Linking the Sanskrit WordNet to the Vedic Dependency Treebank: a pilot study

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Abstract

The Sanskrit WordNet is a resource currently under development, whose core was induced from a Vedic text sample semantically annotated by means of an ontology mapped on the Princeton WordNet synsets. Building on a previous case study on Ancient Greek (Zanchi et al. 2021), we show how sentence frames can be extracted from morphosyntactically parsed corpora by linking an existing dependency treebank of Vedic Sanskrit to verbal synsets in the Sanskrit WordNet. Our case study focuses on two verbs of asking, *yāc-* and *prach-*, featuring a high degree of variability in sentence frames. Treebanks enhanced with WordNet-based semantic information revealed to be of crucial help in motivating sentence frame alternations.

1 Introduction

WordNets (WNs) are lexical databases storing meaning in a relational way; they usually include little or no morphosyntactic information (sentence frames, SFs) for verb senses (Fellbaum, 1998; 2012). Instead, morphosyntactically annotated corpora (treebanks) store parsed sentences in the form of trees and allow automatically extracting all SFs available for each verb.

Building on previous work on Ancient Greek (Zanchi et al., 2021), we present a pilot study in which the Sanskrit WordNet (SWN) is linked to the Vedic Treebank (VTB). By discussing the SFs of two Sanskrit ditransitive verbs of asking, *yāc-* 'beg for' and *prach-* 'ask, ask for, seek', we show how treebanks enhanced with WN-based semantic information (and, vice versa, WNs enhanced with treebank-based syntactic information) can motivate SF alternations. Other ditransitive verbs denote physical ('give', 'lend', 'hand', 'sell') or mental ('tell', 'show') transfer. Generalizations on SF alternations featured by verbs of asking can thus be partially extended and compared with those on other ditransitive verbs.

The paper is organized as follows. Sec. 2 describes the features of the SWN and of the family of WNs to which it belongs. Sec. 3 introduces the VTB and shows how we link the data. Sec. 4 reviews the morphosyntactic information contained in some WNs. Sec. 5 discusses the sentence frames of *yāc-* and *prach-*. Sec. 6 concludes the paper.

2 The Sanskrit WordNet in the family of WordNets for ancient IE languages

The SWN is part of a family of WNs developed by an international team at the Universities of Pavia, Exeter, and Düsseldorf, the Catholic University of Milan, and the Center for Hellenic Studies at Harvard University (Biagetti et al. 2021a).[1] The family also comprises WNs for Ancient Greek and Latin. To enable crosslinguistic comparison of meanings and structures, WNs of the family are designed to be interoperable with each other and facilitate the integration with other linguistic resources, such as treebanks. This is possible thanks to a standardized set of lemma based URIs that ensure identification and allow linking external resources.

The SWN is based on, and extends, original work by Oliver Hellwig at the *Digital Corpus of Sanskrit* (DCS).[2] The core of the SWN was built by manually annotating selected texts in the DCS for lexical semantics using the OpenCyc ontology (Lenat, 1995), a knowledge base containing concepts with English glosses and relations

[1] https://sanskritwordnet.unipv.it.

[2] http://www.sanskrit-linguistics.org/dcs/index.php.

among them. About 600,000 tokens and 32,200 lemmas were semantically tagged, resulting in a semantic network of over 124,000 concepts and 194,000 relations. If OpenCyc lacked concepts for specific words, the ontology was enhanced with Sanskrit-specific concepts and glosses (ca. 24,400), whereas anachronistic concepts were partly dropped from the inventory. Synonymic sets were populated by the Sanskrit words annotated with the same OpenCyc concept, and a large subset of OpenCyc was automatically mapped onto the synsets of the PWN 2.1 and onto WN 45 lexicographic files using OpenCyc concept glosses (Hellwig, 2017). This yielded 50,595 mappings onto PWN 2.1 and 78,198 onto the lexicographer files (out of a total of 124,040 annotated concepts). Lexical relations in SWN were automatically imported from the .xml version of the Sanskrit-English dictionary Monier-Williams, which lists lemmas under their root and specifies the morphological relation deriving lemmas from the root.[3]

Currently, annotators are working on manually validating the imported annotation and framing it in a cognitive linguistic view of polysemy: all non-literal senses of a lemma can be organized in a network and linked to the literal ones through cognitive metonymies and metaphors (Tyler and Evans, 2003; see Biagetti et al., 2021a and Zanchi et al., 2021). To allow investigating semantic change and variation, annotators are adding etymological, morphological, stylistic and diachronic metadata to each synset gloss associated to a lemma, including etymology, principal parts, prosodic information, irregular and/or alternative forms, periodization(s), literary genre(s), author(s) and work(s) (examples are in Biagetti et al. 2021 and Zanchi et al. 2021).

3 Enhancing the Sanskrit WordNet with sentence frames

3.1 The Vedic Treebank

Vedic is the oldest attested sub-branch of Indo-Aryan, handed down to us by a massive corpus of religious and ritual texts. Despite its historical and linguistic importance, scholars only recently undertook the endeavor of building large-scale digital resources for Vedic. Among the outcomes, the VTB is a syntactically annotated corpus of Vedic literature based on the Universal Dependencies standards (UD; Nivre et al., 2016; Hellwig et al., 2020).

Three versions of the VTB have been released (Hellwig and Sellmer, 2021), accompanied by annotation guidelines that fully account for cases in which the VTB annotation diverges from UD.[4] The third release, still under development within the ChronBMM project,[5] currently contains ca. 18,958 sentences and 140,442 tokens, covering the whole diachrony of the Vedic corpus (Hellwig and Sellmer, 2022).

3.2 A pilot study

In this section, we present a pilot study in which the VTB is enriched with WN-based semantic information on the verbs *yāc-* and *prach-*. As the VTB contains selected passages from the whole of Vedic literature, we selected the entire *Ṛ̊gveda*, its oldest representative, as a sub-corpus for our study. We then extracted all occurrences of *yāc-* (9x) and *prach-* (49x) in this text and performed a manual syntactic annotation of the sentences in which they occur.

Like other ditransitive verbs, verbs of asking such as *yāc-* and *prach-* take an agent-like argument (A), a recipient-like argument (R), and a theme-like argument (T) (Malchukov et al., 2010). In case a verb requires more than two core arguments, the UD annotation scheme[6] assigns the role of 'object' (label `obj`) to the noun phrase that is most 'directly affected' by the state of affairs brought about by the verb; the additional argument is labeled as 'indirect object' (`obj`). The UD guidelines further specify that, in languages distinguishing morphological cases, the object is often marked by the accusative, whereas the indirect object takes most commonly the dative.

Determining the SF of verbs such as *yāc-* and *prach-* was a reason for disagreement for the developers of the VTB as both R and T arguments can take the accusative case and it was not clear which of the two arguments should be annotated as the direct object (Biagetti et al., 2021b). Since both R and T can be passivized with the verb

[3] https://www.sanskrit-lexicon.uni-koeln.de/scans/MWScan/2020/web/webtc/indexcaller.php.

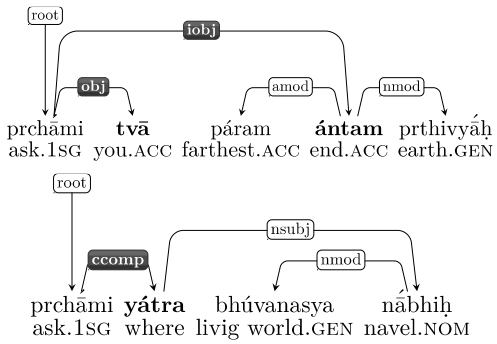
[4] Only the first release of the VTB is available at the UD repository. The subsequent two versions can be found at https://raw.githubusercontent.com/OliverHellwig/sanskrit/master/papers/2020lrec/treebank/sanskrit.conllu.

[5] https://chronbmm.phil.hhu.de.

[6] https://universaldependencies.org/u/dep/index.html.

prach- (Hettrich, 1994), and since *yāc-* is only attested in the active, deciding which argument to label as the direct object based on its similarity to the prototypical patient did not seem the best solution. Instead, since R is always encoded by a nominal in the accusative, whereas T can be encoded in different ways (noun/pronoun in the accusative, infinitival dative, complement clause, direct speech), we decided to label R as `obj` and T as `iobj` when they are both realized as nominals in a sentence. When only one of the two arguments is expressed, it takes the relation `obj`. Finally, when T is encoded by a subordinate clause or by direct speech, it takes the relation `ccomp` (complement clause). Cf. example (1).

(1) ṚV 1.164.34



'I ask you about the farthest end of the earth. I ask where (is) the navel of the living world.'

As a second step, exploiting the MISC field of the CoNLLU format, [7] we manually added the appropriate synset to each occurrence of the two verbs in the treebank. For instance, the verb *pṛcchā́mi* in (1) was assigned the synset v#00608227 "address a question to and expect an answer from". As we will see in Sec. 5, adding sematic information to all forms of a verb in the VTB allows automatically extracting all SFs available for such verb along with information concerning their frequency (see Sec. 5).

4 Sentence frames in WordNets

The verb *request* in the Princeton WN (PWN) is associated to three synsets, including v#00510998 "express the need or desire for". In this sense, *request* features two SFs:

(i) *Somebody ---s something*;
(ii) *Somebody ---s somebody*.

Such SFs provide limited semantic information about animacy of verbal arguments, by distinguishing *somebody* vs. *something*, and aspectual information concerning the verb, in the form of the simple present third singular ending *---s*. Overall, the PWN contains 35 SFs, which indicate "the number of noun arguments that the verb subcategorizes for" (Fellbaum, 1998). [8] In contrast, no information is given on the semantic roles of the noun slots in the frame, and a direct linking between the PWN and other resources richer in this respect (e.g., those in the Unified Verb Index) [9] has not been implemented yet. Finally, SFs of the PWN are intuition-based, and no corpus-based examples accompany SFs.

As pointed out in Zanchi et al. (2021), as SFs are language-specific, they cannot be automatically ported from the PWN to other WNs. Furthermore, the relevant information in SFs is language-specific too, depending, e.g., on how grammatical relations are encoded or on whether verbal aspect is grammaticalized in a specific language. For this reason, WNs greatly vary as to the type of information provided along with SFs. In GermaNet, the German WN, [10] the verb *bitten* 'request', glossed as "jemanden in höflicher Form nach etwas fragen", features two SFs (examples are from GermaNet):

(2) NN.An.AZ – *Er bat mich, ihm zu helfen.*
(3) NN.An.PP – *Meine Eltern haben mich um Hilfe gebeten.*

In (2)-(3), the abbreviations are as follows:

- NN: grammatical subject that is realized as a noun phrase in the nominative case;
- An: optional accusative complement;
- AZ: obligatory accusative plus infinitive clause introduced by *zu*;
- PP: obligatory prepositional phrase.

Thus, GermaNet provides information about case marking and distinguishes between complements and adverbials, which can be either obligatory or optional. In contrast, GermaNet lacks information on verbal aspect, which is not grammaticalized in German, and on animacy. The examples provided by GermaNet are partly corpus-based.

[7] https://universaldependencies.org/format.html.
[8] Instead, the Open English WN (https://en-word.net/lemma/request) does not contain SFs.
[9] https://uvi.colorado.edu.
[10] (https://weblicht.sfs.uni-tuebingen.de/rover/

In the case study on Ancient Greek in Zanchi et al. (2021: 734 ff.), the SFs were modelled on those of GermaNet and integrated with animacy information on nominals and aspectual information on verbs, as verbal aspect is grammaticalized in Ancient Greek and interacts with tense and voice. The Ancient Greek verb *aggéllō*, in the synset v#00659537 "make known", features four SFs (and five additional sub-frames, see Zanchi et al. 2021: 735 f.), represented as follows:

1. NN(+a) ...ptcp.fut/aor Nd(+a);
2. NN(+a) ...impf/aor Na(-a) Nd(+a);
3. NN(+a) ...aor ND(+a) INFINITIVE;
4. NN(+a) ...impf/aor COMPL CLAUSE.

The abbreviations indicate the following:

- NN: as in GermaNet;
- Nd: optional dative complement;
- ND: obligatory dative complement;
- (+a): animate noun;
- (-a): inanimate noun;
- aor, fut, impf, ptcp: usual glosses for tenses and moods (aorist, future, imperfect, participle), which are related to aspectual information.

5 A case study with two verbs of asking: *yāc-* and *prach-*

We now discuss the SFs we extracted for the verbs *yāc-* and *prach-*. Note that Vedic is a null subject language, but we still indicate subject NPs as NN (nominative NP), as it triggers verbal agreement (there are no impersonal forms among the occurrences analyzed). The verb shows a complex aspectual system, with the present stem indicating imperfective, the aorist stem perfective and the perfect resultative aspect. It is not clear to what extent this system, that Vedic inherited for Proto-Indo-European and that is reflected in verbal morphology, was still relevant at the time of the Vedic texts; the VTB allows retrieving only partial information about verbal aspect, as the aorist and the perfect are not kept distinct. The SFs we found in our corpus are discussed in sections 5.1-5.2 and summarized in Table 1. For each SF, the table lists the synset(s) it occurs with as well as the example(s) provided in Sections 5.1 and 5.2.

N	Sentence Frame – Synset(s)	Ex.
1	NN(+a) ...pres/past NA(+a) Na(-a): - v#00515892 "call upon in supplication; entreat" - v#00608227 "address a question to and expect an answer from" NN(+a) ...pres/past pass NA(+a) Na(-a) - v#00511577 "ask (a person) to do something" (passive)	(4), (5)
2	NN(+a) ...pres NA(-a) - v#00510727 "make a request or demand for something to somebody" - v#00608227 "address a question to and expect an answer from" - v#00532796 "inquire about" - v#00494502 "have a wish or desire to know something"	(6)
2_i	NN(+a) ...pres/past NA(±a) - v#01533628 "try to get or reach"	
3	NN(+a) ...pres NA(+a) - v#00608227 "address a question to and expect an answer from" - v#01727931 "make amorous advances"	(7), (11)
4	NN(+a) ...pres NA(+a) Ques - v#00608227 "address a question to and expect an answer from"	(8)
5	NN(+a) ...pres NA(+a) NG(-a) - v#00608227 "address a question to and expect an answer from"	(9)
6	NN(+a) ...pres Ques - v#00532796 "inquire about" - v#00494502 "have a wish or desire to know something"	(10)

Table 1. Sentence frames found in our corpus.

5.1 *yāc-*

The verb *yāc-* occurs nine times in our corpus and comprises two synsets: v#00515892 "call upon in supplication; entreat" and v#00510727 "make a request or demand for something to somebody". The first synset is more frequent and shows SF 1 (NA indicates an obligatory accusative complement). The linear order reflects our assumption that the R argument functions as second argument of the verb (see Sec. 3.2).

1. NN(+a) ...pres/past NA(+a) Na(-a)

(4) *sómam* *ín* *mā* *sunvánto*
soma.ACC PTC 1SG.ACC press.PTCP.NOM
yācatā *vásu*
beg.IMPV.2PL good(N).ACC

‘Just when you are pressing soma, beg me for good things.’ (RV 10.48.5)[11]

(5) *mā́ tvā … sádā yā́cann*
NEG 2SG.ACC always beg.PTCP.N
aháṁ girā́ … cukrudhaṁ
1SG.NOM song(F).INST anger.INJ.AOR.1SG
‘Always begging you with my song […] let me not anger you.’ (RV 8.1.20)

The second synset, v#00510727 “make a request or demand for something to somebody”, is instantiated in a single occurrence with the SF 2, in which the T argument functions as second argument of the verb.

2. NN(+a) ...pres NA(-a)

(6) *śukrā́ āśíraṁ yācante*
clear.NOM.PL mixture(F).ACC beg.IND.MID.3PL
‘The clear ones beg for the milk mixture.’ (RV 8.2.10)

5.2 *prach-*

The verb *prach-* is not only more frequent than *yāc-* as it occurs 49 times, but also shows a more nuanced semantics, comprising six synsets (in order of decreasing frequency):[12]

- v#00608227 “address a question to and expect an answer from” (27x)
- v#00532796 “inquire about” (9x)
- v#01533628 “try to get or reach” (8)
- v#00494502 “have a wish or desire to know something” (2x);
- v#00511577 “ask (a person) to do something” (2x);
- v#01727931 “make amorous advances towards” (1x)

The meaning v#00608227 “address a question to and expect an answer from” features SFs 1 and 2 discussed in Sec. 5.1; further SFs are 3, as in (7), 4, as in (8) and 5, as in (9) (the latter only attested once). All SFs occur with verb forms based on the present stem (present and imperfect); only SF 2 occurs once with a past verb form. In SF 4, “Ques” indicates a direct or indirect question.

3. NN(+a) ...pres NA(+a)

(7) *tám pṛchatā … sá veda*
3SG.ACC ask.IMPV.2PL 3SG.NOM know.PF.3SG
‘Ask him: […] he knows.’ (RV 1.145.1)

4. NN(+a) ...pres NA(+a) Ques

(8) *kavī́n pṛchāmi ajásya*
poet.ACC.PL ask.1SG unborn.GEN
rūpé kím … ékam
form.LOC what(N).NOM one(N).NOM
‘I ask the perceptive poets […]: What is the One in the form of the Unborn [=the Sun]?’ (RV 1.164.6)

5. NN(+a) ...pres NA(+a) NG(-a)

(9) *ví pṛchāmi pākyā̀*
PV ask.2SG ignorance.INST
ná devā́n … adbhutásya
NEG god.ACC.PL unerring.GEN
‘In my naïveté I ask (you), not (other) gods, about the unerring (soma).’ (RV 1.120.4)

The meaning v#00532796 “inquire about” selects SFs that do not involve a R argument. The T argument can be an accusative NP, instantiating SF 2, or a direct question. In this case the SF is 6, as in (10).

6. NN(+a) ...pres Ques

(10) *yáṁ smā pṛcháṇti kúha*
REL.ACC PTC ask.3PL where
sá íti ghorám
3SG.NOM QUOT terrifying.ACC
‘The terrifying one about whom they always ask: Where is he?’ (RV 2.12.5)

Verbal tense is always present, except for an occurrence of a passive past participle, in which the T argument is passivized (RV 3.20.3).

The meaning v#01533628 “try to get or reach” features a T argument which can be animate or inanimate, hence a variant of SF 2:

2$_i$ NN(+a) ...pres/past NA(±a)

In our corpus we also found some passive occurrences that contain a passive past participle, in which the T argument is passivized. Synset v#00494502 “have a wish or desire to know something” occurs twice without a R argument because both occurrences feature the reflexive middle: hence the R is also the subject. The SFs are 2 and 6. We tagged as instantiating synset v#00511577 “ask (a person) to do something” two occurrences, both featuring passive forms with the R argument functioning as subject and no T argument. These occurrences are passive versions of SF 1, in which the non-obligatory T argument does not occur. Finally, the meaning “make amorous advances” features an animate R argument and the SF is 3; note that the only

[11] Abbreviations in glosses follow the *Leipzig Glossing Rules* (https://www.eva.mpg.de/lingua/pdf/Glossing-Rules.pdf).

[12] Two occurrences of the compound verb *sám prach-* feature the synset v#00517734 “discuss the terms of an arrangement” (e.g. *They negotiated the terms*). We have not included them in our discussion.

occurrence we found in the corpus, shown in (11), has a referential null object as R.

(11) *yád aśvinā pr̥chámānāv* **Ø**$_i$
when A.voc ask.PTCP.MID.NOM.DU
áyātaṁ ... vahatúṁ sūryā́yāḥ$_i$
drive.IMPF.2DU wedding.acc S.GEN
'When, o Aśvins, you two drove […] to the wedding of Sūryā to ask for her.' (RV 10.85.14)

Summing up, the most frequent SFs with *prach-* are 1 and 2, which are also the only two SFs that occur with *yāc-*. They both involve the occurrence of a referential T argument, coherently with the meaning of *yāc-* 'beg (for)'; SF 2 is the only one we found that does not involve a R argument. In addition, *prach-* which most often indicates the activity of asking questions, also frequently occurs in SFs 4 and 6 that contain questions as T argument; the latter does not appear in SF 3 while SF 5 constitutes a sporadic variant in our corpus.

Concerning verbal voice, while both verbs are ditransitive, *yāc-* does not occur in the passive in our corpus. In its turn *prach-* can passivize when it features SFs 1 and 2. In the first case, it is the R argument that becomes the passive subject, while with SF 2, which does not contain the R, the T is the passive subject. SFs 2 and 6, with no R as second argument (synset v#00494502 "wish to know something") may contain middle verb forms, in which case the R is also the subject, as the verb has reflexive meaning. Notably, middle voice is not annotated in VTB, and these occurrences have been considered as instantiation of SF 2 and 6, similar to occurrences in which the R does not occur in any syntactic position. However, they are semantically different. A further improvement would be enriching the VTB with information concerning verbal voice, as we discuss in Sec. 6.

6 Future work

We plan to add semantic information to all verbs in the VTB and to extract SFs attested for each verb as well as information on their frequency. While in some cases it will be necessary to manually add synsets to each occurrence of a verb, the process can be partly automated when the relationship between the SF and a verb's sense is stable. Cf. the different synsets associated to active and middle forms of the verb *duh-*:

a. Active 'milk', 'extract', 'benefit from':
- Intransitive/transitive + cognate object: v#00133336 "take milk from female mammals"
- Transitive: v#00925055 "obtain from a substance, as by mechanical action"
- Metaphoric: v#01565865 "benefit from"

b. Middle 'give milk':
- Intransitive/transitive + cognate object: v#00806715 "give suck to"
- Transitive: v#01119839 "give or supply"

As alternations in a verb's SFs often co-occur with voice alternations, automatic annotation will be possible once the VTB has been enriched with information on verbal voice. We also plan to enhance the annotation interface of the SWN to include syntactic information. Since the SWN is enriched with chronological information on the attestation of every single sense of a word, enhancing the annotation interface in such a way will allow studying changes in valency over time.

Acknowledgments

This article results from the joint work of the authors. For academic purposes, Chiara Zanchi is responsible of sections 1, 2 and 3, Erica Biagetti of sections 4 and 6, and Silvia Luraghi of section 5. Furthermore, Erica Biagetti is responsible of data extraction and annotation.

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