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PRATYAYAS IN INDIAN METRICS

Pratyayas in Indian Metrics stand for such devices as determine the various statistical data relating to metrical groups of various categories. They are six in number as follows:

1. *Prastāra* (determination of all permutations and combinations of a given metrical group).
2. *Naṣṭa* (determination of the syllabic sequence in a given serial number of a *prastāra*).
3. *Uddiṣṭa* (determination of the serial number itself on the basis of a given syllabic sequence in a *prastāra*).
4. *Ekadvyādiladgakriyā* (computation of the items of a *prastāra* based on the number of heavy and/or light syllables).
5. *Samkhyāna* {determination of the total number of permutations and combinations (even without the *prastāras*) in a given metrical group}.
6. *Adhvayoga* (the method of spacing in working out *prastāras*).

Let us see for example how the six *pratyayas* work in a tri-syllabic (equisyllabic – *Varṇasamavṛtta*) metrical group called *Madhyā*

1. *Prastāra*

Procedure:

We have to write all heavy syllables in the first line. Then below the first heavy syllable we have to write the light syllable; others on the right side are to be copied as they are in the above line. This procedure is to be followed all throughout until all are converted into light syllables. All light Syllables towards the left in the line are also required to be converted into heavy ones until the stage of “all light” is arrived at.

Thus the *prastāras* of Trisyllabic group would be:-

S.No.	Sequence of Syllables				
1.	—	—	—	magāṇa	Nārī
2.	∪	—	—	yagaṇa	—
3.	—	∪	—	ragaṇa	Mrgī
4.	∪	∪	—	sagaṇa	—
5.	—	—	∪	tagaṇa	—
6.	∪	—	∪	jagaṇa	—
7.	—	∪	∪	bhagaṇa	—
8.	∪	∪	∪	nagaṇa	—

2. *Naṣṭa*

We may be aware of the serial number of a *Prastāra* but its syllabic sequence may have been lost (*naṣṭa*). The serial number itself helps us in restoring the syllabic sequence. If the serial number is even, then the first syllable must be light, heavy otherwise. If the serial number is uneven and so it cannot be halved then it has to be halved after adding one to it. If that half be also uneven, the second syllable too would be heavy, light otherwise. The same procedure is to be continued until the syllabic count of a given syllabic group is over. Thus let us take the serial No. 5 of the trisyllabic group for example.

As this is an uneven number, so the first syllable would be heavy – No. 5 being an uneven number is halved after adding one ($5+1=6\div2=3$) to it. So No... 3 being also an uneven number, the second syllable too is heavy. Again No. 3 is to be halved after adding one to it ($3+1\div2=2$). No. 2 being an even number, the third syllable would be light. So the *Naṣṭa* of the serial No. 5 of a Trisyllabic group would be -- ◡.

3. *Uddiṣṭa*

If we have the syllabic sequence of a given serial number of a *prastāra* but we have to locate the serial number (*Uddiṣṭa*) itself, we have to apply the principle of “successive doubling and additions.” We have to write the Syllabic sequence as such. We have then to write 1 above the first syllable, two above the second one, four above the third one and go on doubling the number until we reach the last limit of a given syllabic group. Then all the numbers, written above “light syllables only” are to be counted and then ‘another one’ added to it. That would be the (*Uddiṣṭa*) serial number of that syllabic sequence in a given syllabic group. So the serial no. of the following sequence of a trisyllabic group is worked out as 5:

$$\begin{array}{ccc} 1 & 2 & (4) \\ - & - & \text{◡} \end{array} \quad 4 + 1 = 5$$

4. *Ekadvyādilagakriyā*

This *pratyaya* gives us the statistical data about the number of metres in a given syllabic group, classified according to the number of heavy and/or light syllables. If we have to work out such statistical data about the trisyllabic group, we have to have four columns (i.e. one extra column) each, both horizontal and perpendicular, with No. 1 written in all the four columns (left to right and top to bottom) as follows:

1	1	1	1
1	2	3	
1	3		
1			

Then we have to write below the numbers one to three (i.e. all the numbers of the given syllabic group). We have to fill in the gaps of all the succeeding columns, here just one column below 2) by writing the number(s) representing the sum total of the number towards the left and the diagonal number(s) above (here $1+2=3$). We have to continue this process until all the columns but one are filled in (here it is the fourth column from the top). So on the basis of the above exercise, the following would be the statistical data of the metres in a trisyllabic group

- 1 metre with all (3) heavy syllables.
- 3 metres with 2 heavy and 1 light syllable.
- 3 metres with one heavy and two light syllables.
- 1 metre with all light syllables.

5. *Samkhyāna*

This *pratyaya* represents a device to determine the total number of metres in a given syllabic group even without working out all its *prastāras* (permutations and combinations). The procedure is very simple. Write the first well known line of the *prastāra* of a given syllabic group. As we did for *uddiṣṭa* let us apply the principle of successive doubling and addition. Count all the numbers placed above the syllables and then add One to it. That would be the total number of metres in a given metrical group. Note that while in *Uddiṣṭa* we have to count the numbers placed above the light syllables only, here we have to count every number.

Thus the total number of metres in a Trisyllabic group can be worked out as under :

$$\begin{array}{r} 1 \quad 2 \quad 4 \quad 1 + 2 + 4 = 7 + 1 = 8 \\ - \quad - \quad - \end{array}$$

The same total number can be arrived at by counting all the *Ekadvyādilagakriyā* numbers together.

6. *Adhvayoga* or *Meru*

Prastāra being the most significant *pratyaya* we have to have proper spacing under each line, so as to facilitate rectification of possible mistakes in a given line and also to work out *Naṣṭa* and *Uddiṣṭa*. So the *Adhvayoga* of a Trisyllabic *prastāra* would be 15, as shown below:-

- 1.
- 1a.
- 2.
- 2a.
- 3.
- 3a.
- 4.
- 4a.
- 5.
- 5a.
- 6.
- 6a.
- 7.
- 7a.
- 8.

Illustrative *pratyayas* of the six-syllabic group (*Gāyatrī*) of metres are also appended for clarity and rechecking.

7. Its interesting to note that metricians follow the above pattern of *prastāras*, even while giving the details of the *gaṇas* of *Vārṇika* metres. The following aphorisms of Piṅgalanāga are quite relevant from an illustrative point of view:

1.	धी श्री स्त्रिम्	<i>dhīśrīstrīm</i>	<i>magāṇa</i>	-	-	-
2.	व रा स्त्र य्	<i>varāsāy</i>	<i>yagāṇa</i>	∪	-	-
3.	क गुह्यर	<i>kāguhār</i>	<i>ragāṇa</i>	-	∪	-
4.	वसुधा च्	<i>vasudhās</i>	<i>sagāṇa</i>	∪	∪	-
5.	सा ते ङत्	<i>sātekvat</i>	<i>tagāṇa</i>	-	-	∪
6.	क वा स ज्	<i>kadāsaj</i>	<i>jagāṇa</i>	∪	-	∪
7.	किं व द भ्	<i>kimvadabh</i>	<i>bhagāṇa</i>	-	∪	∪
8.	न हस न्	<i>nahasan</i>	<i>nagāṇa</i>	∪	∪	∪

Cf. *Vṛttaratnākara*

myarastajabhagnagairlantair ebhir daśabhir akṣaraiḥ
Samastain vānmayam vyāptain
trailokyam iva viṣṇunā // 1.6

The illustrations provided in this paper, all relate to the equi-syllabic *vārṇika* (*varṇasamavṛtta*) group of metres. It is perhaps more convenient to work out the various *pratyayas* for these metrical groups. The maximum count of *prastāras* of the highest 26-syllabic (*utkr̥ti*) group of *varṇasamavṛtta* metres is worked out at 67108864 (vide Ch. 3, *Vṛttaratnākara*).

The formulas for working out these *pratyayas* given by Piṅgalanāga or other succeeding metricians like Vedarabhaṭṭa are simple enough.

For a modern computer scientist the whole of the *pratyayic* procedure may appear to be obsolete and out dated. But what is more important is that we may try to identify the basic logic behind the various formulas mentioned above which are so infallibly and miraculously accurate.

In fact on the basis of a deep study into these *pratyayas*, my esteemed friend and colleague, Prof. B. Van Nooten in his paper enti-

tled Binary Numbers in Indian Antiquity remarks: "I have found good reason, to believe that the rudiments of binary calculation were discovered in India well in advance of their discovery by the German Philosopher Cottfried Leibnitz in 1695."

Notes :

1. Prastāro naṣtamuddiṣṭam ekadvyādilagakriyā
samkhyānam adhva yogaś ca ṣaḍ ete pratyayāḥ smṛtāḥ
Vṛttaratnākara 6. 1
2. Pāde Sarvagurāvādyāl laghuṁ nyasya guror adhaḥ
Yathoparitatha s'eṣain bhūyaḥ Kuryād amuin vidhim
Ūne dadyād gurūn eva yāvat sarvalaghur bhavet
prastāroyain samākhyataś chandovicitivedibhiḥ
id 2-3
3. naṣṭasya yo bhaved aṅkas tasyā'rdhe'rdhe same ca laḥ
viṣame cai kamādhāya tasyā'rdhe'rdhe gurur bhavet
id 4
4. Uddiṣṭain dviguṇan ādyān upary aṅkan samālikhet
laghustha ye tu tatraṅkāś taiḥ saikair miśrito bhavet
id 5
5. Varṇān pṛthagbhavān saikān auttaradharyataḥ sthitān
ekādikramataś caitān upary upari niḥṣipet
upāntyato nivarteta tyajann ekaikam ūrdhvataḥ
uparyādyad guror evam ekadvyadilagakriyā //
id 6-7
6. Lagakriyāṅkasandohe bhavet samkhyā viniśrite
uddiṣṭāṅkasamāhāraḥ saiko vā janayed imām
id. 8
7. Samkhyai va dvigunai'konā sadbhiradhvā prakīrtitaḥ
Vṛttasyā'ṅgulikī vyāptir adhaḥ kuryāt tathā'ṅgulim
id 9
Cf *Chandaḥśāstra* 8.20-35

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Appendix

Illustrative *Pratyayas* of the *Gayatrī* (six-syllabic) group of metres.

1. *Prastāras*

1.	-	-	-	-	-	-	33.	-	-	-	-	-	∪
2.	∪	-	-	-	-	-	34.	∪	-	-	-	-	∪
3.	-	∪	-	-	-	-	35.	-	∪	-	-	-	∪
4.	∪	∪	-	-	-	-	36.	∪	∪	-	-	-	∪
5.	-	-	∪	-	-	-	37.	-	-	∪	-	-	∪
6.	∪	-	∪	-	-	-	38.	∪	-	∪	-	-	∪
7.	-	∪	∪	-	-	-	39.	-	∪	∪	-	-	∪
8.	∪	∪	∪	-	-	-	40.	∪	∪	∪	-	-	∪
9.	-	-	-	∪	-	-	41.	-	-	-	∪	-	∪
10.	∪	-	-	∪	-	-	42.	∪	-	-	∪	-	∪
11.	-	∪	-	∪	-	-	43.	-	∪	-	∪	-	∪
12.	∪	∪	-	∪	-	-	44.	∪	∪	-	∪	-	∪
13.	-	-	∪	∪	-	-	45.	-	-	∪	∪	-	∪
14.	∪	-	∪	∪	-	-	46.	∪	-	∪	∪	-	∪
15.	-	∪	∪	∪	-	-	47.	-	∪	∪	∪	-	∪
16.	∪	∪	∪	∪	-	-	48.	∪	∪	∪	∪	-	∪
17.	-	-	-	-	∪	-	49.	-	-	-	-	∪	∪
18.	∪	-	-	-	∪	-	50.	∪	-	-	-	∪	∪
19.	-	∪	-	-	∪	-	51.	-	∪	-	-	∪	∪
20.	∪	∪	-	-	∪	-	52.	∪	∪	-	-	∪	∪
21.	-	-	∪	-	∪	-	53.	-	-	∪	-	∪	∪
22.	∪	-	∪	-	∪	-	54.	∪	-	∪	-	∪	∪
23.	-	∪	∪	-	∪	-	55.	-	∪	∪	-	∪	∪
24.	∪	∪	∪	-	∪	-	56.	∪	∪	∪	-	∪	∪
25.	-	-	-	∪	∪	-	57.	-	-	-	∪	∪	∪
26.	∪	-	-	∪	∪	-	58.	∪	-	-	∪	∪	∪
27.	-	∪	-	∪	∪	-	59.	-	∪	-	∪	∪	∪
28.	∪	∪	-	∪	∪	-	60.	∪	∪	-	∪	∪	∪
29.	-	-	∪	∪	∪	-	61.	-	-	∪	∪	∪	∪
30.	∪	-	∪	∪	∪	-	62.	∪	-	∪	∪	∪	∪
31.	-	∪	∪	∪	∪	-	63.	-	∪	∪	∪	∪	∪
32.	∪	∪	∪	∪	∪	-	64.	∪	∪	∪	∪	∪	∪

2. *Illustrative Naṣṭas (syllabic sequencies) of S.No. 51 and 58 of gāyatrī group.*

S.No. 51

- i) 51 being an uneven number, first syllable: –
 ii) $51 + 1 = 52 \div 2 = 26$ being an even number, second syllable: ∪
 iii) $26 \div 2 = 13$ being an uneven number, third syllable: –
 iv) $13 + 1 = 14 \div 2 = 7$ being an uneven number, fourth syllable: –
 v) $7 + 1 = 8 \div 2 = 4$ being an even number, fifth syllable: ∪
 vi) $4 \div 2 = 2$ being an even number, sixth syllable: ∪
 So S.No. 51 – ∪ – – ∪ ∪

S.No. 58

- i) 58 being an even number, first syllable: ∪
 ii) $58 \div 2 = 29$ being an uneven number, second syllable: –
 iii) $29 + 1 = 30 \div 2 = 15$ being an uneven number, third syllable: –
 iv) $15 + 1 = 16 \div 2 = 8$ being an even number, fourth syllable: ∪
 v) $8 \div 2 = 4$ being an even number, fifth syllable: ∪
 vi) $4 \div 2 = 2$ being an even number, sixth syllable: ∪
 So S.No. 58 ∪ – – ∪ ∪ ∪

3. *Illustrative uddiṣṭas (Serial numbers) of six-syllabic metres with syllabic sequences.*

i) – – – – ∪ ∪

and

ii) – ∪ – ∪ ∪ ∪

i) 1 2 4 8 16 32

– – – – ∪ ∪

$16 + 32 + 1 = \text{S.No. } 49$

ii) 1 2 4 8 16 32

– ∪ – ∪ ∪ ∪

$2 + 8 + 16 + 32 + 1 = \text{S.No. } 59$

4. *Ekadvyādīlagakriyā* - classification of all six-syllabic metre according to the number of heavy and/or light syllabic

1	1	1	1	1	1	1
1	2	3	4	5	6	
1	3	6	10	15		
1	4	10	20			
1	5	15				
1	6					
1						

So

- 1 metre with all six heavy syllables
 6 metres with 5 heavy and 1 light syllable
 15 metres with 4 heavy and 2 light syllables
 20 metres with 3 heavy and 3 light syllables
 15 metres with 2 heavy and 4 light syllables
 6 metres with 1 heavy and 5 light syllables
 1 metre with all six light syllables

5. *Samkhyāna* - computation of the total number of metres in *Gāyatrī* (six syllabic) group of metres even without *prastāras*

syllables: 1 2 4 8 16 32
 (i) (ii) (iii) (iv) (v) (vi)

$$1 + 2 + 4 + 8 + 16 + 32 + 1 = 64$$

The same total number is arrived at by adding all the *Ekadvyādīlagakriyā* number

$$1 + 6 + 15 + 20 + 15 + 6 + 1 = 64$$

6. *Adhvayoga*

The total number of Prastāras of six-syllabic metres being 64, the total space coverage (*adhvayoga*) is:

$$64 \times 2 - 1 = 127$$

1

1a

2

2a

3

3a

4

4a

and so on. The double spacing will continue till 63a. There will be no double spacing for the last number, i.e. 64.