven swaras.
SINCE IT DOES NOT CONTAIN ATLEAST ONE SWARA, IT CAN BE DERIVED FROM TWO MELAKARTHAS ASSUMING THE ABSENT SWARA TO BE EITHER VERSION.

FOR EXAMPLE, MOHANAM HAS SARIGUPADHISA. MA AND NI ARE ABSENT IN THIS RAGA.

- ASSUMING MA TO BE MA AND NI TO BE NI, WE CAN DERIVE MOHANAM FROM HARIKAMBHOJI.
- ASSUMING MA TO BE MI AND NI TO BE NI, WE CAN DERIVE MOHANAM FROM VACHASPATHI.
- ASSUMING MA TO BE MA AND NI TO BE NU, WE CAN DERIVE MOHANAM FROM DHEERASANKARABHARANAM.
- ASSUMING MA TO BE MI AND NI TO BE NU, WE CAN DERIVE MOHANAM FROM MECHAKALYANI.

THUS, THE EMOTION OF MOHANAM COULD BE VIEWED AS THE EMOTION COMMON TO ALL THESE 4 MELAKARTHA RAGAS. ALTERNATIVELY, MORE PRECISELY, WE COULD TAKE UP MOHANAM AS ANY ONE OF THE MELAS MINUS THE SWARAS ABSENT. IF WE COULD FIND THE EMOTIONS OF THESE SWARAS, WE COULD DELETE THEM FROM THE MELA’S EMOTION. WHAT IS LEFT IS MOHANA’S EMOTION.

THE SAME COULD BE APPLIED TO ALL RAGAS OF THE UPANGA AUDAVA/SHADAVA CATEGORY.

CASE 2: BHASHANGA RAGAS:-

THESE ARE RAGAS WHICH MAY OR MAY NOT CONTAIN ALL 7 SWARAS, BUT CONTAIN SWARAS OTHER THAN THOSE PRESENT IN THE MELA UNDER WHICH THEY ARE DERIVED.

THE ABOVE PROCEDURE APPLIED TO UPANGA RAGAS CAN BE APPLIED HERE ALSO. HOWEVER, IN ADDITION TO IT, ONE SHOULD FIND THE FOREIGN SWARA AND ANALYSE ITS EMOTION. THIS EMOTION PLUS THE PREVIOUSLY FOUND EMOTION WOULD GIVE THE EMOTION OF THE BHASHANGA RAGA.

EMOTIONS OF THE INDIVIDUAL SWARAS:

THE FOLLOWING TABLE SHOWS THE EMOTIONS OF THE 16 SWARAS OBTAINED BY COMPARING RIGAMA AND DHANI COMBINATIONS POSSESSING CERTAIN SWARAS IN COMMON.

<table>
<thead>
<tr>
<th>SWARA</th>
<th>EMOTION</th>
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<td>SA</td>
<td>ATHARA SWARA (FIRMNESS TO THE RAGA)</td>
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<tr>
<td>RA</td>
<td>FEAR, SYMPATHY, SORROW</td>
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<tr>
<td>RI</td>
<td>JOY, SYMPATHY, LITTLE SURPRISE, LOVE</td>
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<tr>
<td>RU</td>
<td>SURPRISE, LITTLE JOY</td>
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<tr>
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<td>MI</td>
<td>SUBTLE JOY, SOOTHINGNESS</td>
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<tr>
<td>PA</td>
<td>NO EMOTION (FIRMNESS TO THE RAGA)</td>
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<td>NU</td>
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QUALITATIVE ANALYSIS OF EMOTIONS OF RAGAS:

THE EMOTIONS OF RAGAS CAN BE EVALUATED WITH A PROCEDURE, WHICH IS GIVEN BELOW:

- NEXT, THE RAGA IS CHECKED FOR ANY VARJATHVA OR ABSENCE OF SWARAS, IN WHICH CASE PRESENCE OF ANUVAADHI AND SAMVAADHI PAIRS OF CONSECUTIVE SWARAS IN AROHANA OR AVAROHANA
ADD TO JOY AND OTHER SUCH POSITIVE EMOTIONS, THIVRA PAIRS CONTRIBUTING MORE THAN KOMAL ONES.

- NEXT, THE RAGA IS CHECKED FOR THE PRESENCE OF ANYA SWARAS OR SWARAS NOT SEEN IN ITS PARENT RAGA AND THE EMOTION OF THIS SWARA IS ADDED TO THE LIST. IF THE SWARA HAS A SAMVAADHI OR ANUVAADHI PAIR, IT ADDS TO JOY AND PEACE.
- NEXT, THE RAGA IS CHECKED FOR VAKRATHVA, OR DEVIATIONS FROM THE ORIGINAL PATTERN OF ASCENT AND DESCENT. IF A VAKRA IS SEEN IN AROHANA IT DECREASES THE INTENSITY OF ALL EMOTIONS AND IF A VAKRA IS SEEN IN AVAROHANA, IT INCREASES THE INTENSITY OF ALL EMOTIONS. AGAIN, THE PRESENCE OF CONSECUTIVE SAMVAADHI OR ANUVAADHI PAIRS AT ANY VAKRATHVA ADDS TO THE POSITIVE EMOTIONS, THIVRA CONTRIBUTING MORE THAN KOMAL.

EMOTIONAL EFFECTS OF THE 22 SHRUTHIS AND GAMAKAS

LIST OF THE 22 SHRUTHIS:

Here is the list of the 22 shruthis and their relative frequencies (in cycles per seconds), along with the ragas in which they are used. The first shruthi in each swara is an increment of the last shruthi of the previous swara by 5.35%, the second by 6.66%, the third by 11.11%, and the fourth by 12.50%.

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<th>SERIAL NO.</th>
<th>NAME</th>
<th>RAGA EXAMPLE</th>
<th>FREQUENCY</th>
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<tr>
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<td>7</td>
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<td>BHAIRAVI</td>
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<td>ALL MELAKARTHA RAGAS</td>
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<td>SAVERI</td>
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<td>21</td>
<td>KALI NISHADHAM</td>
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<td>22</td>
<td>THIVRA KALI NISHADHAM</td>
<td>NEELAMBARI</td>
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</table>
ANALYSIS OF THE EMOTIONS OF 22 SHRUTHIS:

BEFORE ANALYSING THE EMOTIONS OF THE 22 SHRUTHIS A FEW POINTS NEED TO BE NOTED.

- A VIVAADHI SWARA IS NOT A FULL SWARA AS IT DOES NOT HAVE ANY SEPARATE SWARASTHANA.
- FOR EXAMPLE, CONSIDER DHU, A VIVAADHI SWARA. IT IS A VARIATION OF DHAIVATHAM. BUT IT IS PLAYED IN THE SWARASTHANA OF KAISIKI NISHADHAM. THEREFORE, IT IS CONSIDERED TO BE IN BETWEEN DHI AND NI.
- TO ANALYSE DHU’S EMOTION WE CAN CONSIDER THE FACT THAT ONLY THE LAST MELAKARTHA OF EACH OF THE 12 CHAKRAS USES DHU.
- THEREFORE, THE EMOTION COMMON TO ALL THESE RAGAS WOULD BE THE EMOTION OF DHU. THE SAME APPLIES FOR OTHER VIVAADHIS LIKE RU, GA AND NA.
- THEREFORE, IN THE SCHEME OF 22 SHRUTHIS, VIVAADHI SWARAS DO NOT FIND AN EXPLICIT PLACE.
- THEREFORE, AS TOLD BEFORE, A VIVAADHI IS TO BE SEEN AS IN BETWEEN 2 SWARAS AND HENCE, THE EMOTIONS CANNOT BE FOUND OR BE INCLUDED IN THOSE OF THE 22 SWARAS EXPLICITLY.
- AS FOR THE OTHER SWARAS, EACH OF THE 10 (16 SWARAS MINUS SA, PA MINUS 4 VIVAADHI SWARAS) SWARAS HAVE TWO VARIATIONS IN THE SCHEME OF 22 SHRUTHIS.
- THEREFORE, EACH OF THE 10 SWARA’S MOTION IS SPLIT INTO TWO AND FORMS THE EMOTION OF THESE 20 SWARAS WHEREAS SA AND PA DO NOT HAVE ANY.

THE FOLLOWING ARE THE EMOTIONS OF THE 22 SHRUTHIS.

<table>
<thead>
<tr>
<th>22 SHRUTHI</th>
<th>SWARA CODE</th>
<th>PARENT SWARA</th>
<th>EMOTION</th>
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<tbody>
<tr>
<td>ACHALA SA</td>
<td>SA*</td>
<td>SA</td>
<td>NIL</td>
</tr>
<tr>
<td>EKASHRUTHI RI</td>
<td>RA*</td>
<td>RA</td>
<td>MORE FEAR, SYMPATHY</td>
</tr>
<tr>
<td>DVISHRUTHI RI</td>
<td>RI*</td>
<td>RA</td>
<td>MORE SYMPATHY, FEAR</td>
</tr>
<tr>
<td>THRISHRUTHI RI</td>
<td>RU*</td>
<td>RI</td>
<td>MORE SYMPATHY, JOY</td>
</tr>
<tr>
<td>CHATHUSHRUTHI RI</td>
<td>RE*</td>
<td>RI</td>
<td>MORE JOY, SYMPATHY</td>
</tr>
<tr>
<td>SUDDHA GA</td>
<td>GA*</td>
<td>GI</td>
<td>MORE SYMPATHY, LITTLE JOY</td>
</tr>
<tr>
<td>SADHARANA GA</td>
<td>GI*</td>
<td>GI</td>
<td>SYMPATHY, LITTLE JOY</td>
</tr>
<tr>
<td>ANTHARA GA</td>
<td>GU*</td>
<td>GU</td>
<td>JOY, LITTLE SURPRISE</td>
</tr>
<tr>
<td>CHYUTHAMADHYAMAGA</td>
<td>GE*</td>
<td>GU</td>
<td>JOY</td>
</tr>
<tr>
<td>SUDDHA MA</td>
<td>MA*</td>
<td>MA</td>
<td>JOY, LITTLE FEAR</td>
</tr>
<tr>
<td>THIVRA SUDDHA MA</td>
<td>MI*</td>
<td>MA</td>
<td>JOY</td>
</tr>
<tr>
<td>PRATHI MA</td>
<td>MU*</td>
<td>MI</td>
<td>SUBTLE JOY</td>
</tr>
<tr>
<td>CHYUTHAPANCHAMAMA</td>
<td>ME*</td>
<td>MI</td>
<td>LITTLE JOY, LITTLE SYMPATHY</td>
</tr>
<tr>
<td>ACHALA PA</td>
<td>PA*</td>
<td>PA</td>
<td>NIL</td>
</tr>
<tr>
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<td>DHA*</td>
<td>DHA</td>
<td>FEAR, LITTLE SYMPATHY</td>
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<tr>
<td>DVISHRUTHI DHA</td>
<td>DHI*</td>
<td>DHA</td>
<td>SYMPATHY, LITTLE FEAR</td>
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<tr>
<td>THRISHRUTHI DHA</td>
<td>DHU*</td>
<td>DHI</td>
<td>LITTLE JOY, SYMPATHY</td>
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<tr>
<td>CHATHUSHRUTHI DHA</td>
<td>DHE*</td>
<td>DHI</td>
<td>JOY, LITTLE SYMPATHY</td>
</tr>
<tr>
<td>KAISIKI NI</td>
<td>NA*</td>
<td>NI</td>
<td>SYMPATHY, LITTLE JOY</td>
</tr>
<tr>
<td>THIVRA KAISIKI NI</td>
<td>NI*</td>
<td>NI</td>
<td>SYMPATHY, JOY</td>
</tr>
<tr>
<td>KAKALI NI</td>
<td>NU*</td>
<td>NU</td>
<td>JOY, LOVE, LITTLE SURPRISE</td>
</tr>
<tr>
<td>THIVRA KAKALI NI</td>
<td>NE*</td>
<td>NU</td>
<td>JOY, MORE LOVE</td>
</tr>
</tbody>
</table>
EMOTIONS OF 22 SHRUTHIS – THESE WERE OBTAINED FROM THE EMOTIONS OF 16 SWARAS. BUT THE SPLIT UP OF A SWARA SAY RA AS MORE SORROW, FEAR AND MORE FEAR, SORROW AND SO ON WAS PURELY BASED ON THE LISTENING EXPERIENCE.

QUANTITATIVE EMOTIONAL ANALYSIS:

THE NEXT STEP WOULD BE TO CALCULATE POINTS OF VARIOUS BASIC EMOTIONS FOR THE 72 MELA RAGAS. AT THIS JUNCTURE IT IS NECESSARY TO LIST OUT SOME BASIC EMOTIONS. HERE THE PLUTCHIK WHEEL OF EMOTIONS WILL BE FOLLOWED ACCORDING TO WHICH THERE ARE 4 BASIC EMOTIONS AND THEIR OPPOSITES, CONSTITUTING 8 EMOTIONS. THEY ARE:

1. JOY-SADNESS
2. FEAR-ANGER
3. DISGUST-TRUST
4. SURPRISE-ANTICIPATION

BASED ON THESE 8, 4 OTHER EMOTIONS ARE PROPOSED, WITH THEIR OPPOSITES. THEY ARE:

1. ANTICIPATION+JOY=OPTIMISM-DISAPPOINTMENT
2. JOY+TRUST=LOVE-REMORSE
3. TRUST+FEAR=SUBMISSION-CONTEMPT
4. FEAR+SURPRISE=AWE-AGRESSIVENESS

ALL OTHER EMOTIONS ARE CONSIDERED TO BE DERIVED FROM THESE 8. NOW THE PROCEDURE FOR NUMERICALLY FINDING EMOTIONS OF SWARAS ARE GIVEN, WHICH WILL BE USEFUL FOR ANALYSING RAGAS:

1. TO ANALYSE A SWARA EMOTION, SUCH AS JOY, LOOK AT THE TABLE OF EMOTIONS FOR THE 16 SWARAS.
2. IF JOY IS MENTIONED, TAKE THE SWARA UNDER Y (YES) CATEGORY. IF LITTLE/SUBTLE JOY IS MENTIONED PUT THE SWARA UNDER P (PARTIAL) CATEGORY. ELSE PUT IT UNDER N (NO) CATEGORY.
3. THEN CATEGORIES ARE ARRANGED IN THE ORDER OF Y,P AND N. FOR POSITIVE EMOTIONS SUCH AS JOY, IN A CATEGORY, SWARAS ARE ARRANGED IN DESCENDING ORDER OF THEIR PJ VALUES, SINCE MORE PJ INDICATES MORE POSITIVE EMOTION CONTENT AND FOR NEGATIVE EMOTIONS IT IS VICE VERSA. THE FOLLOWING STEPS NOW IMPLY FOR POSITIVE EMOTIONS. REVERSE SHOULD BE APPLIED FOR THE NEGATIVE EMOTIONS SUCH AS FEAR.
4. IF 2 SWARAS HAVE IDENTICAL PJ, THE SWARA WITH HIGHER VALUE OF SECOND HIGHEST PJ VALUE IS TAKEN.

JOY:

• AS MENTIONED ABOVE SWARAS ARE CLASSIFIED AS Y,N OR P. THE CLASSIFICATION YIELDS:
  • RA N
  • RI Y
  • RU P
  • GA N
  • GI P
  • GU Y
  • MA Y
  • MI P
  • DHA N
  • DHI Y
  • DHU P
  • NA N
  • NI P
• NU Y
• Then categories are arranged in the order of Y, P and N. In a category, swaras are arranged in descending order of their PJ values, since more PJ indicates more positive emotion content. If 2 swaras have identical PJ, the swara with higher value of second highest PJ value is taken. Then they are allotted corresponding values which are purely arbitrary. For this analysis, numbers in ascending order, starting from 2 are followed. This forms the points for the swaras. The above-said is done and a few results are as follows:
  • RI 24
  • RU 14
  • GU 26
  • MA 28
  • MI 18
  • DHI 22
  • DHU 10
  • NI 12
  • NU 20

Fear:
• The method adopted for joy is followed here also, except for the fact that swaras in a category are arranged in increasing order of PJ values, since fear is a negative emotion.

Surprise:
• The method adopted for joy is followed here also.

Sympathy:
• The method adopted for joy is followed here also.

Now that the emotions of swaras are analysed quantitatively, analysis of the emotions of ragas can be done.

1. To analyse a melakarta raga:
   For quantitatively analysing the emotions of a raga, the graph theory of discrete mathematics is used. Details and fundamentals of graph theory can be found in the book “Discrete Mathematics” by Dr. M. K. Venkataraman et al. The procedure for finding the percentage of a particular emotion, such as joy, of a particular melakarta raga, such as sankarabharanam, is as given below:
   1. The swaras of the particular melakarta raga are listed
   2. Then a 2 dimensional array, or matrix is formed (in this case 7x7) with every row and every column representing a swara, and hence its points.
   3. Every element in the 2D matrix represents a particular transition (such as GU-MA). Hence the value of that element will be the average of the corresponding “row swara” and “column swara” points (in this case average of GU and MA).
   4. If one of the swara is SA/PA, the value of the element will be the other swara (such as for sanu, it is value of NU).
   5. If both of the “row swara” and “column swara” is SA/PA, then the value of the element will be the highest value of all the occurring values. This is because joy is a positive emotion. For negative emotions this value will be the lowest. Sankarabharanam being a melakarta raga, the SA-PA edge seldom occurs (this edge occurs if RI, GA, MA or DHA, NI is
A DISSERTATION ON THE EMOTIONAL ANALYSIS OF VARIOUS ASPECTS OF CARNATIC AND WORLD MUSIC

VARJA OR SAPA OCCURS AS A VAKRA PHRASE) AND HENCE FOR THIS ANALYSIS IS REPRESENTED WITH AN “E”. SIMILARLY NO JANTA PHRASES ARE PRESENT AND HENCE EDGES LIKE RIRI, GUGU ARE ALSO GIVEN AS “E”.

6. NEXT THIS MATRIX IS USED TO REPRESENT THIS RAGA AS A “GRAPH” (A POLYGON). THE SWARAS ARE THE VERTICES OF THE GRAPH.


8. SIMILARLY THE AVAROHANA GRAPH IS DRAWN. SINCE SANKARABHARANAM, OR ANY OTHER MELAKARTHA RAGA IS SYMMETRIC, THE AROHANA AND AVAROHANA MATRICES ARE THE SAME.


10. NOW THE MAXIMUM POSSIBLE VALUE FOR A MELAKARTHA RAGA, BASED ON THE SCHEME USED HERE IS 23.8571. THIS MAY VARY ACCORDING TO THE QUANTIFYING SCHEME USED. NOW THE OBTAINED AVERAGE IS DIVIDED BY THIS VALUE TO GIVE A NORMALISED PERCENTAGE VALUE.

11. SIMILARLY IT IS DONE FOR FEAR, SURPRISE AND SYMPATHY.

THE MATRIX AND GRAPH FOR SANKARABHARANAM IS AS FOLLOWS:

<table>
<thead>
<tr>
<th></th>
<th>SA</th>
<th>RI 24</th>
<th>GU 26</th>
<th>MA 28</th>
<th>PA</th>
<th>DHI 22</th>
<th>NU 20</th>
</tr>
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<tbody>
<tr>
<td>SA</td>
<td>E</td>
<td>24</td>
<td>26</td>
<td>28</td>
<td>E</td>
<td>22</td>
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<tr>
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<td>E</td>
<td>25</td>
<td>26</td>
<td>24</td>
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<td>E</td>
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<td>26</td>
<td>28</td>
<td>E</td>
<td>22</td>
<td>20</td>
</tr>
<tr>
<td>DHI 22</td>
<td>22</td>
<td>23</td>
<td>24</td>
<td>25</td>
<td>22</td>
<td>E</td>
<td>21</td>
</tr>
<tr>
<td>NU 20</td>
<td>20</td>
<td>22</td>
<td>23</td>
<td>24</td>
<td>20</td>
<td>21</td>
<td>E</td>
</tr>
</tbody>
</table>

FROM THE GRAPH THE % OF JOY THIS RAGA CAN DELIVER CAN BE STUDIED. TO DO SO TAKE THE AVERAGE OF ALL THE EDGE VALUES. THIS GIVES 23.8571. BUT THE MAXIMUM POINTS A MELAKARTHA RAGA CAN TAKE ACCORDING TO THIS SCHEME IS 26.14. THEREFORE THE POINTS OBTAINED ARE NORMALISED TO THIS VALUE AND THIS GIVES JOY%. SIMILARLY OTHER 3 EMOTIONS MENTIONED EARLIER I.E. FEAR%, SURPRISE% AND SYMPATHY% CAN BE CALCULATED. OTHER EMOTIONS ARE FOUND USING THE FOLLOWING RELATIONS. SYMPATHY=0.75LOVE+0.25SORROW AND HUMOUR=0.75JOY+0.25SURPRISE.

- **JOY%** = JOY*100/26.14
- **FEAR%** = FEAR*100/26.14
- **SURPRISE%** = SURPRISE*100/26.14
- SYMPATHY% = SYMPATHY*100/26.14
- SORROW% = 100 - JOY%
- ANGER% = 100 - FEAR%
- ANTICIPATION% = 100 - SURPRISE%
- LOVE% = (SYMPATHY% - 0.25*SORROW%)/0.75
- TRUST% = 2*LOVE% - JOY%
- REMORSE% = 100 - LOVE%
- DISGUST% = 100 - TRUST%
- OPTIMISM = AVE (ANTICIPATION%, JOY %)
- DISAPPOINTMENT = 100 - OPTIMISM%
- SUBMISSION% = AVE (TRUST%, FEAR %)
- CONTEMPT% = 100 - SUBMISSION%
- AWE% = AVE (FEAR%, SURPRISE %)
- AGGRESSIVENESS% = 100 - AWE%
- HUMOUR% = 0.75*JOY% + 0.25*SURPRISE%

II. TO ANALYSE A JANYA RAGA:

I. TO ANALYSE A UPANGA RAGA:

THE MATRICES FOR JANYA RAGAS ARE THE SAME AS THAT OF THE MELA FROM WHICH THE RAGA IS DERIVED.
FOR AN UPANGA RAGA, THE SUBTYPE MAY BE AUDAVA (5 SWARAS), SHADAVA (6 SWARAS), SAMPOOORNAAA (7 SWARAS).

DEPENDING ON THESE, THE GRAPH IS DRAWN. CONSIDER AUDAVA RAGA. LET US TAKE MOHANAM. THE MATRIX
IS SAME AS ABOVE. THE EDGES ARE PLOTTED AS SHOWN, AND A GRAPH IS DRAWN FOR AROHANA, BASED ON THE
SWARA TRANSITIONS INVOLVED. THE VALUES OF THE EDGES ARE ADDED AND DIVIDED BY THE SUM TOTAL OF
SWARAS IN AROHANA. HERE THE SAME EDGE BEING REPEATED MORE THAN ONCE SHOULD BE COUNTED MORE
THAN ONCE IN THE SUM TOTAL. THE TOTAL HERE IS 24+25+26+22+22 = 119 AND THE POINTS ARE 119/5 = 23.8.

- FOR AN AUDAVA RAGA THE MAXIMUM POINTS THAT CAN BE OBTAINED IS 26.6. HENCE THE OBTAINED
  POINTS ARE NORMALISED TO 26.6 TO GET THE % OF BASIC EMOTIONS.
- FOR A SHADAVA RAGA THE MAXIMUM POINTS THAT CAN BE OBTAINED IS 26.33. HENCE THE OBTAINED
  POINTS ARE NORMALISED TO 26.33 TO GET THE % OF BASIC EMOTIONS.
- FOR A SAMPOORNA RAGA THE MAXIMUM POINTS THAT CAN BE OBTAINED IS 26.14. HENCE THE
  OBTAINED POINTS ARE NORMALISED TO 26.14 TO GET THE % OF BASIC EMOTIONS.

IN A SIMILAR WAY THE % OF BASIC EMOTIONS OF AVAROHANA SHOULD BE CALCULATED. THE AVERAGE OF THE
CORRESPONDING VALUES GIVE THE % OF BASIC EMOTIONS OF THE RAGA. FOR A RAGA LIKE AUDAVA AROHANA
AND SHADAVA AVAROHANA, THE AROHANA IS TO BE CONSIDERED AUDAVA AND THE AVAROHANA SHADAVA.
SAME APPLIES FOR OTHER VARIANTS.
USING THESE AND THE ABOVESAID RELATIONS, THE OTHER EMOTIONS CAN BE FOUND. IT MAY BE NORMALISED
USING THE METHOD TOLD EARLIER.
II. ANALYSIS OF NON-UPANGA RAGA.

For Vakra Raga the normal method is followed, the Vakrathva also being counted. Let us see how Kedara Raga is analysed for joy. The matrix is same as the above one.

The graph is as follows. Note that the Guma edge occurs twice for Arohana (Samaguma) and once for Avarohana (Pamagurisa).

Arohana is SMGMPN. Points = Ave (28, 27, 28, 20, 20) = 25 = 93.98% normalised to 26.6

Avarohana is SNPMGR. Points = Ave (20, 20, 28, 27, 25, 24) = 24 = 91.15% normalised to 26.33

Hence Joy% = Ave (93.98, 91.15) = 92.565%

In the case of Bhashanga Ragas, the matrix is rewritten with the Anya Swara also included. And the graph is also redrawn with corresponding vertices. Other procedures are same.

- Reason for calculating sympathy and not disgust as the fourth emotion – Though disgust is a basic emotion, the table of 16 swaras, in turn obtained from Rigama and Dhani combinations, which was in turn obtained from musical experience, does not give sufficient details about the content of disgust. Hence an emotion related to disgust, but present in the table, sympathy was chosen. From analysis of day to day emotional situations one could roughly find that sympathy=75%love + 25%sorrow. But love=50%joy + 50%trust, according to Plutchik, where trust is the opposite of disgust. Since love and joy are found, if we can find sympathy, we can easily find out disgust. Consider the following relation:

Love = 50% Joy + 50% Trust
SYMPATHY = 75% LOVE + 25% SORROW
HENCE LOVE = (SYMPATHY - 25% SORROW) / 75%
WHERE SORROW = 100% - JOY%
NOW TRUST = (LOVE - 50% JOY) / 50%
TRUST = 2 LOVE – JOY
DISGUST = 100 - TRUST.

Since the % of a basic emotion is calculated from a derived one, certain ragas have certain emotion % greater than 100% or lesser than 0%. This is acceptable as we are concerned only about the relative emotions of ragas. But for practical purposes we could take the maximum point as 100% and normalise the others to this value, if necessary.

• Formula for emotions- The formula for other derived emotions were calculated with the following concepts. The points of basic emotions are normalised to the points as mentioned. Now they are in %. The opposites of each emotion are calculated as 100% - that emotion%. Certain emotions are combination of two emotions. Hence they are calculated as 50% EMOTION1 + 50% EMOTION2, unless the ratio is specified.

• The reason for having an edge connecting Sa/PA to any other swara as the point of that swara is that when Sa or Pa is considered to be 0, the edge happens to be average of Sa/PA and that swara, which means (SA/PA+SWARA)/2 = SWARA/2. But in practical experience this is not the case, it is = SWARA. Therefore this can be obtained only if Sa=Swara. As for Sa-Pa edge since there is no fixed value, we can count on the fact that Sa-Pa is a Samvaadhi pair and so adds to positive emotions. Therefore for graph of positive emotion, maximum value occurring in the graph is allotted and for negative emotions the lowest value occurring in the graph is taken.

Relation between basic and derived emotions
As per mathematical relationships, we can find that
• SORROW DECREASES WITH INCREASE IN JOY
• ANGER DECREASES WITH INCREASE IN FEAR
• ANTICIPATION DECREASES WITH INCREASE IN SURPRISE
• LOVE INCREASES WITH INCREASE IN JOY
• LOVE INCREASES WITH INCREASE IN TRUST
• TRUST INCREASES WITH INCREASE IN LOVE
• REMORSE DECREASES WITH INCREASE IN LOVE
• DISGUST DECREASES WITH INCREASE IN TRUST
• OPTIMISM INCREASES WITH INCREASE IN JOY
• OPTIMISM INCREASES WITH INCREASE IN ANTICIPATION
• DISSAPPOINTMENT DECREASES WITH INCREASE IN OPTIMISM
• SUBMISSION INCREASES WITH INCREASE IN FEAR
• SUBMISSION INCREASES WITH INCREASE IN TRUST
• CONTEMPT DECREASES WITH INCREASE IN SUBMISSION
• AWE INCREASES WITH INCREASE IN FEAR
• AWE INCREASES WITH INCREASE IN SURPRISE
• AGGRESSIVENESS DECREASES WITH INCREASE IN AWE
• HUMOUR INCREASES WITH INCREASE IN JOY
• HUMOUR INCREASES WITH INCREASE IN SURPRISE
• SYMPATHY INCREASES WITH INCREASE IN LOVE
• SYMPATHY INCREASES WITH INCREASE IN SORROW
• HEROISM INCREASES WITH INCREASE IN JOY
• HEROISM INCREASES WITH INCREASE IN OPTIMISM
EXAMPLES AND ILLUSTRATIONS

THE FOLLOWING SECTION GIVES ILLUSTRATIONS ON THE ANALYSIS OF EMOTIONS OF A SELECT RAGAS. THE RULES ARE ALL AS EXPLAINED IN THE PRECEDING SECTIONS. ONE WOULD BE IN A BETTER POSITION TO CALCULATE THE RAGA EMOTIONS IF ONE COULD COMPARE THE RULES WITH THE GRAPH AND VALUES GIVEN BELOW.

IN ORDER TO SIMPLIFY THE PROCESS THE MATRIX HAS BEEN OMITTED AND THE CORRESPONDING VERTICES OR EDGE VALUES ARE GIVEN IN THE GRAPH BESIDE THE CORRESPONDING VERTICES OR EDGES. THE GRAPHS OF 4 EMOTIONS ARE DRAWN AS A SINGLE GRAPH WITH EACH EDGE/VERTEX ASSIGNED 4 VALUES IN THE ORDER OF JOY, FEAR, SURPRISE AND SYMPATHY. THE LIGHT LINES DENOTE AROHANA AND THE DARKER ONES AVAROHANA.

1. RASIKAPRIYA
MELA: 72
AROHANA: SARUGUMIPADHUNUSA
AVAROHANA: SANUDHUPAMIGURUSA

<table>
<thead>
<tr>
<th>EMOTION</th>
<th>AAROHANA</th>
<th>AVAROHANA</th>
<th>OVERALL %</th>
</tr>
</thead>
<tbody>
<tr>
<td>JOY</td>
<td>17</td>
<td>17</td>
<td>65.03</td>
</tr>
<tr>
<td>FEAR</td>
<td>11.143</td>
<td>11.143</td>
<td>42.63</td>
</tr>
<tr>
<td>SURPRISE</td>
<td>21.51</td>
<td>21.51</td>
<td>82.29</td>
</tr>
<tr>
<td>SYMPATHY</td>
<td>8.43</td>
<td>8.43</td>
<td>32.25</td>
</tr>
</tbody>
</table>

2. NATTAI
MELA: 36
AROHANA: SARUGUMAPADHUNUSA
AVAROHANA: SANUPAMARUSA

<table>
<thead>
<tr>
<th>EMOTION</th>
<th>AAROHANA</th>
<th>AVAROHANA</th>
<th>OVERALL %</th>
</tr>
</thead>
<tbody>
<tr>
<td>JOY</td>
<td>19.57</td>
<td>21.4</td>
<td>77.66</td>
</tr>
</tbody>
</table>
3. **BEHAG**

MELA: 29

AROHANA: SAGUMAPANUDHINUSA

AVAROHANA: SANUDHIPAMIGUMAGURISA

<table>
<thead>
<tr>
<th>EMOTION</th>
<th>AAROHANA</th>
<th>AVAROHANA</th>
<th>OVERALL %</th>
</tr>
</thead>
<tbody>
<tr>
<td>JOY</td>
<td>23.28</td>
<td>22.88</td>
<td>87.97</td>
</tr>
<tr>
<td>FEAR</td>
<td>8.857</td>
<td>9.88</td>
<td>35.715</td>
</tr>
<tr>
<td>SURPRISE</td>
<td>23.71</td>
<td>20.111</td>
<td>83.49</td>
</tr>
<tr>
<td>SYMPATHY</td>
<td>15.29</td>
<td>17.222</td>
<td>61.975</td>
</tr>
</tbody>
</table>

Thus using these values other emotions are found using the relations given. Following is a table of the emotions of the 72 Melakartha ragas, followed by a table for selected Janya ragas.
|   | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T |
| 1 | RAGA | JOY | FEAR | SADNESS | SURPRISE | SYMPATHY | SORROW | ANGER | ANTICIPATION | LOVE | TRUST | REMORSE | DISGUST | OPTIMISM | DISAPPROVE | SUBMISSION | CONTENTMENT | DISREGARD | AGGRESS | HUMOUR | HEROSIM |
| 2 | CHARUKESI | 68.3 | 57.3 | 53.0 | 74.8 | 71.9 | 69.2 | 67.3 | 66.9 | 66.7 | 66.3 | 66.3 | 66.2 | 58.7 | 43.2 | 43.2 | 43.2 | 43.2 | 43.2 | 43.2 |
| 3 | JHALAVARU | 42.0 | 67.2 | 48.6 | 56.2 | 57.9 | 57.9 | 57.9 | 57.9 | 57.9 | 57.9 | 57.9 | 57.9 | 57.9 | 57.9 | 57.9 | 57.9 | 57.9 | 57.9 | 57.9 |
| 4 | RASIKAPIYA | 65.0 | 42.3 | 82.2 | 32.0 | 34.9 | 57.7 | 37.7 | 57.7 | 57.7 | 57.7 | 57.7 | 57.7 | 57.7 | 57.7 | 57.7 | 57.7 | 57.7 | 57.7 | 57.7 |
| 5 | BHOPALAM | 27.8 | 21.5 | 25.5 | 78.3 | 52.3 | 18.3 | 52.3 | 18.3 | 52.3 | 18.3 | 52.3 | 18.3 | 52.3 | 18.3 | 52.3 | 18.3 | 52.3 | 18.3 | 52.3 |
| 6 | RAGHAVSHREE | 81.8 | 63.8 | 64.3 | 84.2 | 18.2 | 63.2 | 23.6 | 63.2 | 23.6 | 63.2 | 23.6 | 63.2 | 23.6 | 63.2 | 23.6 | 63.2 | 23.6 | 63.2 | 23.6 |
| 7 | ABHISHERI | 73.4 | 44.7 | 47.0 | 79.3 | 26.5 | 35.2 | 52.3 | 52.3 | 52.3 | 52.3 | 52.3 | 52.3 | 52.3 | 52.3 | 52.3 | 52.3 | 52.3 | 52.3 | 52.3 |
| 8 | BAHUDARI | 81.25 | 41.5 | 64.8 | 78.4 | 18.4 | 58.5 | 43.9 | 58.5 | 43.9 | 58.5 | 43.9 | 58.5 | 43.9 | 58.5 | 43.9 | 58.5 | 43.9 | 58.5 | 43.9 |
| 9 | SHRINJAVE | 75.9 | 39.2 | 50.6 | 86.0 | 24.0 | 60.7 | 43.7 | 57.7 | 43.7 | 57.7 | 43.7 | 57.7 | 43.7 | 57.7 | 43.7 | 57.7 | 43.7 | 57.7 | 43.7 |
| 10 | CHAAYAVATHI | 74.6 | 49.0 | 78.2 | 70.5 | 25.3 | 23.7 | 23.7 | 23.7 | 23.7 | 23.7 | 23.7 | 23.7 | 23.7 | 23.7 | 23.7 | 23.7 | 23.7 | 23.7 | 23.7 |
| 11 | NAARTAI | 77.6 | 48.2 | 89.7 | 43.5 | 22.3 | 51.7 | 10.2 | 28.7 | 10.2 | 28.7 | 10.2 | 28.7 | 10.2 | 28.7 | 10.2 | 28.7 | 10.2 | 28.7 | 10.2 |
| 12 | RISHIPRIYA | 79.1 | 50.7 | 59.1 | 71.7 | 20.8 | 40.2 | 40.2 | 40.2 | 40.2 | 40.2 | 40.2 | 40.2 | 40.2 | 40.2 | 40.2 | 40.2 | 40.2 | 40.2 | 40.2 |
| 13 | NAVARASAKANTHAN | 92.0 | 46.6 | 78.3 | 64.7 | 7.9 | 57.3 | 3.1 | 21.6 | 8.1 | 21.6 | 8.1 | 21.6 | 8.1 | 21.6 | 8.1 | 21.6 | 8.1 | 21.6 | 8.1 |
| 14 | KUNILALAVARI | 82.1 | 35.8 | 56.9 | 78.7 | 17.8 | 61.5 | 41.1 | 55.6 | 41.1 | 55.6 | 41.1 | 55.6 | 41.1 | 55.6 | 41.1 | 55.6 | 41.1 | 55.6 | 41.1 |
| 15 | KAANADA | 80.2 | 43.2 | 68.5 | 83.7 | 47.1 | 57.9 | 57.9 | 57.9 | 57.9 | 57.9 | 57.9 | 57.9 | 57.9 | 57.9 | 57.9 | 57.9 | 57.9 | 57.9 | 57.9 |
| 16 | ESSAMANOHARI | 94.7 | 36.5 | 36.5 | 70.5 | 21.6 | 62.5 | 15.3 | 62.5 | 15.3 | 62.5 | 15.3 | 62.5 | 15.3 | 62.5 | 15.3 | 62.5 | 15.3 | 62.5 | 15.3 |
| 17 | BHARAVI | 68.9 | 51.7 | 45.1 | 81.6 | 67.3 | 41.8 | 54.8 | 41.8 | 54.8 | 41.8 | 54.8 | 41.8 | 54.8 | 41.8 | 54.8 | 41.8 | 54.8 | 41.8 | 54.8 |
| 18 | BEHAG | 87.9 | 35.7 | 57.9 | 67.9 | 21.6 | 57.9 | 57.9 | 57.9 | 57.9 | 57.9 | 57.9 | 57.9 | 57.9 | 57.9 | 57.9 | 57.9 | 57.9 | 57.9 | 57.9 |

**Identification and Synthesis of Ragas**

August 29, 2010
Numerous ragas are available and possible in Carnatic music. Hence it is difficult to calculate the emotions for all ragas and then arrive at a conclusion as to which raga gives a maximum of a particular emotion. Hence procedures are desired that helps to identify a raga that maximizes a particular emotion. Here are the guidelines:

- Choose the number of notes you want in the raga.
- Choose the emotion to be maximised.
- Find the transitions that yield a maximum in that emotion. This depends on the 4 emotion values for the swaras.
- Draw the graph and calculate the emotion value. Thus the raga is obtained.

Examples:

- Suppose that we want to maximize joy. The edge SP has highest value for positive emotions and lowest for negative. Since joy is positive, include SP.
- For a raga with 5 notes it is sarigumapa. This procedure can be extended to any number of notes.
- If we want to maximize fear, the edge SP should not be used as it decreases negative emotions values.
- When a hybrid emotion such as optimism is considered, the average of the basic emotions should be calculated for each swara (like Ave(joy,surprise)).
- Only if all basic emotions of the hybrid emotion are positive, pa can be included. The other swaras can be found out as above.
- Thus the raga can be found and emotion(max value) can be calculated.

Emotions and color

Bharata Muni enunciated the eight rasas in the nāṭyasāstra, an ancient work of dramatic theory. Each rasa, according to [Nāṭyasāstra]], has a presiding deity and a specific color. There are four pairs of rasas. For instance, hasya arises out of sringara. The aura of a frightened person is black, and the aura of an angry person is red. Bharata Muni established the following:

- Shāntam Deity: Vishnu. Color: Blue., or tranquility, was suggested by Abhinavagupta and had to undergo a good deal of struggle between the sixth and the tenth centuries, before it could be accepted by the majority of the alankarikas, and the expression navaras (the nine rasas), could come into vogue.

Hence, the next step would be to correlate the set of nine emotions with those based on Plutchik’s wheel of emotions. However, this is not difficult except for two emotions:

- Veeram: Courage, as such is not present in the wheel of emotions. But from day to day experience and on a literary basis, it can be thought of as a combination of optimism and joy in equal proportions.
- Shaantham: This, as mentioned is a later addition and moreover is classically known as “the absence of all emotions”. Hence this emotion will not be discussed further as such an emotion is difficult to be calculated and quantised. Moreover, this emotion, which is tranquility, occurs only when there is a perfect balance in all aspects of the rendering, be it speed, gamakams, shruthi, swara or bhava.

As for the others, the correspondence is as follows:
1. SHRINGAARA : LOVE
2. HAASYA : HUMOUR
3. KAARUNYA : SYMPATHY
4. ADBHUTHA: SURPRISE
5. RAUDRA: ANGER
6. BHAYANAKA: FEAR
7. BHIBHATSA: HATRED
8. VEERA: JOY + OPTIMISM

EMOTIONAL COLOURS OF A RAGA

As can be observed, colours are mentioned for each rasa. This can be used for finding out the colour of each raga. This would give us a true “visualisation” of a raga from an emotional point of view. To do so, consider the following illustration of Mela 29 – Dheera Sankarabharanam.

COLOUR OF SYMPATHY: GREY
PERCENTAGE OF SYMPATHY FOR THE RAGA: 74.87157.
THEREFORE, SYMPATHY SHADE OF THE RAGA = 0.7487157 * GREY.

Expressed in RGB colour scheme Grey = 808080 in hexadecimal and 128 128 128 in decimal. We would have to find 128 * .7487, 128 * .7487, 128 * .7487 which would yield 95.8336 95.8336 95.8336 as the values for red, green and blue.

Similarly, shades for the other emotions have to be obtained and the aggregate colour is formed by mixing all these shades. This gives the emotional colour of a raga. This procedure applies for janya ragas as well.

• The first raga of each chakra starts on a dark tone and this slowly lightens up. This explains the effect of komal swaras (especially Dha and Ni) on the initial ragas and the slow transition to thivra swaras.

• The % emotions listed give a method to find the maximum % of emotions a raga can yield. The colours are also based on these values. Since certain swaras are responsible for certain emotions, it is possible that we can elaborate a raga without touching these swaras in detail. Consequently, the associated emotion% for that rendering reduces. Thus the colour also changes. The above colours represent the maximum overall capability of the raga when all swaras get equal coverage.

• A raga is multi-faceted. Hence the emotions can change drastically. But there are some ragas, in which, to diminish an emotion (and hence make others look prominent), we tend to avoid or over stress one or more swaras. But this swara may affect other emotions too and hence the % of those emotions also decreases. It may come to a stage where % of all emotions decrease and the emotion dominant in the maximum becomes dominant here also. Hence it is difficult (or nearly impossible) to remove that emotion in that raga. Such ragas admit only of a single dominant emotion.

MUSIC NOTATIONS

As mentioned earlier the emotion of a rendering can vary from person to person and time to time as different swaras and different factors come into play each time. Hence in situations demanding emotions, exact reproduction is necessary and hence to prevent alterations in swara, rhythm, melody, pitch, key etc… a universal system of notations is a must. This is done in 2 steps:

1. The system of western and carnatic music notations have to be studied with illustrations. Western is chosen because of the remarkable perfection of the universality of notation.
2. From this a graph of time vs. frequency is drawn and salient features if the same are studied.
GRAPH NOTATION

For the purpose of universal notation a system is proposed which represents renderings as a graph of time vs. frequency. Here octaves can easily be represented and the various gamakas and oscillations are represented with appropriate curves and oscillatory portions. This can be well understood with an illustration as shown below. Thaala constraints can be relaxed as their effects on emotions are less pronounced.

The following graph shows the “pallavi” of “Shivakaaameshwarim” of “Shaanthakalyani raagam” set to “aadhi thaalam” by “shri. muthuswamy dikshithar”.

Interpretation of the graph notation

As mentioned earlier the graph notation can be used to find out the emotions being concentrated in a particular rendering. This can be done only if the emotion of the raga is known first. Now the features of the 4 emotions and the way in which other emotions depend on these 4 are given.

Joy

From previous tables it can be found that joy depends
1. Heavily on ri, gu, ma, dhi and nu
2. Partially on ru, gi, mi, dhu and ni
3. Slow music
4. Low key
5. Harmonic simultaneities. Here 4 and 5 can be neglected.

From the graph, these are respectively
1. Number of standings (horizontal portions) in ri, gu, ma, dhi, nu
2. Number of standings on ru, gi, mi, dhu, ni
3. Less number of transitions per unit time

Hence one can get a view of how much the rendering concentrates on joy. A quantization is not required here as it is just an understanding of a rendition and occurs only after the raga values have been seen and analysed. This point would become clear in the following “virtual application”.

Fear

From previous tables it can be found that fear depends
A DISSERTATION ON THE EMOTIONAL ANALYSIS OF VARIOUS ASPECTS OF CARNATIC AND WORLD MUSIC

August 29, 2010

1. HEAVILY ON NA,DHA,GA AND RA
2. PARTIALLY ON MA
3. FAST MUSIC

FROM THE GRAPH, THESE ARE RESPECTIVELY
1. NUMBER OF STANDINGS(HORIZONTAL PORTIONS) IN NA,DHA,GA AND RA
2. NUMBER OF STANDINGS ON MA
3. MORE NUMBER OF TRANSITIONS PER UNIT TIME

HENCE ONE CAN GET A VIEW OF HOW MUCH THE RENDERING CONCENTRATES ON FEAR.

SURPRISE

FROM PREVIOUS TABLES IT CAN BE FOUND THAT SURPRISE DEPENDS
1. HEAVILY ON GU,NU,RU,DHU
2. PARTIALLY ON MA,RI,DHI
3. SLOW MUSIC

FROM THE GRAPH, THESE ARE RESPECTIVELY
1. NUMBER OF STANDINGS(HORIZONTAL PORTIONS) IN GU,NU,RU,DHU
2. NUMBER OF STANDINGS ON MA,RI,DHI
3. LESS NUMBER OF TRANSITIONS PER UNIT TIME

HENCE ONE CAN GET A VIEW OF HOW MUCH THE RENDERING CONCENTRATES ON SURPRISE.

SYMPATHY

FROM PREVIOUS TABLES IT CAN BE FOUND THAT SYMPATHY DEPENDS
1. HEAVILY ON RI,DHI,RA,G,I,NI AND DHA
2. SLOW MUSIC

FROM THE GRAPH, THESE ARE RESPECTIVELY
1. NUMBER OF STANDINGS(HORIZONTAL PORTIONS) IN RI,DHI,RA,G,I,NI,DHA
2. LESS NUMBER OF TRANSITIONS PER UNIT TIME

HENCE ONE CAN GET A VIEW OF HOW MUCH THE RENDERING CONCENTRATES ON SYMPATHY.

OTHER EMOTIONS

AS PER MATHEMATICAL RELATIONSHIPS, WE CAN FIND THAT
• SORROW DECREASES WITH INCREASE IN JOY
• ANGER DECREASES WITH INCREASE IN FEAR
• ANTICIPATION DECREASES WITH INCREASE IN SURPRISE
• LOVE INCREASES WITH INCREASE IN JOY
• LOVE DECREASES WITH INCREASE IN TRUST
• TRUST INCREASES WITH INCREASE IN LOVE
• REMORSE DECREASES WITH INCREASE IN LOVE
• DISGUST DECREASES WITH INCREASE IN TRUST
• OPTIMISM INCREASES WITH INCREASE IN JOY
• OPTIMISM DECREASES WITH INCREASE IN ANTICIPATION
• DISSAPOINTMENT DECREASES WITH INCREASE IN OPTIMISM
• SUBMISSION INCREASES WITH INCREASE IN FEAR
• SUBMISSION INCREASES WITH INCREASE IN TRUST
• CONTEMPT DECREASES WITH INCREASE IN SUBMISSION
• AWE DECREASES WITH INCREASE IN FEAR
• AWE INCREASES WITH INCREASE IN SURPRISE
• AGGRESSIVENESS DECREASES WITH INCREASE IN AWE
• HUMOUR INCREASES WITH INCREASE IN JOY
• HUMOUR DECREASES WITH INCREASE IN SURPRISE
• SYMPATHY INCREASES WITH INCREASE IN LOVE
• SYMPATHY INCREASES WITH INCREASE IN SORROW
• HEROISM INCREASES WITH INCREASE IN JOY
• HEROISM INCREASES WITH INCREASE IN OPTIMISM
HENCE FROM THESE RELATIONS AN ESTIMATE OF THE OTHER EMOTIONS IN THE RENDERING COULD BE MADE.

GAMAKAS
THE CONCEPT OF GAMAKAS IS UNIQUE TO CARNATIC MUSIC AND ANALYSIS OF GAMAKAS FOR EMOTION CAN BE DONE IN 3 WAYS:
1. FINDING THE ABSOLUTE FREQUENCY OF THE OSCILLATION
2. FINDING THE DEVIATION FROM THE NOMINAL FREQUENCY AND CALCULATING PARAMETERS SUCH AS DEVIATION, AMOUNT OF OSCILLATION AND SPEED.
3. ANALYSING QUALITATIVELY THE GAMAKA TAKING A RAGA THAT USES IT AND THEN APPLYING THIS TO THE OTHER RAGAS/PIECES THAT USE THE SAME GAMAKA.

METHOD 3 IS VERY TEDIOUS AND METHOD 1 AND 2 CAN BE EASILY DONE USING THE ABOVESAID GRAPH NOTATION.

VIRTUAL APPLICATION
THIS SECTION DESCRIBES A VIRTUAL APPLICATION THAT COULD BE CONCEIVED OF WHEN THINKING OF HOW TO USE THE METHODS AND INFORMATION. FOR AN UNDERSTANDING OF AN APPLICATION, LET US CONSIDER THE VIRTUAL CASE STUDY BELOW:
• X. IS AFFECTED WITH A CERTAIN DISEASE ‘A’ WITH TERRIBLE PAIN AND CONSULTS A DOCTOR.
• THE DOCTOR AFTER TESTING X TELLS THAT A PARTICULAR NERVE IS AFFECTED VERY BADLY DUE TO SOME REASON.
• X THEN DECIDES TO RESORT TO MUSIC THERAPY.
• THE MUSIC THERAPIST LOCATES THE NERVE AND FINDS OUT THE EMOTION THAT IS ABLE TO CONTROL THAT PARTICULAR NERVE. LET THAT HAVE THE FOLLOWING COMPOSITION: P% OF JOY, Q% OF FEAR, R% OF SURPRISE AND S% OF SYMPATHY.
• THROUGH A DATABASE, THE THERAPIST SEARCHES THE RAGA THAT MATCHES THE SPECIFIED COMPOSITION. LET IT BE RAGA ‘H’.
• WHEN THE MATCH IS FOUND, THE THERAPIST THEN DECIDES WHETHER TO DO AN ALAPANA OR RENDER A SONG.
• IF RENDERING AN ALAPANA IS CHOSEN, THE THERAPIST SEES WHICH SWARAS CARRY TRAITS OF THE REQUIRED EMOTIONS AND LAYS STRESS ON THAT SWARA(S).
• IF RENDERING OF A SONG IS CHOSEN, THE THERAPIST THEN ANALYSES ALL GRAPHS FOR ALL SONGS COMPOSED IN THAT RAGAAGAIN POSSIBLE THROUGH A DATABASE),AND FINDS THE ONE THAT IS CLOSEST TO HIS REQUIREMENTS.
• THEN, THE REQUIRED ALAPANA/SONG IS RENDERED.
• THE PATIENT GETS CURED AND ALL IS WELL.

MUSIC FROM ALL AROUND THE WORLD
THE HIGHLIGHTING FEATURES OF VARIOUS MUSIC SYSTEMS FROM DIFFERENT PARTS OF THE WORLD IS STUDIED. ONLY TRADITIONAL MUSIC, MUSIC BEFORE AND UNTIL 19TH CENTURY IS CONSIDERED, LEAVING OUT THE MORE RECENT POP, JAZZ, ROCK ETC...

CHORDS AND EMOTIONS:
FROM THE STUDIES DONE, AS MENTIONED IN THE PRECEDING SECTION, IT IS OBSERVED THAT THE ONLY FEATURE THAT IS NOT PRESENT IN CARNATIC MUSIC IS THAT OF CHORDS. HENCE, IF AN ANALYSIS OF THE EMOTIONS
ASSOCIATED WITH CHORDS IS DONE, THEN THE THEORIES AND METHODS StATED IN THE ABOVE SECTION CAN BE EXTENDED TO WORLDWIDE MUSIC AS WELL.

HERE FOR THE ANALYSIS OF EMOTIONS, ONLY CHORDS CONTAINING 3 NOTES ARE CONSIDERED. SPECIFICALLY, THE MAJOR, MINOR AND SUSPENDED CHORDS (SUCH AS C, CM, CSUS).

THE PROCEDURE OF CALCULATING CHORD EMOTIONS IS SAME AS THAT MENTIONED FOR THE JANAKA AND JANYA RAGAS, BUT WITH THE CONSIDERATION THAT CHORDS HERE ARE EQUIVALENT TO RAGAS WITH THREE SWARAS. HENCE THE GRAPHS OF THESE CHORDS WOULD BE TRIANGLES. THE CALCULATIONS ARE PERFORMED AND RESULTS ARE PRESENTED AS FOLLOWS:
IT IS INTERESTING TO NOTE THAT THE PROFILE OF CSUS CHORD (SAMAPA) REPRESENTS THE RAGA THRISSAKTHI/SARVASHRI, CONTAINING THE SAME NOTES.

INCORPORATING CHORDS INTO CARNATIC MUSIC:
THERE ARE CERTAIN ISSUES TO BE CONSIDERED WHILE APPLYING CHORDS TO A CARNATIC RAGA OR SONG. THEY ARE:
1. THE CHORDS CONTAINING NOTES NOT USED BY THE RAGA CANNOT BE USED SINCE THEY SPOIL THE PURITY OF THE RAGA. EXAMPLE, F CHORD CANNOT BE USED WITH MOHANAM AS IT CONTAINS MA.
2. CHORDS CONTAINING THE SWARAS OF A RAGA THAT CAN BE PLAYED ONLY WITH A GAMAKA CANNOT BE CONSIDERED. THIS IS BECAUSE CHORDS ARE PLAYED FLAT WITHOUT ANY KAMPITHA. IF A SWARA CAN BE PLAYED WITH OR WITHOUT KAMPITHA, A CHORD CONTAINING THAT SWARA MAY BE USED.
3. FOR APPLYING CHORDS TO A SONG, WE NEED TO CONSIDER THAALA STRUCTURE OF THE SONG AND APPROPRIATELY WE CAN PLACE THE CHORDS AT BEGINNING OF AVARTHANA OR BEAT, ENDING OF AVARTHANA OR BEAT AND SO ON.

UNIVERSAL EMOTIONAL ANALYSIS
FOUR DIMENSIONAL APPROACH
AFTER HAVING SEEN ASPECTS OF MUSIC FROM ALL AROUND THE WORLD, WE CAN INFER THAT FACTORS AND FEATURES OF MUSIC ARE GENERALLY FOUR-FOLD AND THEY ARE CALLED THE 4 DIMENSIONS OF MUSIC:
1. MELODY
2. HARMONY
3. RHYTHM
4. LYRICS.

FACTORS AFFECTING EMOTIONS
THERE ARE SEVERAL FACTORS AFFECTING EMOTIONS THEY ARE:
MELODY(SANCHARA/ALAPANA):- A MELODY, ALSO TUNE, VOICE, OR LINE, IS A LINEAR SUCCESSION OF MUSICAL TONES WHICH IS PERCEIVED AS A SINGLE ENTITY. IN ITS MOST LITERAL SENSE, A MELODY IS A SEQUENCE OF PITCHES AND DURATIONS, WHILE, MORE FIGURATIVELY, THE TERM HAS OCCASIONALLY BEEN EXTENDED TO INCLUDE SUCCESSIONS OF OTHER MUSICAL ELEMENTS SUCH AS TONE COLOR. MELODIES OFTEN CONSIST OF ONE OR MORE MUSICAL PHRASES OR MOTIFS, AND ARE USUALLY REPEATED THROUGHOUT A SONG OR PIECE IN VARIOUS FORMS. MELODIES MAY ALSO BE DESCRIBED BY THEIR MELODIC MOTION OR THE PITCHES OR THE INTERVALS BETWEEN PITCHES (PREDOMINANTLY CONJUCT OR DISJUNCT OR WITH FURTHER RESTRICTIONS), PITCH RANGE, TENSION AND RELEASE, CONTINUITY AND COHERENCE, CADENCE, AND SHAPE. THIS IS A COMPLEX ENTITY AND THE DEPENDANCE OF EMOTIONS ON IT CANNOT BE STATED IN A LINEAR RELATIONSHIP. THE MAIN CONTRIBUTIONS BEING SWARAS ARE TO BE CONSIDERED HERE AND HENCE THE PROCEDURE FOLLOWED TILL NOW HOLDS GOOD IN DESCRIBING THE EFFECT OF MELODY ON EMOTIONS.

RHYTHM (THAALA):- (FROM GREEK ΥΘΜΌΣ – RHYTHMOS, "ANY MEASURED FLOW OR MOVEMENT, SYMMETRY") IS THE VARIATION OF THE LENGTH AND ACCENTUATION OF A SERIES OF SOUNDS OR OTHER EVENTS. THIS AGAIN IS A COMPLEX ENTITY AND CAN BE STATED AS RELATIVE TEMPO. THE EFFECTS ON EMOTIONS ARE NOT STRAIGHT FORWARD BUT AN INSIGHT CAN BE OBTAINED CONSIDERING THE FOLLOWING ILLUSTRATION: CONSIDER A RENDERING IN MISRA JATHI EKA THAALAM(1 LAGHU OF 7 BEATS, 0 DHRUTHAM). HERE EACH SECTION WOULD CONSIST OF 7 UNINTERRUPTED MEASURES. HENCE AN EMOTION CAN BE DEPICTED IN ONE SECTION. IF A TRANSITION IS DESIRED A SMOOTH ONE CAN BE MADE AS THERE ARE SEVEN MEASURES WHICH IS A SUFFICIENT TIME TO SWITCH OVER. IF THE SAME RENDERING WAS RENDERED IN THISRA JATHI TRIPUTA THALAM(1 LAGHU OF 3 BEATS, 2 DHRUTHAM OF 2 BEATS EACH), THE TOTAL LENGTH WOULD REMAIN UNALTERED BUT THE TRANSITIONS, OR EMOTION STANDINGS SHOULD BE MADE WITHIN 3, 2 OR 2 BEATS, WHICHEVER APPROPRIATE. HENCE THE EFFECTIVE TEMPO RISES. IF THE SAME TEMPO WAS TO BE MAINTAINED, THEN TRANSITIONS WOULD INVOLVE MORE THAN 1 LAGHU/DHRUTHAM SECTION AND THE RENDERING WOULD
APPEAR TO BE SLOW AND DRAGGING. HENCE CHANGES IN THAALA CAN BE EFFECTIVELY ANALYSED AS CHANGES IN TEMPO WHICH IS DISCUSSED NEXT.

**TEMPO:** IN MUSICAL TERMINOLOGY, TEMPO IS THE SPEED OR PACE OF A GIVEN PIECE. IT IS A CRUCIAL ELEMENT OF COMPOSITION, AS IT CAN AFFECT THE MOOD AND DIFFICULTY OF A PIECE.

FOR THIS AND THE FOLLOWING FACTORS EFFECTS WILL BE CONSIDERED ONLY ON 4 EMOTIONS - JOY, SURPRISE, SYMPATHY AND FEAR. OTHERS CAN BE UNDERSTOOD USING THE GIVEN MATHEMATICAL RELATIONS.

IN HUMAN ANATOMY, THE ADRENALINE CAN BE DESCRIBED AS THE “FLIGHT, FIGHT AND FRIGHT” HORMONE. THIS IS CAPABLE OF INCREASING THE EFFECTIVE WORKING SPEED OF AN INDIVIDUAL. HENCE SPEED IS INCREASED DUE TO FIGHT AND FRIGHT. THE CONVERSE ALSO HOLDS. HENCE INCREASE IN TEMPO CAN INCREASE ANGER OR FEAR. BUT FEAR% = 100 - ANGER% (COMPLEMENTARY EMOTIONS). HENCE IT INCREASES THE MORE DOMINANT OF THE TWO. AS FOR JOY, THE FLAVOUR CHANGES FROM A MORE BLISSFUL TO A MORE ECSTATIC JOY. SYMPATHY AND SURPRISE ARE LARGELY SWARA DEPENDANT AND HENCE BY INCREASING TEMPO STANDING AT THE SWARAS IS LOST AND HENCE DECREASE IS OBSERVED.

**MODE (RAGA):** MODE IS A TERM FROM WESTERN MUSIC THEORY HAVING THREE DEFINITIONS

1. THE RHYTHMIC RELATIONSHIP BETWEEN LONG AND SHORT VALUES IN THE LATE MEDIEVAL PERIOD;
2. IN EARLY MEDIEVAL THEORY, INTERVAL;
3. MOST COMMONLY, A CONCEPT INVOLVING SCALE AND MELODY TYPE.

IN ADDITION, FROM THE END OF THE EIGHTEENTH CENTURY, THE TERM BEGAN TO BE USED IN ETHNOMUSICOLOGICAL CONTEXTS TO DESCRIBE PITCH STRUCTURES IN NON-EUROPEAN MUSICAL CULTURES, SOMETIMES WITH DOUBTFUL COMPATIBILITY (POWERS 2001, §V,1).[1] THIS DISCUSSION ADDRESSES THE SCALE AND MELODY-TYPE MEANING.

**KEY (SHRUTHI):** THIS REFERS TO THE TONIC NOTE OR AATHAARA SHADJA. HENCE SHIFTING THE KEY REFERS TO SHIFTING THE ABSOLUTE FREQUENCY. THE FOLLOWING GRAPH SHOWS THE RELATIVE SENSITIVITY OF THE HUMAN HEARING.

![Tonaudiogramm](image)

AS CAN BE SEEN, MAXIMUM RESPONSE OCCURS ONLY FOR A PARTICULAR RANGE. IF THE TESSITURA EXTENDS BEYOND THIS RANGE, TENSION IS CREATED IN THE AUDITORY ORGANS AND THIS IS A GOOD PLATFORM FOR THE NEGATIVE EMOTIONS TO SHOW MORE PROMINENTLY. HENCE POSITIVE EMOTIONS JOY AND SURPRISE AS WELL AS SYMPATHY SHOW A DECREASE FOR HIGHER KEYS.

**HARMONY (SAMVAADHITHVA):** IN MUSIC, HARMONY IS THE USE OF SIMULTANEOUS PITCHES, OR CHORDS.[1] THE STUDY OF HARMONY INVOLVES CHORDS AND THEIR CONSTRUCTION AND CHORD PROGRESSIONS AND THE
PRINCIPLES OF CONNECTION THAT GOVERN THEM.[2] HARMONY IS OFTEN SAID TO REFER TO THE “VERTICAL” ASPECT OF MUSIC, AS DISTINGUISHED FROM MELODIC LINE, OR THE “HORIZONTAL” ASPECT. COUNTERPOINT, WHICH REFERS TO THE INTERWEAVING OF MELODIC LINES, AND POLYPHONY, WHICH REFERS TO THE RELATIONSHIP OF SEPARATE INDEPENDENT VOICES, ARE THUS SOMETIMES DISTINGUISHED FROM HARMONY. THIS IS THE CONCEPT OF SOUNDING A NOTE AND ITS FIFTH OR FOURTH SOUNDED IN CONJUNCTION AND IS SeldOM SEEN IN CARNATIC MUSIC. BUT THE EFFECT OF RELATIVE SAMVAADHI AND ANUVAADHI PAIRS WERE ALREADY DISCUSSED EARLIER.

DYNAMICS(LOUDNESS/VOLUME): IN MUSIC, DYNAMICS NORMALLY REFERS TO THE VOLUME OF A SOUND OR NOTE, BUT CAN ALSO REFER TO EVERY ASPECT OF THE EXECUTION OF A GIVEN PIECE, EITHER STYLISTIC (STACCATO, LEGATO ETC.) OR FUNCTIONAL (VELOCITY). THE TERM IS ALSO APPLIED TO THE WRITTEN OR PRINTED MUSICAL NOTATION USED TO INDICATE DYNAMICS. THIS ALSO AFFECTS EMOTION AND A PARTICULAR LEVEL IS PLEASANT. AS THE VOLUME INCREASES THE MUSIC GETS HARSHER AND NEGATIVE EMOTIONS BECOME MORE PROMINENT. HENCE LOUDNESS SHOULD BE AT A MINIMUM, BUT ABOVE THE THRESHOLD OF HEARING AND AT AN ENJOYABLE LEVEL THAT DEPENDS ON THE SENSITIVITY OF THE INDIVIDUAL.

THRESHOLDS OF HEARING FOR MALE (M) AND FEMALE (W) SUBJECTS BETWEEN THE AGES OF 20 AND 60

TIMBRE/TONE COLOR:- IN MUSIC, TIMBRE (PRONOUNCED /ˈtæmbər/, LIKE TAHMBER, OR SPELLING PRONUNCIATION /ˈtɪmbrər/; FRENCH: [TB]) IS THE QUALITY OF A MUSICAL NOTE OR SOUND OR TONE THAT DISTINGUISHES DIFFERENT TYPES OF SOUND PRODUCTION, SUCH AS VOICES OR MUSICAL INSTRUMENTS. THE PHYSICAL CHARACTERISTICS OF SOUND THAT MEDIATE THE PERCEPTION OF TIMBRE INCLUDE SPECTRUM AND ENVELOPE. TIMBRE IS ALSO KNOWN IN PSYCHOACOUSTICS AS TONE QUALITY OR TONE COLOR. FOR EXAMPLE, TIMBRE IS WHAT, WITH A LITTLE PRACTICE, PEOPLE USE TO DISTINGUISH THE SAXOPHONE FROM THE TRUMPET IN A JAZZ GROUP, EVEN IF BOTH INSTRUMENTS ARE PLAYING NOTES AT THE SAME PITCH AND LOUDNESS. TIMBRE HAS BEEN CALLED A "WASTEBASKET" ATTRIBUTE[1] OR CATEGORY,[2] OR "THE PSYCHOACOUSTICIAN'S MULTIDIMENSIONAL WASTEBASKET CATEGORY FOR EVERYTHING THAT CANNOT BE QUALIFIED AS PITCH OR LOUDNESS." I.E, THE ‘SHAPE’ OF THE SOUND. THIS AFFECTS THE EMOTION AND AN ILLUSTRATION IS SHOWN HERE. WIND INSTRUMENTS USUALLY PRODUCE A LOW FREQUENCY HARMONIC THAT USUALLY PRODUCES A “BOOING” SOUND. SIMILARLY METAL INSTRUMENTS PRODUCE A HIGH FREQUENCY HARMONIC HISSING SOUND. BOTH OF THESE ARE IRRITATING TO THE LISTENER AND CAN BE ELIMINATED BY PROPER FILTERING USING ELECTRONIC EQUIPMENTS. ANYWAY THESE DO NOT AFFECT MUCH OF EMOTION PERCEPTION AND HENCE WILL BE NEGLECTED.

UNIVERSAL MUSIC EMOTION ANALYSIS:
IN THE ABOVE SECTIONS, ALL ASPECTS OF MUSIC AND THEIR EFFECT ON EMOTIONS HAVE BEEN ANALYSED. HENCE WE CAN APPLY THIS TO DIFFERENT PIECES OF MUSIC ALL OVER THE WORLD FOR ANALYSIS. HOWEVER, MAIN IMPORTANCE WILL BE GIVEN TO CARNATIC MUSIC IMPLEMENTATIONS, AS IS THE AIM OF THIS WORK. THE MUSIC ASPECTS CAN BE DIVIDED INTO THE FOLLOWING CATEGORIES IN DECREASING ORDER OF EFFECT: MELODY, DYNAMICS, TEMPO, PITCH, HARMONY AND RHYTHM.
MELODY:
This forms the crux of Carnatic music. It sets the basic emotion of the piece. In general, only melody and harmony can determine the emotion of a piece. Other factors act as mere modifiers. The effects of melody has been discussed in detail by means of swara and raga effects and the emotion profile of all melakartha ragas have also been given.

TEMPO:
The tempo of a piece is easily specified as the number of beats (such as a metronome beat) per minute. (denoted as BPM) for universality, we can set each metronome beat for each syllable (like ka) or a syllable extension (like aa). Let us now consider a few examples:
1. Kamalambam Bhajare – Kalyani – Adhi - Dikshithar – 60BPM – A RELATIVELY SLOW SONG
3. Shri Valli – Natabhairavi – Adhi – Papanasan Sivan – 90BPM – A MEDIUM PACED SONG
All these have been set to 1 metronome beat per syllable. Hence, tempo is independent of Thaalam. But usually, composers choose an appropriate Thaalam to merge with the tempo while composing a song. Here, for the analysis, 90BPM is taken as the reference speed and most of the songs fall in the 3 categories of 60, 90 and 120BPM. As mentioned earlier, with an increase in tempo the more dominant of fear and anger increases, surprise and sympathy decrease. Since surprise decreases, anticipation increases; hence optimism increases; hence courage increases; hence the joy changes from a blissful one to an ecstatic joy. Thus joy also increases. Let us consider the following illustrations:
1. Let us take a song at 100BPM and let anger be more prominent than fear.
   100 – 90 = 10; 10/90 X 100 = 11.11%. Hence there is a 11.11% increase in anger, 11.11% decrease in sympathy, 11.11% decrease in fear, 11.11% increase in joy, and 11.11% decrease in surprise. Since the tempo affects emotions to a lesser extent than melody the factor (11.11%) should be halved before applying it. Thus the amount of increase/decrease of various emotions = (11.11%)/2 = 5.55%. Therefore if the joy was initially 90%, it becomes 90+5.55 = 95.55%.
2. Let us now take a song at 120BPM with fear being more prominent. 120 – 90 = 30; 30/90 X 100 = 33.33%. 33.33/2 = 16.67% thus joy and fear increase by 16.67% and surprise and sympathy get decreased by 16.67%.

KEY:
The key/pitch comes third in decreasing order of effect on emotions. Most of the western and other music systems follow a fixed key. The Indian music on the contrary has a variable key. The performer has freedom to choose the frequency of the Aathaara Shadja. According to the work investigation of the factors influencing music listening emotions and music liking for Taiwan undergraduate students done by Ching-fang Huang, Shun-wenwu1, Sieh-hwa Lin and Sheau-yuh Lin, major key, non harmonized fast melodies are happier and produce more positive emotions. And according to international standards 440Hz is taken to be the pitch of A. Hence 261.5Hz is taken to be the frequency of Sa or C. Hence while calculating, the pitch used is seen and the swara range in which the pitch belongs is determined. For example a pitch of 445Hz and a pitch of 890Hz falls in the vicinity of A(Dhi) and 520Hz falls in B(Nu). Then for the emotions joy, fear, surprise and sympathy, it is determined whether the swara falls under the Y, N or P categories. If Y, a factor of 12.5% is added, 6.25% is added if P and 12.5% is subtracted if N. For example consider a piece in a pitch of 300Hz. This falls in E(Gu). If the joy is 45%, it will rise to 45+12.5 = 57.5% since Gu is Y for joy.

HARMONY:
According to the paper mentioned in the above section, non harmonized music appears happier. As we have already calculated the emotions of various chords, these will be taken into
CONSIDERATION AND THE VALUES WILL BE ADDED. BUT THE EFFECT OF HARMONY IS LESSER THAN THAT OF TEMPO OR PITCH. HENCE A FACTOR OF 1/6 HAS TO BE MULTIPLIED TO THE CHORD EMOTIONS BEFORE ADDING IT. C MINOR CHORD (CM) HAS THE FOLLOWING: JOY = 56%, FEAR = 56%, SURPRISE = 28% AND SYMPATHY = 78%. THEREFORE, JOY IS INCREASED BY 9.5%, FEAR DECREASED BY 9.5%, SURPRISE INCREASED BY 5% AND SYMPATHY INCREASED BY 13%.

RHYTHM:
THE ANALYSIS OF RHYTHM IS A COMPLEX ONE. MOREOVER, IT IS HIGHLY DEPENDANT ON TEMPO. INHERENTLY, ANY COMPOSER PLANS THE RHYTHM SEQUENCE ACCORDING TO TEMPO WHILE COMPOSING. HENCE EMOTION CHANGES ONLY WHEN A COMPOSITION CHANGES THALA. MOREOVER THE EFFECT OF RHYTHM ON EMOTION IS THE LEAST, EVEN LESSER THAN HARMONY. HENCEN THIS IS NEGLECTED IN CALCULATIONS.

DYNAMICS:
THIS IS ALSO A VERY VAGUE CONCEPT AND LARGELY DEPENDS ON THE SENSITIVITY OF THE INDIVIDUAL. NORMAL HUMAN HEARING OCCURS BETWEEN 15DB AND 100 DB. HENCE THE ANALYSIS OF DYNAMICS WILL NOT BE INCLUDED HERE.

PROCEDURE OF UNIVERSAL QUANTITATIVE ANALYSIS

- FIRST, CONSIDER MELODY. IF IT IS A RAGA ALAPANA, FIND THE EMOTIONS OF THE RAGA USING THE APPROACH BASED ON GRAPH THEORY DISCUSSED EARLIER. IF IT IS A SONG OR OTHER MUSICAL PIECE, DRAW THE GRAPH FOR THAT PIECE AND FIND THE EDGE VALUES AND TAKE NORMALISED AVERAGE OF THOSE. THIS GIVES THE % OF JOY, SURPRISE, FEAR AND SYMPATHY.
- NEXT, CONSIDER TEMPO. IF NORMAL TEMPO (90BPM) IS FOLLOWED NO CHANGES ARE MADE. IF TEMPO IS HIGHER OR LOWER, CALCULATE THE FACTOR AND APPROPRIATELY INCREASE OR DECREASE THE 4 EMOTION % VALUES CALCULATED
- NOW, PITCH WILL BE CONSIDERED. FIND THE REGION OF SWARA UNDER WHICH THE PITCH OR ATHARA SHADJA FALLS. IF IT IS SA OR PA OR OCTAVES OF SA/PA, NO CHANGES ARE MADE. IF IT IS IN ANY OTHER REGION APPLY THE APPROPRIATE FACTOR OF INCREASE/DECREASE FOR THE 4 EMOTIONS CALCULATED IN THE ABOVE STEP. FROM THE RELATIONS GIVEN IN PRECEDING SECTIONS, OTHER EMOTIONS % ARE CALCULATED.
- NEXT CONSIDER HARMONY. CONSIDER THE VARIOUS CHORDS USED IN THE SONG/RAGA ALAPANA. TAKE THE AVERAGE OF ALL OF THEM AND DIVIDE THE RESULTS BY THE FACTOR OF 6. THEN ADD THIS VALUE TO THE % CALCULATED IN PREVIOUS STEP. IN PREVIOUS STEPS FACTORS AND VALUES WERE ADDED ONLY TO THE 4 EMOTIONS OF JOY, FEAR, SURPRISE AND SYMPATHY. THIS WAS BECAUSE THERE WAS ONLY 1, OR A MAXIMUM OF 2 FACTORS. BUT IN HARMONY, EACH EMOTION HAS ITS OWN FACTOR TO BE ADDED AND HENCE, THE EMOTION % OF CHORDS NEED TO BE ADDED. FOR EXAMPLE, IF JOY OF SONG IS 45% AND HENCE SORROW = 100-JOY = 55 AND JOY OF CHORD AFTER DIVIDING BY 6 = 1% AND HENCE SORROW = 16%. IF ONLY JOY WAS ADDED, JOY = 45+1=46% OR SORROW = 100-JOY = 54%. THIS MEANS THAT THE SONG HAS BECOME HAPPIER WHEREAS THE CHORD APPLIED SEEMS TO BE A SORROWFUL ONE. HENCE THIS CALCULATION IS WRONG. RATHER, IF BOTHN JOY AND SORROW VALUES OF CHORD IS ADDED, WE GET JOY = 46% AND SORROW = 71%. THIS IS MORE MEANINGFUL SINCE THE SORROW HAS INCREASED. HENCE, WHILE APPLYING CHORD VALUES, ALL EMOTION VALUES OF CHORD SHOULD BE ADDED WITH CORRESPONDING VALUES OBTAINED IN PREVIOUS STEP.
- THE VALUES THUS OBTAINED GIVE THE "EMOTIONAL PROFILE" OF THE MUSICAL PIECE.

CASE STUDIES:
TO ILLUSTRATE THE PROCEDURE OF CALCULATING EMOTIONAL PROFILES, WE SHALL CONSIDER A FEW CASE STUDIES.
CS1: RAGA ALAPANA OF SHUBHAPANTHUVARALI, NORMAL TEMPO, NORMAL PITCH, CHORDLESS
SHUBHAPANTHUVARALI is MELA NO. 45. THE EMOTION PROFILE IS THE SAME AS THAT CALCULATED FOR MELA RAGAS EARLIER. SINCE THERE ARE NO MODIFICATIONS TO BE MADE FOR THE OTHER ASPECTS, THE VALUE CALCULATED EARLIER IS THE FINAL VALUE. THEY ARE JOY=46.45%, FEAR=62.84%, SURPRISE=45.36%, SYMPATHY=62.84%. EMOTIONAL PROFILE IS GIVEN IN TABLE.

CS2: CHARANAM OF GURUMURTHE – DIKSHITHAR, NORMAL TEMPO AND PITCH, CHORDLESS
ALTHOUGH TEMPO IS MENTIONED AS NORMAL, SEPARATE ANALYSES SHOULD BE MADE FOR THE CHARANAM AT A TEMPO OF 90BPM AND THE MADHYAMA KALA PORTION WHICH IS AT A TEMPO OF 120BPM. BOTH THE GRAPHS ARE GIVEN AND THE MELODY VALUES ARE
CHARANAM: JOY=78.21%, FEAR=48.24%, SURPRISE=82.14% SYMPATHY= 74.39%. PITCH NORMAL, TEMPO AT 90BPM, NO CHORDS. HENCE OTHER EMOTIONS ARE CALCULATED AS IN THE TABLE.
FOR MADHYAMAKALAM, JOY=94.6, FEAR= 40.61,SURPRISE=82.14 SYMPATHY=75.95. PITCH NORMAL, TEMPO = 120BPM. THUS, 120-30=90; 30/90*100=33.33% AND 33.33/2=16.67%. THUS THE EMOTIONAL PROFILE BEFORE AND AFTER TEMPO FACTOR ADDITION IS GIVEN.

CS3: CS1 WITH CHORDS:
The chords possible with SHUBAPANTUVARALI are B,AB,CM,ABM,DBSUS,GBSUS,ABSUS. THESE CHORDS AND THEIR AVERAGE EMOTION PROFILE IS GIVEN. THIS IS DIVIDED BY 6 AND ADDED WITH CS1 PROFILE. RESULTS ARE GIVEN.

CS4: CS2 WITH CHORDS
HERE THE CHORDS FOR THE CS2 ARE CONSIDERED. THE CHORDS USED ARE G(4 TIMES), EM(2 TIMES), F AND C. THESE ARE GIVEN IN TABLE AND AVERAGE, MODIFIED AVERAGE ALSO GIVEN. FINAL IS ALSO GIVEN.

CS5: CHARANAM OF NAGAGANDHARI- DIKSHITHAR, 120BPM, 300HZ, WITH CHORDS
MADHYAMA KALAM IS OMITTED FOR SIMPLICITY. THE GRAPH OF THE PIECE IS GIVEN. THE VALUES ARE JOY=71.3, FEAR=59, SURPRISE=50.19 SYMPATHY=77.88%. SINCE TEMPO IS 120, 120-90=30; 30/90*100=33.33; 33.33/2 = 16.67%. THEREFORE THIS VALUE IS ADDED. NEW VALUES ARE GIVEN FOR THE 4 EMOTIONS. SINCE PITCH IS 300 IT IS IN REGION OF RI. THUS RI IS Y FOR JOY AND SYMPATHY, P FOR SURPRISE AND N FOR FEAR. THUS, NEW VALUES ARE CALCULATED AND GIVEN. THEN CHORDS (2 CM, 6AB) ARE APPLIED. THE CHORD PROFILES AND AVERAGE AND MODIFIED AVERAGE IS GIVEN. THIS IS ADDED AND FINAL PROFILE IS ALSO GIVEN IN TABLE.

CS6: A NON CARNATIC PIECE
NOW ANALYSIS WILL BE MADE ON FEW NON-INDIAN MUSIC PIECES BASED ON DIFFERENT REGIONS. FOR SIMPLICITY PURPOSES, TEMPO IS ASSUMED TO BE AT NORMAL(90BPM) FOR ALL THESE PIECES.

A. WESTERN CLASSICAL MUSIC
CONSIDER THE FIRST THEME OF EINE KLEINE NACHTMUSIK OF MOZART K.525. THE ANALYSIS CAN BE DONE IN 2 WAYS.
1. WITH NORMAL PITCH AND STARTING NOTE AS G. THE VALUES ARE GIVEN IN TABLE. CHORDS USED ARE G AND D7. THE CHORD PROFILE AVERAGE, MOD AVERAGE AND FINAL VALUE ARE GIVEN.
2. WITH PITCH AT G AND STARTING NOTE AT C. THE VALUES ARE GIVEN IN TABLE. CHORDS USED ARE C AND G7. THE CHORD PROFILE AVERAGE, MOD AVERAGE AND FINAL VALUE ARE GIVEN. SINCE PITCH IS IN VICINITY OF G(PA) NO NEED OF ANY CHANGES.

B. MIDDLE EAST
CONSIDER THE ARABIC PIECE BELAZY ASKARA,A FOLKLORE PIECE, SET TO MAQAM BAYATI. THIS IS AVAILABLE AS A MIDI FILE AT http://www.pro.com.eg/melcom/elangExamples.htm HERE, WE FIND A QUARTER NOTE, ie E HALF-FLAT, E-. THUS THE NOTE CORRESPONDS TO THE QUARTER TONE LOCATED IN BETWEEN GI AND GU. HENCE WHILE DRAWING THE GRAPH, THE JOY, FEAR, SURPRISE AND SYMPATHY POINTS OF THIS VERTEX ARE TAKEN TO
BE THE AVERAGE OF GI AND GU. THIS APPLIES FOR ANY QUARTER TONE. OTHER FACTORS REMAIN THE SAME AND
THUS THE PROFILE IS CALCULATED.

C. ORIENTAL

FOR THIS 2 EXAMPLES ARE GIVEN.

CONSIDER THE CHINESE TRADITIONAL PIECE, LITTLE SWALLOW (XIAO YANZI) COMPOSED BY WANG LU. THIS IS
THE CHINESE TUNING SYSTEM IS VERY DIFFERENT TO THE WESTERN/ INDIAN ONE. BUT AS A REASONABLE
APPROXIMATION THE SAME TUNING SYSTEM CAN BE ASSUMED FOR THE CALCULATIONS. THE PIECE
CORRESPONDS VERY MUCH TO THE PENTATONIC SCALE MOHANAM. HENCE THE PROCEDURE SPECIFIED ABOVE
CAN BE EASILY USED TO CALCULATE THE VALUES.

NEXT, CONSIDER THE FAMOUS JAPANESE PIECE SAKURA. THIS CAN BE VIEWED IN 2 ASPECTS,
1. WITH THE STARTING NOTE AS A. THIS THEN CORRESPONDS TO THE WESTERN MAJOR SCALE OR
   DHEERASANKARABHARANAM.
2. WITH STARTING NOTE AS C. THEN IT BECOMES A PIECE USING THE NOTES SARIGIPADHASA. THIS IS A
   MORE SORROWFUL VERSION.

WHICH WAY IT IS SUNG DEPENDS ENTIRELY ON THE PITCH SELECTION. THE FIRST ONE WILL BE USED HERE. VALUES
ARE GIVEN.

D. SOUTH EAST ASIA

CONSIDER THE BALINESE GAMELAN PIECE PERMAS – GAMELAN SEMAR PEGULINGAN, THAT CAN BE FOUND AT
CORRESPONDS TO RAGA GAMBEERANAATTAI. VALUES ARE AS PRESENTED.

E. AFRO-CARIBBEAN

CONSIDER THE CALYPSO PRESENT IN http://gfxc.smpgfx.com/Look-Inside/large/3885508_00-01.jpg. FROM THE
SHEET NOTATION WE CAN EASILY COMPUTE THE EMOTIONS. VALUES ARE AS GIVEN IN THE TABLE.
CONCLUSION

THE EMOTIONS CAUSED BY THE SWARAS AND OTHER ASPECTS OF CARNATIC MUSIC SUCH AS RAGAS WERE ANALYSED, BOTH QUALITATIVELY AND QUANTITATIVELY, SUCH THAT THE EMOTIONAL EFFECT OF ANY RAGA COULD BE GIVEN AS A “PROFILE” CONSISTING OF PERCENTAGES OF VARIOUS EMOTIONS. THEN A NOTATION SCHEME CONVENIENT FOR EMOTIONAL ANALYSIS WAS PROPOSED. THE MUSICAL SYSTEMS FROM DIFFERENT PARTS OF THE WORLD WERE THEN CONSIDERED. TECHNIQUES WERE THEN STATED TO APPLY CHORDS TO CARNATIC MUSIC TO ENHANCE THE EMOTIONAL CONTENT. A FOUR DIMENSIONAL THEORY OF MUSIC AND EMOTIONS WAS PROPOSED. FINALLY, A UNIVERSAL QUANTITATIVE AND QUALITATIVE EMOTIONAL ANALYSIS PROCEDURE WAS SPECIFIED, WHICH COULD BE APPLIED TO ANY MUSICAL PIECE/SYSTEM FROM ANY PART OF THE WORLD.

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