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Grammars of all Indian languages on the lines of *Pânini*, they will certainly help not only the machine-man interaction, but also help to understand the peculiarities of those languages.

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PRINCIPLES OF MÎMÂMSÂ FOR
NATURAL LANGUAGE PROCESSING

P. Ramanujan

Introduction :

The *Mîmâmsâśâstra* is variously described as the science of knowledge (or Epistemology), study of Vedic text interpretation, Science of Sentence and Science of Instruments of Knowledge. However, it has not received the attention it richly deserves probably due to the difficulty in mastering Vedic texts and rituals which is considered a pre-requisite for its study and the complex structure of Vedic passages. Nevertheless, it is such a veritable treasure-house of basic ideas and principles, most notably, common-sense-related ones, that it will be immensely beneficial in devising suitable heuristic rule-base at Discourse level of Natural Language Processing (NLP).

Having claimed this, we should also objectively look into the contents of the *śâstra* for ways and means of understanding, assimilating and then adapting its tenets in Natural Language Processing. In this direction, a small step taken by C-DAC, working in its DESIKA package, is presented here. The fundamental details are only mentioned here, while a detailed discussion would have to await our progressing a lot more in this direction. If interest and receptivity on the topic is aroused by this paper, it would have served its purpose.

Mîmâmsâśâstra

All the branches of Oriental learning have Vedic texts as their foundation. Knowledge relating to the four-fold objectives of morality, material gain, worldly desire and spiritual liberation is contained in the whole of Vedic literature. The whole mass of vedic text was classified into four vedas with numerous

branches in each, by sage *Vyâsa*. He also propagated these Vedas with a detailed set of *Sâstras* to aid in their understanding. The Vedic texts are in poetic, prose and mixed forms in their different sections like *Samhita, Brâhmana, Upanisads* etc. The branch of *Mîmâmsâ* is meant to devise means of analyzing and interpreting vedic texts/passages with a view to bring out their tenets, specifically, *Dharma* (which of course, defies proper translation in English). The word *Mîmâmsâ*, per se, means 'sacred discussion (about a sacred subject)'.

Jaimini took up the task of providing the necessary methodology for interpretating Vedic text in their application domain which is mainly sacrifices. In this task, the *Kalpasûtras* which are one of the Vedic auxiliaries and *Dharmasâstras* (which is another supplementary science like *Mîmâmsa*) are also closely related. The applications specified by Kalpa Sûtras are arrived at on the basis of the generic principles established in *Mîmâmsa*. We also find the criteria involved in such a determination explicitly mentioned. We here outline the contents of one typical branch of Vedas, the तैत्तिरीयशाखा (*taittirîyasâkha*) of कृष्णयजुर्वेद (*krsnayajurveda*) which is the principal text discussed in great detail in *Mîmâmsâsûtras*.

कृष्णयजुर्वेदः (*krsnayajurveda*)

The text is divided into five sections काण्डाः (*kândâh*) called प्राजापत्य, (*prâjâpatya*), सौम्य (*saumya*), आग्नेय (*âgneya*), वैश्वदेव (*vaisvadeva*) and स्वायम्भुव, (*swâyambhuva*) with hymns pertaining to the deities प्रजापति (*prajâpati*), सोम (*soma*), अग्नि (*agni*), विश्वेदेव (*visvedeva*) and स्वयम्भु (*swayambhu*) respectively.

The various sacrifices covered under these sections as follows :

प्राजापत्यकाण्ड (*prâjâpatyakânda*) – पौरोडाशिक (*paurodâsika*), याजमान (*yâjamâna*), होत (*hota*), होत्र (*hautra*), पितृमेध (*pitrmedha*) with ब्राह्मण (*brâhmana*) and अनुब्राह्मण (*anubrâhmana*) ।

सौम्यकाण्ड (*saumyakânda*) – आध्वर्यव (*âdhvaryava*), ग्रह (*graha*), दाक्षिण (*dâksina*), समिष्टयजुस् (*samistayajus*), अवभृथयजुस् (*avabhrtayajus*), वाजपेय (*vâjapeya*), शुक्रिय (*sukriya*) and सव (*sava*) with ब्राह्मण (*brâhmana*) and अनुब्राह्मण (*anubrâhmana*) ।

आग्नेयकाण्ड (*âgneyakânda*) – अग्न्याधेय (*agnyâdheya*), अग्निहोत्र (*agnihotra*), अग्न्युपस्थान (*agnyupasthâna*), अग्निचयन (*agnicayana*), सावित्र (*sâvitra*), नाचिकेत (*nâciketa*), चातुर्होत्रिय (*caturhotriya*), वैश्वसृज (*vaiśvasrja*), आरुण (*âruna*) with ब्राह्मण (*brâhmana*) and अनुब्राह्मण (*anubrâhmana*) ।

वैश्वदेवकाण्ड (*vaiśvadevakânda*) – राजसूय (*râjasûya*), पशुबन्ध (*paśubandha*), इष्टि (*isti*), नक्षत्रेष्टि (*naksatresti*), दिवश्श्येनी (*divaśśyenî*), अपाघा (*apâghâ*), सात्रायण (*sâtrâyana*), उपहोम (*upahoma*), कौलिकी (*kaulikî*), सूक्त (*sûkta*), उपानुवाक्य (*upânuvâkya*), याज्य (*yâjyâ*), अश्वमेध (*aśvamedha*), पुरुषमेध (*purusamedha*), सौत्रामणी (*sautrâmanî*), अच्छिद्र (*acchidra*), पशुहौत्र (*paśuhautra*), उपनिषद् (*upanisad*) with ब्राह्मण (*brâhmana*) and अनुब्राह्मण (*anubrâhmana*) ।

स्वायंभुवकाण्ड (*svâyambhuvakânda*) – काठकविधि (*kâthakavidhi*) (स्वाध्याय ब्राह्मण) (*svâdhyâyabrâhmana*).

One peculiarity of कृष्णयजुर्वेद (*krsnayajurveda*) is that the मन्त्र (hymns) and ब्राह्मण (their explanatory parts) are thoroughly interspersed in a mass of संहिता (*samhita*) and ब्राह्मण (*brâhmana*) text having in all eighty प्रश्न / प्रपाठक (chapters) and about 1234 अनुवाक (paragraphs). To seperate them into the above topics is the main aim of the discourse analysis which should also establish unique coherence of the topic.

Mîmâmsâsûtras of *Jaimini*

To address the problem of Vedic text interpretation Jaimini devised मीमांसासूत्र (*mîmâmsâsûtras*). The *sûtras* try to (1) assign various functional roles to various sentences, (2) disambiguate word and sentence meaning in terms of context and commonsense reasoning and (3) fixes the correct sacrifice to which the sentence belongs and also the position in it.

Functional Classification

The discussion however, presumes another classification of Vedic text i.e. functional classification. We present an overview here.

The functional classification of the vedic text is done in order to arrive at the details of the various principal, subordinate, coordinate or supplementary acts, their sequence, filling elipses, extensions and modifications while applying the प्रकृति (model) sacrifice details to the विकृति (evolute) sacrifices.

The functional classes of vedic text arrived at are विधि (injunctions), मन्त्र (hymns) नामधेय (technical terms), निषेध (prohibitions) and अर्थवाद (illustrations) types. Of these the important ones are injunctions in our context. Injunctions are also further classified into उत्पत्तिविधि *(utpattividhi)*, विनियोगविधि *(viniyogavidhi)* and अधिकारविधि *(adhikâravidhi)*. विनियोगविधि *(viniyogavidhi)* further has अपूर्व (applications) गुण (accessories) विशिष्ट (composite) forms.

With the help of मीमांसा *(mîmâmsa)* we arrange the various parts of the vedic text in order of the objective (typically of the sacrifice or topic under discussion), the characteristic and a complete sequence of all activities involved in detail pertaining to each topic for the entire vedic text.

Contents and Arrangement

The tenets of *mîmâmsâ* are crisply contained in the aphorisms of sage Jaimini. There are 2,617 *sûtras* (aphorisms), in 12 chapters, 60 quarters and 907 topics or sections. The subject matter dealt in these are respectively, (chapterwise) : Sources of knowledge, Distinction among rituals, Auxiliary or dependent rituals, Purpose / utility, Sequence or order, Authority, General Extension, Special Extension, Extrapolation/ guessing, its Exceptions, Commonality and Incidence (or universality).

The topics dealt with, quarterwise, are:

Chapter 1 : Characteristic definition of sources of knowledge, discussion regarding prescribed rule, laudatory (illustrative) texts, prayers and remembrances (or recollection).

Chapter 2 : Rituals are said to differ due to six factors like use of a different word (verb), repetition, number, character or type, method and name. Introduction, the six factors, their exceptions and differences of application are discussed.

Chapter 3 : Dependence is discussed with its definition, characteristics and reasons in eight quarters. The direct scriptual text, indicatory mark (as a means of proof), sentence etc., discord, occurrence, isolated statements, multiple dependency and rituals of the agent (in a sacrifice) are dealt with.

Chapter 4 : Purpose of the various rituals as the instruments of pleasure and otherwise are discussed. Main benefactor, secondary benefactor, utility aspects and lower order auxiliaries are described.

Chapter 5 : Sequence rules are discussed. The six types of sequences based on scriptural text order, meaning, prose order, invocation, section and main orders, their special cases, extension or otherwise and relative strengths or weightages of text etc., are dealt with.

Chapter 6 : Authority to perform rituals is described here. Determination of authorised agents, their qualities, determination of substitutes, privation or exemption of activities, sacrificial discipline, offering and sacred fire aspects are dealt with in the eight quarters.

Chapter 7 : Extended applications are discussed in general. Extension by express instruction, its subordinates, extension by name and indicatory marks are dealt.

Chapter 8 : Special cases of extended applications are discussed under the headings of extension by clear indications, unclear indications, strong indications and their exceptions.

Chapter 9 : The procedure for extending applications is discussed. Extrapolation and guessing issues, extrapolation in Sâma hymns with details, guessing in prayers with details and incident aspects are dealt with.

Chapter 10 : Treats exceptions to extrapolation. Impossibility (chancelessness), its detail, unary frequency of rituals, specialities, certain sacrificial components, sacrificial discussions, miscellaneous topics and negation issues are discussed.

Chapter 11 : Commonality of certain rituals is discussed. Activities required to be performed once (commonly) for many different rituals, activities to be repeated for different rituals and the details of these two types are dealt with.

Chapter 12 : Incidental nature of certain activities are discussed here. Specific cases, exceptions, uses etc. are dealt with.

Each quarter is further divided into अधिकरण (sections or topics) each dealing with a particular point containing one or more aphorisms. On any particular issue, the reason for a doubt to arise, the prime facie view, its logical untenability, proper reasoning and final conclusion are enumerated. Besides, the utility and connection with other topics are also indicated. The underlying principle or maxim of each topic is called a *nyâya*. Hence, *Mîmâmsâ* contains 907 *nyâyas*, as there are so many sections. The *nyâyas* are mainly meant for vedic text, but some of them are also applicable to general situations.

A few examples of abstracted *Mîmâmsâ nyâyas*

Listed below are the abstractions of the discussions in few illustrative sections in *mîmâmsâ* which finally present an outcome which is language independent and is applicable to discourse analysis in general. These happen to be the possible situations of ambiguity or conflicts between segments of a discourse (inter and intra).

(1) We take a situation where we need to map words against expected functional roles. There can be three types of expectancies in a sentence pertaining to the object, accessories and the manner. We need to relate as many words as that are present against the proper expectancies. Here, we are concerned with proximity as well compatibility. In a typical case where we get different words to take on the same functional roles by proximity and compatibility criteria individually, we need a solution as to which of them has to have priority and under what conditions. Proximity requires the nearest words getting connected to the expectancies in order. Compatibility would allow us to forgo proximity, if necessary in such a case, we take compatibility

as the stronger criterion to ensure meaningfulness rather than immediate cognition. This has to be ensured for all the words of the sentence.

(1-a) For a given word to function as an objective it should be in the form of happineess (or a mental state). This is not the case with activities. Hence an activity cannot be an objective. Thus, the activity can only be an accessory.

(2) In cases where words could denote names as well as certain qualities or attributes, we need a principle to decide which of them is to be taken. It may also be possible to posit multiple denotations for words. In such cases, we assign multiple functional roles simultaneously if they are compatible. The factors involved in this compatibility check are the consideration of the attributes of the concerned word in terms of the dual triplets i.e., being intended, being cited and primary as the first triplet and being performed, being directed and secondary nature as the second triplet. Sentence splitting also has to be avoided.

(3) In situations where a subset of sentences (discourse segment) denotes attributes different from the main set (discourse) then we assign certain special relationships (typically substrate) which will ensure that the main objective or accessories are given prominence while still connecting the current sentence meaning in the discourse. These are conceptual relations which are guided by the analysis of the dual triplets and sentence splitting criteria applied to the words of the sentence. These sentences are describing the manner or paraphernelia required for the main function and hence do not have the ability to alter it.

(4) When attributes like number, gender, etc. are used in generic injunctions the fact whether these features are specifically or generally intended is to be decided based on whether it is the original direction or is a citation. If in a sentence an act and many of its subordinate qualities are directed, then if that act is not already directed by any other sentence, then

since it is not known, its injunction is understood. But if it is already directed, then it is treated as being cited and the various qualities are taken as directed by different sentences. Similarly, in general, if a material or subordinate (quality) or act is already directed, then by its citation, other similar or dissimilar material, quality or act cannot be taken to be directed without split of sentences.

(5) In cases where multiple activities are present in sentences or single activity is related to many things by reference (pronominals etc.) to decide whether the individual acts or independent ones we apply the principal of sentence split. This requires that any material, quality, or act cannot have connection with many things without a sentence split.

(6) In the common applicability of direct statement, word meaning, syntactic connection, context, position and name, the weakness of the latter is by reason of the sense. Among the 6 factors for decision, the first, i.e. direct statement will prevail over others and when it is present others will not be considered. Similarly, the last factor, name, will always be affected in case any other factor is applicable. Now, there are totally 15 situations of conflicts between these factors possible. i.e., 1 Vs. the others = 5; 2 Vs. the others = 4; and so on. Of these, the first 5 and the last 1 are of fixed priority as stated above. So, the relative priority we have to apply gets decided dynamically.

A detailed explanation of the hierarchy of knowledge sources is presented in the chapter on explanation.

(7) Though in a discourse all the words of different sentences must denote the objective in tune with the main function, they need not directly do so. There can also be elaboration of the different stages involved in accomplishing the main objective through subsidiary acts. These can have their own objects. For the discourse coherence, an abstract entity called अपूर्व (apûrva) is proposed which takes up the key objective or function of each segment of the discourse and provides the link to the main objective.

(8) The key function in a sentence is the productive urge denoted by the verbal suffix. This is precisely in the form of a mental resolve (intention)

to achieve the main objective through the current subsidiary act and includes the effort taken to realize it. The main objective thus gets qualified by the segment objectives. Thus the principal objective can be linked to the intention to produce the various verbal meaning (activity).

(9) In a specific discourse with a defined objective further sentences describing the details of the topic need not fulfill all the three required expectencies (regarding objective accessories and the manner) individually. Thus an incomplete sentence also can be linked up using the known factors inherited from earlier sentences. An analysis of the derivational process for meanings of the words and the sentence can also be restored to supply the missing factor i.e. the unfulfilled expectancy. In other words, we can complete the sense of the sentence from the information in the other sentences.

(10) In sentences where an injunction is related to an agent with a particular desire the objective can only be the object of desire. Here the activity required to obtain the object is necessarily an instrument. This is based on the maxim that only happiness or one leading to it can be the objective. If in the company of such activities, we find words in the instrumental case i.e. other candidates for instrument, these are preferred as names of the activities denoted by the verbs. We need not assign other function status like an attribute or accessory to these words with respect to the verbal meanings.

This case arises because adjectives have to syntactically agree with the qualified entity in terms of gender, case and number. The point to note is any expectancy is sought to be satisfied by the words present closest to it and once a suitable candidate is found, expectancy gets satisfied. Further, even if other candidates exist (but at a distance), they are not considered for the functional role, as the vacancy is already filled. This implies that in the case of non-functor relations (adjectives, subtantives etc.) the word order is given prominence by the principle of proximity.

(11) When the question of the sequence in which a set of subordinate sentences are to be related to the principle sentence arises, the approach

followed is for a given objective all sentences which contain details regarding accessory or manner offer themselves simultaneously for consideration. The result of the expectancy analysis from each of such sentences is summed up and linked to the main objective. There could be different sub-objectives in these sentences.

This is likened to a situation where a group of birds flying over a grain pounding field descending simultaneously on to the grains irrespective of their seniority (young, old etc) as their common interest is to get food which is independent in each of them. Similarly sub-ordinate sentences capable of satisfying the same expectancy in the principal sentence are not mutually subordinate i.e., they all have equal priority.

(12) Guidenline for determining the meaning of words is based on the denotative power of words understood through the process of base-suffix analysis and the conceptual category of the object that can be denoted. If such a primary meaning is inadmissible in some situation due to strong reasons like a direct statement only then we take recourse to secondary meanings in which the object denoted has a direct or an indirect relation with the primary meaning. Thus in cases where a word occurs for the first time (that is an unknown word) then we prefer it to be a proper noun if acceptable. A diluted sense taken in a particular sentence is treated as a local phenomenon i.e. it is not carried through to the rest of the sentences in a discourse. We begin with taking a primary meaning in each of the subsequent sentences.

(13) Word-meaning relationships are closely scrutinized to come up with three possible alternatives, viz. Words denote only particular forms (shape) or particular form with genus and only genus. Here, due to quick recognition, potency of words is taken in genus only and particular form is got by expectancy. This principle when applied to words means that words denote generic classes (conceptual categories) and the particulars are established by expectancy.

(14) Another principle applied in cases of determining word-senses is the division of denotative or conventional process of the meaning derivation.

With conventional words no analysis is needed to come up with the meaning denoted while in the denotative meanings derivational analysis is the basis. While convention restricts the absolute potential of the word to denote meaning it has the advantage of generating immediate cognition.

(15) If in a Vedic situation we find any injunction without an express mention of an objective, then we assume this to be the ultimate objective possible i.e. heaven. The principle here is that no unnecessary word is used in serious and meaningful discourses and that every word used contributes uniquely to the total sense. Then gaps are to be filled by the most suitable items from the same conceptual categories. This also implies that if any constraint is not expressed then it is not assumed, ie., the absolute is taken.

(16) In the above context (15) implicit indications or suggestions contained in the same discourse (typically as a sub-goal etc.) can be alternatively taken as the objective. This can also be found in the illustrative or laudatory parts even. However, a compatibility check is necessary here.

(17) In cases where specific details regarding the manner of activities etc. are not available implicitly or expliciltly, then we take recourse to prevalent practice by tradition. Here the basis is that the tradition has a Vedic text as its basis which now is not known or available.

(18) Whenever certain extra information other than what is expressly stated is assumed, then such assumptions are to be local to the concerned sentence or segment level only. Typically while dissolving compound words, the possible alternatives are evaluated on the basis of minimum effect on expressly stated information. This is specifically relevant where different types of compounding or sub-types of a same compound are applicable. This is based on the fact that in case of compound words, the emphasis could be on the first, last, all, or an external object (technically none).

Some adapted *Mîmâmsa nyâyas*

The universal nature of the generic principles of extended sentence and discourse analysis dealt with in *mîmâmsa* is amply clear from the numerous

maxims applicable in classical language situations and domains like jurisprudence, behavioural sciences, etc. These are popularly known as लौकिकन्याय (laukikanyâya). A few examples are discussed below.

प्रधानमल्लनिबर्हणन्यायः (pradhânamallanibarhana nyâyah)

The Maxim of vanquishing the main wrestler implying the futility of the need to tackle the rest of his men. This occurs while discussing the various sources of knowledge about *Dharma*. Since direct sensory perception itself is incapable of enlightening us about *dharma*, there is no question of others like inference etc. which depend on direct sensory perception for their operation, enlightening us about it.

पूर्वोधावतिन्यायः (pûrvodhâvati nyâyah)

The maxim of the 'the first fellow runs' says that if a sentence said 'the first runs' it should only be meant that there exists at least one more (a second) person but not for deciding what he is doing (i.e., it does not imply that the second person is also running). This is used in support of prime facie view in holding that number associated with a word form denotes only the quantity and not any other attribute.

गार्हपत्यन्यायः (gârhapatya nyâyah)

In sense determination of words, the connotational sense could be overridden by derivational or etymological (denotational) sense in case of express scriptural statement. This fixes a sort of criterion for sense determination in case of ambiguity or doubt.

सत्रन्यायः (satra nyâyah)

Substitution principle. Where a ritual has to be performed with a minimum of n (17) number of participants and if one of them dies, there has to be a substitute for him, but the substituting person is ineligible for the benefits of the ritual or sacrifice.

दर्विहोमन्यायः (darvihoma nyâyah)

Independence principle. Something that neither borrows or inherits anything from others, nor lends to other rituals is said to be self-reliant and independent.

Theory of coherence in discourse

We consider the following question to propose a theoretical basis explaining relation between words and parts of the sentence to the total discourse.

Does the hearer understand the sentence being uttered, particularly in cases of extended/connected sentences, as he hears, i.e, gradually build up an understanding and, of course, apply changes as the incoming words are understood or does he wait for the end of communcation to be signalled, for beginning the process of understanding, so that there would be no need to apply subsequent correction, as a unique import can be made out ? This is the central issue for proposing sentence coherence theories. Evidently, this depends on the process by which isolated words in Sanskrit (though composite) denote their objects, i.e, meaning, this leads us to the following question :

Do the words in the sentence convey their meanings in isolation or as connected together ? There are two different views offered by the two schools of *mîmâmsâ* regarding the function of the words in a sentence. According to one view, known as अन्विताभिधानवादः *(anvitâbhidhânavâdah)*, words convey their own senses not in isolation, but as connected together, in a sentence, no word gives by itself any clear meaning, but only as related to other. According to the other view, known as अभिहितान्वयवादः *(abhihitânvayavâdah)*, words primarily signify their own senses; but the meaning thus derived conveys the combined meaning of the sentence. We regard the first view as the sounder one. In other words, there is no need of apprehending each word ·separately before combining them in a sentence, when the meaning of the whole sentence can as well be conveyed at once as the collective sense of all the words, i.e, the potency lies in the process of coherence itself, if the three previously mentioned requisities are satisfied.

Words denoting known objects are collocated to denote an activity etc, in a sentence. There is no basis to establish a sentence meaning which is isolated from its constituent word meanings. That sentential meaning contains

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something different from word meanings is not even known or corroborated by inference. The words end after denoting their objects. The objects thus known give us the sentential meaning. When words denoting color like white, black, etc, are used, the respective colors are understood. To denote the object with that attribute, the word denoting attribute itself (as a qualifier) is sufficient (through the expectancy raised) and thus combined meanings (objects with their qualities) are denoted by qualifiers themselves. The combined meaning thus obtained is the sentential import.

Experience suggests a right combination of both the processes of incremental cognition/verification as well as a final confirmation. Thus, both the above theories have been found to have practical applications. With the aid of *kâraka* theory, however, the अन्विताभिधानवादः *(anvitâbhidhânavâdah)* is found convenient to apply in most cases. The details of the discussions, though availble, are avoided here.

Thus, we have briefly hinted at certain exciting material contained in *mîmâmsa* works, which, in our opinion, could be beneficial to NLP. We wish to evoke further discussions from the researchers in the field, particularly regarding our system, DESIKA.

(Text provided by author)

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DEVELOPMENT OF SEMANTICS IN ANCIENT INDIA

A. Bharadwaj

Introduction

Language is the subject of study of the academic descipline known as Linguistics. We use the word language to refer to a limited stock of movements or utterences by which we communicate a limited number of messages. In doing so we recognise that we are speaking of something different in kind from our own language.

Lexicon

Lexicon is a book containing an alphabetical arrangement of the words in a language and their definition. Collection of words and word elements which we put together in various way to form larger units of discourse : Phrases, Clauses, Sentences form a lexicon. All languages have lexicons and all lexicons are governed by rules that permit some kinds of word formation, make others dubious and render still other clearly impossible. Grammatical system of language governs the way in which words are put together to form the larger units of discourse. Such units find an origin from the very Vedic texts. Semantics is the study of the way in which interpretation is explicitly attached to a formalized logistic system.

Brâhminical texts give the explanation for the *samhitas* and give the derivation of meaning Cf : उदानिषुर्महीरिति तस्मादुदकमुच्यते (अथ. वे. ३-१३-१) (*Udânisurmahîriti tasmâdudakamucyate - Atha. V.* 3-13-1). These were discussed in detail in *Yâska's Nighantu* and *Nirukta* whose ideas are taken from the *Sulba sûtras*. The evolution of these thoughts are traced in the following paragraphs.

In the days of yore *vedas* used to be imparted by oral tradition. Hence the meaning of the sentences and sequence of the words used to be preserved