A Brief Biodata of K. Ramasubramanian

A. Qualifications and Publications

- Prof. Ramasubramanian holds a doctorate in Theoretical Physics from University of Madras. He has also obtained a Bachelors degree in Engineering (AMIE) from Institution of Engineers, Kolkata, and a Masters in Sanskrit from Sri Venkateswara University, Tirupati.
- Prof. Ramasubramanian is one of the authors who prepared the Explanatory Notes of the celebrated work *Ganita-yuktibhasha* (Rationales in Mathematical Astronomy) which brings out the seminal contributions of the Kerala School of astronomers and mathematicians in the field of Mathematical Analysis. This book was published by Hindustan Book Agency (HBA), New Delhi in 2008 in two volumes and has been reprinted by Springer in 2009.
- Besides this Prof. Ramasubramanian has edited the work *500 Years of Tantrasangraha* with Prof. Sriram and Prof. Srinivas published by Indian Institute of Advanced Study, Shimla.
- His work on *Tantrasangraha* has been brought out jointly by HBA and Springer in 2011. Currently he is authoring a couple of Monographs and Textbooks on Indian Astronomy and Mathematics.

B. Awards and Distinctions

- For completing a rigorous course in *Advaita Vedanta* (a 14 semester program) Prof. Ramasubramanian was honored with the coveted title "Vidvat Pravara" by the Shankaracharya of *Sri Sringeri Sharada Peetham* in the year 2003.
- In 2008, he has been conferred the prestigious award of Maharshi Badarayan Vyas Samman by the President of India in recognition of the outstanding research work done by him to the process of synergy between modernity and tradition. The award is given to young scholars of Sanskrit in the age group of 30 to 40 years, who have made a breakthrough in the interdisciplinary studies.
- In 2010, the National Academy of Sciences India, honored him by conferring upon him the R. C. Gupta Endowment Lecture Award.
- He got elected as a Council member of the International Union of History and Philosophy of Science and Technology in the year 2013.
- He is also a Member of the Second Sanskrit Commission formed by by the Ministry of Human Resource Development, Government of India, in the year 2014.
- Presently he is Professor at IIT Bombay in the Cell for Indian Science and Technology in Sanskrit.

The Beauty & Richness of Sanskrit Grammar

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Introduction

Recounting the lineage

Those who learn *Vyākaraṇa* in the traditional style usually commence their study by paying homage to the lineage:

ओम् नमः पाणिनि-कात्यायन-पतञ्जलिभ्यः शब्दविद्या-
सम्प्रदाय-कर्तृभ्यः वंशऋषिभ्यो नमो महद्भ्यो नमो गुरुभ्यः ॥

- पाणिनि – author of the unparalled treatise *Aṣṭādhyāyī*
- कात्यायन – the author of *vṛtti* (a paraphrase statement) made (and usually keyed in with the *sūtra*) after analysing what is stated, what has not been stated and what has been poorly stated.
- पतञ्जलि – the author of renowned *Mahābhāṣya*. This would be filled with short questions, answers, refutations, resolutions, examples and counter-examples.

Introduction

The antiquity of *Vyākaraṇa*

- The antiquity of *Vyākaraṇa* as a separate and important discipline of study can be understood from the following mantra in the *Muṇḍakopaniṣad*:

  द्वे विद्ये वेदितव्ये ...
  तत्र अपरा – ऋग्वेदो, यजुर्वेदः, ...
  शिक्षा कल्पो व्याकरणं ...

- In *Rāmāyaṇa*, Rāma describing the speech of Hanuman to Lakshmana observes:

  नूनं व्याकरणं कृत्स्नं अनेन बहुधा श्रुतम्।
  बहु व्याहरतानेन न किञ्चिदपशब्दितम्॥

  Indeed the entire *Vyākaraṇa* has been thoroughly studied by him. Having spoken for so much, not a single mistake was committed by him.

Introduction

In praise of *Vyākaraṇa*

R. N. Dandekar, a scholar of great repute of the recent times, in his foreword to the edition of *Vākyapadīya* observes:

> If there is any one single branch of knowledge to which the scholars of ancient India have made the most outstanding contributions, it is the science of language. One can hardly discountenance the claim that the linguistic literature, which began with the Vedic S'ikṣā or Phonetics, Vyākaraṇa or Formal Grammar, and Nirukta or Etymology, has a unique place in the intellectual history, not only of India but of the whole world. The *Aṣṭādhyāyī* of Pāṇini, which is easily the most fundamental work on Sanskrit grammar, must, indeed, be regarded as one of the few marvellous productions in the field of scientific literature of the world. Speaking of Pāṇini, the Dutch Indologist, Barend FADDEGON, exclaims with almost lyrical ecstacy : " I adore Pāṇini, because he reveals to us the spirit of India; I adore India because she reveals to us the Spirit, the Spirit. "

Special features of Sanskrit grammar

- No other natural language can claim to have such a completely formulated 'full-fledged' grammar.
- It forms an example (only example?) of what is called a *generative* grammar, in contrast to *descriptive* grammar which most of the other languages of the world have.
- Generative grammars are those, which on the basis of a well-developed lexicon (कोश) and a set of rules (विधि), can generate **all** and **only**[1] the acceptable expressions of a language.
- Whereas, descriptive grammars are those which simply try to describe / state regularities, and do not aim to generate 'all' and 'only' accepted expressions of the language.

[1] Based on some *vārtikas*, we understand that usages of Pāṇini 's time differ from those of the times of Kātyāyana. We must understand such usages as innovations, and not as Pāṇini 's oversight.

Bhartṛhari 's praise of *Vyākaraṇa*

Bhartṛhari, one of the greatest intellectual giants, in his *Vākyapadīya* observes:

आसन्नं ब्रह्मणस्तस्य तपसामुत्तमं तपः।
प्रथमं छन्दसामङ्गं प्राहुर्व्याकरणं बुधाः॥
तद्द्वारमपवर्गस्य वाङ्मलानां चिकित्सनम्।
पवित्रं सर्वविद्यानां अधिविद्यं प्रकाशते॥
इदमाद्यं पदस्थानं सिद्धिसोपानपर्वणाम्।
इयं सा मोक्षमाणानां अजिह्मा रजपद्धतिः॥
यदेकं प्रक्रियाभेदैः बहुधा प्रविभज्यते।
तद्व्याकरणमागम्य परं ब्रह्माधिगम्यते॥ *(VP 1:11,14,16,22)*

. . . Considered foremost among the *Vedāṅgas* by the wise, . . . therapy for getting rid of the blemish in speech . . . For those who want to get liberated here is the Royal road without windings. . . . By resorting to the study of *Vyākaraṇa* that Supreme Brahman is easily gained.

The purpose served by *Vyākaraṇa*

- Right at the beginning of *Vākyapadīya* Bhartrhari explains why *Vyākaraṇa* shines at the top of all other branches knowledge:

  अर्थप्रवृत्तितत्त्वानां शब्दा एव निबन्धनम्।
  तत्त्वावबोधः शब्दानां नास्ति व्याकरणादृते॥
  तद्द्वारमपवर्गस्य वाङ्मलानां चिकित्सनम्।
  पवित्रं सर्वविद्यानां अधिविद्यं प्रकाशते॥ *(VP 1:13–14)*

- The primary purpose of *Vyākaraṇa* is शब्दसाधुत्वज्ञानम् – understanding the right usage of words. Having unambiguously stated this purpose, *Vākyapadīya* also recounts how this body of knowledge (*smṛti*) has been handed down in the tradition meticulously:

  साधुत्वजानविषया सेयं व्यकरास्मृतिः।
  अविच्छेदेन शिष्टानाम् इदं स्मृतिनिबन्धनम्॥ *(VP 1:142)*

The importance of *Vyākaraṇa* in Bhaskara's words

यो वेद वेदवदनं सदनं हि सम्यक्
ब्राह्म्याः स वेदमपि वेद किमन्यशास्त्रम्।
यस्मादतः प्रथममेतदधीत्य धीमान्
शास्त्रान्तरस्य भवति श्रवणेऽधिकारी ॥

यो वेद वेदवदनं सम्यक्	–	the one who knows the face of the Veda (grammar) quite well
सदनं हि ब्राह्म्याः	–	house of *Sarasvatī*
स वेदमपि वेद	–	he will know the Veda itself
किमन्यशास्त्रम्	–	what to speak of other disciplines
प्रथममेतदधीत्य	–	having learnt first
धीमान्	–	a person endowed with intellect
श्रवणेऽधिकारी	–	he is qualified to learn this text

Relation between *Vyākaraṇa* and *vāk*

- Without *śabda* there is no question of discussing शब्दसाधुत्व. Thus *Vyākaraṇa* owes its existence as a discipline to *śabda* .
- The connection between *Vyākaraṇa* and *śabda* or *vāk* is described to be one of उपजीव्य-उपजीवकभाव. In fact, the text *Vākyapadīya* declares:

  अनादिनिधनं ब्रह्म शब्दतत्त्वं यदक्षरम्।
  विवर्ततेऽर्थभावेन प्रक्रिया जगतो यतः॥

- In a similar vein the great poet Daṇḍin proclaims:

  इदमन्धं जगत् कृत्स्नं जायेत भुवनत्रयम्।
  यदि शब्दाह्वयं ज्योतिः आसंसारं न दीप्यते॥...

  If the lamp in the form of *śabda* were not to be illuminating the entire universe consisting of the three worlds would be doomed with darkness.

Personification of $v\bar{a}k$ in the Veda

चत्वारि शृङ्गा त्रयो अस्य पादा द्वे शीर्षे सप्तहस्ता सो अस्य।
त्रिधा बद्धो वृषभो रोरवीति महो देवो मर्त्यान् आविवेश॥

चत्वारि शृङ्गानि	–	चत्वारि पदजातानि नामाख्यात-उपसर्गनिपाताश्च
त्रयो अस्य पादा	–	त्रयः कालाः
द्वे शीर्षे	–	द्वौ शब्दात्मानौ नित्यः कार्यश्च
सप्तहस्ता सो अस्य	–	सप्त विभक्तयः
त्रिधा बद्धः	–	त्रिषु स्थानेषु बद्धः, उरसि कण्ठे शिरसीति
वृषभः	–	वर्षणात् (as the bull showers (fetches) lot of yield when properly employed in the field
महो देवः	–	शब्दः

(महाभाष्यम् 1:17)

The organization and the content of *Aṣṭādhyāyī*

- Besides the content, the mere organization of the text has put many scholars to wonder and puzzlement.
- The content of the material in the 8 chapters has been nicely captured in the following verses:[2]

संज्ञानां परिभाषाणां पूर्वाध्याये प्रदर्शनम्।
समासश्च विभक्त्यर्थः द्वितीयाध्यायगोचरः॥
तृतीये धातुविहितः प्रत्ययः सुव्यवस्थितः।
तुर्यपञ्चमयोरुक्ताः अवशिष्टाश्च ते क्रमात्॥
षष्ठे प्रकृतिकार्याणि प्रायेणादर्शयन् मुनिः।
सप्तमे प्रत्ययस्थानि द्विष्ठानि च यथाक्रमम्।
अष्टमे पूर्वचरणे पदकार्यं समासतः।
यान्यसिद्धानि पूर्वत्र त्रिपाद्यां तान्न्यवेशयत्॥

[2] आषं पणिनीयम् by Hari Shankara Pandeya.

The organization and the content of *Aṣṭādhyāyī*

Typical examples of *sūtras* from Chapter 1

संज्ञानां परिभाषाणां पूर्वाध्याये प्रदर्शनम्।
Technical terms and metarules are introduced in the first chapter.

As many as 64 technical terms and 29 metarules are introduced here, which will be repeatedly used through out *Aṣṭādhyāyī* .[3] For example,

वृद्धिरादैच् – This defines the technical term वृद्धि। In common parlance this term means increase / growth, whereas in *Vyākaraṇa* it refers to the characters (आ, ऐ, औ).

अदेङ्गुणः – This defines the technical term गुण, which as opposed to the common meaning here refers to the 3 characters (अ, ए, ओ).

[3] Few others of lesser utility are defined at other relevant places.

Is there any grammar comparable to $Vyākaraṇa$?

- The answer is a cool NO!
- The sophistication of $Vyākaraṇa$, the admiration it generated, and the influence it had in the European circles, when they got first acquainted with it, has been nicely captured by H. Scharfe in one of the of scholarly volumes brought out in 1970s.[4]

> Acquaintance with the $Pāṇini{\cdot}an$ analysis of root and suffixes and his recognition of *ablaut* (though only indirect via Ch. Wilkin's Sanskrit Grammar) inspired Franz Bopp and others to develop the imposing structure of Indo-European comparative and historical linguistics. The generality of phonetic and morphophonemic rules was rigidly established only in the last decades of the 19th century; at about the same time the notion of "becoming" gave way to that of substitution.

[4] *Grammatical Literature*, Vol. 5, Fasc 2, Otto Harrassowitz, Wiesbaden, 1997, p. 115.

Shift in the attitude: From ridicule $\rightarrow$ respect!

H. Scharfe further observes.[5]

> A purely grammatical description of language and a formalized set of derivational strings are hotly debated issues today. It is a sad observation that we did not learn more from Pāṇini than we did, that we recognized the value and the spirit of his "artificial" and "abstruse" formulations only when we had independently constructed comparable systems. The Indian New Logic ($Navya\text{-}ny\bar{a}ya$) had the same fate: only after the Western mathematicians had developed a formal logic of their own and after this knowledge had reached a few Indologists, did the attitude towards the $Navya\text{-}ny\bar{a}ya$ school change from ridicule to respect.

When can we expect it to happen soon in India?

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[5] *Grammatical Literature*, Vol. 5, Fasc 2, Otto Harrassowitz, Wiesbaden, 1997, p. 115.

What is the contemporary relevance of *Vyākaraṇa* ?

Understanding the science of language

- What is an object (*karma*) of a mental act?

  कर्तुरीप्सिततमं कर्म।
  What is most desired by the doer is the object

- Bhartṛhari further subdivides this 'desired' entity into broadly three types.
  1. that which is to be accomplished (*nirvartyam*)
  2. that which is to be transformed (*vikāryam*)
  3. that which is to be attained (*prāpyam*)
- Of them, *nirvartyaṃ* can further be of two types:
  - अविद्यमानं असत् जायते – Potter makes (completes) the pot (editing the volume).
  - विद्यमानं सत् जन्मना प्रकाश्यते – She rendered the verse (simply the musical note got produced at the *vaikharī* level).

What is the contemporary relevance of *Vyākaraṇa* ?

Type 2, *vikāryaṃ* can also be thought of two types:

नाशरहिता – Without the feeling of being destructed

- Ex. 1: सुवर्णकारेण माला विकृता – The goldsmith transformed the chain into bangles
- Ex. 2: Mother transformed the milk into curd.

नाशसहिता– With the feeling of being destructed

- Ex. 1: हनूमता अशोकवनिका विकृता – The Asokavana was transformed by Hanuman.
- Ex. 2. The highjackers transformed the twintowers into rubble.

How to disambiguate?

- Suppose we may have sentences, in which both निर्वर्त्य and विकार्य appear. For example — मूकं करोति वाचालम्।
- This can be translated in two ways (both equally valid):

  Tr. 1: Makes the mute ($uddeśya$) loquacious.
  Tr. 2: Makes the loquacious ($uddeśya$) mute.

- Which one to take? How do we diambiguate, to convey the desired meaning, which can be either of them ?
- The problem arises because we have free word-order in Sanskrit, and therefore either of them can become $uddeśya$.
- This can be resolved in English either by tagging 'out of' to $uddeśya$, or by tagging 'into' to $vidheya$.
- What to do in Sanskrit? By using अभूततद्भावे च्वि, we can say मूकीकरोति वाचालम्, or the other way round.

The case of *prāpyam*

- Consider the event of myself landing in China. I would describe it simply as – अहं चीनां प्राप्तवान्।
- Since China is not a product that is generated, and hence it is not *nirvartya*. Neither is it *vikārya* for me.[6] It is just a place to be reached *prāpya*.
- Mostly the objects of cognitive attributes fall under this category of *prāpya*. For example

  अहं शताब्दिमहोत्सवं स्मरामि।
  अहं आगामिकैलासयत्रां भावयामि।

- Here the act of recounting, or contemplating on what may happen about the future event, does not make/ alter the event. These cognitive acts just connect with the event, and hence the events are mere *prāpyas*.

[6] For people like Columbus, and Chengis Khan, the place where they land is a *vikārya*!

What is the contemporary relevance of *Vyākaraṇa* ?

- What is an object (*karma*) of a mental act?

  An object of a mental act is that of which the idea is the content of the mental act.

- The idea of 'content' in the above definition is not only unsatisfactory, but quite ambiguous and cloudy. Not clear what's being conveyed.
- What one is looking for is not a mere abstract /clever answer. But, by which one can have some sort of an understanding.
- In fact, this is sort of comparable to what is described in the following verse.

  किमौषधं ज्वरस्य इति पृष्टो यदि वदेत् क्वचित्।
  येनेदं शाम्यति इत्येवं किं तेन कथितं भवेत्॥

- This is because, the 'content' can be the object, or nexus of objects, their relationships etc. of the intended cognition.

Citrabandhas – Verses displaying nice symmetries

- Verses displaying some beautiful and sophisticated symmetries have been composed from earlier times in literature.
- Such verses are called *Citrabandha-padyas*. While there are several varieties of them, we shall now present one variety constructed by the horse movement *turagagati*.
- Here the problem is to construct two (different) verses from the same set of syllables.
- As per the traditional practice, having constructed the first verse, all its syllables are sequentially written in one half of the chess board *Caturaṅga*. The second one is then obtained from the first, by picking up syllables as given by the horse movement.
- The earliest known reference of this kind of composition goes back to the 9th century. Rudraṭa in his work *Kāvyālaṅkāra* demonstrates an example of *turagapadabandha* (tying up the syllables following the steps of a horse).

Citrabandha – Example given by Śrī Vedānta Deśika

- Among the several works of Desika *Pādukāsahasram* is considered to be his Magnum Opus – where one finds a beautiful blend of poetic genius and supreme devotion.
- The skills exhibited by Desika in composing these 1008 verse are simply stupendous. It is nothing short of an inspired work!
- The following verse (929) is presented by Deśika (in *anuṣṭubh* metre), which forms the first of the *turagabandha* pair:

स्थिरागसां सदाराध्या विहताकततामता।
सत्पादुके सरासा मा रङ्गराजपदन्नय॥

That *pādukā* having the potential of putting an end to the sequence of sorrows (*akatata*) as well as the undesirable ends (*amata*), is to be always worshipped by those who are habitual sinners. O sacred, *pādukā*! may you playfully lead me unto the abode of Lord Raṅgarāja.

Citrabandha – Example given by Śrī Vedānta Deśika

स्थिरागसां सदाराध्या विहताकततामता।
सत्पादुके सरासा मा रङ्गराजपदं नय॥

विहताकततामता	–	That $pādukā$ having the potential of putting an end to the sequence of sorrows ($akatata$) as well as the undesirable ends ($amata$)
स्थिरागसां	–	by those who keep committing sins perpetually (by habit)
सदाराध्या	–	is to be worshipped at all times
सत्पादुके	–	O, the sacred Padukas
सरासा	–	playfully
मा	–	me
रङ्गराजपदं	–	unto the abode of Lord Raṅgarāja
नय	–	lead

Citrabandha – Example given by Śrī Vedānta Deśika

The movement of the horse and the verse that gets generated



स्थिता समयराजत्पा गतरा मादके गवि।
दुरंहसां सन्नतादा साध्या तापकरासरा॥

Citrabandha – Example given by Śrī Vedānta Deśika

The verse generated by *turagagati* and its meaning

स्थिता समयराजत्पा गतरा मादके गवि।
दुरंहसां सन्नतादा साध्या तापकरासरा॥

The $vigrahas$ of some of the compounds appearing in the above verse in presented below:

गतरा	–	गतं (नष्टं) राति (प्रापयति)
समयराजत्पा	–	समये (धर्मे) राजन्ते इति समयराजन्तः, तान् पातीति
तापकरासरा	–	तपन्तीति तापकाः, तेभ्यः रासं (आनन्दं) रातीति
दुरंहसां	–	दुःखं अंहः येषां ते (पापभीरवः इत्यर्थः)
सन्नतादा	–	सन्नः (दीनः) तस्य भावः सन्नता, तां द्यति (नाश्यति) इति

Citrabandha – Example given by Śrī Vedānta Deśika

स्थिता समयराजत्पा गतरा मादके गवि।
दुरंहसां सन्नतादा साध्या तापकरासरा॥

समयराजत्पा	–	That [$pādukā$] which protects the people who are unswerwing from Dharma
गतरा	–	(and) that which brings back what has been lost
मादके गवि स्थिता	–	is dwelling in the mersmerising light
तापकरासरा	–	(Similarly) that which brings in bliss to those who engage themselves in penance
सन्नतादा	–	(and) that which destroys the pitiable state
दुरंहसां	–	of those who shy from performing sins
साध्या	–	is to be gained

A note on splitting the Syllables / Sandhis

- In order to obtain the second verse from the first, the first thing that we need to do, is to split the syllables in order to arrange them in the cells of the $caturaṅga$.
- Doubt arises whenever we encounter a conjunct consonant: Should we club "hanging" consonant(s) (without vowel), with the previous syllable or with the succeeding one?
- This cannot be settled "blindly" unless we know the nature of the conjunct consonant, that can arise in two ways:
  - The conjuct consonant that is an integral part of the word — as in the case of the word रङ्ग, and
  - The conjuct consonant that arises because of the $sandhi$ — as appearing in the string पदन्नय.
- For the word रङ्ग, it seems there are two ways of splitting:

रं	ग

or

र	ङ्ग

- Are both forms valid? Or, only either of them?

A note on splitting the Syllables / Sandhis

- The word रङ्ग (appearing in रङ्गराज) can be etymologically derived as: रञ्जयते अस्मिन् = रङ्गः।[7] If one were to do the अलौकिकविग्रह — getting into little more details — we have,

$$
\begin{aligned}
\text{रङ्ग} &= (\text{र} + \text{न्} + \text{ज्}) + \text{घञ्} && (1)\\
&= (\text{र} + \text{न्} + \text{ग्}) + \text{अ} \quad (\text{चजोः कुघिण्ण्यतोः}) && (2)\\
&= (\text{र} + \text{न्}) + \text{ग}\\
&= \text{रं} + \text{ग} \quad (\text{नश्चापदान्तस्य झलि}) && (3)\\
&= \text{रङ्ग} \quad (\text{अनुस्वारस्य ययि परसवर्णः}) && (4)
\end{aligned}
$$

- Though all the above *sandhi* rules are *nitya* rules, they are context-based. Hence, the tranformation of अनुस्वार into ङकार as indicated from (3) → (4), happens because of the presence of 'ग'.

[7] 'हलश्च' इति सूत्रेण अधिकरणार्थे 'घञ्' प्रत्ययः।

A note on spliting the Syllables / Sandhis

- While writing the syllables in the cells of the *caturaṅga*, if the ग were to be separated out, then by the *nyāya* निमित्तापाये नैमित्तिकस्याप्यपायः, the अनुस्वार would remain as it is. Thus the splitting as indicated in 18/15 in slide 5 is perfect — there is nothing wrong as per the rules of grammar!.
- However, it is purely left to the choice of the poet to split the syllables in रङ्ग as | रं | ग | or | र | ङ्ग |
- This is a freedom that in given to the poet as per the accepted norms: (कविसमयसिद्धो नियमः)।. However, it must be noted that, all the cells in slide 5 end with vowels. This is invoilable rule!
- By the same argument, while splitting the syllables in पदन्नय and placing them in the cells it can be done as

  | प | दं | न | य | or | प | द | न्न | य |
- The choice is left to the poet, and is dicated by his convenience!

Is Sanskrit grammar a Context-free-grammar (CFG)?

With simple examples of *sandhi* rules we would like to illustrate why Sanskrit grammar is not a CFG.

Example 1: Suppose we would like to combine the two words

$$\text{एक} + \text{एकम्} \tag{5}$$

Here the last letter of the first word is अ, and the first letter of the second word is ए. As per the rule give by the $sūtra$ वृद्धिरेचि (6.1.88), the two letters would be replaced by the letter ऐ. That is,

$$\text{अ} + \text{ए} = \text{ऐ} \tag{6}$$

Hence (5) becomes,

$$\text{एक्} + \text{ऐ} + \text{कम्} = \text{एकैकम्} \tag{7}$$

Is Sanskrit grammar a Context-free-grammar (CFG)?

Example 2: Suppose we would like to combine the two words

$$\text{प्र} + \text{एजते} \tag{8}$$

As in the previous case (5), here again the last letter of the first word is अ, and the first letter of the second word is ए. Hence, one expects the word in combined form to be प्रैजते. But that's not the case!

Actually, another rule given by the $sūtra$ एङि पररूपम् (6.1.94), comes into operation preventing the above form. Without getting into finer details, it essentially states that if the second word happens to be a 'verb' commencing with ए, then the two letter have to be combined as per the prescription given by this $sūtra$, which may be written as

$$\text{अ} + \text{ए} = \text{ए} \qquad \text{(choose the latter form)} \tag{9}$$

Hence (8) becomes, $\text{प्र्} + \text{ए} + \text{जते} = \text{प्रेजते}$

Some observations

- Several concepts and methods of Pāṇini have inspired similar concepts and methods in Modern Linguistics.
- Sanskrit grammarians have arrived at a very systematic method of analysing the meaning of a given sentence (शाब्दबोध).
- This point was highlighted by Briggs in his paper, and he even argued that the method adopted by Sanskrit grammarians is akin to what is referred to as knowledge representation in AI.
- With sufficient research, I am sure we can discover several novel techniques by seriously contemplating and investigating the concepts, methods and techniques of Indian grammarians.
- How are they relevant to computer science?
- At this point, we can only say that they have great potential—a fact which is proved by the several concepts spawned by the study of Sanskrit grammar by Europeans in 19th and 20th centuries!

How to harness the potential?

- One way to do so, is to initiate a national program for developing all the standard computer applications for processing Indian languages.
  - searching for a string,
  - spell check, grammar check,
  - predictive typing
  - finding synonyms, antonyms, etc.
- These are widely available for English, Chinese, French, German, Russian, or even Spanish, but not for Indian languages.
- Though several texts in various local languages of India (Sanskrit, Tamil, Malayalam, Telugu, Bengali, Marathi, etc.) are available in digital format (thanks to Google!), most of them are scanned versions, and we do not have any text processing facilities!

Concluding remarks

- In my understanding there are three major tasks on which we can work on:
  1. Text processing tools to handle Sanskrit and as other Indian languages.
  2. Digital to voice converter and vice verse that can help people read texts, as well as record in Sanskrit and other regional languages.
  3. Machine translation tools to move from one language to the other.
- It is in 3 that the most systematic structure of grammar ('scientific' if one may call so) that has been created by $Pāṇini$, has been found useful.
- In fact, this is what one means by saying that the Sanskrit or Sanskrit Grammar is 'useful for Computer Science.

Concluding remarks

- Needless to say several brilliant computer scientists have to engage themselves in order to accomplish this task of machine translation.
- But they can't move much forward without the help of grammarians and linguists.
- What is most desirable is a blend of all these in the same individual. To begin with, at least we need to have a group consisting of both these set of people who can understand the language of one another.
- It is high time that we focus our attention in training a large group of scholars who have high competence in modern computer science, Sanskrit grammar and the modern Indian languages—most of which would have their base in Sanskrit.
- In this process of developing expertise, it is possible that we may end up becoming leaders of innovation!

Thanks!

THANK YOU !