

STUDY OF PANINIAN ALPHABET IN A NEUROLOGICAL PERSPECTIVE – PART I – THE CONSONANTS

Bijoy M Misra

Harvard University and India Discovery Center

Prem S Nagar

Oracle Corporation and India Discovery Center

Bela Kosaras

Harvard Medical School (Retd.)

Jaspal Singh

South Asia Center and India Discovery Center

Hardeep Mann

South Asia Center and India Discovery Center

(with assistance from **Dr. Sheshadri Ramswamy**, MIT, Cambridge)

Paper to XVII World Sanskrit Conference, Vancouver, Canada, July 9-13, 2018.

Address for communication: Bijoy M Misra, 180 Bedford Road, Lincoln.

Email: misra.bijoy@gmail.com, bmisra@fas.harvard.edu

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INTRODUCTION

(A)

- *Rasa* रस conveys the cosmic existence of an object and hence is a property of the object in the ambiance of nature.
- *Rasa's* effect in a subject is *bhāva* भाव , the cognitive response in the brain
- Expression is the biological response to neutralize the effect of *bhāva*
- All expression is muscular, intentional expression is acoustic.

(B)

- *dhātu* धातु (roots) (AsD I.3.1) is a cognitive acoustic unit and it is the etymological basis for creation of words, which are based on cognition
 - *dhātu* is action-oriented that helps define the state “*bhāva* भाव”
 - “*ātmanepadī* आत्मनेपदी” (internal) denotes effect on the agent,
 - “*parasmaipadī* परस्मैपदी” (external) denotes effect on the object.
- We attempt to show evidence that
 - Consonants are the innate response to *bhāva*
 - Vowels are the acoustic translation of the modalities in *bhāva*

(C)

- Goal in this paper is to study the neurological basis of the origin of consonants

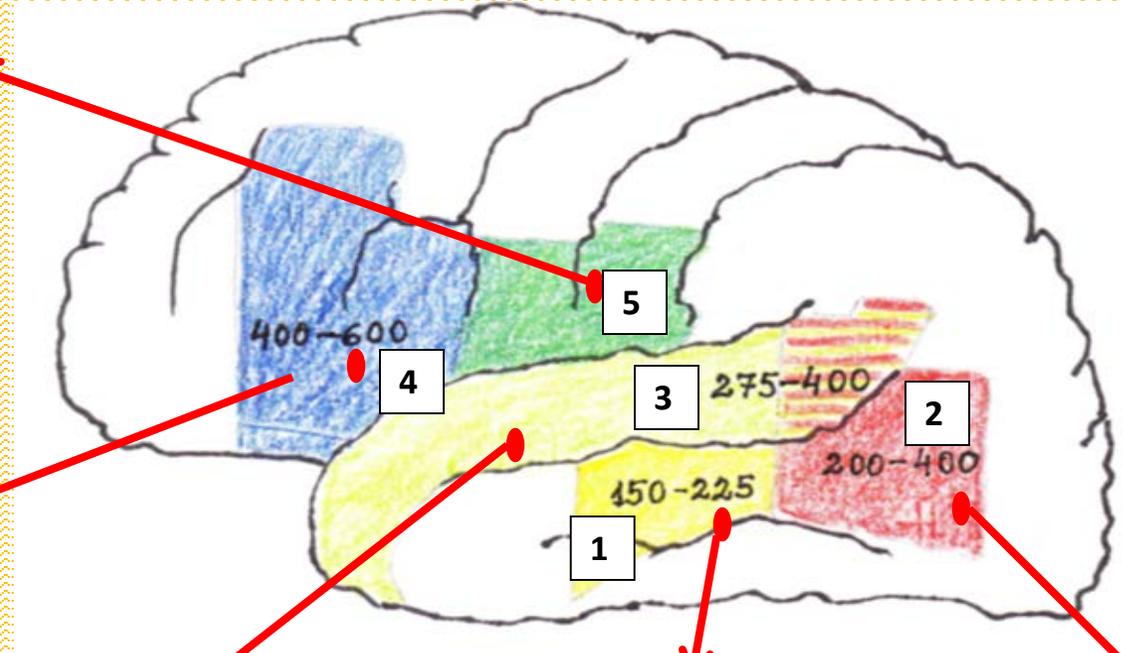
RASA AND LANGUAGE

- **Semantic origin of words (Misra et al 2015)**
 - Words that convey same meaning, irrespective of languages, elicit similar neural response
 - Primitive human settlements developed phonetic expressions based on semantics
 - Cognition of objects and environment point to an innate human signature,
 - Based on anatomical findings (Levelt et al 2004), tried to map stages of speech expression as in Vedas and articulated by Bhartr̥hari (*Vakyapadiya*)
- **Cognitive Memory**
 - An innate characteristic of the human species
 - Imagination and creative thinking achieved through the cognitive memory
 - Residence of the *bhāva* response for stimuli and builds on our accumulated knowledge and intuition
- **Lexical memory**
 - is local
 - is language specific

SYLLABIFICATION AND ARTICULATION

phonetic encoding
articulation
वैखरी

syllabification



self monitoring

lexical selection
from concept
पश्यन्ती

phonological
code retrieval
मध्यमा

| | Brain Area | Activity | Time-Scale | Indian Grammatical Term |
|---|---|------------------------------------|--------------|-------------------------|
| 1 | Middle and inferior temporal gyri | lexical selection from concept | 150-225 msec | पश्यन्ती |
| 2 | Middle temporal gyrus and parieto-occipital gyrus | phonological code retrieval | 200-400 msec | मध्यमा |
| 3 | Superior temporal gyrus | self monitoring | 275-400 msec | |
| 4 | Middle and inferior frontal gyri | syllabification | 400-600 msec | |
| 5 | Pre- and postcentral gyri | phonetic encoding and articulation | 600- msec | वैखरी |

PANINIAN ALPHABET

- Acoustic letters
- Grouping into anatomical sets to simulate sounds
 - Two principal sets are “*ac अच्*” and “*hal हल्*” now identified as vowels and consonants in the literature, (Figure: 3)
 - *hal* grouping is further subdivided into sub-groups called:
 - *sparśa स्पर्श* with twenty-five letters,
 - *antaḥstha अन्तःस्थ* with four letters, and
 - *uṣṇa उष्ण* with four letters,
 - Empirical reasoning establishes that each letter represents an independent sound unit,
 - Panini’s nine letters in *ac अच्* group are expanded to twenty-one letters by expanding their allotropic variations through duration of their utterance
- Panini used the letters as production units and mapped the vedic recitation and the common language to them

PANINIAN ALPHABET

māheśvarīsūtra

| | |
|---------------------|--------------------------------|
| अ इ उ ण्। | ai u ṅ |
| ऋ लृ क्। | r k |
| ए ओ ङ्। | e o ṅ |
| ऐ औ च्। | ai au c |
| ह य व र ढ्। | ha ya va ra ṭ |
| ल ण्। | la ṅ |
| ज म ङ ण न म्। | ña ma ña ṅa na m |
| झ भ ञ्। | jha bha ñ |
| घ ढ ध ष्। | gha ḍha dha ṣ |
| ज ब ग ड द श्। | ja ba ga ḍa da ś |
| ख फ छ ठ थ च ट त व्। | kha pha cha ṭha tha ca ṭa ta v |
| क प य्। | ka pa y |
| श ष स र्। | śa ṣa sa r |
| ह ल्। | ha l |

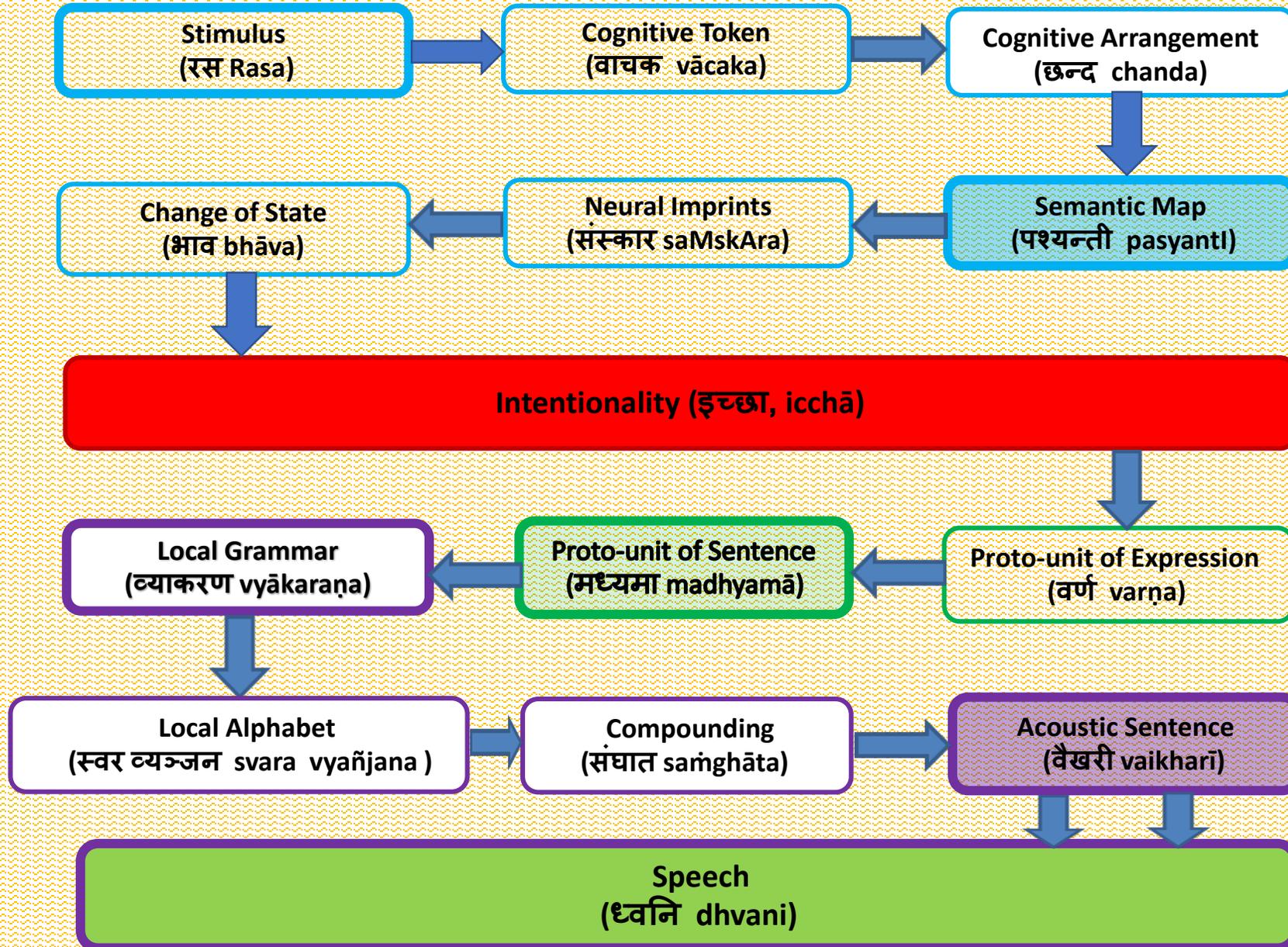
Red – svara - स्वर Violet - antahstha अन्तःस्थ Green - sparśa स्पर्श Dark Green - uṣṇa उष्ण

MODEL OF HUMAN SPEECH

Empirical Assertions and Assumptions

- **Rasa and Cognition**
 - Rasa is the synthetic signal that creates perception
- **Thought and Language:**
 - Thought is a neurological cognitive arrangement
 - Thoughts themselves carry no language
 - Thoughts may not see external expression due to lack of intentionality
 - Language is a limited mechanism to express thoughts
- **Language and Speech**
 - Innately triggered muscle reaction is a biological response
 - Speech is a tool that converts thoughts to acoustic signal
- **Words and Grammar**
 - Words and grammar assist in rendering thoughts
 - Cognitive metaphorical expressions orient communication or produce creative composition

MODEL FLOW FROM RASA TO DHVANI



MEANING IN LANGUAGE

- **Observations from the Sphoṭa theory of Bhartr̥hari**
 - Comprehension is assimilating full signal, *vākya वाक्य* “sentence”
 - Meaningful kernel is in a tacit cognition called *sphoṭa स्फोट*, built into *dhvani sound*
 - Basic cognitive unit in the speech is letter *वर्ण varṇa*
 - A *varṇa* is the proto-expression unit which is expressed as an acoustic syllable
 - A “Sentence” expressed in different voices conveys the same meaning because of inherent *sphoṭa*,
 - Word is a given sequence of letters, together constitute kernel *sphoṭa* and contribute to the total effect

EXPERIMENT WITH THE LANGUAGES

- **Data**

- Chose Sanskrit, Tamil and Hungarian as languages
- Syllables “ka” and “pa” because of availability of words
- Vowel “a” (Sanskrit अ) was chosen to be the simplest of the vowels to reduce distortion
- Tamil and Hungarian are used only as references
- Sanskrit verbs were analyzed

- **Results**

- “ka’ group and “pa” group of verbs are a mix of *parasmaipadī* परस्मैपदी’ and *ātmanepadī* आत्मनेपदी’ type conjugations
- Profusion of *ātmanepadī* types
- “ka” and “pa” verbs appear to exhibit different behavior
 - **Ātmanepadī actions connoted by the “ka” group are more intransitive “self-inflicted” e.g. “I go”**
 - **Ātmanepadī actions connoted by the “pa” types are more transitive “supported action” e.g. “I go using a stick”**

VERBS BEGINNING IN "KA"

| Sanskrit | Meaning | Tamil | Meaning | Hungarian | Meaning |
|----------|---|----------|--------------|------------|----------------------------|
| kak | to wish (A) | kadikka | to bite | kacag | to laugh |
| kakh | to laugh | karka | to study | kacérkodik | to play coquette, to flirt |
| kac | to sound, to bind(A) | katta | to tie | kacsint | to wink at |
| kaṭ | to go, to live in hardship (A) | kaththa | to scream | kalandozik | to adventure, to roam |
| kaṅṭh | to remember, to be anxious(A) | kazhatta | to remove | kap | to get, to obtain |
| kaṅḍ | to separate (P and A) | kalaikka | to dismantle | kapcsol | to connect |
| kaṅ | to cry, to wink (A) | kakka | to throw up | kapál | To hoe, to hack |
| kaṅḍūy | to rub (P and A) | karaikka | to melt | kandikál | to peep |
| katth | to praise | kalakka | to mix | kalapál | to hammer |
| kath | to tell (P and A) | karakka | to milk | kavar | to mix |
| kad | to grieve (A) | | | kaszál | to scythe, to reap |
| kan | to shine | | | kajál | to stuff |
| kam | to desire (A) | | | | |
| kamp | to shake (A) | | | | |
| kamb | to go | | | | |
| karṅ | to pierce (P and A) | | | | |
| kart | To slacken (P and A) | | | | |
| kal | to sound (A); to go (P and A); to throw (P and A) | | | | |
| kav | to praise (A) | | | | |
| kaś | to sound; to punish (A) | | | | |
| kaṣ | to test | | | | |
| kas | to go; to destroy (A) | | | | |

In Sanskrit meaning column, A = ātmanepadī, P = parasmaipadī, default = parasmaipadī

VERBS BEGINNING IN "PA"

| Sanskrit | Meaning | Tamil | Meaning | Hungarian | Meaning |
|-----------------|-----------------------|----------|-------------|-------------|--------------|
| paksh (P and A) | to accept | parakka | to fly | pajzánkodik | to caper |
| pac (P and A) | to cook | padikka | to read | pakol | to pack |
| pañc (P and A) | to make clear | padukka | to lie down | papol | to chatter |
| paṭ (P and A) | to move | parikka | to pluck | palástol | to disguise |
| paṭh | to study | pagukka | to divide | panaszkodik | to complain |
| paṇḍ (A) | to go | paniya | to yield | parancsol | to command |
| paṇ (A) | to bargain, to praise | padhukka | to hide | paskol | to shoe |
| pat | to fall | parappa | to spread | patronál | to patronize |
| path (P and A) | to go, to throw | parimara | to serve | | |
| pad (P and A) | to attain, to go | pazhaga | to befriend | | |
| pan (A) | to praise | | | | |
| panth (P and A) | to go | | | | |
| pay (A) | to move | | | | |
| parN (P and A) | to make green | | | | |
| pard(A) | to break wind | | | | |
| parv | to go, to fill | | | | |
| pal | to move | | | | |
| pash (P and A) | to bind | | | | |
| paS (P and A) | To go | | | | |

In Sanskrit meaning column, A = ātmanepadī, P = parasmaipadī, default = parasmaipadī

ORIGIN OF CONSONANTS – PITCH EXPERIMENT

- **Articulation in Paninian Alphabet**

- Panini's grammar prescribes rule of articulation in *तुल्यास्यप्रयथनं सवर्णम्*
tulyāsyaprayathnam savarṇam

- It classifies stop consonants into five distinct groups depending on the origin of their articulation in the mouth

I. kaṇṭha कण्ठ "throat", *II. tālu तालु* "palate", *III. mūrddhā मूर्द्धा* "head",
IV. dantāḥ दन्ताः "teeth", and *oṣṭhau ओष्ठौ* "lips".

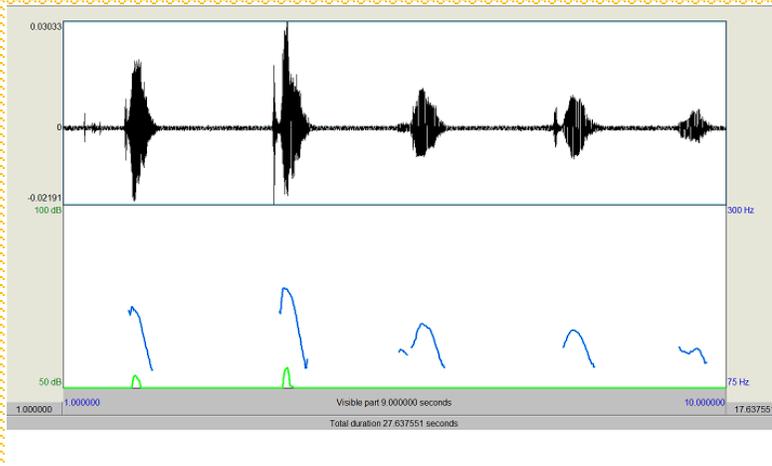
The "nose" *nāsikā नासिका* can supplement in each group to produce a nasal variation

- **Pratt software (Paul Boersma & David Weenink (2018): *Doing phonetics by computer* [Computer program], Netherlands.)**

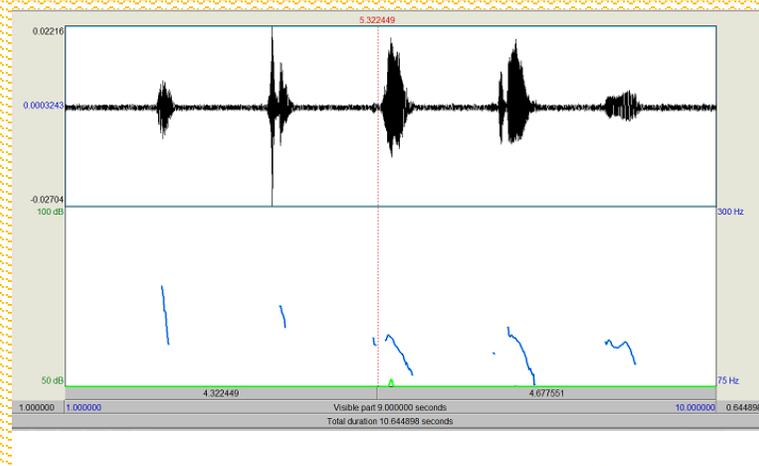
- Public domain software
- Easy-to-use interface
- Well-documented
- Extraction of detailed pitch characteristics is possible
- Formants and frequency can be read out

FREQUENCY PLOTS OF "KA" TO "MA" CONSONANTS

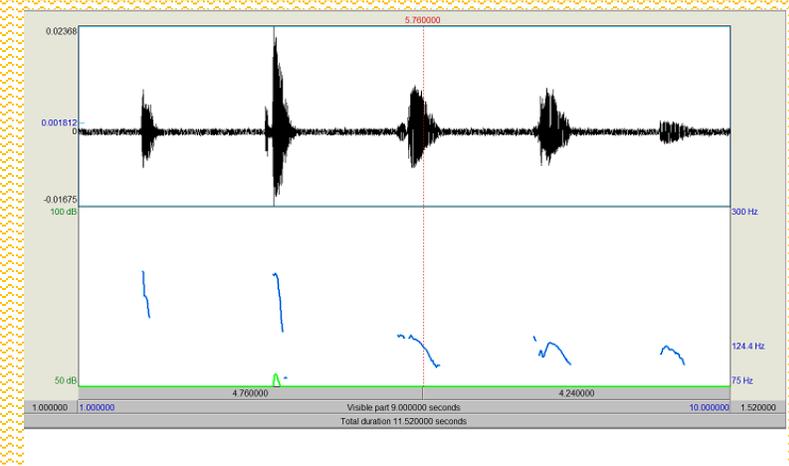
ka group (क ख ग घ ङ)



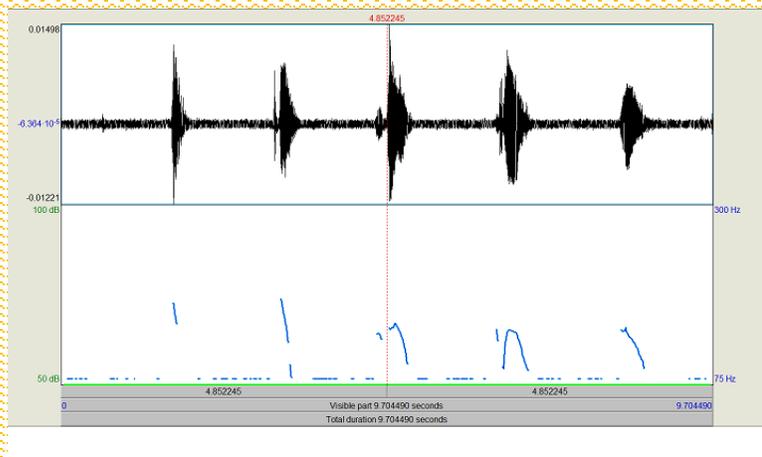
ca group (च छ ज झ ञ)



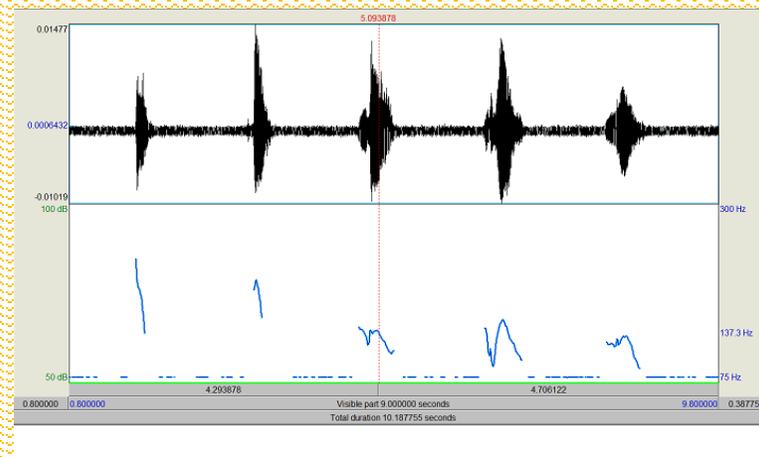
Ta group (ट ठ ड ढ ण)



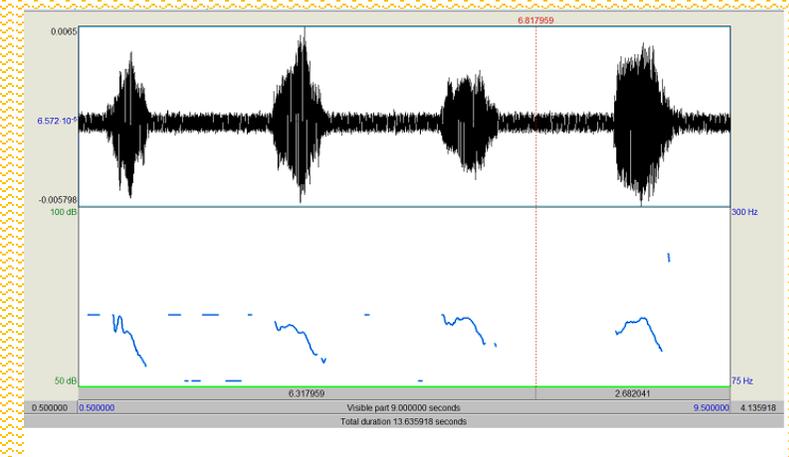
ta group (त थ द ध न)



pa group (प फ ब भ म)

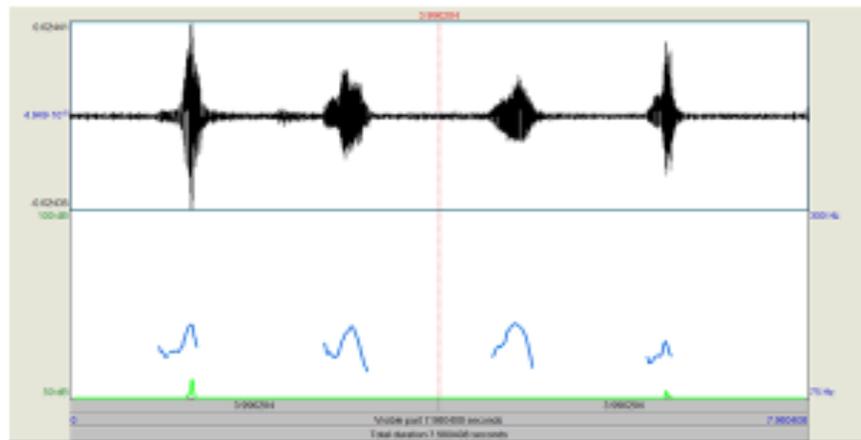


vowel a (अ अ अ अ)

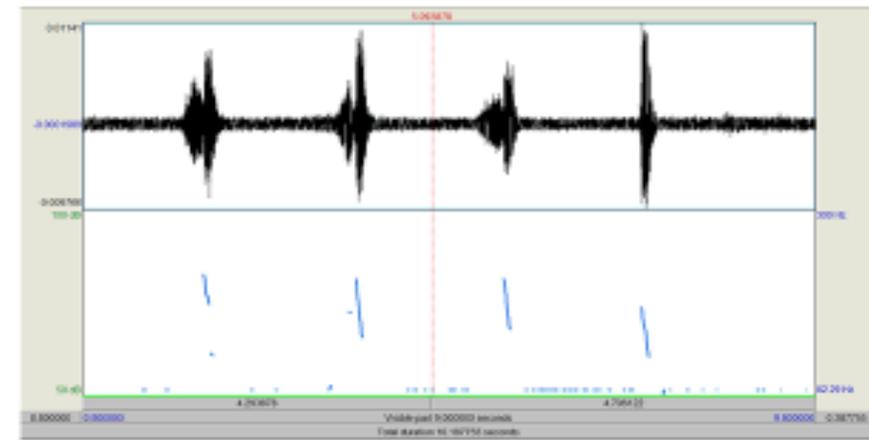


FREQUENCY PLOTS OF “YA” GROUP AND “SHA” GROUP CONSONANTS

ya group (य र ल व)



sha group (श ष स ह)



OBSERVATIONS FROM THE PLOTS

- We ignore the resonance and the higher frequencies through the channel vibration, but only concentrate on the fundamental frequency.

Principal pattern:

- Signature of each consonant is different from each other
- Each characteristically different from the frequency plot of अ
- Nasal consonants are computed to have lowest pitch while the highest comes in प (pa)
- Cerebral consonants exhibit relatively higher vocal cord frequency

General Conclusion

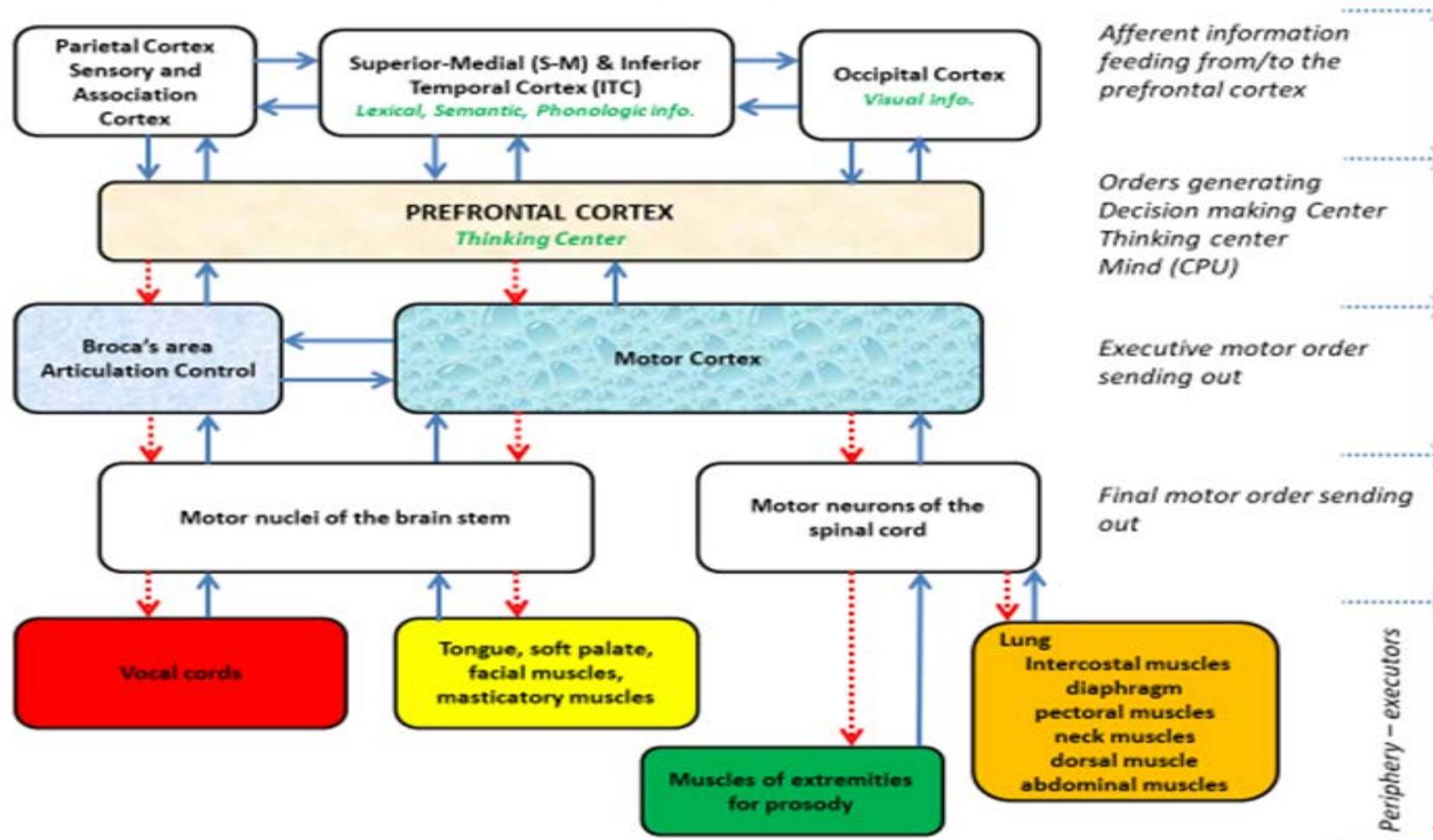
- Consonant carries its frequency at the source of pulmonary function
- We continue to do more quantitative observations and calculations.

NEUROLOGICAL MODEL OF CONSONANT PRODUCTION

- **Our thesis builds on the following three postulates from the neurological point of view:**
 - There is a universal cognitive translation of stimulus to multi-modal proto-speech units
 - Intentionality in the brain helps to convey these units in muscular response and speech expression
 - Cognitive faculty is universal, but the speech is local
- **Decision to express is created in Prefrontal Cortex where proto-unit of expression resides in our model**
 - The proto-unit is transformed by the local grammar in the Broca's area which has capacity to render it as acoustic signal
 - Signal to vocal cords and oral cavity help produce pitch, thus creating the vowels अच् "ac" with intentional time variation
- **Signal to the body muscles is routed via the Motor Cortex**
 - Signal creates necessary breathing through contraction of participating muscles and produces intensity, produces the consonants हल् "hal"
- **In our terminology the consonants carry the "static" information of the original *bhāva* in cognitive unit.**
 - The modalities in the *bhāva* are rendered as prosodic contributions with the signal to throat muscles and extremities.

NEUROANATOMICAL MODEL OF PRODUCTION OF PANINIAN CONSONANTS

Figure 7



Thank You!

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