

**RCT trial in Pondicherry
Tamil Nadu, South India
Spring 2019**

preliminary report

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1. EXPERIMENTAL DESIGN

Assumption

that X-System may predict both levels of arousal and mood (valence) in listeners to given tracks of music in more than one, if not all, world cultures.

Research Question

Can X-System predict levels of arousal and mood in South Indian children listening to Carnatic music?

Procedure

An application was made to the local education authority for ethics clearance, and permission was granted.

A population of 40 schoolchildren was selected, with an equal number of girls and boys, from the same age group (11-12) with a similar level of educational achievement, as assessed through methods approved by the National Council of Educational Research and Training (NCERT).

A computer randomisation program, was used to choose 20 children, 10 girls, 10 boys. The chosen children were further divided randomly into two groups: A and B, each with 10 children, 5 girls, 5 boys

$n = 20$ (10 plus 10)

To a certain extent, this may be considered to be a single blind study; although the children participated in making choices, they were not aware of the purpose of the experiment.

Protocol

For group A

Children were tested individually, by one researcher, in one 45 minute session

During the session the children listened to four 5-minute tracks of Carnatic vocal music with the kind permission of Sudha Ragunathan, predicted by X-System to be, respectively,

- | | | |
|----------------------|-------------------------------|-------------|
| 1. Negative valence | Sarvam Brahmanayam | (Sarvam) |
| 2. Low Arousal. | Ragam-Tanam-Pallavi-Dhamavati | (Dhamavati) |
| 3. Positive Valence. | 05-Mamavathu..... | (Mamavatu) |
| 4. High Arousal. | 01-Era Napai..... | (Era Napai) |

The children wore X-System wristband heart rate sensors; there was a minute-long silence before each track to establish an HR baseline, and a pause after each track, where the children answered a simple question. The track order was not randomised, and remained the same for every child.

How did the music make you feel?

(for tracks 1 and 2)

Happy? Sad?

சந்தோஷமாக, வருத்தமாக
Cantōṣamāka, Varuttamāka

(for tracks 3 and 4)

Energy, peace

ஆற்றல், சமாதானம்
Ārral, Camātāṇam

A 3 minute game of naughts and crosses was played between tracks 1-2, 2-3 and 3-4.

For group B (control group)

Children were tested individually, by one researcher, in sessions lasting 45 minutes

During the session. Children watched four 5-minute video clips of nature, with as neutral a mood and sense of arousal as possible, and no sound.

The children wore X-System wristband heart rate sensors; there was a minute-long pause before each clip to establish an HR baseline, and a 5-minute pause after each clip, where the children answered a simple question.

How did the film make you feel?

(for films 1 and 2)

Happy? Sad?

சந்தோஷமாக, வருத்தமாக
Cantōṣamāka, Varuttamāka

(for films 3 and 4)

Energy, peace

ஆற்றல், சமாதானம்
Ārral, Camātāṇam

A 3 minute game of naughts and crosses was played between clips 1-2, 2-3 and 3-4.

2. SENSOR STUDY RESULTS

Sensor data for the music and control groups was collected by means of a Sony wristband sensor and X-System commercial i-phone app. Data from tracks with drop-outs was eliminated (two from both sets of data). For each of the remaining tracks, the average HR was calculated. The values for the **music group** were as follows

Sarvam	89.27
Dhamavati	92.94
Mamavatu.	93.25
Era Napai	93.43

This may be compared to the X-System arousal prediction values of

Sarvam	4.22
Dhamavati	4.38
Mamavatu	6.67
Era Napai	6.70

X-System **predicts the ranking correctly**, and in proportion, except for Dhamavati, which has a higher relative HR arousal rate than predicted. This may be related to the fact that a number of children recognised the track as a “god song” (dedicated to the goddess Parvathi). There is a **relatively strong range of HR values** for the music sensor data, i.e. a range of 4.16 bpm. The average HR for the four tracks (92.22), represents a **generally high level of excitement** above average HR for 12 year old children (70)

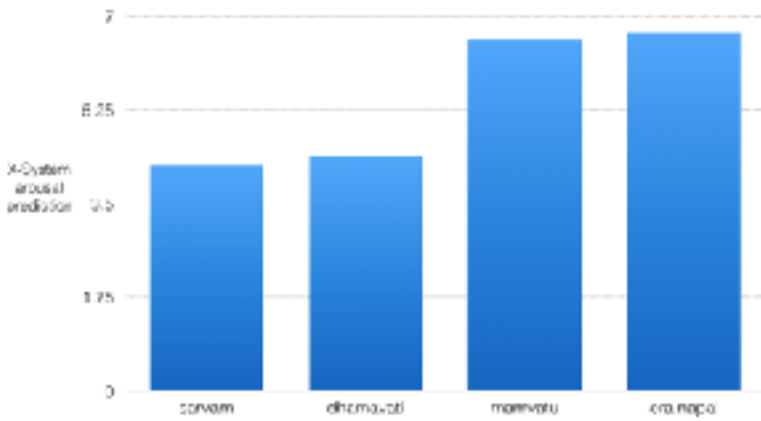
For the **control (silent film) group** the average HR values were

Film 1	82.69
Film 2	84.32
Film 3	81.72
Film 4	84.40

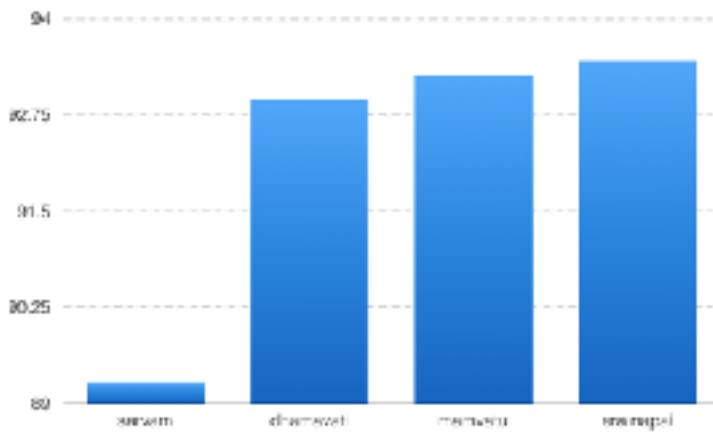
There is **far less profile** than for the music group results. There is a **relatively weak range of HR values**, i.e. a range of 1.71 bpm, and a **generally far lower level of excitement** (average 83.28), indeed 41% lower than the music group.

The difference between the music and control group results was **highly statistically significant** $p = 0.000351$, $t = 3.5804$

X-System arousal prediction



Music group average HR sensor data



HR range **4.16bpm**
(89.27-93.43)

Control (silent film) group sensor data

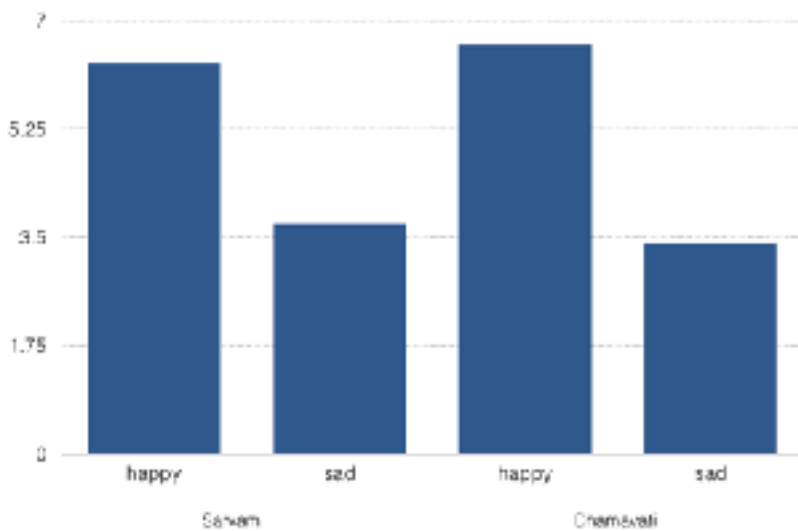


HR range **1.71bpm**
(82.69-84.40)

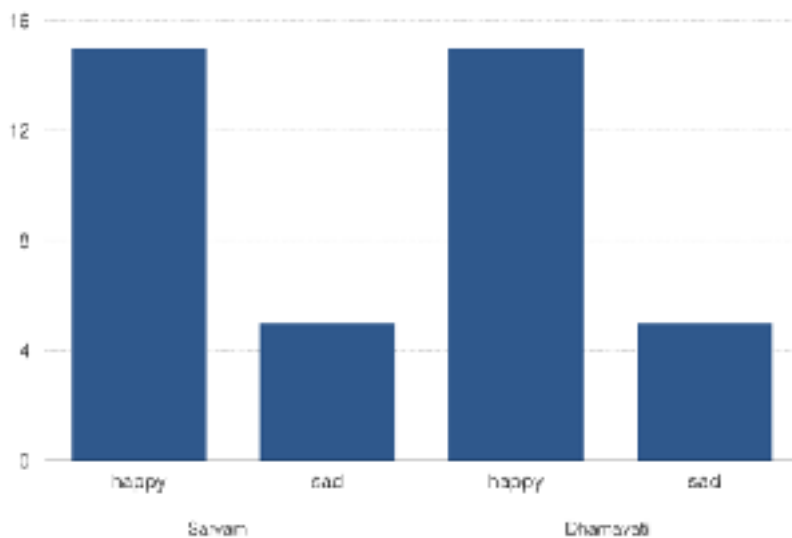
3. QUESTIONNAIRE RESULTS

The system crashed repeatedly during the first days of the trial. The team took the trial off-line, but in the process the track order was corrupted. The result was that the two tracks that were compared for arousal had almost identical arousal predictions, and tracks for valence had very similar valence values. Nevertheless, the results show that X-System predictions of both valence and arousal are robust. Here, two tracks with similar valence predictions are compared. In this case, some of the children described the tracks as happy-sad, or “happy but with some sadness”. The “sad” values in the X-System prediction are derived by subtracting values for the maximum score of 10.

X-System valence prediction



Subjective valence scores



The tables 1. The Music Group

X-System predicted *Sarvam* and *Dhamavati* as low positive valence (6.3 and 6.6 respectively). This seems to be confirmed by the X scores (both tracks: 6 X's happy, 1 X sad); this is further nuanced by the combined X and / scores (both tracks: 15 happy, 5 sad). It is also confirmed by the subjective comments, which include "happy", but also "gentle", "peaceful" and "silent". Although the children were not asked to score these two tracks for energy/peace, their comments appear to reflect the low autonomic arousal (4.2 and 4.4) predicted by X-System. **On the whole, the children's responses appear to confirm X-System predictions of valence, and most likely also of arousal.**

X-System predicted moderately high arousal values for *Mamvatu* and *Era Napai* (both 6.7). The X scores reflect this, although Mamvatu has 5 X's for "energy" and Era Napai has 3. Once again, the combined X and / values are helpful., where the respective values are 11 and 9. For this pair children were only asked about arousal, but it is interesting that most children provided either X's or /s for both "energy" and "peace". If this is cross-referenced with the comments, "very happy", "very much happy", I tentatively propose that the children may have used the "peace" column to register valence. If this is the case, then the identical 9 scores for combined X and / values may reflect the identical valence prediction (7.1). **On the whole, the children's responses appear to confirm X-System predictions of arousal, and most likely also of valence.**

The tables 2. The Control Group - Films

Here all participants seem to have scored the films for both pairs of values (happy/sad;energy/peace), which explains the discrepancy in numbers, i.e. higher combined scores than the music group, although fewer X's, implying less certainty in emotional response. The films were nature films with many animals. In their comments, the children appear to have reacted more to narrative than to the simple emotions of the music group.

If we allow for the discrepancy in filling in the questionnaire, **the children appear to have reacted to the music tracks in a more powerful, coherent and profiled way than to the films.**

MUSIC (EXPERIMENTAL) GROUP n = 10

SUBJECTIVE RESPONSES - AROUSAL AND VALENCE QUESTIONNAIRE - "X" ENTRIES

	Valence prediction	Arousal prediction	Happy	Sad	Energy	Peace
SARVAM	6.3	4.2	XXXXXX	X		
DHAMAVATI	6.6	4.4	XXXXXX	X	XX	
MAMVATU	7.1	6.7	X	X	XXXXX	XXXX
ERA NAPAI	7.1	6.7			XXX	XXX

SUBJECTIVE RESPONSES - AROUSAL AND VALENCE QUESTIONNAIRE - "X" and "/" ENTRIES

	Valence prediction	Arousal prediction	Happy	Sad	Energy	Peace
SARVAM	6.3	4.2	15	5		
DHAMAVATI	6.6	4.4	15	5		4
MAMVATU	7.1	6.7	1	3	11	9
ERA NAPAI	7.1	6.7			9	9

SUBJECTIVE COMMENTS

	Valence prediction	Arousal prediction	Comments	
SARVAM		8.3	4.2	distracted, I feel silent, I feel peaceful, I feel happy, relaxing
DHAMAVATI		8.6	4.4	happy, I feel gentle, peaceful in my mind, silent
MAMVATU		7.1	6.7	very happy, happy, very happy, joyful, energetic
ERA NAPAI		7.1	6.7	excited, fast, feeling great, very much happy, very joyful, I feel happy, I feel peaceful

CONTROL GROUP - FILM n = 10
SUBJECTIVE RESPONSES - AROUSAL AND VALENCE QUESTIONNAIRE - "X" ENTRIES

	Happy	Sad	Energy	Peace
1st film	X	X		
2nd film	XXX		XXX	X
3rd film	XXXXXXXXXX		XXXXXXXXXX	
4th film			XX	X

SUBJECTIVE RESPONSES - AROUSAL AND VALENCE QUESTIONNAIRE - "X" and "/" ENTRIES

	Happy	Sad	Energy	Peace
1st film		10	10	
2nd film		13	7	12
3rd film		19	1	17
4th film				10

SUBJECTIVE COMMENTS

	Comments
1st film	Feel bad for the bird, very bad for bird, sad for the bird, bad feeling, sad
2nd film	little happy, little sad, happy and sad, sad, happy because monkey helping bat, sad, monkey touch the heart
3rd film	Happy for Squirrel, happy, very happy, happy, happy, happy, very happy, I feel happy because I like snow
4th film	Boring, very happy, sleepy, I feel happy seeing mountains, beach and trees

4. CONCLUSIONS

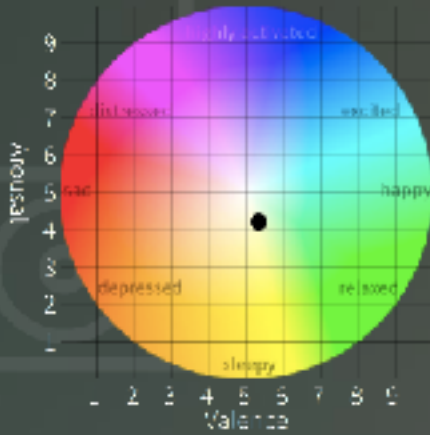
- that the children in South India reacted in rich ways, in terms of both arousal and mood, to Carnatic vocal music, at a high level of excitement, a wide range of arousal and counterarousal (4.16 bpm) and a variety of strong emotions
- that they reacted far less vividly to silent films of nature and animals, at a 41% lower level of excitement and a narrower range of HR (1.71 bpm)
- that there was a highly statistically significant difference in autonomic response between the music group and the control (silent film) group, $p = 0.000351$, $t = 3.5804$
- that X-system predicted rankings of levels of autonomic arousal accurately in all cases, and in three out of four cases in the correct proportional relationships
- that X-System predicted levels of valence (vagal power) accurately, and in the correct proportionality
- that X-System may therefore be capable of predicting arousal and valence accurately in both European and Indian musical cultures
- that there is every reason to consider rolling out an educational-therapeutic method for South Indian (and other) children, based on Carnatic vocal music.

APPENDICES

Analysis and discussion of tracks

REFLECTIVE, SERIOUS, SAD

Sarvam Brahmamayam - Sudha Raghunathan



Linear Arousal	3.6814936107
Neural Arousal	4.5442089998
Linear Valence	6.43890078688
Neural Valence	5.22382170653
Combined Arousal	4.21785180515
Combined Valence	6.33186124719

DURATION 7 minutes 40 seconds; play first 5 minutes, then fade-out

RAAG JHINJHOTI Arohana D2 S R2 G3 M1 P D2 N2
Avarohana D2 P M1 G3 R2 S N2 D2 P D2 S

Jhinjhoti is sometimes considered to be a playful raag, but it is also associated with late night, and for some commentators it seems to be poised at the threshold of hope and no hope.

TEXT

pallavi
sarvam brahmamayam rE rE
caraNam 1
kim vacanlyam kima vacanlyam kim racanlyam kima racanlyam
caraNam 2
kim paThanlyam kima paThanlyam kim bhajanlyam kima bhajanlyam
caraNam 3
kim bOddhavyam kima bOddhavyam kim bhOktavyam kima bhOktavyam
caraNam 4
sarvatra sadA hamsa dhyAnam kArtavyam bhO mukti nidAnam

Translation

Everything is Brahma Mayam; All is just the Almighty's presence.

1. What may be spoken and what may not be spoken, what can be created and what may not be created (in relation to poetry or otherwise)

2. What may be studied and what not to be studied, what may be recited and what may not be recited

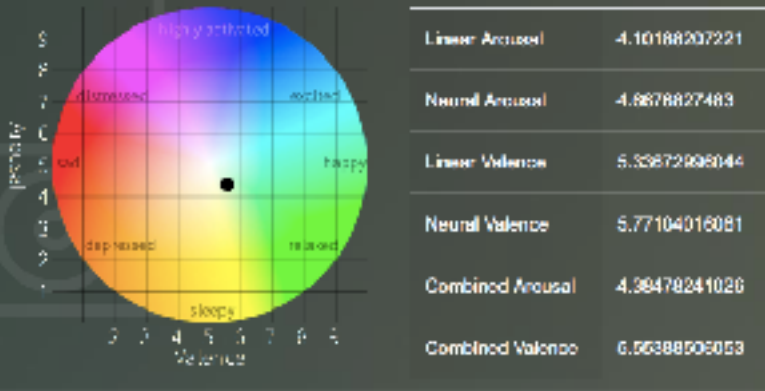
3. What may be taught and what may not be taught; what may be enjoyed and what may not be enjoyed - everything is HIS creation and HIS work.

4. So, always immerse yourself in HIS dhyaanam and that will take you towards 'salvation'

The short message of this song is do not enter into arguments and discussions as to what is right and what is wrong; all that would be meaningless and unnecessary. What is meaningful is 'Pray HIM' and 'Merge in HIM'

RELAXED, CALM

rAgam_tAnam_pallavi-dhamavati - Sudha Raghunathan



DURATION 25 minutes; after 5 minutes fade out

RAAG GOWRIMANOHARI Arohana S R2 G2 M1 P D2 N3 S
Avarohana. S N3 D2 P M1 G2 R2 S

The name of the raag is interpreted as “Gauri (Goddess Parvathi) who steals the heart” or “one that is pleasant and beautiful”. It is a raag for any time of day, and expresses the feeling of Bhakhti (attachment, participation, fondness, homage, faith, love, devotion, worship, purity) and Srīngara (one of the nine “rasas” or “flavours”, usually translated as erotic love, romantic love, or as attraction or beauty).

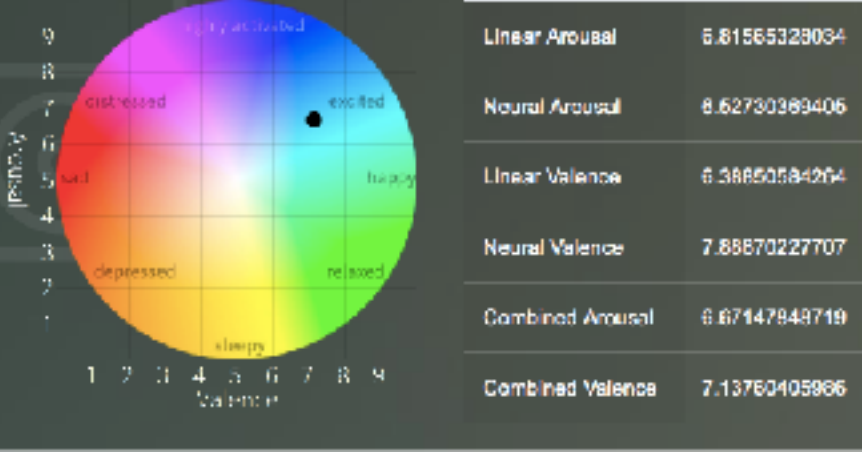
This excerpt includes a section of the first part (alapan) of the Carnatic Ragam-Tanam-Pallavi improvisatory structure.

TEXT

Radiant
In her abode
Amidst the holy
Goddess Parvati
Ever youthful
Consort of Shiva
Has revealed the supreme form
Mother to their son Guruguha
She is eternal
Pleasure to Shiva

HAPPY, CHEERFUL

05-mAmavatu shrI sarasvati-hindOLam - Sudha Raghunathan



DURATION. 4 minutes 52 seconds

RAAG HINDOLAM Arohana. S G2 M1 D1 N2 Avarohana S' N2 D1 M1 G2 S

The raag is associated with Vasantha Rithu (Spring), and with feelings of freshness and well-being. It is said to have been created from Siva's Taandav (cosmic dance), so it is both vigorous and energetic

TEXT

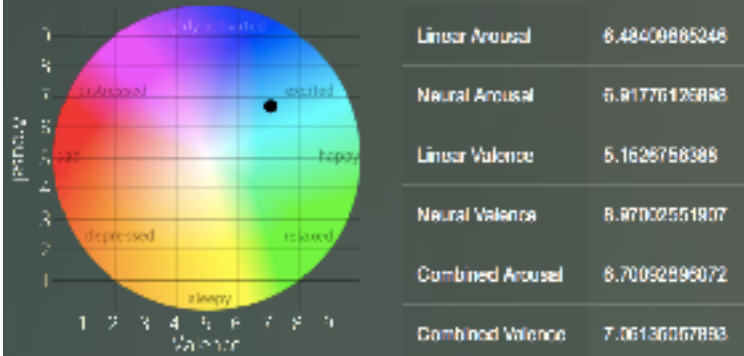
pallavi
mAmavatu shrI sarasvatI
kAmakOti pITHa nivAsinI
anupallavi
kOmala kara sarOja dhRta vINA
slmAtIta vara vAgvibhUshaNA
charaNam
rAjAdhirAja pUjita charaNA rAjIva nayanA ramaNIya vadanA
madhyamakAla sAhityam
sujana manOratha pUraNa chatura nijagala shObhita maNimaya hArA
aja bhava vandita vasudEva charaNARpita sakala Veda sARA

Translation

Protect (ava – root av) me (mAm) Shri Saravati ! The One who lives (nivAsinI) in the seat of Kamakoti. Holding (dhRuta) a Veena in your gentle (kOmala) lotus-like (sarOja) hands (kara), beyond (atIta) limits (slmA), bestower (varada) of beauty (vibhUshana) to speech (vAk). Whose feet (charaNa) are worshipped by (pUjita) kings (rAja) and emperors (adhirAja), with lotus-like (rAjiva) eyes (nayana) and a beautiful (ramaNIya) face (vadana). Swift (chatura) to fulfil (pUraNa) the wishes (manOratha) of the virtuous (sujana), whose own (nija) neck (gala) is adorned by (shobhita) a jewelled (maNimaya) necklace (hArA). Extolled (vandita) by Brahma (aja=unborn) and Shiva (bhava), the essence (sARA) of all (sakala) Vedas, ffered (arpita) to your feet (charaNa) by Vasudeva (name of poet-composer).
Share this:

EXCITED, AROUSED

01-ErA nApai inta-VARNAM-tODi - Sudha Raghunathan



DURATION 7 minutes 14 seconds; play first 5 minutes then fade out

RAAG HANUMATH THODI Arohana. S R1 G1 M1 P D1 N1 S
Avarohana. S N1 D1 P M1 G1 R1 S

Thodi is a morning raag, and sometimes described as “brilliant”, invigorating and capable of lifting a performance to “sublime heights”.

TEXT

Pallavi: Era napai intha chouka seya merakadura ma sami

Anupallavi: Maruni kannu Sree Venkatesa Sukumara nannelu kora sarasuda

Charanam: Dani matalu vini intha sahasa melara

P: Era nApai inta cauka sEya meragAdurA mA sAmi

A: mAruni ganna shri venkatEshA sukumAra nannElukOrA sarasUDa

C: dAni mATalu vini inta sAhasa mElarA

Translation

O! Thou, why is it that you scorn me so much,

It is not respectable, My Lord {p}

Young Sri venkaTESha, Father of cupid, man of good taste, possess me {rule me} {ap}

listening to her words, why are you so rash. {c}